



Under Bridge Installation Work Practice For Fiberglass Conduit Systems



Atkore[™]
FRE Composites

Introduction

FRE Composites is one of the world's foremost manufacturer of filament wound epoxy conduit. FRE Composites pioneered the technology in 1958 when a need was identified for electrical tubing that could withstand intense electrical arcing and immersion in oil. By the mid-1960s, FRE Composites had developed a process to manufacture strong lightweight filament wound conduit. Telecommunication companies and power utilities were then able to realize considerable cost reductions in underground, under bridge and underwater conduit installations. Today, FRE® Conduit is installed throughout the world. FRE Composites has engineered conduit installations in North America, South America, the Far East, Southeast Asia, the Middle East and Africa. Engineering assistance is available to engineers from our network of manufacturer's representatives (please consult our website or call our office for more information).

C.S.A. Approval

FRE® Above Ground Conduit system is recognized by the Canadian Electrical Code in Articles 12-1200 to 12-1220 as an approved conduit material. The product is C.S.A certified by the electrical division per the requirements of Bulletin 1089A under the listing number LR 28032, class 1833.

U.L. Approval

The National Electrical Code in Article 355-1 recognizes "fiberglass conduit" as an acceptable conduit material. FRE® Conduits are listed by Underwriters Laboratories Inc. under file number E53373.

Reference Manual

Additional aids in the evaluation and design of your FRE bridge crossing installation are available from your FRE manufacturer's representatives or our technical personnel at our factory.

Conduit Criteria

Manufacturing

FRE® Above Ground Conduit system products are manufactured from quality thermosetting epoxy resin and glass fiber reinforcement. The fiberglass reinforcement is applied in continuous and unbroken filaments throughout the various product by the use of a manufacturing technique known as filament winding. This continuous reinforcement technique produces products with exceptional strength-to-weight characteristics and outstanding installed performance.

UV Resistance

FRE® Above Ground Conduit system products are specifically formulated for resistance to ultraviolet rays. This is achieved by blending ultraviolet inhibitor with the epoxy resin before the manufacturing process. Which acts as a screen and gives our Above Ground Conduit system products its uniform standard black color. FRE Composites is constantly searching for other UV-resistant inhibitors so as to allow color choices. Please consult our local manufacturer's representative for color samples.

Thermal Expansion

The design engineer is afforded a major advantage when specifying fiberglass conduit system for bridge applications. The thermal expansion of FRE® is 40% less than PVC conduits, reducing the amount of expansion joints required. Regardless of conduit run length, the conduit assembly will exhibit different expansion characteristics than the bridge structure, thus requiring the use of at least (1) one expansion joint per run. The coefficient of thermal expansion of FRE conduit is a low 1.37×10^{-5} in/in/°F. A simplification of this data is that for a temperature change of 1°F or 0.56°C, a 100 ft. or 30.5 m length of conduit will expand or contract of 0.016 in. or 0.4 mm. The table below offers some typical installation conditions.

The watertight FRE O-Ring expansion joint is designed to allow 6 in. or 152.4 mm of travel in either direction, therefore one (1) O-Ring expansion joint should be installed in every 200 ft. or 60.96 m to conduit run. An expansion joint will permit a 130°F or 54°C rise or fall in temperature from the temperature at the time of installation, without causing binding or excessive travel within the expansion joint. Further details regarding placement and configuration of O-Ring expansion joints are detailed in Section 4.

Conduit Thermal Contraction / Expansion

Ambient Temp Change		Conduit Length Change	
°F	°C	(inches/100ft of conduit)	(Millimeters/30.5m of conduit)
1°	0.5°	0.016	0.40
40°	22.4°	0.650	16.6
80°	44.8°	1.310	33.1
120°	67.2°	1.970	49.7
160°	89.6°	2.630	66.3



Chemical Resistance

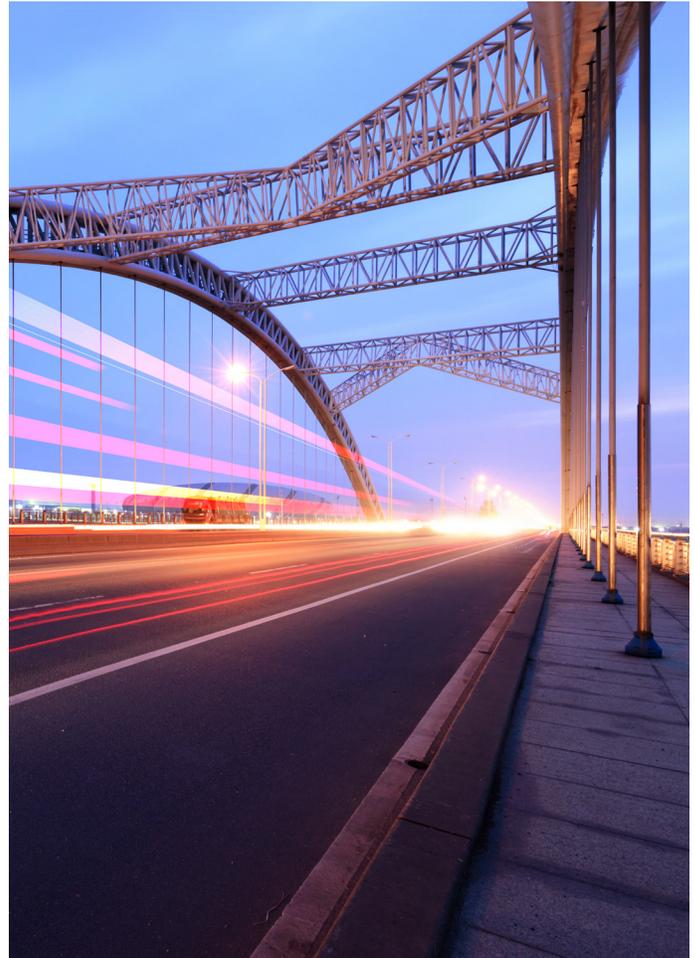
Thermosetting resins such as the epoxy material used in the manufacture of FRE[®] products are extremely resistant to degradation from corrosive agents. Our Above Ground Conduit is unaffected by rain, snow, road salts, seepage and spillage of hydrocarbon fuels, high concentrations of most acids or airborne pollutants and hence is maintenance-free.

Weight

Considerable savings in conduit hangers and supports can be realized due to the lightweight and high flexural strength of fiberglass. FRE[®] is twice the strength to weight ratio than PVC and much lighter weight than steel and aluminum alternative products.

Conduit Runs

The planning of the conduit run should include extra capacity to accommodate future requirements either for additional cables or possibly additional conduit runs. It is generally found to be more economical to initially allow for vacant conduits than to repeat the conduit installation procedure at a later date.



Hanger Support Criteria

Permits and Approvals

Use of a bridge as a means of carrying conduits is generally subject to the approvals of various government agencies. Any modifications to structural bridge components should be done with the approval of all agencies responsible for the bridge. Supporting conduit runs on bridge members, or the suspension of conduit support systems from bridges either through welding, clamping, drilling or bolting will require considerable engineering and design data. FRE Composites has acquired extensive field experience in the design and installation of supporting hardware.

Hanger Design Considerations

FRE Composites recommends that the following factors be considered in the selection of conduit hangers:

- The hangers should have a minimum support surface width of 2 in. or 50.8 mm for adequate load-bearing capability. Sharp edges and point contacts must be avoided.
- The commercially available grid type of conduit support hanger designed for non-metallic conduits is recommended.
- To minimize abrasion and wear at the duct and hanger interface, the materials should be of the same or similar composition and hardness. There are several premium-quality fiberglass bridge hangers available.
- The hanger opening should be such as to allow free and unrestricted movement of the conduit during installation and during thermal expansion and contraction. The openings should not, however, be so large as to allow the passage of the enlarged conduit bell end, Double Bell coupling, O-Ring expansion joints or Split stop rings.

