WORK PRACTICE FOR FRE® CONDUITS

BRIDGE INSTALLATIONS

FRE COMPOSITES®

FIRST IN THE FIELD

®

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Work Practice for Bridge Installations

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1. General

1.1 - Introduction

FRE Composites is the world's foremost manufacturer of filament wound epoxy conduit. FRE Composites pioneered the technology in 1940 when a need was identified for electrical tubing that could withstand intense electrical arcing and immersion in oil. By the mid 1960's, 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® is installed throughout the world FRE Composites has engineered conduit installations in North America, South America, the Far East, South East Asia, the Middle East and Africa. Engineering assistance is available to engineers through our network of manufacturer's representatives (please consult our website or call our office for the most current information).

1.2 - 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.

1.3 - U.L. Approval

The National Electrical Code in Article 352-1 recognizes "fiberglass conduit" as an acceptable conduit material. FRE® conduits are listed by Underwriters Laboratories Inc. under file number E53373.

1.4 - 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.

2. Conduit Criteria

2.1 - 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.

2.2 - UV Resistance

FRE® Above Ground Conduit system products are specifically formulated for enhanced resistance to ultra violet rays. This is achieved by blending ultra violet inhibitor within the epoxy resin before the manufacturing process. This acts as a screen and gives the FRE Above Ground Conduit system products its uniform standard black color.

2.3 - Thermal Expansion

The design engineer is afforded a major advantage when specifying FRE® Conduit system for bridge applications. FRE®'s low thermal expansion is equal to 40% of that of P.V.C. conduits hence reducing the number of expansion joints required. It is expected that regardless of conduit run length, the conduit assembly will exhibit different expansion characteristics than the bridge structure, therefore every bridge crossing installation of FRE® Conduit system will require at least one (1) expansion joint per conduit run. FRE®'s coefficient of thermal expansion is a low 1.37 x 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 0.015 in. or 0.4 mm. The table below offers some typical installation conditions.

FRE® Conduit Thermal Expansion

Ambient Temp Change		Conduit Length Change	
°F	**°C**	**(inches/100ft of conduit)**	**(Millimeters/30,5m of conduit)**
1°	0.5°	0.015”	0.4 mm
40°	22.4°	0.600”	16.7 mm
80°	44.8°	1.200”	33.4 mm
120°	67.2°	1.800”	50.1 mm
160°	89.6°	2.400”	66.8 mm

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 for every 200 ft. or 60.96 m of conduit . 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.

2.4 - Chemical Resistance

Thermosetting resins such as the epoxy material used in the manufacture of FRE® products are extremely resistant to degradation from corrosive agents. FRE® 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.

2.5 - Weight

Considerable savings in conduit hangers and supports can be realized due to FRE 's Above Ground Conduit light weight and high flexural strength. FRE has twice the strength to weight ratio of PVC conduit and is much lighter in weight than steel and aluminum alternative products.

2.6 - 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.

3. Hanger support criteria

3.1 - Permits and Approvals

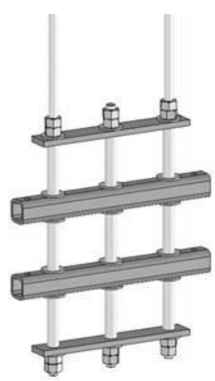
Use of a bridge as a means of carrying conduits is generally subject to the approvals of various government agencies. Any modifications to structural bridge components should be done with the approval of all agencies responsible for the bridge. Supporting conduit runs on bridge members, or the suspension 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.

3.2 - 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.

Typical grid type conduit hanger



- 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.

3.3 - Grid Type Hangers

The grid type hangers are designed such that each conduit run is individually supported and isolated from the adjacent conduit. 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.

3.4 - 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.

3.5 - Vertical Loading

FRE Composites recommends that 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.

3.6 - 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.

3.7 - 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 at 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 ½ 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 ½ 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 ¾ 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, please contact your FRE® manufacturer's representative or consult with the factory.

3.8 - 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 which 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.

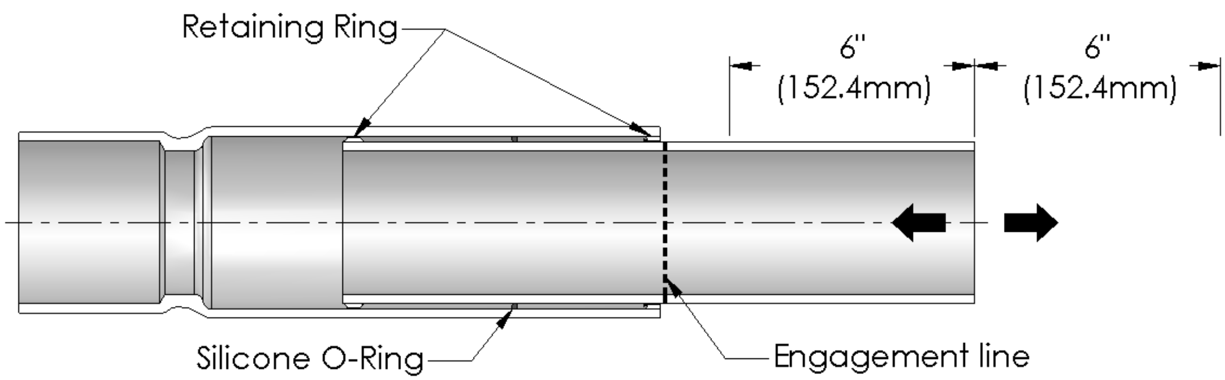
FRE Composites places an additional safety factor into its figures by reducing all stress and modulus figures to take into account factors such as long term creep, aging and other phenomena. It is these conservative figures which are then used to make up the span charts. The deflection curves are further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

