

TECHNICAL DOSSIER GRP PIPES & FITTINGS

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GLASSFIBER REINFORCED PLASTICS (GRP) PIPES

1. FEATURES & ADVANTAGES OF GRP AS PIPING MATERIAL

By virtue of its superior material characteristics, GRP pipes have become the ultimate choice replacing steel, DI and Concrete pipes for transporting different process fluids, sea water, raw water and potable water for different underground and aboveground applications.

The single most reason why people go for GRP is the total corrosion resistance that this material offers. Well-engineered GRP pipelines can be totally forgotten after installation for its life period without cathodic protection or periodic maintenance and for this reason, GRP pipelines are called as “**ZERO-MAINTENANCE PIPING**”.

International Codes and specifications are available for GRP pipe design, construction, testing and installation. All service requirements are met by the GRP pipes in total by suitable and appropriate design.

On the cost front, with optimum engineering and productivity matching the best of industries worldwide, we are able to compete with steel, ductile iron and other conventional piping material.

The prime advantages of GRP pipes are:

- a) **ABSOLUTELY CORROSION FREE:** The material is inert to any type of water(sea water, raw water, potable water etc.) and for handling different process fluids, chemicals, acids , bases etc. With suitable GRP material system(resin), pipes can be designed for handling all fluids. M/s Strategic Engineering will advise customers on this based on their requirement. **No coating, gunniting, mortar lining or cathodic protection required with GRP piping.**
- b) **SMOOTH INNER SURFACE:** The inner surface of GRP pipe is the best among piping materials, due to which the friction loss is minimum with GRP pipes. **Again, unlike steel and other materials, the smooth surface will remain the same throughout its intended service life, as the corrosion is absent in GRP.** This gives less power consumption and low pumping cost throughout the pipeline life.

Hazen Williams Coefficient (“C” Value) for GRP is 150 for the purpose of design as per standards; however the tested values are in the range of 160-165. Because of higher 'C' Value, frictional losses in GRP Pipes are much less compared to that of conventional pipes. Hence, recurring energy charges and pump cost is lower in GRP Pipes compared to same diameter of other conventional pipes. Alternatively, we can reduce the diameter of GRP Pipes keeping frictional losses same as in case of conventional pipes.

- c) **LONGER LIFE:** GRP pipes are designed for 50 years of life for normal applications. For Offshore applications, the design life is 20 years.
- d) **HIGH STRENGTH TO WEIGHT RATIO:** The high-strength to weight ratio of this material offers the advantage of weight reduction and due to this, it is easy to handle & transport and this aids faster installation. It is light in weight, 1/5th of Steel, 1 /8th of CI and 1/10th of PSC for the same pressure rating and strength criterion.
- e) **EXCELLENT JOINT TIGHTNESS:** Different joints like bell & spigot with rubber seal, coupler, butt & wrap flanged joints are available. Engineered joints totally eliminate ex-filtration / infiltration.
- f) **RESISTANCE TO SURGE PRESSURE:** The water hammer in GRP pipe is less due to elasticity of GRP pipe. GRP pipes can withstand pressure up to 1.4 times of its pressure class in case of surge, which is higher than conventional pipes.
- g) **FREE OF MAINTENANCE:** GRP pipelines are virtually maintenance free after installation. In case of repair, it can be repaired at site easily without any necessity of heavy equipments.

2. GENERAL SPECIFICATIONS: GRP PIPES & FITTINGS

This section gives the overview of the Glassfiber Reinforced Plastic (GRP) pipes and fittings for different industrial, chemical and water conveying applications. The piping system shall be furnished and installed complete with all fittings, joining materials, supports, and other necessary accessories.

2.1. CLASSIFICATION OF PIPES AND FITTINGS

2.1.1 Based on Nominal Diameter

Nominal size of pipe and fitting is based on internal diameter. The complete list of the available size produced by Strategic Engineering is in the table given hereunder. The nominal diameters (in mm) are: 25, 40, 50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1600, 1800, 2000, 2200, 2400,2600,2800,3000.

2.1.2 Based on Nominal Pressure Classes

Pipes and fittings are classified according to nominal pressure. Standard pressure classes (in bar) are 3, 6, 9, 12, 15, 20, 25, 32 and 40. Intermediate or higher-pressure classes are considered depending on the design conditions.

2.1.3 Specific Pipe Stiffness Classes

Pipes are also classified according to pipe stiffness. Stiffness is the prime design criteria in the case of underground pipes. GRP pipe stiffness is classified into four classes, viz. A, B, C, D. and expressed as “pipe stiffness” as per ASTM, AWWA and IS standards in kPa. It is also expressed as “Specific Tangential Initial Stiffness” as per BS 5480 & European norms, EN. Different stiffness classes are given below.

GRP Pipe Stiffness Classes

| Pipe Class | A | B | C | D |
|---|--------|----------|----------|----------|
| Pipe Stiffness, psi(kPa) | 9 (62) | 18 (124) | 36 (248) | 72 (496) |
| Specific Tangential Initial Stiffness, N/m ² | 1250 | 2500 | 5000 | 10000 |

2.3 GOVERNING STANDARDS

The governing documents commonly used in specifying, testing and applying GRP piping are the following:

| <i>Product Specifications</i> | |
|-------------------------------|---|
| AWWA C950 | American Water Works Association Standard for Fiberglass pressure pipe |
| ASTM D2310 | Standard Classification for Machine-Made Reinforced Thermosetting-Resin Pipe |
| ASTM D2996 | Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe |
| ASTM D3262 | Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe |
| ASTM D3517 | Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe |
| ASTM D3754 | Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting- Resin) Sewer and Industrial Pressure Pipe |
| ASTM D2517 | Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings |
| BS 5480 | British Standard Specification for Glass reinforced plastics (GRP) pipes, joints and fittings for use for water supply or sewerage. |
| BS 7159 | Design and construction of glass reinforced plastics (GRP) piping systems for individual plants or sites |
| IS 12709 | Indian Standard for Glass fiber Reinforced Plastics(GRP) Pipes, Joints and Fittings for use for Potable Water Supply |
| IS 14402 | Indian Standard for Glass fiber Reinforced Plastics(GRP) Pipes, Joints and Fittings for use for Sewerage, Industrial Waste and Water(Other Than Potable) |
| <i>Testing Standards</i> | |
| ASTM D2992 | Standard Practice for Obtaining Hydrostatic or Pressure Design Basis |

| | |
|-------------------|--|
| | for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings Procedure B - Steady pressure |
| ASTM D3681 | Standard Test Method for Chemical Resistance of "Fiberglass"(Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition |
| ASTM D3567 | Standard Practice for Determining Dimensions of Reinforced Thermosetting Resin Pipe (RTRP) and Fittings |
| ASTM D2412 | Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading |
| ASTM D2290 | Standard Test Method for Apparent Tensile Strength of Ring or Tubular Plastics and Reinforced Plastics by Split Disk Method |
| ASTM D638 | Standard Test Method for Tensile Properties of Plastics |

2.4 QUALITY ASSURANCE

Our internal quality assurance program is in compliance with international GRP pipe standards.