Grid Type Hangers

The grid type hangers are designed so that each conduit run is individually supported and isolated from the conduit above and below. In this way, each conduit carries only its own weight and the internal cable weight but not the weight of any other conduit in the conduit bank. In installations where conduits must be stacked, the bottom duct can be damaged due to overloading. In these instances, please consult with our local manufacturer's representative for technical assistance.

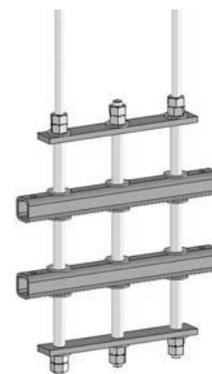
Vibration Effects

Bridge structures are subject to the transmission of vibrations from the road surfaces to the conduit runs. Adequate provisions must be made in the use of threaded fasteners and specified fastening torque, lock nuts, lock washers and thread sealants to ensure the hanger's integrity. These provisions will reduce costly maintenance and avoid hazardous situations over the life of the installation.

Vertical Loading

FRE Composites recommends the design engineer consult with the hanger supplier to assure the vertical load of the conduit run, cable contained therein and hanger assembly will not exceed the vertical load capacity of the hanger support components.

Typical grid type
conduit hanger



Hanger Orientation

Hangers should be installed at right angles to the duct run, and in line with each other to avoid bends and kinks in the conduit run.

Span Calculations

The superior flexural strength of FRE conduit system enables the design engineer to increase the support spans thereby reducing the number of hangers required. FRE Composites has compiled comprehensive span deflection charts for use in the determination of the correct hanger spacing. These tables are available in Appendix 1. To use the span tables, the Engineer must first determine the weight of the cable to be installed inside the conduit. In cases where a variety of different cable types will be used, the design will be calculated for the conduit run which will carry the heaviest cable. The tables list the cable weights on the vertical axis and the conduit span on the horizontal axis. To determine the optimum span, select the correct cable weight from the vertical axis and follow the horizontal line to the right until it intersects the 1/2 in. or 12.7 mm design deflection curve. By extending this point down to the horizontal axis, the recommended span distance is thus determined. The 1/2 in. or 12.7 mm deflection line is the most commonly used as it provides a visually aesthetic appearance.

Some engineers prefer to work with a deflection of 3/4 in. or 19.1 mm OR 1 in. or 25.4 mm and these curves are also provided on the tables.*

Under no circumstances should the designer exceed the stress level of the duct by planning his design to the right of the stress limit line. The intersection point must always fall to the left of the stress limit line for a safe installation. Where this is not possible, your FRE manufacturer's representative or consult the factory.

Span Safety Factors

FRE Composites has provided adequate safety margins in the calculation of long-term stresses. Conduit samples selected at random from the plant's production undergo an extensive test program where they are subjected to a variety of loading conditions to failure. The analysis provided from this test program yields data that is used in the computation of the conduit's flexural modulus and other relevant data. From this data, a safe allowable working stress limit is arrived at.

FRE Composites places an additional safety factor into it figures by reducing all stress and modulus figures to take into account factors such as long term creep, aging and other phenomena. It is these conservative figures which are then used to make up the span charts. The deflection curves are further modified to take into account unpredictable deflections such as when expansion joints or other fittings fall at or near the mid-span position.

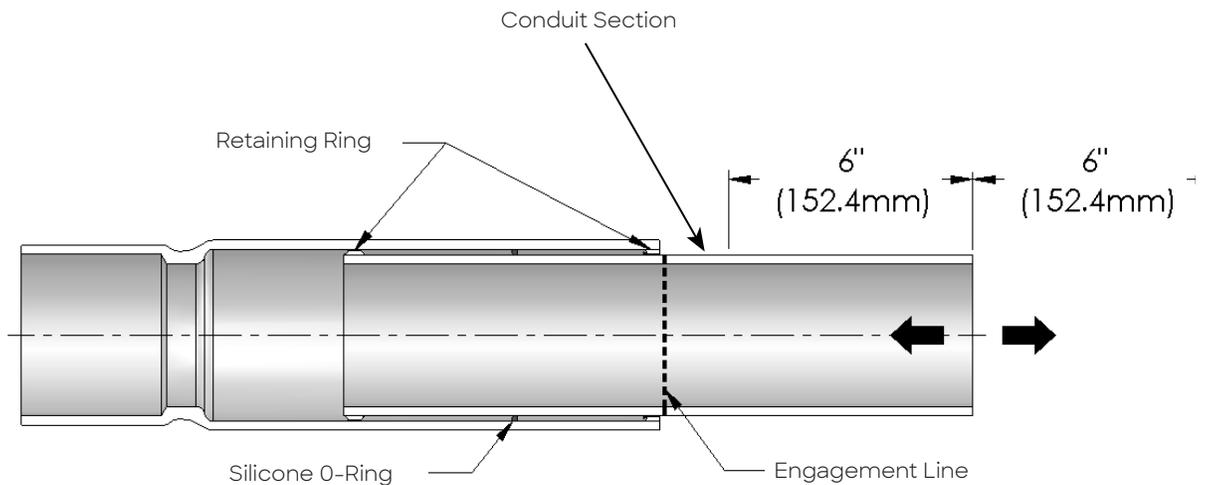


O-Ring Expansion Joint

Design

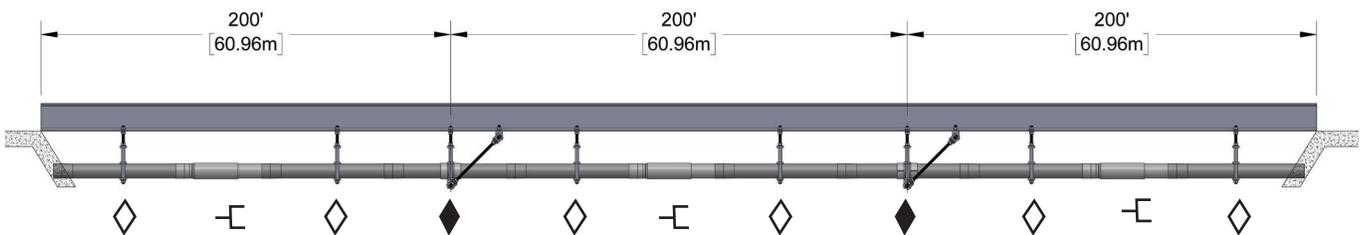
Our O-Ring expansion joint fittings have been designed for use in bridge crossing applications. A silicone O-Ring seals the unit to keep dirt and water out of the fitting while ensuring freedom of movement. The fitting also employs retaining rings to contain the silicone O-Ring and prevent the conduit section from accidentally disengaging if extended too far.

Additionally, every O-Ring expansion joint has a yellow line traced on the conduit section that serves as a reference to ensure the correct setting of the unit during installation. When properly positioned, the yellow line remains be visible and a minimum of 6 in. or 152.4 mm of free travel will be available in either direction.



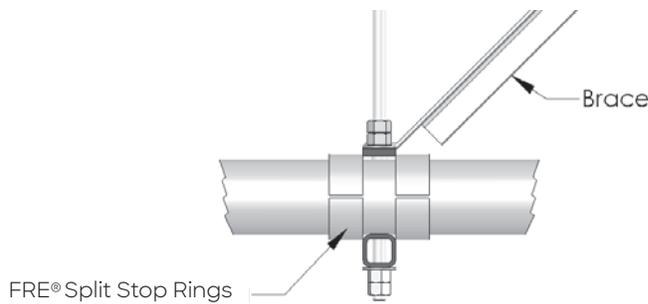
Placement

Expansion and contraction of the conduit will usually be greater and independent of any expansion and contraction in the bridge structure. For this reason, expansion joints and restraining points which anchor the conduit must be employed to adequately control this motion predictably. An O-Ring expansion joint must be provided for every 200 ft. or 60.96 m of conduit run to adequately control motion. To ensure that each expansion joint works independently from the others, the conduit must be securely braced at each 200 ft. or 60.96 m interval. The diagram below shows a typical bridge installation.