4. O-Ring expansion joint designs & applications

4.1 - Design

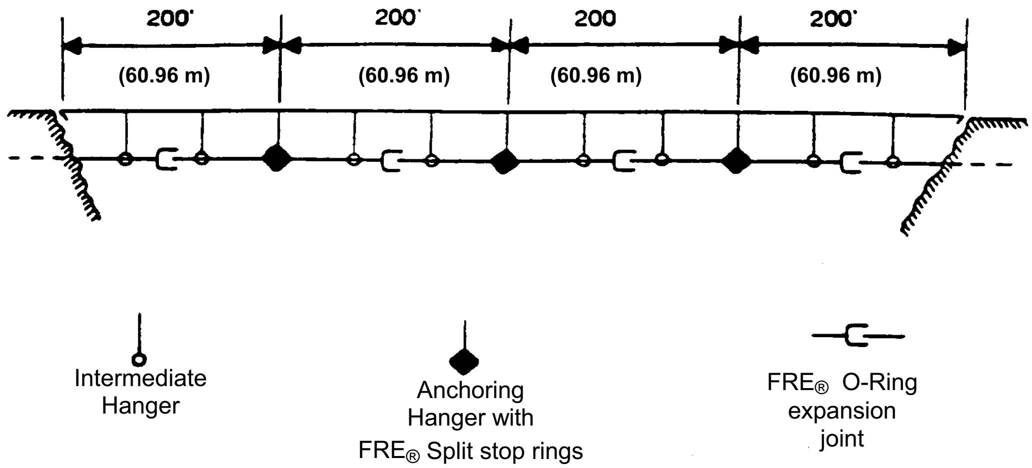
Our O-Ring expansion joints have been specifically designed for use in bridge crossing applications. A silicone O-Ring is used in sealing the unit to keep out dirt and water while maintaining freedom of movement. The unit also employs retaining rings to contain the O-Ring seal and to prevent the sleeve from accidentally disengaging should it be extended too far.

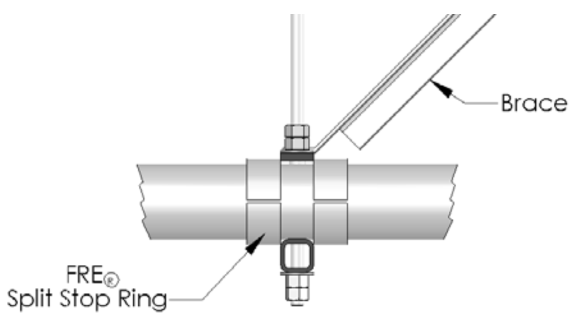
This is a useful feature during installation as it ensures that the two (2) components will not disengage. Each O-Ring expansion joint is provided with an engagement line which guarantees the correct setting of the unit during installation. The O-Ring expansion joint spigot should be positioned such that the engagement line is just showing when the unit is installed. When in this position, the unit has a minimum of 6 in. or 152.4 mm of free travel in either direction.



4.2 - Placement

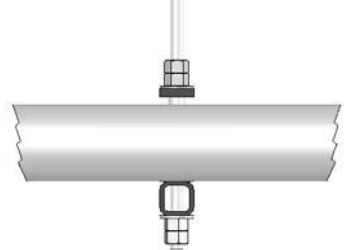
Expansion and contraction of the conduit will usually be greater and independent of any expansion and contraction in the bridge structure. For this reason, expansion joints and restraining points which anchor the conduit must be employed to adequately control this motion in a predictable manner. An O-Ring 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 form 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.





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



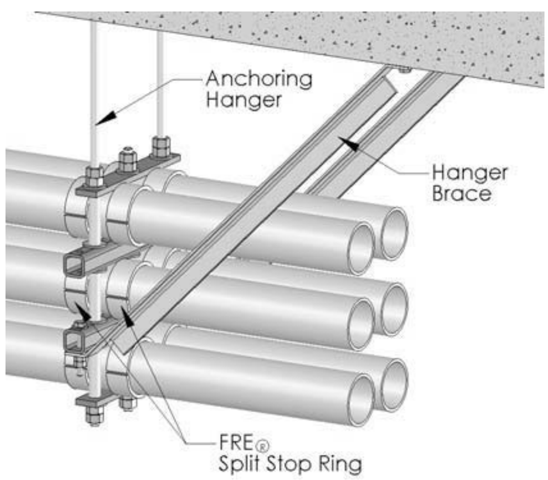
4.3 - Split stop rings

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 either 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.