2.5 MATERIALS AND CONSTRUCTION

Pipes are manufactured by the filament winding process using appropriate resin system to impregnate the strands of continuous glass filaments, which are wound around a mandrel at a predetermined angle of winding. The resin controls the corrosion resistance properties of the composite material system and hence the type of resin for a given application is selected for the service fluid. All pipes have a resin-rich corrosion barrier(liner) reinforced with C-Glass surface mat. The corrosion barrier has high resin content of at least 70%. Liner shall be at least 0.5 mm thick. The structural glassfiber reinforcement for pipes and fittings shall be of E-Glass. GRP pipes exposed to sunlight (aboveground applications) are given a top resin coat that contains additives for UV protection.

2.6 FLANGES AND FITTINGS

All fittings are manufactured using the same type materials as the pipe. Fittings are manufactured by contact moulding process. Fittings shall be adhesive bonded matched tapered bell and spigot or flanged. Flanges shall have ANSI B16.5 Class 150 bolt hole patterns.

2.7 PIPE INSTALLATION

The piping system shall be installed in accordance with the manufacturer's current published installation procedures. All joints installed or constructed in the field shall be assembled only by trained technicians. After the completion of pipe installation at site, the pipeline in full or in sections will be tested for 1.5 times the working pressure or working pressure plus five bar; whichever is lower for 30 minutes with water. All pipe joints shall be water-tight. All joints that are found to leak by observation or during testing shall be repaired and retested.

COMPARISON OF GRP PIPES WITH OTHER PIPING MATERIALS

| Description | GRP Pipes | DI | MS Epoxy coated | HDPE |
|-------------------------|--|--|--|--|
| Corrosion resistance | Good | Very poor corrosion resistance. Hence inside cement lining and outside wrapping/ coating is required | Very poor corrosion resistance Cathodic protection is required | Good |
| Inside smoothness | Hazen William Co-efficient (C' Value) = 150. Hence less pumping cost | “C” value = 120 Hence pumping cost is higher | C” value = 120 Hence pumping cost is higher | C” value = 150 |
| Weight | Light in weight | 4 times higher than GRP | 4 times higher than GRP | Weight is higher than GRP due to higher wall thickness |
| Life | GRP pipes are designed for 50 Years of life | Due to corrosion the life of pipe is 15 – 20 years | Due to corrosion the life of the pipe is 10 – 15 years | Life of HDPE pipe is 10 – 15 years depend upon the service condition |
| Handling | Handling is very easy since very light in weight | Difficult, due to heavy weight | Difficult, due to heavy weight | Handling is very easy |
| Underground Application | Best design optimization possible with 50 years life. | The life of the under ground DI pipe is reduced due to external corrosion | The life of the under ground pipe is reduced due to external corrosion | Uneconomical design calling for very high thickness. |
| Maintenance | Less Maintenance is required | External coating may peel off in due course of time. Periodical maintenance is required. | External coating may peel off in due course of time. Periodical maintenance is required. | Repair is not possible |
| Specific Gravity | 1.8 – 1.9 | 7.05 | 7.85 | 0.95 |
| Tensile Strength | 375 MPa (Hoop) | 420 MPa | 400 MPa | 35 MPa |
| Modulus of Elasticity | 30 GPa (Hoop) | 150 – 170 GPa | 210 – 240 GPa | 5 GPa |
| Cost | Initial & life-cycle cost benefits | 10% - 20% higher than GRP | 10% - 20% higher than GRP | Higher for 150 NB and above sizes |

3. DESIGN METHODOLOGY OF GRP PIPES

Rational and experimental methods are used in designing GRP piping design. Most of performance limits are determined from long-term strength characteristics. Design factors are used to ensure adequate system over the intended system life of the pipe by providing for unforeseen variations in materials properties and loads.

The structural design procedure involves establishing of the design conditions, selection of the pipe classes and corresponding pipe properties, selection of installation parameters, and performing pertinent calculations to satisfy the design requirements.

3.1 DESIGN CONDITIONS

The following design conditions should be established:

- Nominal pipe diameter
- Working pressure
- Internal vacuum pressure
- Installation conditions: aboveground or underground
- Average service temperature
- Other special conditions such as ground water-table, seismic loading, sub-aqueous laying etc.

3.2 ALLOWABLE STRESSES

The allowable stresses are calculated based on the long-term hydrostatic test performed in accordance with ASTM D2992 Procedure B. GRP pipes are designed for 50 years of life. The design stress value used in the calculations to establish the thickness of GRP pipes corresponds to the 50 years life of the glassfiber reinforced plastic material system.

The design stress value for GRP pipes is evaluated based on long-term test in accordance with ASTM D2992. Long-term hydrostatic strength is known as Hydrostatic Design Basis(HDB) and this is evaluated by testing a minimum of 18 samples at various pressures for different failure time over 10,000 hours and extrapolating for 50 years life by least square regression curve fitting. The assumption is that aging depends on resin, curing agent, glass type and sizing and geometry of the reinforcement, but does not depend on the diameter and pressure rating and hence, this testing is required only for family representatives. Hydrostatic design stress (HDS) is the value obtained by dividing the HDB by a safety factor of 1.8(minimum).

