

TABLE OF CONTENTS

1. Introduction	01
2. Normative References	03
3. Transport, Unloading & Handling, Inspection, and Storage	04
4. Trench Construction	13
5. Pipe Joining	33
6. Thrust Blocks, Concrete Encasement, Rigid Connections & Special Requirements	44
7. Field Adjustments	50
8. Post Installation	52
Appendix I: Pipe & Coupling Weights	60
Appendix II: Classification of Native Soils	61
Appendix III: Soil Characteristics	62
Annendix IV: Flange Installation Instructions	63

I. INTRODUCTION

I.I Foreword

This manual is intended to assist the installer in understanding the requirements by providing guidelines for transporting, trenching, laying, backfilling and testing of underground installation of Glass Reinforced Plastic pipes manufactured by Tamdid Pipes® and attempts to cover all standards direct bury applications. Pipe diamter ranges from 80 mm up to 4000 mm with pressure classes of 1, 3, 6, 10, 12, 16, 20 and 25 barg, and stiffness classes of 2500, 5000, 10000 and 12500 N/m². Table 1.1 illustrates the standard lengths of GRP/GRV pipes by Tamdid Pipes®.

NOMINAL DIAMETER – ND (mm)	STANDARD PIPE LENGTH – L (m)
80 - 200	6
250 - 4000	6/12

Table 1.1 – Standard Pipe Length

This manual does not purport to be a design guide and does not address unusual installations for which special procedures will be developed.

This manual should be read carefully by all persons involved in installation work and the client has to make sure that his staff will follow the proper procedures to insure proper system performance. It will be the full responsibility of the client for installation as this manual is not intended to replace common sense, good engineering judgment, safety regulations or local ordinances, nor the specifications and instructions of the owner's engineer.

Please consult Tamdid Pipes® and the owner's engineer in case of disagreement in the interpretations of the guidelines presented in this manual. The owner's engineer is always the final authority in a particular project.



1.2 Field Service Representative

Tamdid Pipes® can provide a Field Service Representative to advise the contractor on the proper handling, storage, bedding, laying, joining, backfilling and testing procedures.

The responsibilities of the Field Service Representative include:

- □ To review Tamdid Pipes® «installation manual» and specific Tamdid Pipes® installation recommendations with the contractor engineers prior to start of the installation.
- Periodic visits during the period of pipe installation to insure all activities of handling, storage, bedding, laying, jointing, backfilling, and field testing are performed properly as noted in this installation guide.
- □ Insure the contractor and his crew has a copy of this installation manual and are aware of all the installation procedures.
- ☐ To insure site presence during critical activities. Frequency of visits can be agreed upon with the contractor depending on the nature of the project and the contractor's crew skills.
- ☐ Tamdid Pipes® shall not be liable for any failures related to misusing and not implementing the printed instructions in this manual or the field service representative's advice.





I.3 Saf∈ty

The contractor must implement good judgment by avoiding hazardous situations such as pipe exposure to welder's sparks, cutting-torch flames, intense heat, or electrical sources which could damage the pipe material.



2 NORMATIVE REFERENCES

Tł	ne following referenced documents / standards can be used as help with this Manual:
	AWWA MANUAL M45 , Standard for Fiberglass Pressure Pipe
	AWWA C950, Standard for Fiberglass Pressure Pipe
	ASTM D698 , Moisture-Density Relations of Soil
	ASTM D 3839 , Underground Installations of Flexible Reinforced Thermosetting Resin Pipe and Reinforced Plastic Mortar Pipe
	ASTM D 2049 , Test for Relative Density of Cohesion less Soils
	ASTM 2487 , Classification of Soil for Engineering Purposes
	ASTM 2498 , Recommended Practice for Description of Soils (Visual/Manual Procedure)
	ANSI B 16.5 , Steel Pipe Flanges and Flanged Fittings
	ANSI/AWWA C207, Steel Pipe Flanges for Waterworks Service, 4" to 144"
	ASTM D2563 , Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts
	ASTM D 4024 , Reinforced Thermosetting Resin Flanges
	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 D4161 , Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
	BS 6464 : 1984 British Standard Specification for Reinforced plastic pipes, fittings and joints for process plants
	BS 5480 British Standard Specification for Glass Reinforced Plastic (GRP) pipes, joints and fittings for use for water supply or sewerage.
	KRV A98402-82/ Kunststoff Rohrverband. Instruction for design and installation of piping made of glassfibre reinforced thermosetting resin, with and without liner
	BS 8010, Section 2.5 Glass reinforced thermosetting plastics, Part 2. Pipelines on land: design, construction and installation
	ISO 146924:2002- , Petroleum and natural gas industries – Glass reinforced plastics (GRP) piping –Part 4: Fabrication, installation and operation