Legend

- ◇ Intermediate Hanger
- ◆ Fixed (Braced) Hanger with Split Stop Rings
- Expansion Joint



With Anchoring Hangers
Duct is fastened with FRE®
Split stop rings & Hanger is
held rigid with braces

On Intermediate Hangers
Duct must not be clamped
tightly at this point but
must be free to slide



O-Ring Expansion Joint

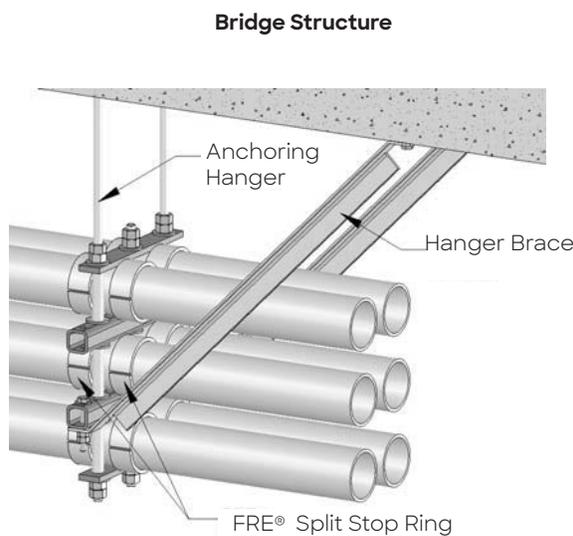
Split stop rings

The bracing of the conduit every 200 ft. or 60.96 m is done with the use of anchoring hangers. These hangers are rigidly fastened to the bridge structure to avoid swaying or bending motion.



FRE Split stop ring

The conduit is held firmly in the hanger by use of Split stop rings cemented to the conduit on both side of the hanger. The conduit should always be restrained by Split stop rings and never by clamping the conduit tightly in the hanger. This procedure restricts the conduit and permits no motion at the anchoring hanger.

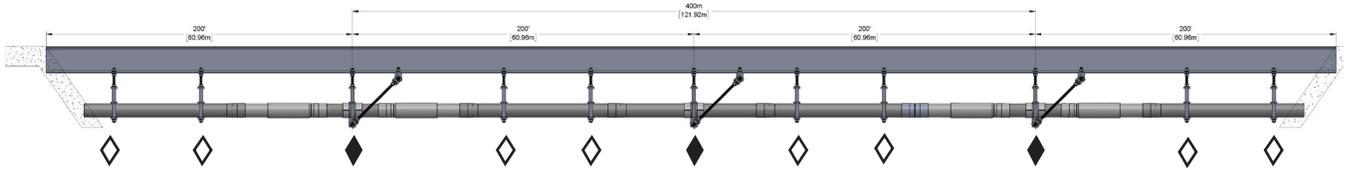


Typical Anchoring Hanger Installation

The conduit run between two (2) such anchoring hangers acts as an independent until transferring its motion to the O-Ring expansion joint located in that line.

Back To Back O-Ring Expansion Joints Installation Technique

An alternate method of installing O-Ring expansion joints which merits consideration is the back-to-back technique. With this method, an O-Ring expansion joint is placed on either side of the anchoring hanger as shown in the diagram below.

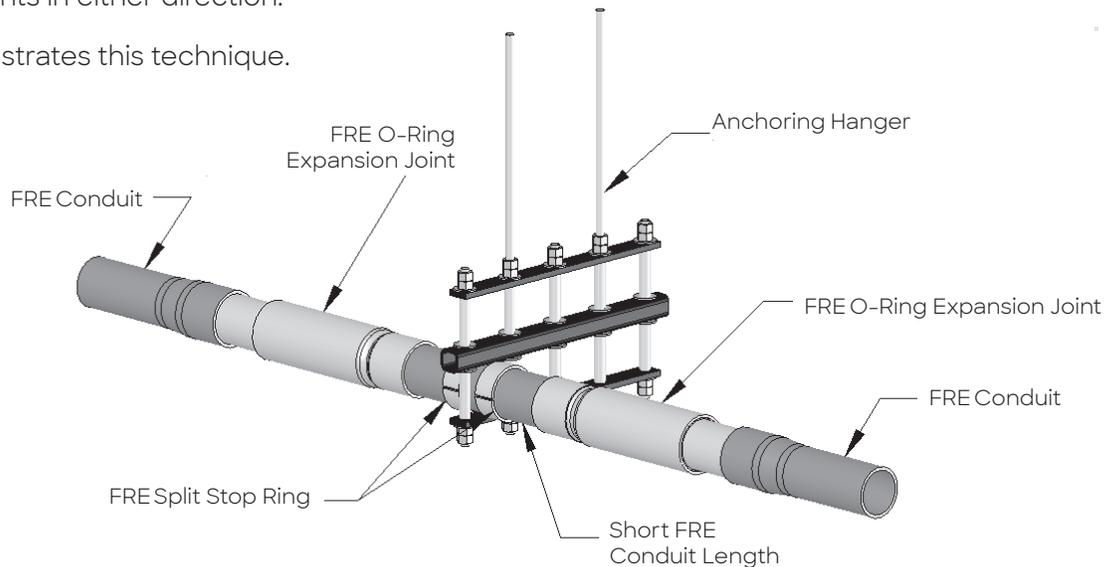


This method may save some installation time when applied to certain bridge types. With this technique, a short length of conduit is positioned in the anchoring hanger and held in place by Split stop rings on either side of the anchoring hanger. O-Ring expansion joints are then attached back-to-back on this short piece of conduit and the conduit run is installed out from these O-Ring expansion joints in either direction.

Legend

- ◊ Intermediate Hanger
- ◆ Fixed (Braced) Hanger with Split Stop Rings
- ◻ Expansion Joint

The sketch below illustrates this technique.

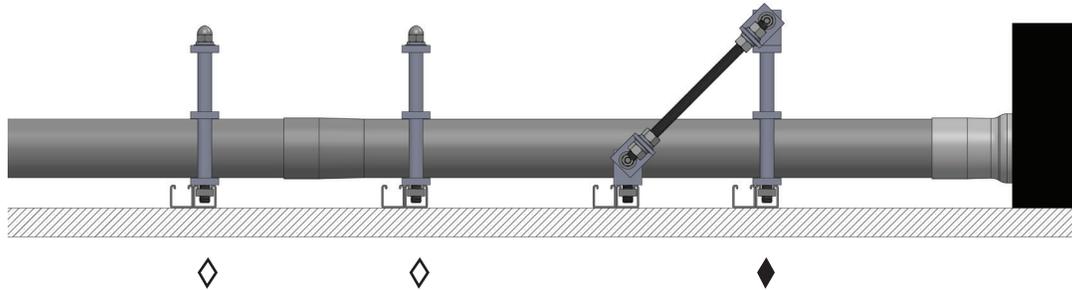


Installation Considerations

Additional factors to be considered when using O-Ring expansion joints are listed below:

- An O-Ring expansion joint must be installed for maximum every 200 ft. or 60.96 m of conduit run.
- An O-Ring expansion joint must always be located between an abutment wall and an anchoring hanger regardless of the distance between them.
- Split stop rings must always be located on both sides of anchoring hangers to securely restrain the conduit.
- Intermediate hanger openings must be large enough to permit free unrestricted motion of the conduit in the hanger.
- After installing O-Ring expansion joints, an alignment check is necessary to ensure the unit will travel freely and not bind due to misalignment.