BRIDGE STRUCTURE

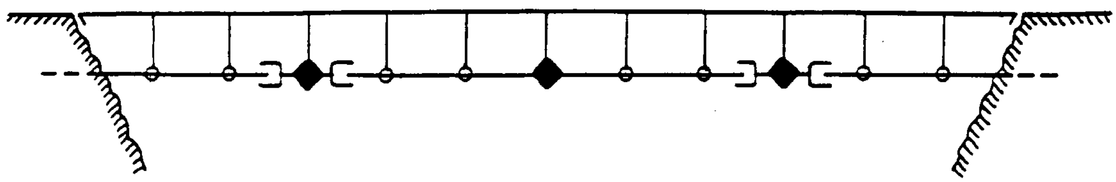


Typical Anchoring
Hanger Installation

The conduit run between two (2) such anchoring (fixed) hangers is isolated allowing the expansion and contraction of the conduit run into the O-Ring expansion joint.

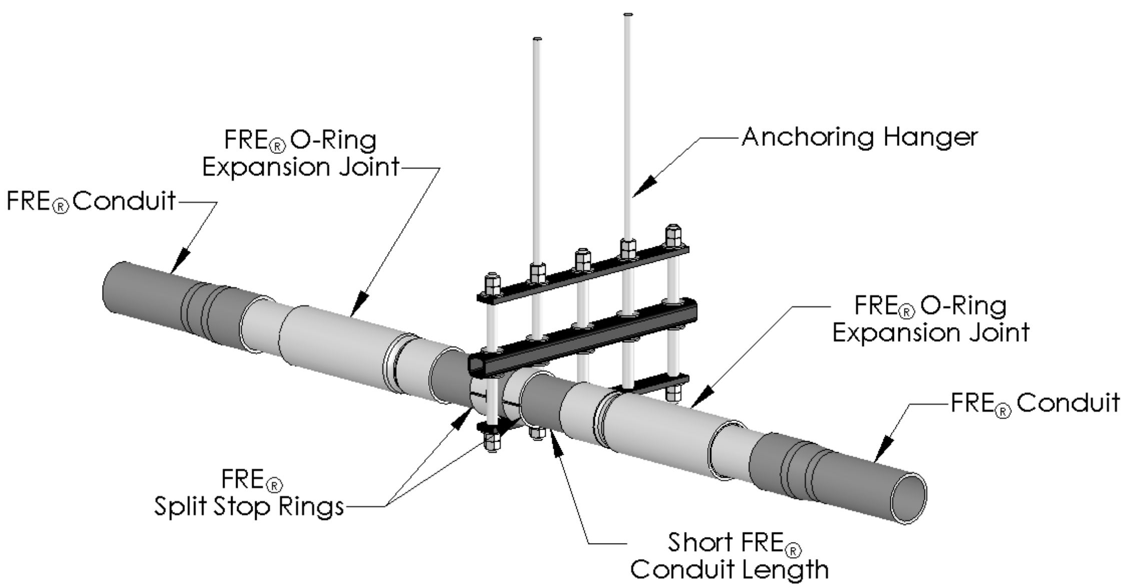
4.4 - Back to Back O-Ring expansion joints technique

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 FRE® conduit is positioned in the anchoring hanger and held in place by Split stop rings on either side of the anchoring hanger. FRE® 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.

The sketch below illustrates this technique.



4.5 - Installation Considerations

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

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

5. Installation procedures

5.1 - 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 FRE® 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 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 waste. Double Bell couplings may be used to join shorter lengths of FRE® conduit so as to again maximize use of the material purchased.

5.2 - Adapters

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

5.3 - Adhesive or TriSeal™ Gasketed Joint

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

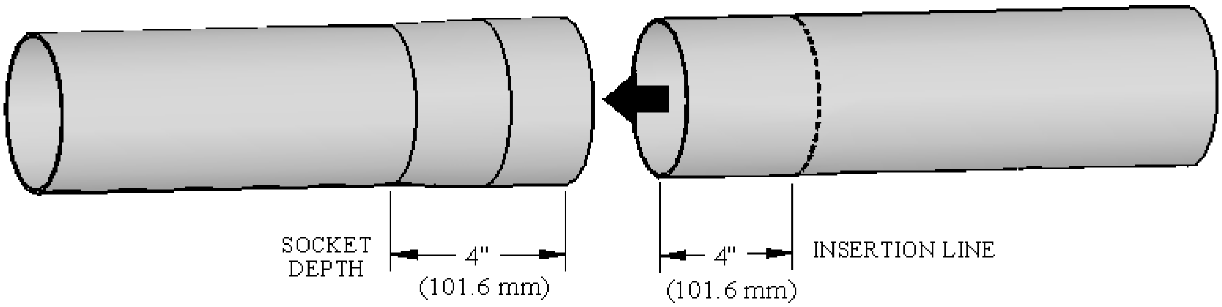
A. Adhesive Joint

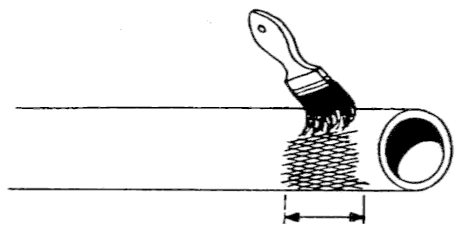
The designing engineer should elect to specify a two part epoxy adhesive be applied to each joint over TriSeal™ gasketed joint type when:

- 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 over the bridge crossing conduit runs from the existing conduit.