4. TECHNICAL SPECIFICATIONS –DESIGN DATA

| ITEM DESCRIPTION | SPECIFICATIONS |
|-------------------------|--|
| Design Standard | ASTM D2996, 2992, 3517 AWWA C950, BS 5480, 7159 IS 12709, 14402 |

| Property | Unit | Standard | Value |
|---|---------------------|------------------------------|----------------------------|
| Long- Term Hydrostatic Strength: Hydrostatic Design Basis (HDB)-Static | MPa | ASTM D 2992 Procedure “B” | 140 |
| Short - term Hydrostatic Strength | MPa | ASTM D 1599 | 225 – 275 |
| Mechanical Properties | | | |
| Hoop Tensile Modulus | MPa | ASTM D 2412 | 20500-28000 |
| Axial Tensile Stress | MPa | ASTM D 638 | 45 -60 |
| Axial Tensile Modulus | MPa | ASTM D 638 | 9000-11000 |
| Hoop Bending Modulus | MPa | ASTM D 2412 | 20500-28000 |
| Poisson’s ratio : axial to hoop | - | ASTM D 2290 | 0.65 |
| Poisson’s ratio : hoop to axial | - | ASTM D 2290 | 0.38 |
| OTHER PROPERTIES | | | |
| Coefficient of linear expansion | m/m.°C | ASTM D 696 | 2 x 10⁻⁵ |
| Thermal Conductivity | W/m. K | - | 0.29 |
| Electrical Resistivity (standard pipe) | Ohm/m | ASTM D 257 | 10⁹ |
| Electrical Resistivity (conductive pipe) | Ohm/m | ASTM D 257 | <10⁵ |
| Glass Content (by Weight) | - | ASTM D 2584 | 70 ± 5 |
| Density | Kg / m ³ | - | 1750 ± 50 |
| Barcol Hardness | - | ASTM D2583 | 30 - 50 |
| Hazen – William co-efficient (C value) | - | - | 150 |

5. TESTING & QUALITY ASSURANCE PROCEDURE

| S.No. | Raw Material Inspection | Test Method | Sampling |
|-------|---|----------------------------------|-------------------------------|
| 1. | C-Veil, CSM & W/R Mat: <ul style="list-style-type: none"> ▪ Moisture Content ▪ Loss on Ignition ▪ Tensile Strength ▪ Mass per unit length ▪ Visual Inspection | IS 11320 IS 11551 IS 11271 | Every Batch of Glass delivery |
| 2. | Resin <ul style="list-style-type: none"> ▪ Specific Gravity ▪ Viscosity ▪ Volatile Content ▪ Gel Time ▪ Acid Value | IS 6746 | Every Batch of Resin delivery |

| S.No. | Product Inspection | Test Method | Sampling |
|---|---|-------------------------|--------------------------|
| 100% Testing on Product | | | |
| 1. | Visual Inspection | AWWA C 950/ M45 | 100% of the item |
| 2. | Dimensional Control | ASTM D 3567 | 100% of the item |
| 3. | Hydraulic Pressure Test | BS 5480 | 100% of the pipes |
| 4. | Barcol Hardness | ASTM D 2583 | 100% of the pipes |
| Batch Test on Product | | | |
| 5. | Pipe Stiffness (Destructive Test) | ASTM D 2412/ BS 5480 | Minimum One in 100 pipes |
| 6. | Axial Tensile Strength (Destructive Test) | ASTM D 638/ BS 5480 | Minimum One in 100 pipes |
| 7. | Hoop Tensile Strength (Destructive Test) | ASTM D 2290/ BS 5480 | Minimum One in 100 pipes |
| 8. | Loss on Ignition Test of Pipe (Destructive Test) | ASTM D 2584 | Minimum One in 100 pipes |
| Equipment Calibration | | | |
| 9. | Testing Equipment Calibration | SEPL's Manual | Frequency as per Manual |
| Product Marking & Identification | | | |
| 10. | Product marking /Identification | SEPL's Manual | Frequency as per Manual |
| 11. | Final Inspection Activities and Review of Documents | SEPL's Manual | Before Delivery |

6. JOINTS FOR GRP PIPES

6.1 CATEGORIES

GRP pipe joints include two general categories:

6.1.1 Restrained Joints: Pipe joints capable of withstanding internal pressure and axial load due to internal pressure.

- a) Flanged Joint
- b) Butt & Wrap Joint
- c) Adhesive Bonded Joint(Bell & Spigot with Adhesive)
- d) Rubber Seal Lock Joint (Bell & Spigot with Rubber Sealing Rings and a Locking Key)

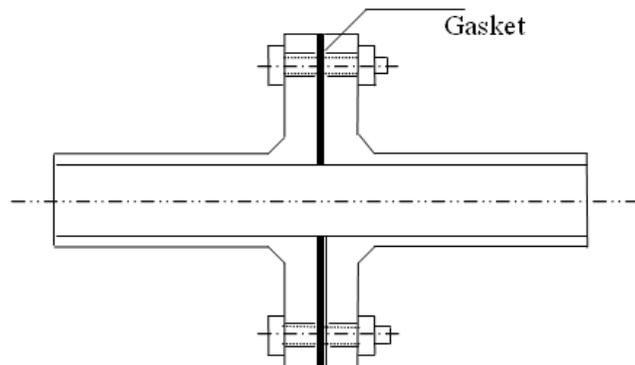
6.1.2 Unrestrained Joints: Pipe joints capable of withstanding only hoop loading due to internal pressure. In this type, the axial forces in the system have to be taken by external provisions on the pipeline.

- a) Bell & Spigot with Rubber Sealing Rings
- b) Coupler with Rubber Sealing Rings

6.2 RESTRAINED JOINTS

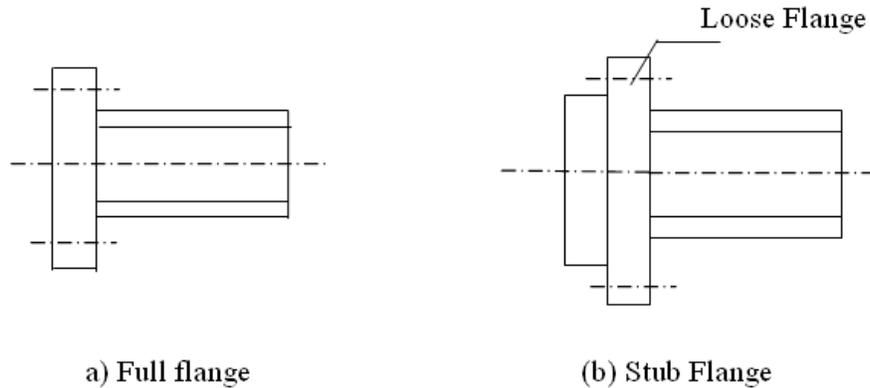
6.2.1 FLANGED JOINT

To enable connections and to allow for easy assembling and disassembling of process lines. Pipes and fittings are supplied with flanges, drilled in accordance with ANSI, DIN or other specifications.