Installation Base Mount Hangers Designs & Applications



Legend

- ◇ Intermediate Hanger
- ◆ Fixed (Braced) Hanger with Split Stop Rings
- ⌊ Expansion Joint

Conduit Handling

FRE products for installation will arrive at site from FRE Composites in a trailer long enough to accommodate 19.68 ft. or 6 m lengths of conduit.

To avoid the bands snapping, bundles of conduit should be lifted and carried from the trailer rather than sliding. Bundles of conduit can be handled by one (1) workman and placed near the installation point. Regardless of installation temperature, FRE materials With a wide operating temperature (-40 to 230 F), FRE materials will not become brittle or soft. Estimates for quantities required need not include a breakage factor. Unlike thermoplastics which can experience significant material loss through breakage, FRE eliminates wastage. Double Bell couplings may be used to join shorter lengths of FRE conduit so as to again utilize 100% of the material purchased.

Adapters

The conduit placement on the bridge structure usually starts with the joining of FRE fiberglass conduit to the existing conduit whether it be protruding from an abutment or in a trench adjacent to the bridge. Adapters are available to mate fiberglass to metallic and other non-metallic conduits.

Adhesive or TriSeal® Gasketed Joint

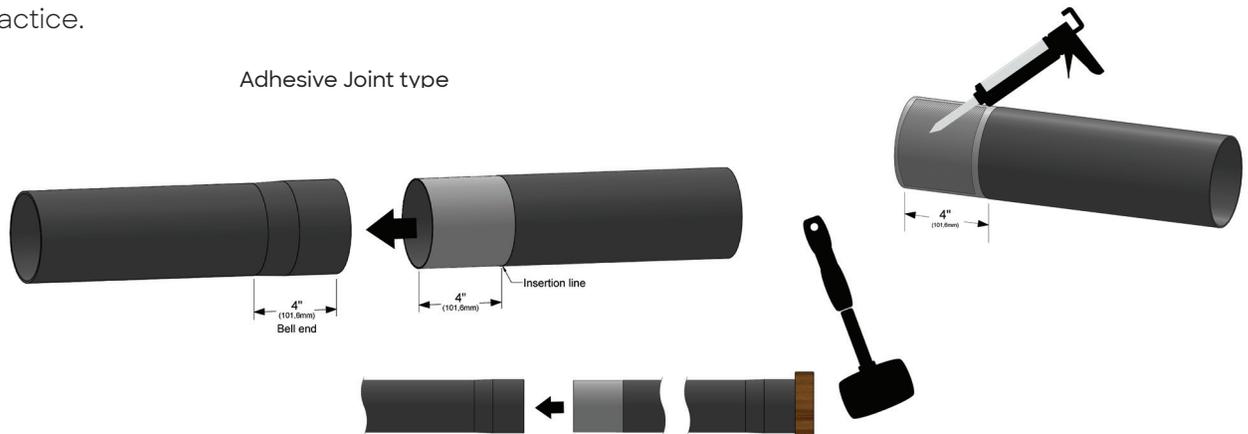
The designing engineer should consider several factors before to determining the joint type selection such as vibration, bridge structure movement and presence of water flowing.

A. Adhesive Joint

The designing engineer should elect to specify a two-part epoxy adhesive be applied to each joint over TriSeal® engineer gasketed joint type when:

- Excessive vibration or movement in the bridge structure may require additional resistance to decoupling (i.e. 1,000 lbs or 453.51 kg per inch trade size / 4" = 4,000 lbs).
- Presence of water flowing through the bridge crossing conduit runs from the existing conduit.

Having determined the need for adhesive type joint, the contractor may refer to the application procedure for Adhesive kit. First, the proper adhesive application process must be followed. The spigot end must be sanded into an abrasive surface before applying adhesive. The spigot is then driven inside the bell such that the joint meets maximum socket depth. Please refer to the adhesive work practice.



Installation Procedures

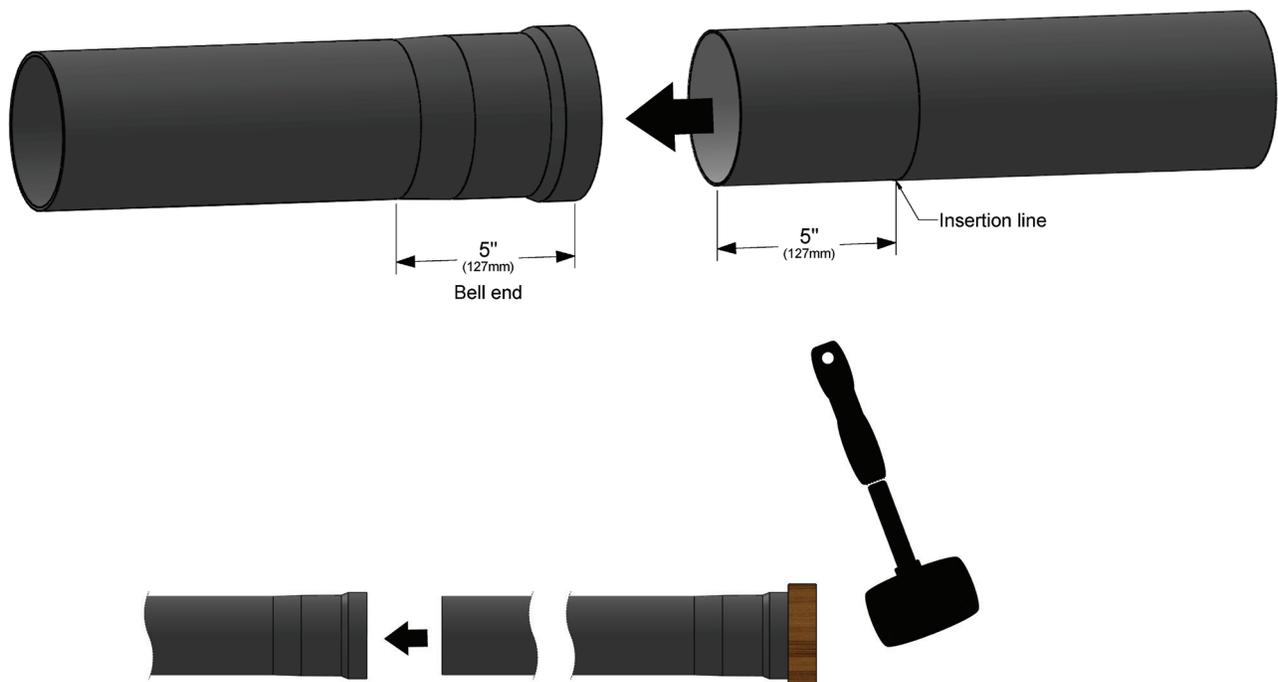
B. TriSeal® Gasketed Joint

The designing engineer should elect to specify a TriSeal® gasketed joint be applied to each joint over adhesive joint type when:

- Normal vibration or movement in the bridge structure may not require joint resistance greater than 500 lbs or 226.75 kg.
- Presence of water flowing through the bridge crossing conduit runs from the existing conduit.

To obtain a tight gasketed joint that provides for maximum decoupling resistance (500 lbs/226.75 kg), the workman places the spigot end of the conduit over the retaining ring and TriSeal® inside the bell end. Using a 3 or 4 lbs or 1.36 to 1.81 kg, the workman drives the spigot end inside the bell by striking a wooden pad placed at the opposite end of the conduit. Such joint type has a 5 in. or 127 mm socket depth (see figure below).