3. TRANSPORT, UNLOADING, HANDLING, INSPECTION AND STORAGE

3.1 Transport

Tamdid Pipes® can offer transportation services to job site. It is preferable to use the original shipping dunnage when loading the truck. If this material is no longer available, support all pipe sections on flat timbers spaced on a maximum of 4 meter centers (3 meter for small diameters) with a maximum overhang of 2 meters. Chock the pipes to maintain steadiness and separation. Insure no pipes get in touch with other pipes, so vibrations during transport will not cause abrasion. *See figure 3.1*.



Figure 3.1 – Pipes Transport

Strap pipes to the vehicle over the support points using pliable straps or rope - never use steel cables or chains without adequate padding to protect the pipe from abrasion. Also, maximum diametrical deflection must not exceed the values in Table 3.2. Bulges, flat areas or other abrupt changes of curvature are not permitted. Transport of pipes outside of these limitations may result in damage to the pipes.

3.2 Unloading & Handling

Unloading the pipe is the responsibility of the contractor's crew. Be sure to sustain control of the pipe during unloading. Guide ropes attached to pipes or packages will facilitate easy manual control when lifting and handling. Spreader bars may be used when multiple support locations are necessary. Do not drop, impact, or strike the pipe, especially at pipe ends.



3.2.1 Handling Bundled Loads:

Normally, pipes with nominal diameters of 600mm and smaller are packaged as a bundle.

Bundled loads may be handled using a pair of slings as shown in Figure 3.2. Larger diameters may be delivered in unitized packages also.

Consult Tamdid Pipes® if you are in doubt as to the type of packaging you have received. Do not lift a non-unitized stack of pipes as a single bundle. Non-unitized pipes must be unloaded and handled separately (one at a time).

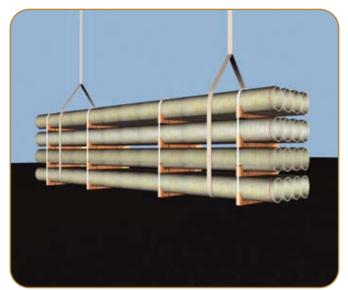


Figure 3.2 – Lifting bundled package

3.2.2 Handling Single Pipes:

When handling single pipes, use pliable straps, slings or rope to lift. Do not use steel cables or chains to lift or transport the pipe. Pipe sections can be lifted with only one support point (Figure 3.3) although two support points placed as in (Figure 3.4) make the pipe easier to control. Do not lift pipes by passing a rope through the section end to end.

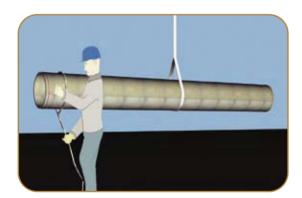


Figure 3.3 – Lifting at one support point

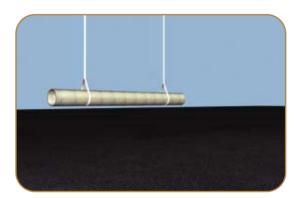


Figure 3.4 – Lifting at two support points

See "Appendix I" for estimated weights of pipes and couplings.

If at any time during handling or installation of the pipe, any damage such as a scratch, crack, or break occurs, the pipe should be repaired before the section is installed. Contact Tamdid Pipes® for inspection of damage and for recommendation for repair method or disposal. See section 3.5 on Repairing Pipe.