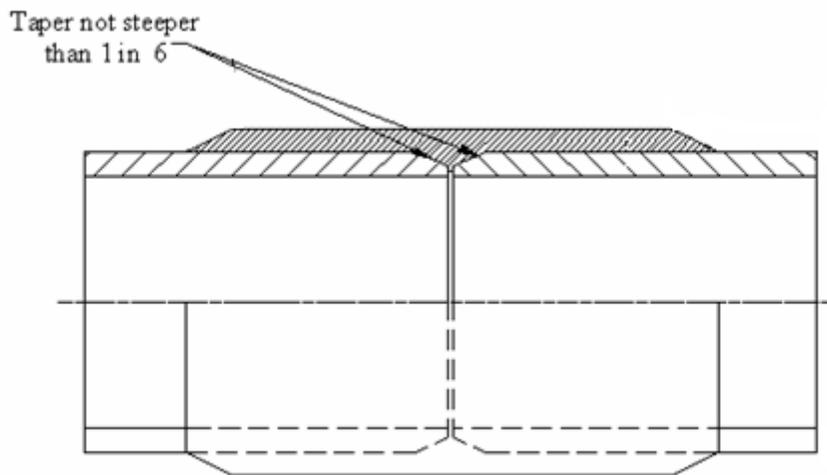
Glassfibre reinforced flanges are always flat faced and in view of this, matching flanges should also be flat faced. The flanged joint is completed by using a gasket. Standard gasket is a flat gasket.

For severe application and in any case for diameter >1200 mm and NP >10 bar, it is suggested to use O-ring gasket that are accommodated in a groove realized on the face of the flange. GRP Flanges are normally made as fixed flanges; however GRP stub flanges are also used in some applications. For GRP stub ends, the loose backing rings can be made either in GRP or in steel.



6.2.2 BUTT & WRAP JOINT (LAMINATED OVERLAY)

The Butt & Wrap joint consists of plain-ended pipes and fittings, prepared, aligned and laminated with reinforcing fibers and adhesives. The pipe ends are abutted end to end, aligned on the same centerline, and the joint over wrapped with layers of resin impregnated glassfiber materials.



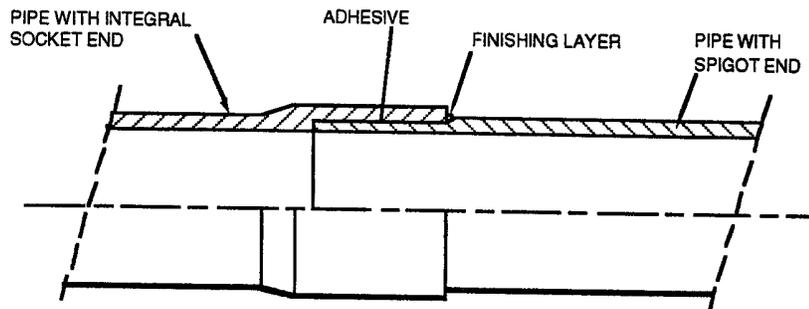
Note: Internal Joint Sealing Laminations are given for Pipe Diameters Above 800mm

6.2.3 ADHESIVE BONDED JOINT (Bell & Spigot with Adhesive)

The adhesive bonded joint is a rigid type of joining. Three types of adhesive bonded joints are available.

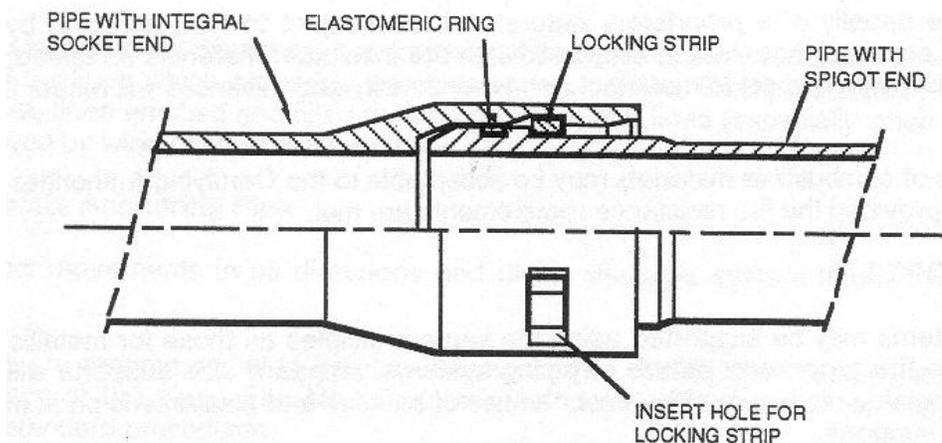
- A joint using a tapered bell and a tapered spigot
- A straight bell and a straight spigot joint
- A joint using a tapered bell and a straight spigot.

Adhesive bonded joints are generally used for pipes upto 400mm diameter.



6.2.4 RUBBER SEAL LOCK JOINT

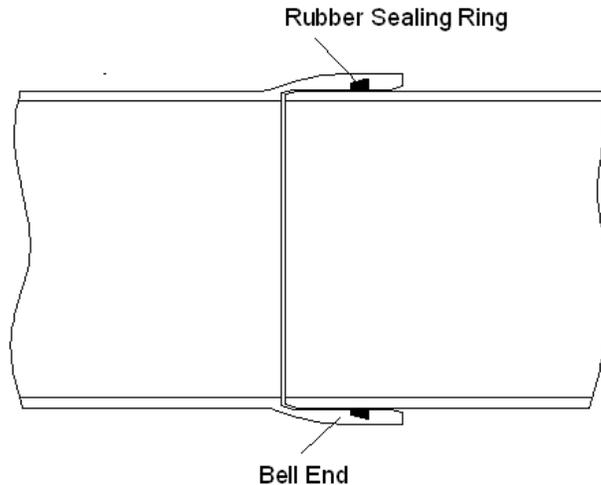
The joint is a bell and spigot with rubber sealing rings and a locking key. The locking key can be inserted through a bell opening into a groove and this provides the axial restraint for the pipes. This joint is a non-destructive, separable joining system which accommodates longitudinal forces. Both metallic and shear resistant plastic materials are used for locking key.