TriSeal® Gasketed Joint type



Excessive force should be avoided. The first joints will provide a firm structure for the subsequent lengths of conduit to be assembled. Joining conduit lengths without a firm structure backing up the assembly is not recommended.

Conduit Placement

The first lengths of conduit being joined to the adapters must be cut to random lengths. These adjacent conduits should vary in length a minimum of 12 in. or 304.8 mm to eliminate the possibility of interference between the bells and fittings. Once the first conduits are properly staggered, the remaining conduit run will maintain this orientation without the need for further cutting or trimming. Free travel of the conduit through intermediate hangers requires that all fittings and bell ends be located at least 6 in. or 152.4 mm from these hangers, to avoid binding.

Wobble Couplings

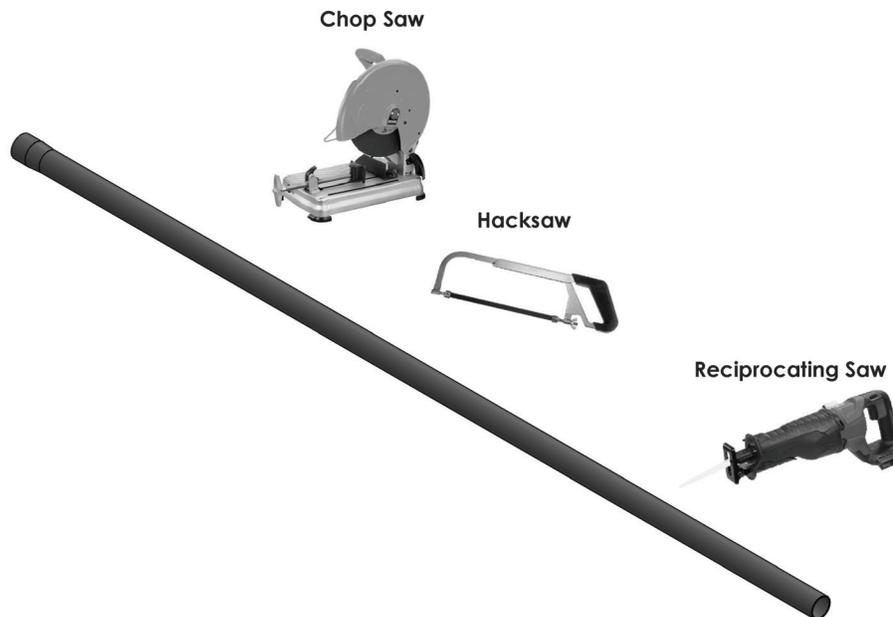
In the event the conduit protruding from the abutment walls is slightly misaligned with the conduit hangers, Wobble couplings will compensate for minor misalignments. If conduit has not been previously installed in the abutment wall, Skew Wobble couplings are used at this point. The Skew Wobble couplings are factory machined to assure the angle on the wobble coupling sleeve matches the angle at the abutment. The Skew Wobble couplings may then be cemented flush into the abutment and will compensate for slight misalignments when joining the conduit runs.

Placement Sequence

The sequence of the actual conduit installation into the conduit hangers will depend on site services, bridge access and distance between hangers. Nonetheless placing of conduit will usually be done from one (1) direction only.

Cutting the Conduit

Cutting Equipment and Procedures



The previous installation procedures have described the requirements for fiberglass conduit to be cut to less than the 19.68 ft. or 6 m length as shipped from the factory. This need for accurate cutting to length and subsequent joining was largely responsible for FRE Composites engineering the friction fit (inside tapered bell ends) rather than using costly male and female threaded components. FRE conduit can be cut to length quickly and accurately using plumbing pipe stands to support the conduit at each end. Use either a large diameter power saw utilizing an abrasive type blade or a large hacksaw with a fine-tooth blade.

The integrity of the joint is somewhat dependent on the leading edge of the spigot being cut square. Cuts can be made absolutely square with the use of a miter box. Depending on the skill of the operator, a satisfactory cut can be accomplished without a miter box. Cuts of this type must be checked with a square. Deviation should be limited to an 1/8 in. or 3.175 mm. The ideal cutting method is to use pipe stands leading to the table of a large capacity 10 in. or 254 mm plus power chop saw with an abrasive blade. This configuration will provide factory efficiencies at lowest possible costs considering labor and materials. The condition of the saw blade may warrant the filing of the spigot. Field cut of the conduit joints is made up using a Double Bell coupling, as described in the our Above Ground Conduit system product catalog or consult our website. Unlike threaded conduit joining systems, Field cut joints do not require painstaking thread cutting with elaborate equipment.

Conduit Deflection Tables

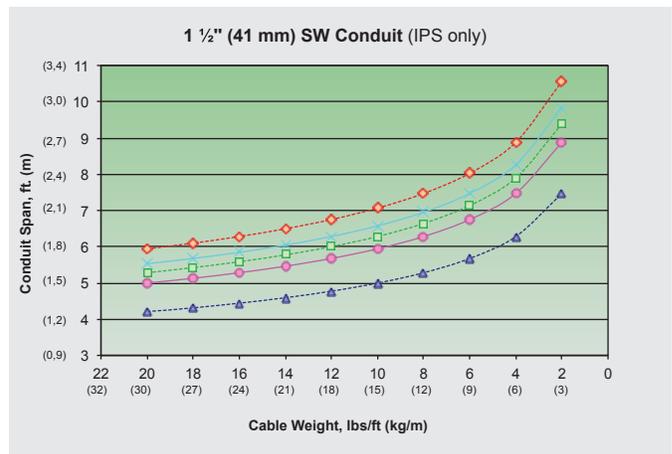
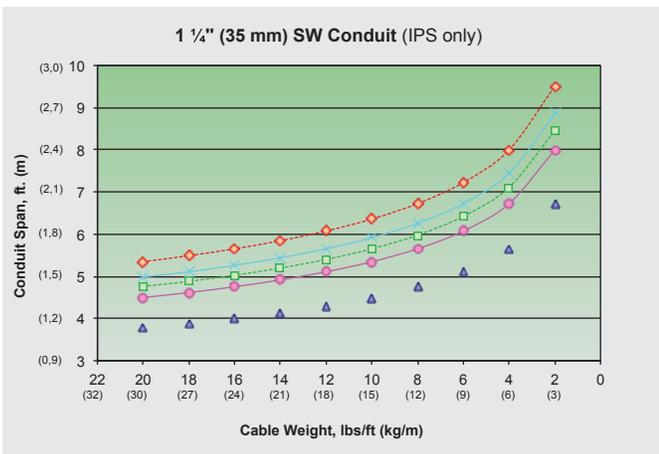
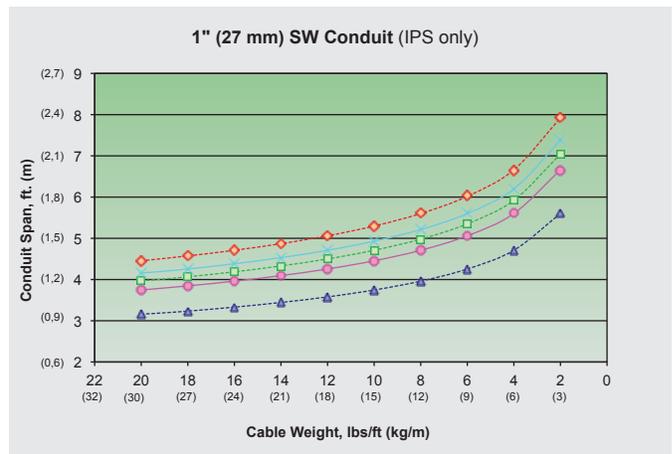
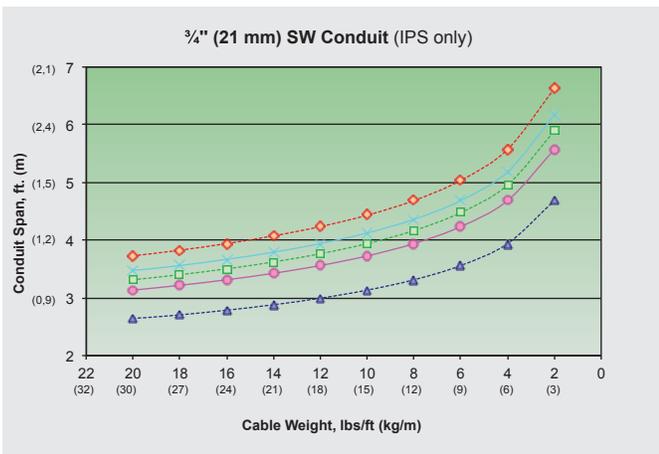
The graphs on the following pages reflect the span-deflection characteristics of FRE conduit. By following in from the left margin with the desired cable weight, various deflection lines will be intercepted. At the appropriate deflection line for your application, read down the chart to find the recommended span between supports.