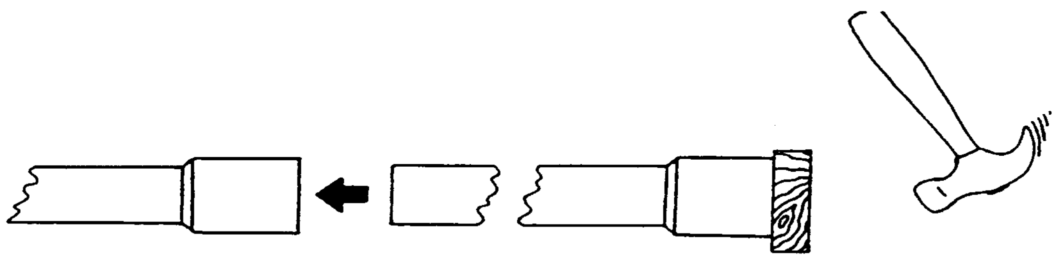
Having determined the need for adhesive type joint, the contractor may refer to the application procedure for FRE® Adhesive kit. First, the application of adhesive to the FRE® conduit spigots is made prior to insertion into the bell ends. To complete the joints, the spigot is driven inside the bell end. A 3 or 4 lbs or 1.36 to 1.81 kg ~~ledge~~ is used to strike a wooden pad placed over the opposite end of the conduit. Such joint type has a 4 in. or 101.6 mm socket depth (see figure below).

Adhesive Joint type





4”   (101.66 mm)



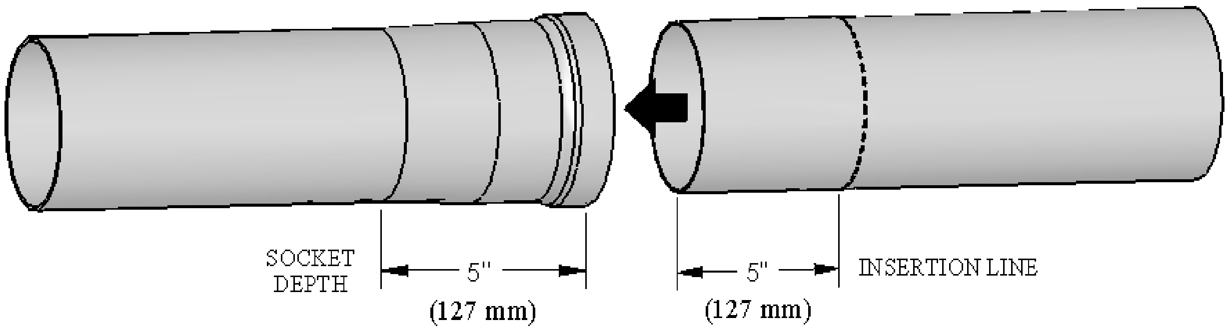
B. TriSeal™ Gasketed Joint

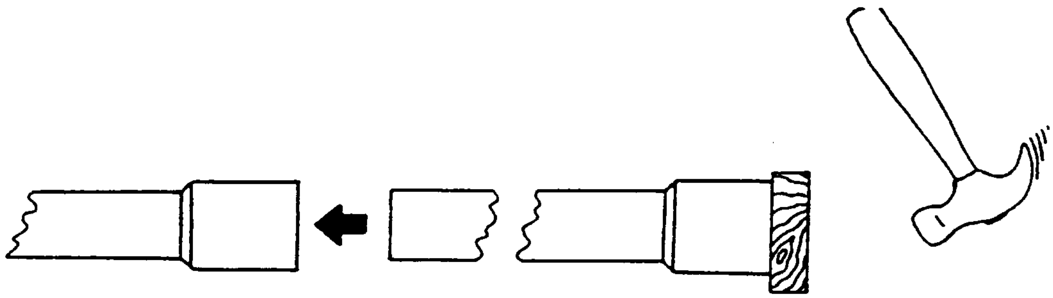
The designing engineer should elect to specify a TriSeal™ gasketed joint be used over adhesive joint type when:

- Normal vibration or movement in the bridge structure may not require joint resistance greater then 500 lbs or 226.75 kg.
- Presence of water flowing over 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 sledgehammer, 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 on next page).

TriSeal™ Gasketed Joint type





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

5.4 - Conduit Placement

The first lengths of conduit being joined to the adapters must be cut to unequal lengths. These adjacent conduits should vary in length a minimum of 12 in. or 304.8 mm so as 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 of 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, so as to avoid binding.