6.3 UNRESTRAINT JOINTS

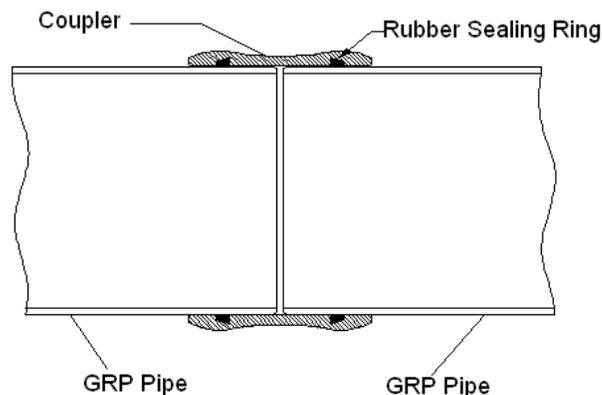
6.3.1 BELL & SPIGOT WITH RUBBER SEALING RINGS

It has a groove either on the spigot or in the bell to retain an elastomeric gasket that shall be the sole element of the joint to provide the water-tightness. The socket end of this joint is an integral filament wound part of the pipe. The spigot end is a machined part on which the rubber seal is positioned. This flexible joint allows for axial movement of the spigot in the socket and some angular deflection.



6.3.2 COUPLER WITH RUBBER SEALING RINGS

Double bell coupler is employed to connect two GRP pipes, which are mainly used for underground application. Double bell coupler has grooves inside the coupler to retain elastomeric seals that shall be the sole element of the joint to provide the water-tightness. This flexible joint allows for axial movement of the pipe in the coupler and some angular deflection. The both ends of GRP pipe will have spigot, which will match with the coupler.



7. Supports for Aboveground GRP Pipelines

GRP Pipe supports can be either of a hanger type, guide type or anchor type. The selection of the particular type depends upon the piping layout, other accessories like pumps, valves etc. that are fitted in the pipe lines and also the field configuration.

Most of the clamps that are used for steel piping can be used for GRP pipes. However an important aspect of GRP pipe clamping is that line contacts and point loads should be avoided. Therefore, a protective rubber layer should be provided between pipe and steel collar to minimize abrasion.

7.1 Support Types

7.1.1 Hangers: Hangers are free to move laterally or longitudinally with reference to the pipe. Hangers include band, ring, clevis or roller.

7.1.2 Guides: Guides restrict lateral movement but may permit longitudinal and rotational movement. Guides are recommended for lines which are subjected to side loads or uplift. Examples include lines subjected to pressure surges, lines emptied and filled during operation and lines (especially empty) which can be lifted or moved by wind or other external loads.

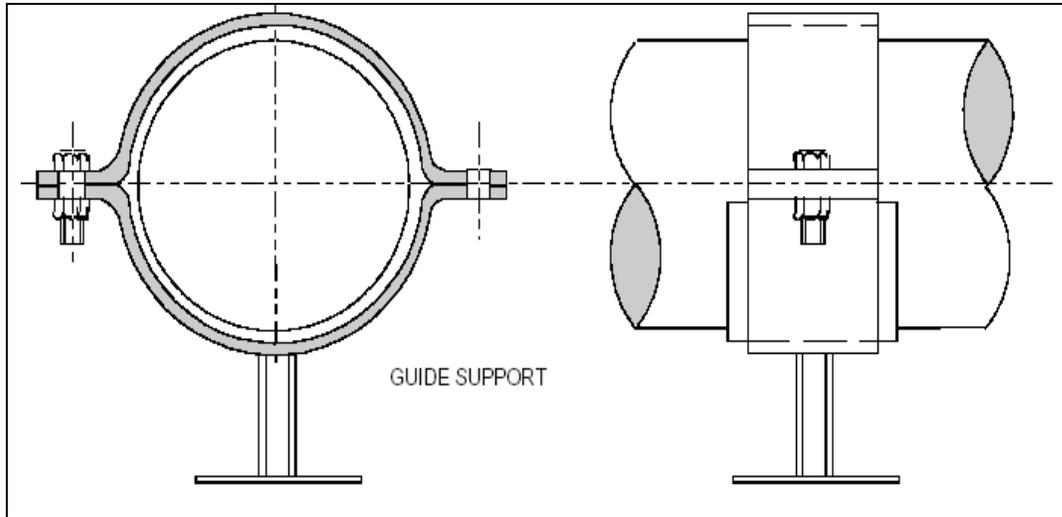
7.1.3 Anchors: Anchors restrict movements in all directions and divide the pipe system into individually expanding sections. Anchors prevent the pipe axial movement against applied forces and can be installed in both horizontal and vertical directions.

7.2 Guide Design

7.2.1 Typical Guide Usage

- Between anchors to prevent buckling of pipeline at elevated temperatures.
- Near entry points of expansion joints and loops to ensure proper functionality.
- To provide system stability.

Properly designed and installed guides prevent the pipe from sliding off support beams and allow the pipe to freely move in the axial direction. A 180° support "wear" saddle is recommended to prevent point contact between the bolt and pipe wall. The U-bolt should not be tightened down onto the pipe. It should be tightened to the structural support member using two nuts and appropriate washers. Clearance is recommended between the U-bolt and the top of the pipe.



Horizontal pipe should be supported at intervals suggested by the support spacing data. For the supporting of pipe systems several types of pipe clips can be used. The clips must fit firmly but must not apply excessive force to the pipe wall. This could result in deformations and excessive wall stresses. The pipe must be allowed to expand within its clamps. A 3mm rubber sheet is provided between the GRP pipe and the metallic clips.

7.3 Avoid Excessive Loading in Vertical Runs

Vertical pipe runs should be supported as in Figures. Fig(a) illustrates the preferred method. If fig(b) is used, take care to keep the tensile load on the pipe below the recommended tensile loads. Install guide collars at the same spacing as supports for the horizontal piping. The clamp in figures is placed below anchor sleeves that have been bonded to the pipe.