To take long-term creep into account, the charts have been tabulated using the long-term modulus in the calculations. Because of this, conduit sections will actually deflect much less than the charted value when first installed.

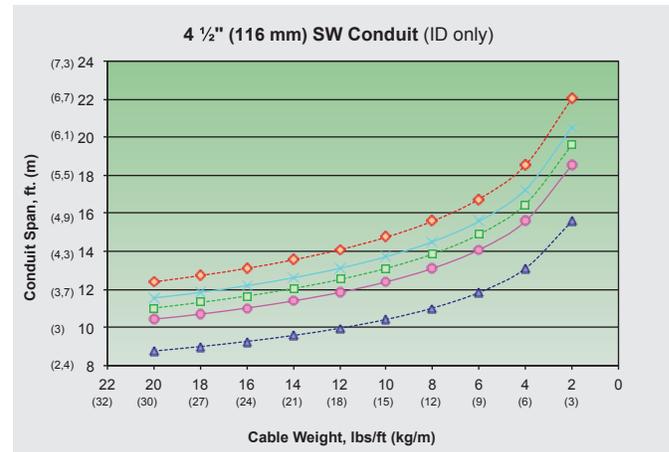
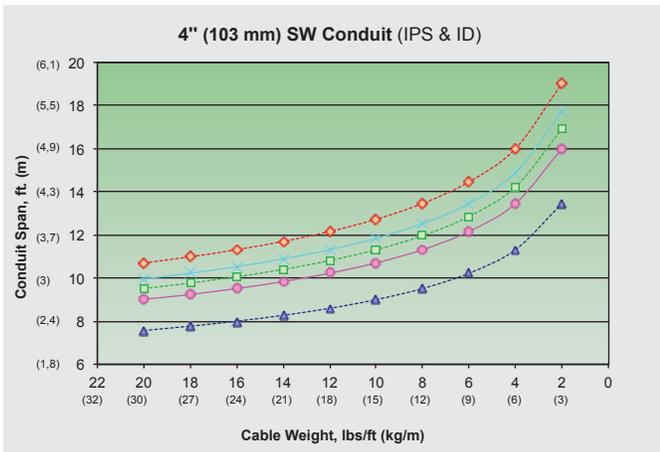
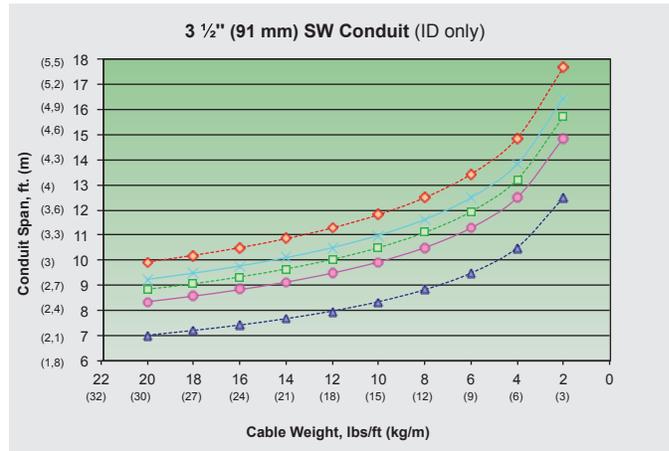
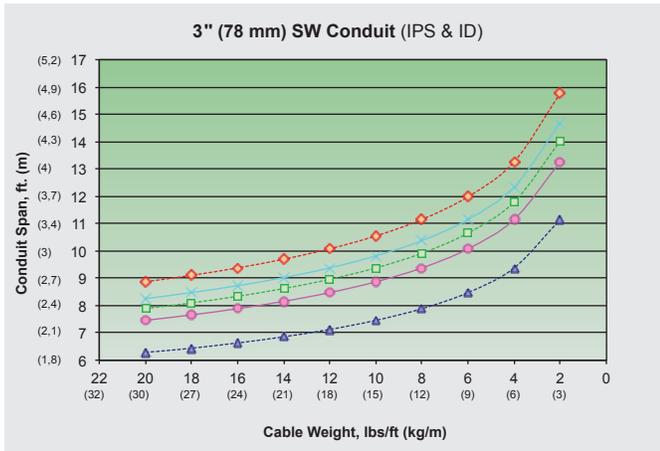
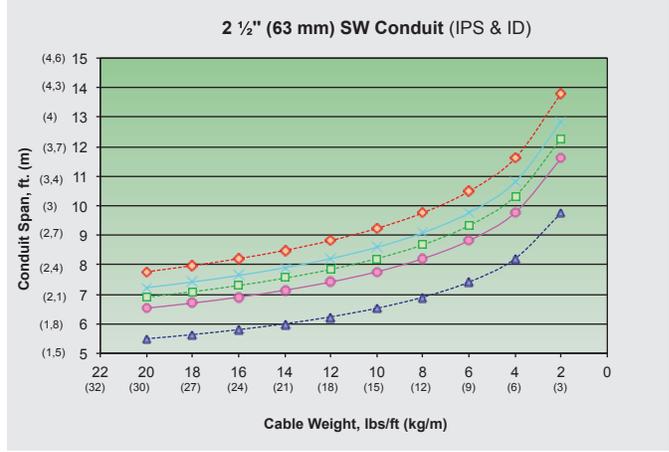
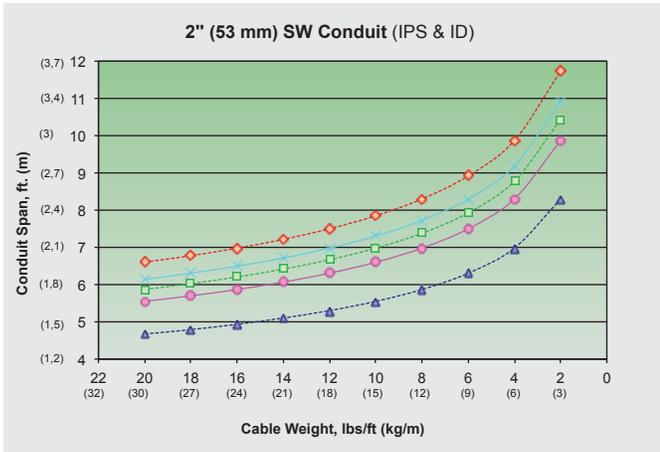
If this long-term safety margin is not required, FRE Composites will prepare appropriate span charts for your application on request.