5.5 - Wobble Couplings

In the event the conduit protruding from the abutment walls is slightly misaligned with the conduit hangers, FRE® Wobble couplings will compensate for minor misalignments.

If conduit has not been previously installed in the abutment wall, FRE® 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.

5.6 - 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.

6. Cutting FRE® conduit

6.1 - Cutting Equipment and Procedures

The previous installation procedures have described the requirements for FRE® 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 FRE® joint is dependent on the leading edge of the spigot being cut square. Cuts can be made absolutely square through 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 FRE® conduit joints are made up using a Double Bell coupling, as described in the FRE® Above Ground Conduit system product catalog or consult our website. Unlike threaded conduit joining systems, FRE® field cut joints do not require painstaking thread cutting with elaborate equipment.

APPENDIX 1

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.

In order 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.

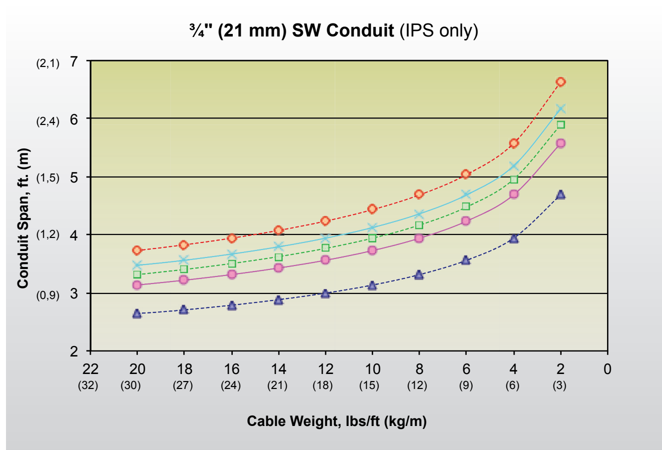
Where fittings and expansion joints are expected to fall near mid-span, deflections may be greater than those published. Multiplying the published deflection by 1.5 will take all these variables into account.

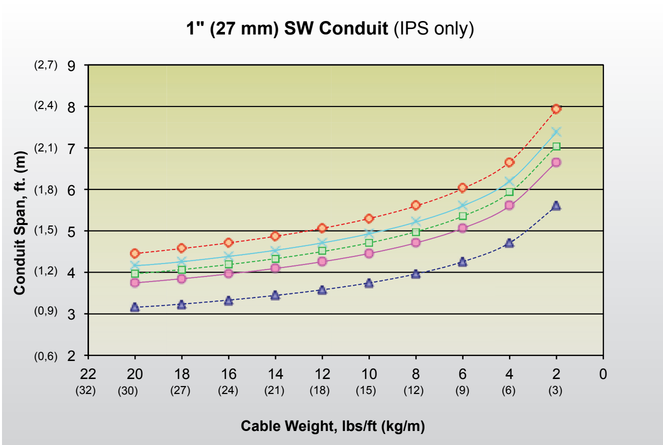
The long-term design stress level on the charts should never be exceeded. FRE Composites will assist in any designs where the stress or deflection must exceed recommended limits.

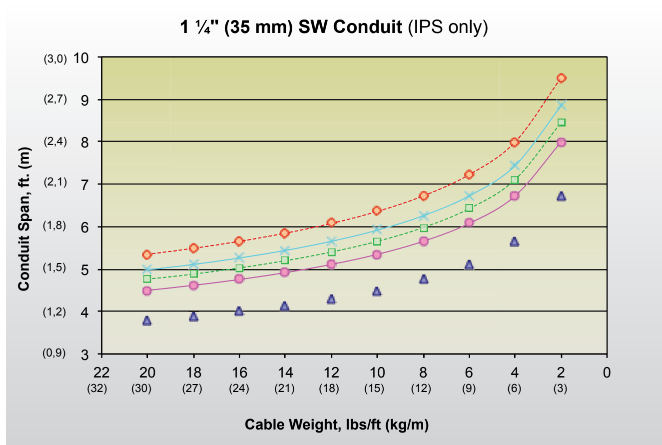
CONDUIT DEFLECTION TABLES

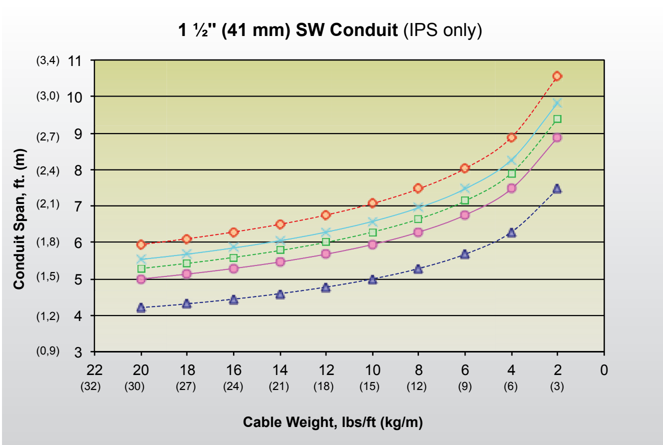
The graphs on the following pages reflect the span-deflection characteristics of FRE® Conduit. First, select the appropriate deflection graph. Continue by selecting the appropriate cable weight from the X-axis and move in a vertical direction, intercepting various deflection lines. At the appropriate deflection line for your application, look left the chart to find the recommended span between supports.