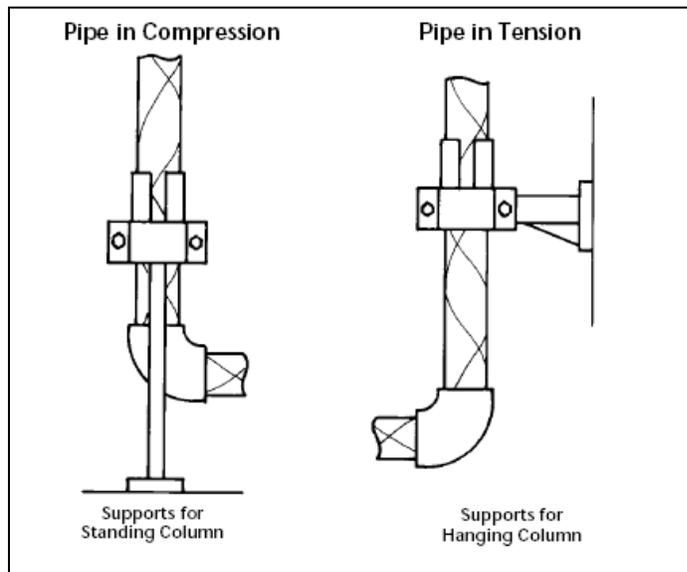


Fig. (a)

Fig. (b)

7.4 Anchor Design

Pipe anchors restrain the pipe against axial movement or applied forces. These forces may result from thermal loads, water hammer, vibrating equipment, or externally applied mechanical loads under compressive loading. For example: When anchors are used to control thermal expansion, guides are always required.

7.4.1 Anchor Usage

- a) To protect piping at "changes-in-directions" from excessive bending stresses
- b) To protect major branch connections from primary pipeline induced shears and bending moments. Particular consideration should be given to saddle and lateral fitting side runs.
- c) Installed where fiberglass piping is connected to steel piping.
- d) To protect a piping system from undesirable movement caused by water hammer.
- e) To reduce thrust and movement at line diameter changes.
- f) To protect sensitive in-line equipment.
- g) To absorb axial thrust at in-line reducer fittings when fluid velocities exceed 2.2 m/s.
- h) To provide stability in long straight runs of piping.

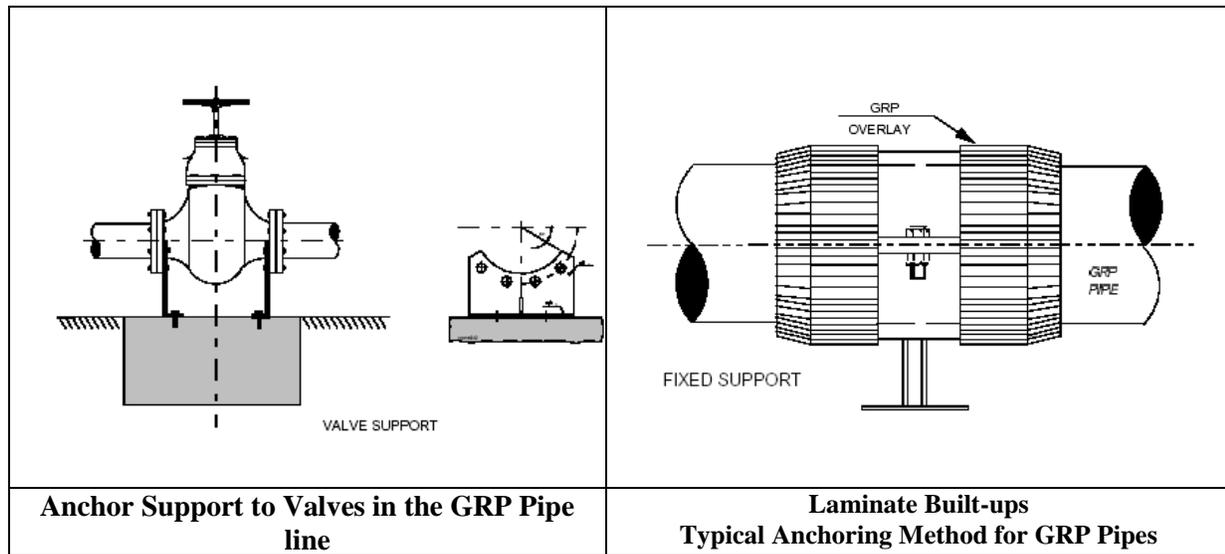
An anchor must positively restrain the movement of the pipe against all applied forces. Anchors can be installed in both horizontal and vertical directions.

Pipe anchors divide a pipe system into sections and must be attached to structural material capable of withstanding any applied forces. In some cases pumps, tanks and other similar equipment function as anchors. Additional anchors are usually located at valves, changes in direction of piping and major branch connections.

When applying unrestrained joints or mechanical couplers, pipelines must be anchored at each change of direction. Anyway the correct location of anchor points shall be settled after a detailed stress analysis.

To be effective, an anchor must be attached to a substructure capable of supporting the applied forces. In practice, pumps, tanks, and other rigidly fixed equipment function as anchors for fiberglass piping systems. Figure given below show typical methods of anchoring fiberglass piping systems. The reactions generated at anchors when restraining large thermal loads can be significant and should be calculated. The anchors brackets and substructure design should be designed with sufficient stiffness and strength to withstand these loads combined with any other system loads. Other system loads may include water hammer, the static weight of the pipe, fluid and any external loads such as insulation, wind, ice, snow, and seismic.

Heavy equipments (valves etc.) have to be supported independently from the pipe to avoid overloading in both horizontal and vertical directions.



7.5 Summary

- a) Do not exceed the recommended support span.
- b) Support valves and heavy in-line equipment independently. This applies to both vertical and horizontal piping.
- c) Protect pipe from external abrasion.
- d) Avoid point contact loads.
- e) Avoid excessive bending. This applies to handling, transporting, initial layout, and final installed position.
- f) Avoid excessive vertical run loading. Vertical loads should be supported sufficiently to minimize bending stresses at outlets or changes in direction.
- g) Should connections be necessary with machinery or bodies subject to vibrations, such as pumps or other equipment, it is a good engineering practice to avoid a direct link with such systems, because vibrations induce stresses on GRP pipe, which may prevail over the allowable value. The usual method to avoid vibrations is to install a flexible joint between the source of vibration and the pipe.