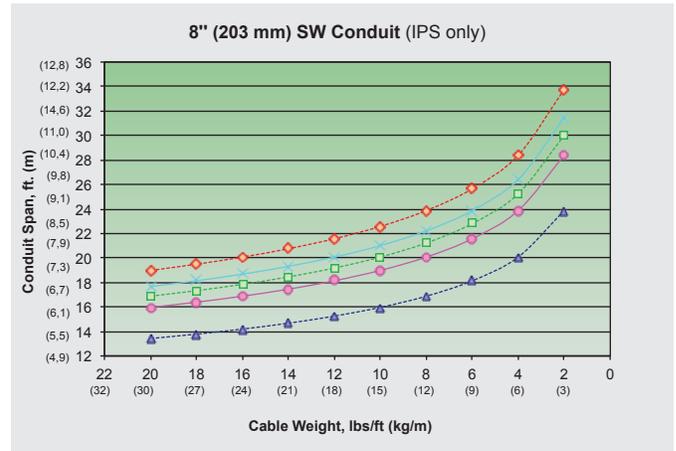
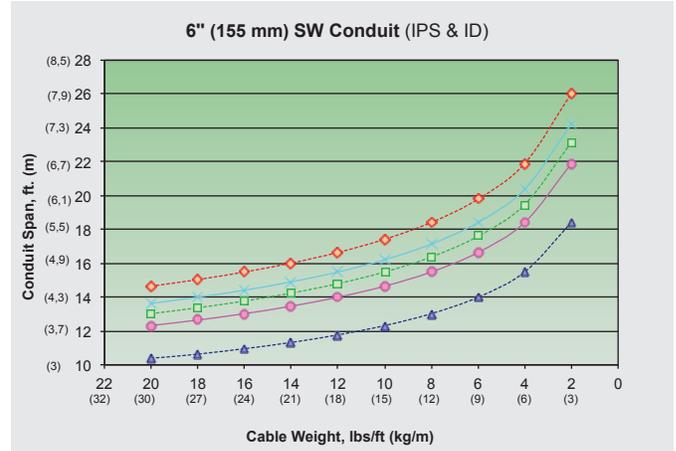
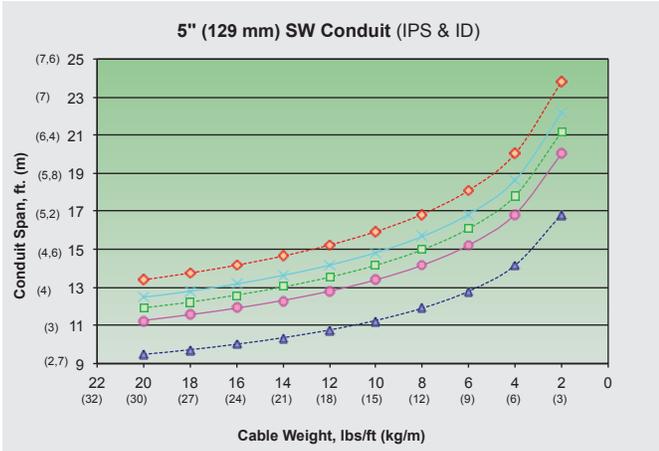
Where fittings and expansion joints are expected to fall near mid-span, deflections may be greater than those published. Multiplying the published deflection by 1.5 will take all these variables into account.

The long-term design stress level on the charts should never be exceeded. FRE Composites will assist in any designs where the stress or deflection must exceed recommended limits.

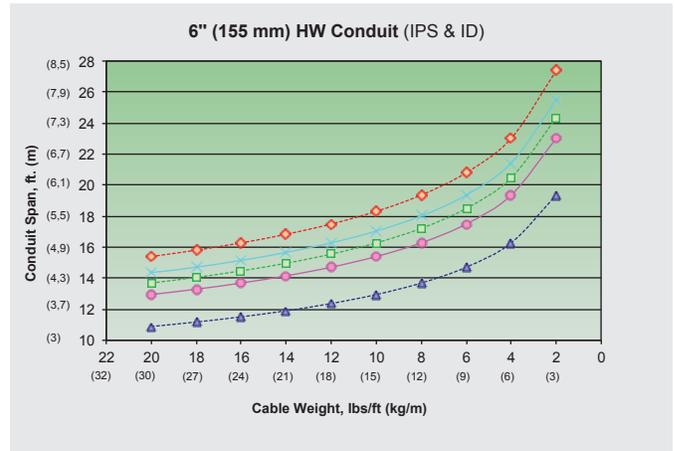
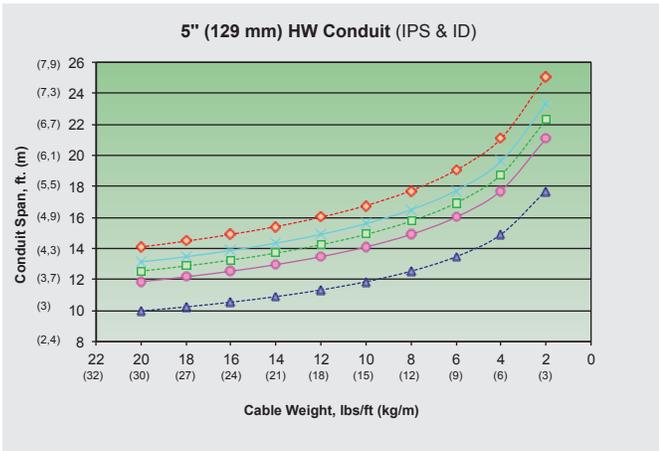
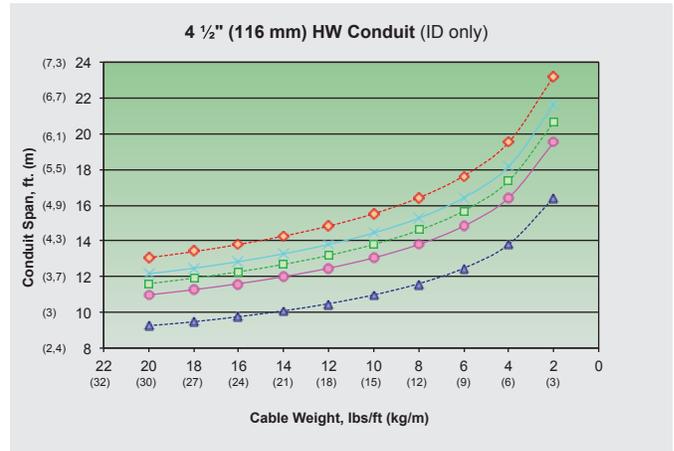
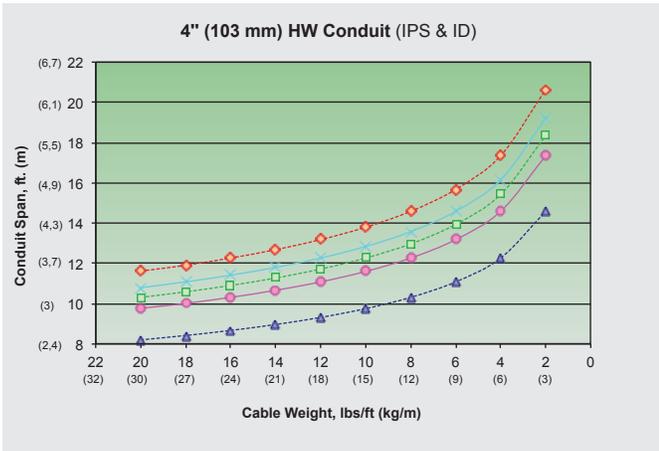