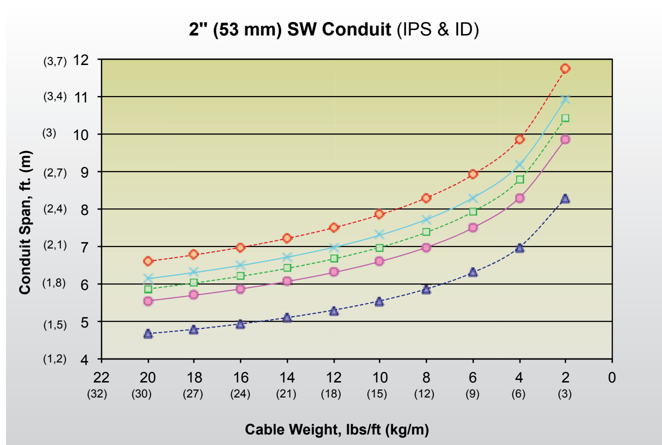
In order to take long-term creep into account, the charts have been tabulated using the long-term modulus in the calculations. Because of this, conduit sections will actually deflect much less than the charted value when first installed. If this long-term safety margin is not required, FRE Composites will prepare appropriate span charts for your application on request.





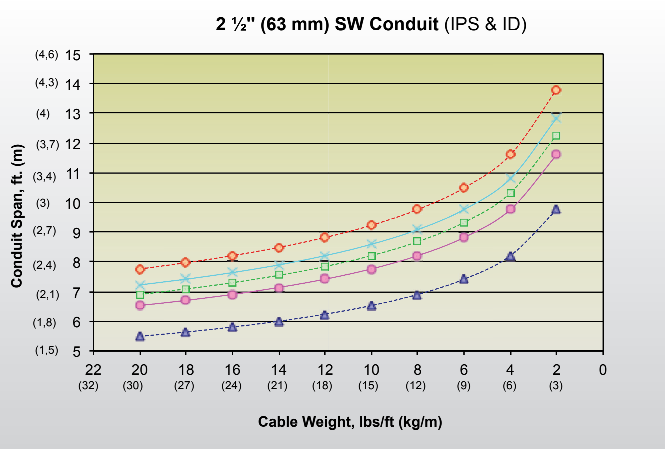


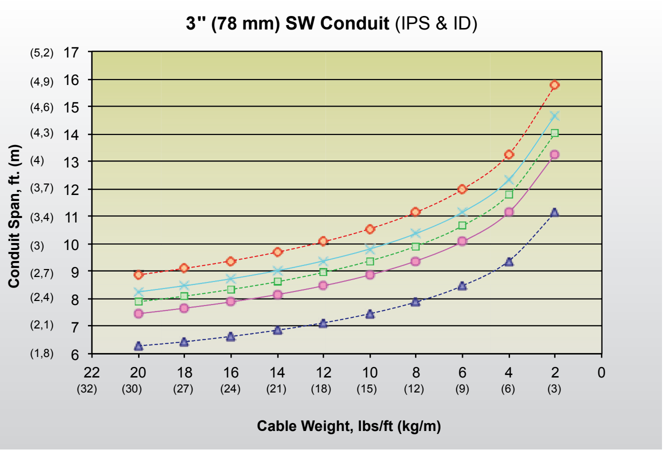


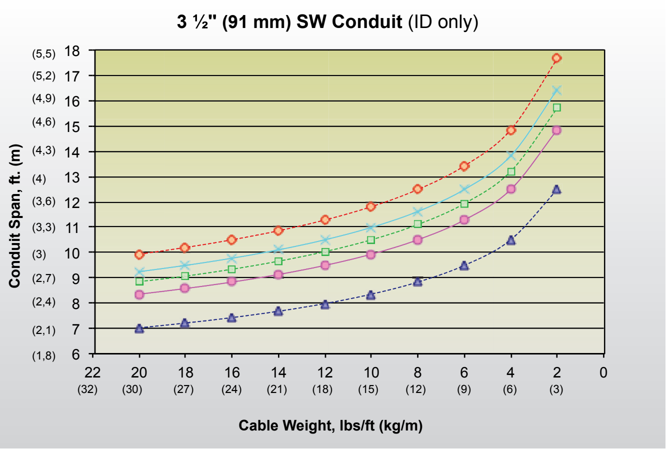


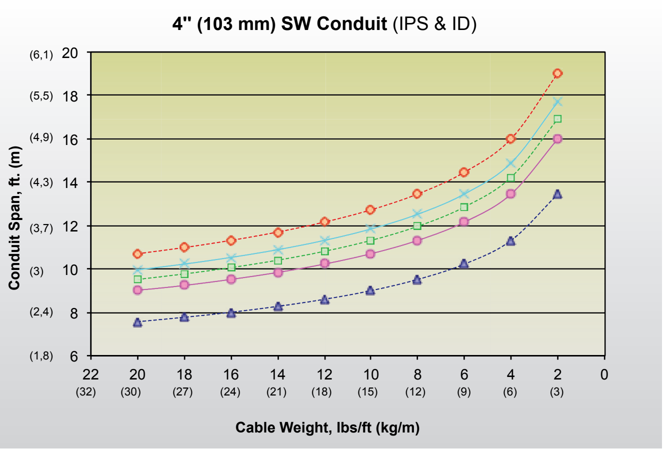
1/4" (6mm) Deflection — 1/2" (13mm) Deflection — 5/8" (16mm) Deflection — 3/4" (19mm) Deflection — 1" (25mm) Deflection