8. Installation Instructions of Underground GRP Pipes

To ensure long life and trouble free service from a piping system, proper application of the essential principles of excavation, laying and jointing, bedding, backfilling and field-testing is required. The recommended practices presented in this guide for the installation of buried GRP pipe should be rigorously followed to obtain best results.

8.1 Handling

- Pipe and fittings should never be thrown or dropped under any circumstances.
- Pipe lifting is done with slings of adequate strength and of such construction as not to damage pipe. Straight continuous lengths of pipe are capable of being lifted at one point. However, due to the very smooth surface, it is safer to lift pipes at two points symmetrical with respect to pipe center. Running of lifting rope inside the pipe shall never occur. Pipe assemblies fabricated of multiple sections may require two points lifting.
- While handling the pipes, impacts must be avoided, particularly of pipe ends.
- Do not let your pipe or fitting rest on the bed of the truck where nails, studs and other object might damage them. Whenever pipe or fittings in contact with wood or metal, padding such as excelsior, carpet or foam should be used.
- The pipe should be securely fastened with tie-downs consisting of nylon straps or manila rope. Avoid over-tightening, which may cause excessive localized deformation in the pipe.
- Do not allow the pipe to extend more than 0.5m feet beyond the truck or trailer bed as permanent damage can result from excessive flexing.
- GRP pipe is a light load, particularly with larger diameter pipe. Therefore, reduce speed on rough loads to minimize bouncing.

Caution: Do not place supports under bells, spigots or factory made joints.

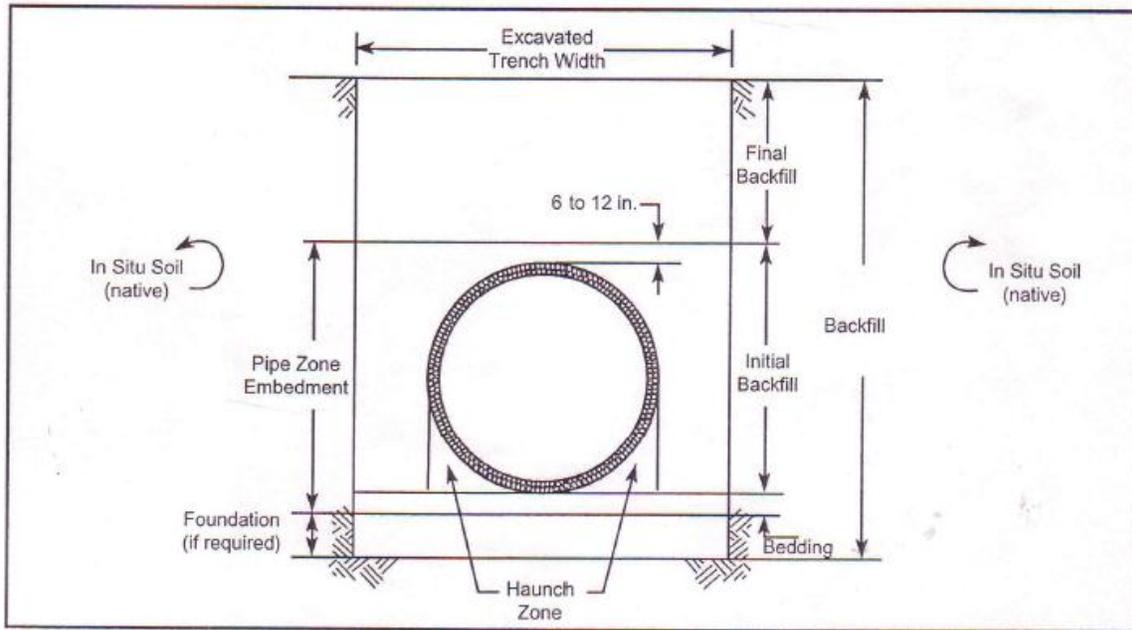
8.2 Storage

GRP pipes may be stored outside for extended periods provided the following procedures are observed.

- a) Support should be spaced as indicated in the sketch. The supports should have a minimum 100mm wide bearing surface.
- b) A pipe stack should not exceed 3m in height and should have side support or blocks to prevent rolling or slipping in the stack.
- c) If it is necessary to stack the pipe directly on the ground, make sure that the surface is level, soft and free of rocks or sharp objects.

- d) Protective end coverings should be left in place until the time of installation to protect the pipe ends and to prevent dirt or other material entering the pipe.
- e) Fitting should be stored in their shipping box under cover and protected from water, mud and extreme heat or cold.

8.2 Trenching



GRP Pipe Back Filling Diagram

8.3.1 Trench width:

The width of the trench, at the top of the pipe should not be greater than is necessary to provide safely and adequate room for jointing of the pipe in the trench and compacting the pipe – zone at the haunches and side of the pipe. Minimum trench widths should be 1.25times the outside diameter of the pipe plus 12in (300mm).

The Minimum trench width = 1.25 x OD of Pipe + 300mm

When butt and wrap joints is executed within the trench, it must be widened by 2 meters for a length of two meters in the joining area, in order to allow proper operations. At the above locations the trench bottom shall be adequately lowered. These joint housings will be filled during backfilling

The trench must always be wide enough to permit the placement and working of compaction equipment to ensure proper compaction of backfill material around the pipe, especially in

haunch regions. This may require a wider trench than the minimum specified above, particularly for smaller diameters.

8.3.2 Trench Depth:

The recommended normal cover depth (height of soil above pipe crown) is 1.2m. Cover depth can be reduced to a minimum of 600mm; however, engineering check is a must to predict the effects of traffic load and vacuum conditions.

8.4 BEDDING & BACKFILL REQUIREMENT

The buried GRP pipes undergo deflection in proportion to the top load and this deflection is resisted considerably by the side restraint provided by the soil around the pipe. It is therefore important that GRP pipes are bedded and surrounded by a well-compacted soil, which is capable of providing the necessary restraint to the pipe.