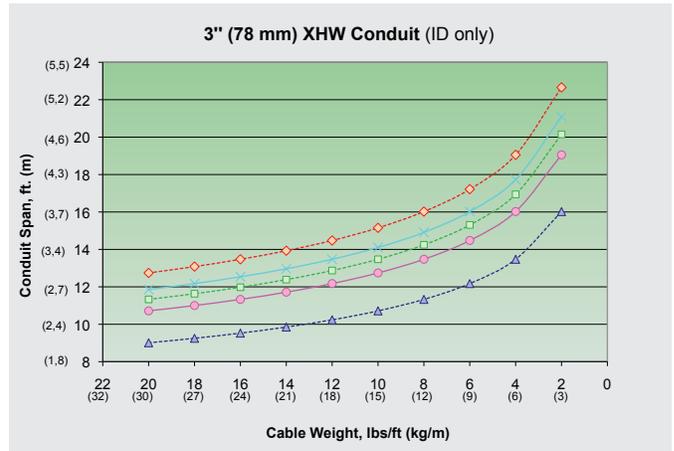
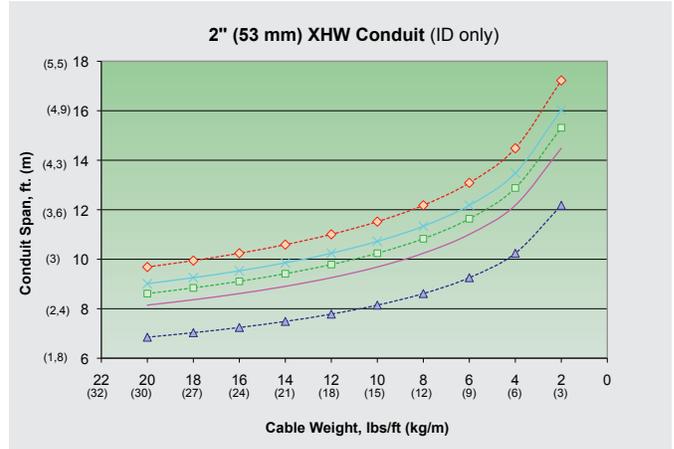
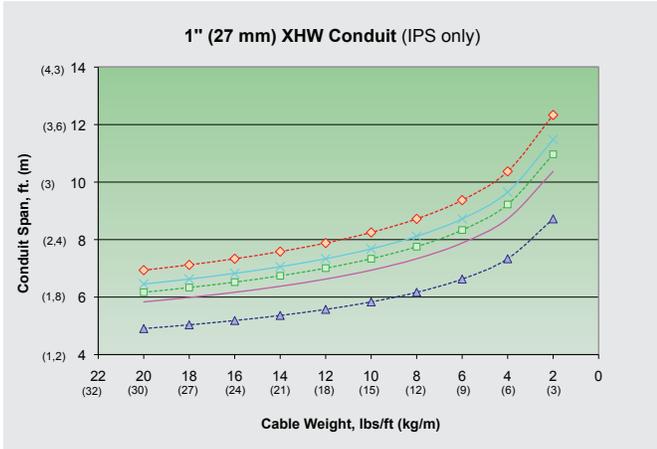
Conduit Deflection Tables



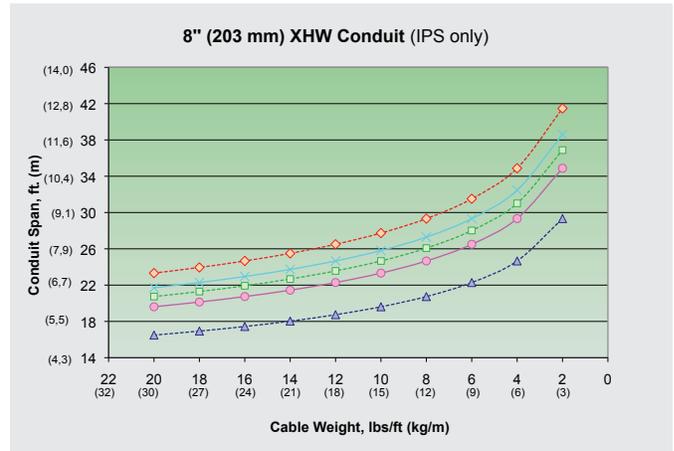
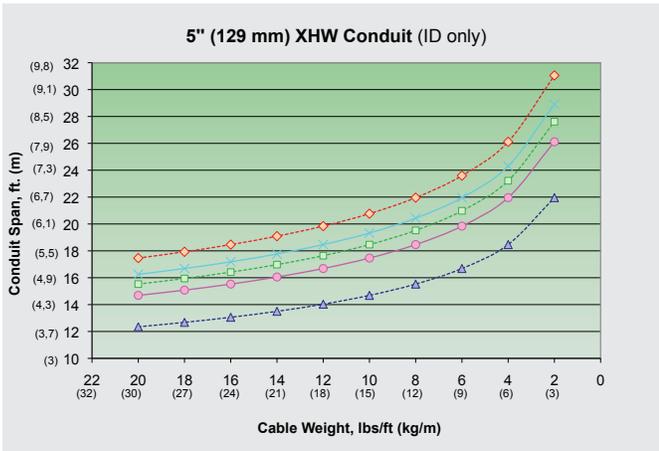
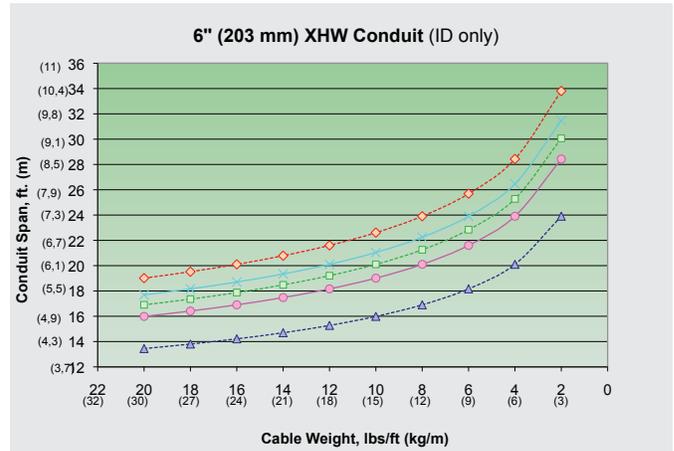
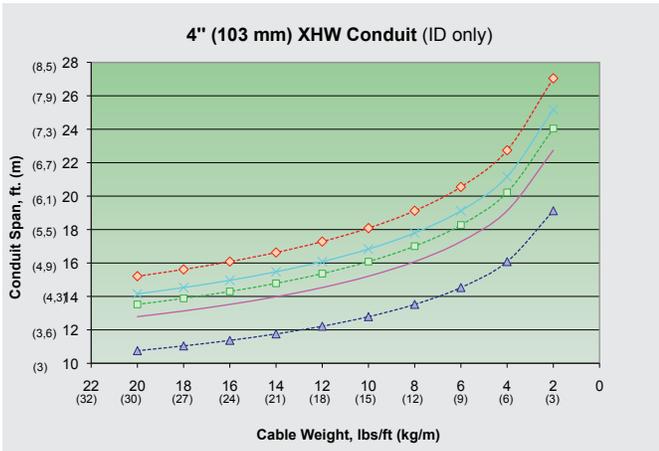


Conduit Deflection Tables





Conduit Deflection Tables





Allied Tube & Conduit ▲ AFC Cable Systems ▲ Heritage Plastics ▲ Unistrut
Unistrut Construction ▲ United Poly Systems ▲ Calbrite ▲ Calbond ▲ Cii ▲ US Tray
Power-Strut ▲ Calconduit ▲ Razor Ribbon ▲ Calpipe Security ▲ Vergokan ▲ Marco
Columbia-MBF ▲ Eastern Wire + Conduit ▲ ACS/Uni-Fab ▲ Sasco Strut ▲ Kaf-Tech
Cope ▲ FRE Composites ▲ Queen City Plastics ▲ Four Star Industries ▲ Flexicon

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