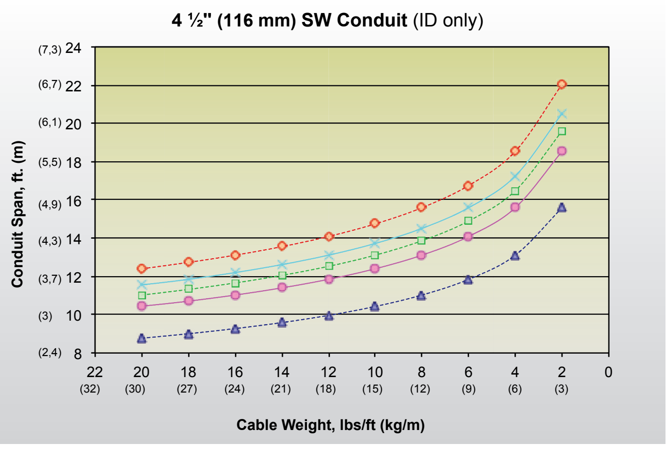
CONDUIT DEFLECTION TABLES *(CONTINUED)*

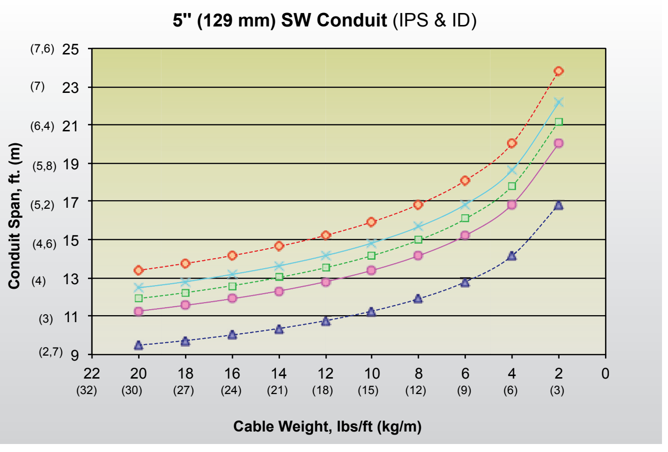








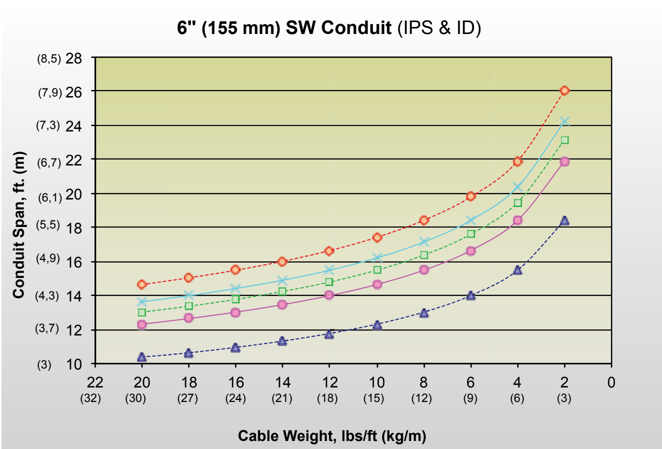


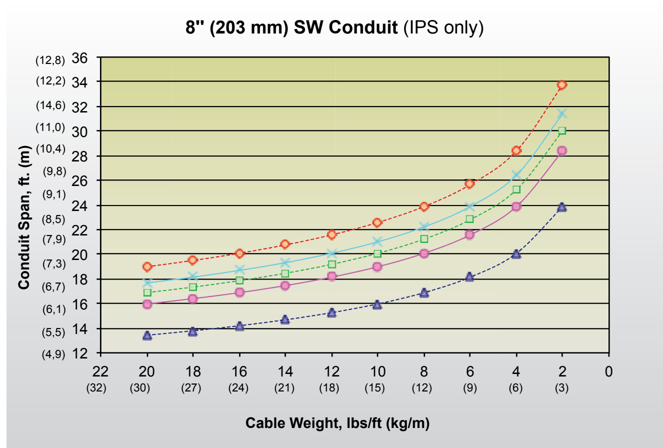


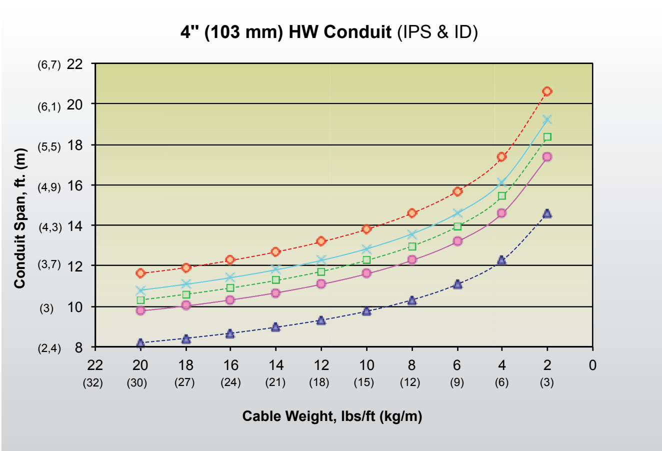
1/4" (6mm) Deflection — 1/2" (13mm) Deflection — 5/8" (16mm) Deflection — 3/4" (19mm) Deflection — 1" (25mm) Deflection

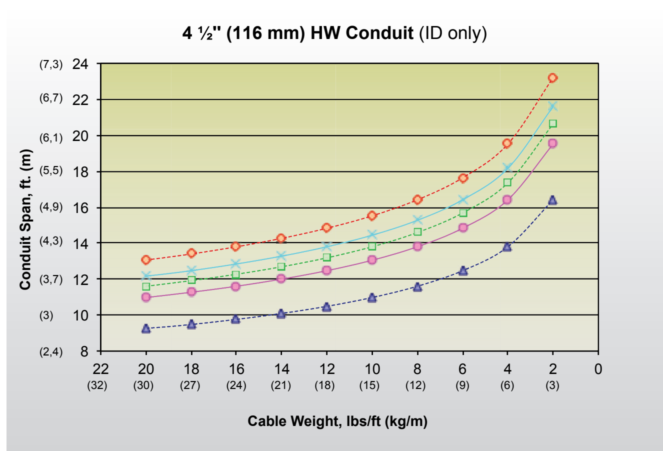
FRE COMPOSITES®

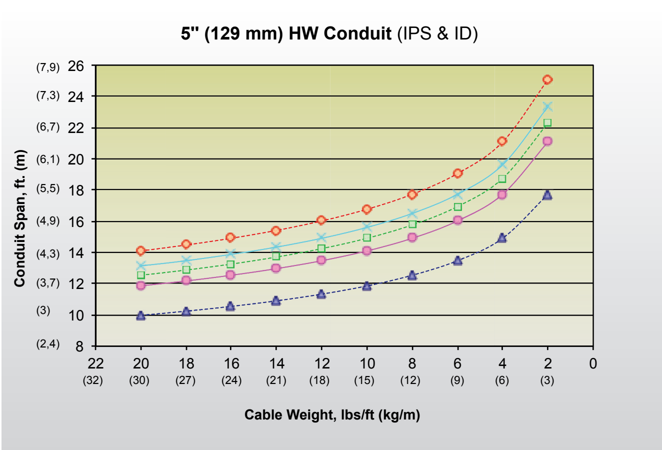