The buried GRP pipe undergoes deflection in proportion to the top load and this deflection is resisted considerably by the side restraint provided by the soil around the pipe. It is therefore important that GRP pipes are bedded and surrounded by a well-compacted soil. The bedding shall provide the pipe with a uniform and continuous support at the bottom over its entire length and the backfill material shall provide adequate support around the pipe so that the pipe deflection is resisted under the top soil overburden.

The native soil must adequately confine the pipe zone backfill to achieve proper pipe support. *When unstable or highly expansive soils are encountered in the trench bottom, it may be necessary to increase the depth of the bedding layer or a concrete foundation may be provided so that a uniform and continuous pipe support is available for the pipeline.*

For buried GRP pipelines, the long-term vertical pipe deflection must not exceed 5% on the diameter. The initial pipe deflection is limited between 3 to 4%. Pipes installed outside these limits may not perform as intended.

The buried GRP pipe deflection depends on the **modulus of soil reaction provided by backfill material, cover depth and pipe stiffness.**

Bedding & Backfilling Material: For the purpose of serving as backfill material, the soils are categorized as given below.

- A: Crushed stone, 12% fines
- B: Sand, <12% fines
- C: Silty Sand, 12-35% fines
- D: Silty, clayey sand, 35-50% fines
- E: Sandy, clayey silt, 50-70% fines
- F: Low plasticity fine grained soil

The group “A” backfill soil is the best to use and requires the least compactive effort while the group “F” backfill soils will require the greatest compactive effort to achieve a given level of relative compaction. The measure of the level of backfill soil support (strength) is expressed as the soil modulus E'_b in MPa. For any given backfill soil group, the higher the compaction the higher the soil modulus and the higher the support.

Soil groups A, B and C are normally acceptable for GRP pipe bedding and pipe zone installation. Excavated native trench soils can also be used when it is of good soil category and be able to provide the support to the pipe as per the above guidelines. Excavated native soils when used shall be free from foreign objects.

Soil groups D, E and F require very high compactive effort to achieve the required soil modulus and are normally not used as bedding or pipe zone backfill materials, since achieving very high compaction (above 95% SPD) uniformly along the pipeline is practically difficult. Soil groups D, E and F are not recommended at all when water table is present in the trench.

8.5 Bedding and Backfilling Procedure

8.5.1 Backfilling

The bed must be compacted until reaching 90% Standard Proctor Density before the pipe installation.

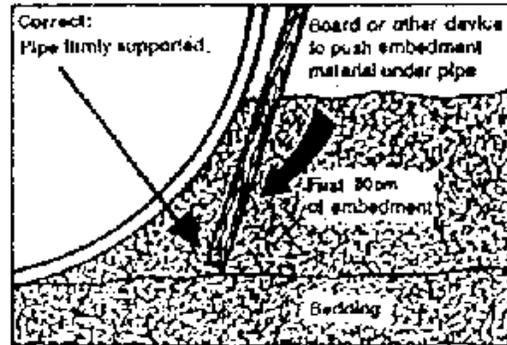
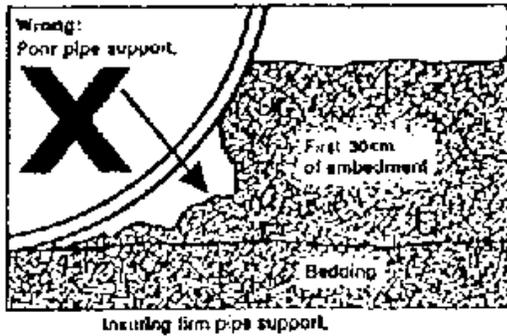
Where rock, hard pan, soft, loose, unstable or highly expansive soils are encountered in the trench bottom, it may be necessary to increase the depth of the bedding layer to achieve adequate longitudinal support.

8.5.2 Backfilling

Backfilling shall be placed in singly compacted layers 200-250 mm high up to 70% of pipe diameter and 300 mm high up to the top.

Compaction can be made by using an impulsive compactor or any other suitable equipment. **It is important to ensure that the material is completely filled and well compacted under the haunches of the pipe.**

Place thee compacted primary- zone backfill material to a minimum of 70 % of the pipe diameter. Backfill should be compacted to 90 – 95 % Proctor.



8.6 Field Repair procedure

When damage occurs or is revealed during an inspection, the appropriate method of correction or repair shall be decided. The repair method will depend on the extent of the damage. Typically, damaged pipe can be repaired quickly and easily by qualified personnel at jobsite. The repair procedure based on the extent of damage is described below.

8.6.1 Minor Repair

Minor repair to pipe and fittings may be repaired on site. The damaged outer layer shall be ground, cleaned and resin/hardened mix applied as per recommendations. Damages in GRP pipes and Fittings are to be repaired as follows.

8.6.1.1 Pipe Interior

- a) The damaged area is ground upto the end of liner with sand paper or with an electrical grinder.
- b) The ground surface is washed with acetone to remove dust
- c) A thin coat of previously prepared resin is applied with a brush onto the surface to be repaired
- d) Chopped Strand Mat (CSM 225 or CSM 300) is applied, saturated with resin using a brush
- e) Air bubbles are squeezed out using a roller
- f) Steps(d) and (e) must be repeated up to the liner thickness;
- g) A glass surfacing "C" veil is applied and saturated with resin using a brush
- h) After one hour, the resin will be hardened. The repaired surface is then ground to an even surface and a paraffinated resin (post coat) coat is applied.

8.6.1.2 Pipe Exterior

- a) The damaged area is ground upto the end of liner with sand paper or with an electrical grinder.
- b) The ground surface is washed with acetone to remove dust
- c) A thin coat of previously prepared resin is applied with a brush onto the surface to be repaired

- d) Chopped Strand Mat (CSM 225 or CSM 300) is applied, saturated with resin using a brush
- e) Air bubbles are squeezed out using a roller
- f) Steps(d) and (e) must be repeated up to the liner thickness;
- g) After one hour, the resin will be hardened. The repaired surface is then ground to an even surface and a paraffinated resin (post coat) coat is applied.

8.6.2 Major Repairs

It is recommended that damaged sections be replaced, if the damage is large. Replacement of damaged piping sections with new piping sections shall be considered as a new installation and be performed according to the methods and requirements of fabrication. Requirements of pipe fitter and inspector qualifications for replacement of piping shall be identical to the requirements for installing original piping.