CONDUIT DEFLECTION TABLES *(CONTINUED)*

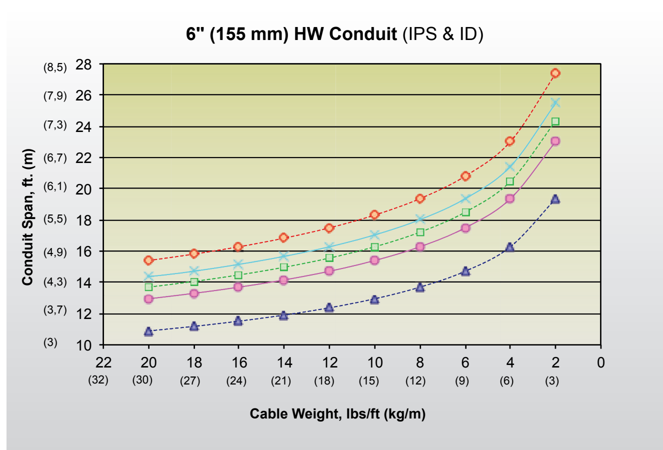












1/4" (6mm) Deflection — 1/2" (13mm) Deflection — 5/8" (16mm) Deflection — 3/4" (19mm) Deflection — 1" (25mm) Deflection

75 WALES STREET
ST-ANDRE-D'ARGENTEUIL (QUEBEC)
CANADA J0V 1X0
TELEPHONE: +1 450 537-3311
FAX: +1 450 537-3415
TOLL FREE: 888 849-9909

FRE COMPOSITES®

WWW.FRECOMPOSITES.COM

60 GREENHORN DRIVE
PUEBLO CO 81004
TELEPHONE: +719-565-3311
FAX: +719-564-3415
TOLL FREE: 888 849-9909