3.2.3 Handling Nested Pipes:

In order to reduce the transportation costs, pipes may be nested. Nested pipes normally have customized packaging and required special procedures for unloading, handling, storing and transporting. The following general procedures should always be followed:

- Always lift the nested bundle using at least two pliable straps (Figure 3.5). Restrictions, if any, for spacing between straps and lifting locations will be specified for each project. Insure that the lifting slings have adequate capacity for the package weight. This may be calculated from the approximate pipe weights given in "Appendix I".
- □ Nested pipes are usually best stored as received. Stacking of these packages is not recommended.
- □ Nested pipe bundles can only be safely transported in the original transport packaging. Special requirements, if any, for support, configuration and/or strapping to the vehicle will be specified for each project.
- □ For pipes larger than 1200 mm, de-nesting of the inside pipe(s) is best accomplished at a de-nesting station. Typically, this consists of three or four fixed cradles to fit the outside diameter of the largest pipe of the bundle. Inside pipes, starting with the smallest size may be removed by lifting slightly with an inserted padded boom to suspend the section and carefully move it out of the bundle without touching the other pipes (Figure 3.6). Pipes smaller than 1200 mm do not require such stations.
- ☐ Special procedure will be developed in case of larger pipes with weight, length, close sizes, and/or equipment limitations.
- De-Nesting can be accomplished by inserting a forklift frok into a padded boom. The forklift capacity should be appropriate to handle the weight and length of the pipes being de-nested. Proper padding is essential with rubber, several wraps of corrugated cardboard sheets, or a PVC or PE pipe slipped over the boom to avoid damaging the inside surface of the nested pipes.

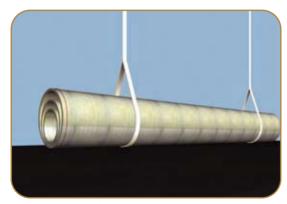


Figure 3.5 – Double support point

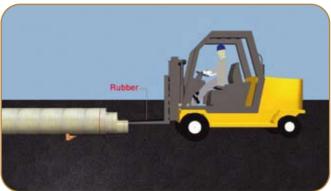


Figure 3.6 – De-nesting

3.3 Inspection

Client must inspect all pipes upon receipt at the job site to insure that no damage has occurred in transit. Depending on length of storage, amount of job site handling and other factors that may influence the pipes' condition, it may be wise to re-inspect the pipe just prior to installation.

Inspect the shipment upon delivery, as follows:

- Perform an overall inspection of the load. If the load is intact, ordinary inspection while unloading is enough to make sure the pipe has arrived without damage.
- ☐ In case of any indication of load shifting or rough treatment, carefully inspect each pipe section for damage. Generally, an exterior inspection will be sufficient to detect any damage. When pipe size permits, an interior inspection of the pipe surface at the location of an exterior scrape may be helpful to determine if the pipe is damaged.
- ☐ Check the quantity of each item against the delivery note.
- □ Note on the delivery note any transit damage or loss and have the carrier representative sign your copy of the receipt. Make prompt claim against the carrier in accordance with their instructions.
- ☐ Do not dispose damaged items.
- ☐ If any deficiency or damage is found, immediately separate the affected pipes and contact Tamdid Pipes®.

Do not use pipes that appear damaged or defective.

3.4 Storage of Pipes

3.4.1 Trench Side Storage

In order to reduce multiple handling, it is preferable to unload the pipes from trailer to trench side. Pipes should be placed on the opposite side of the excavated material allowing sufficient space between pipes and the trench for site equipment to operate.

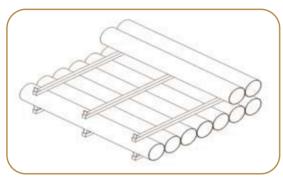




3.4.2 Storing GRP Pipes in Stock Areas:

Alternatively, if it is not possible to store on the trench side, pipes must be stored in a stock area which is relatively flat and free of rocks and debris. Place the pipes on flat timber to ease placement and removal of lifting slings around the pipe, timbers must be spaced 3m to 6m apart depending on size of the pipe. All pipes should be chocked to prevent rolling in high winds.

In case of limited storage space at site, it may be necessary to stack pipes in which case it is best to stack on flat timber supports spaced 6m apart for large diameters and 3m apart for smaller diameters.



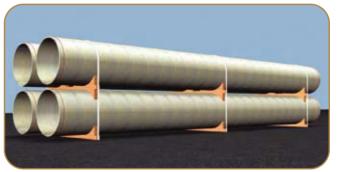


Figure 3.7 – Typical Pipe Storage

Stack height should not exceed the value shown on table 3.1 and must be stable and able to resist high winds, unlevel storage area or unexpected horizontal loads. It is not recommended to stack pipes larger than 1400mm in diameter. See Figure 3.7 for typical storage.

Stackingheight and pipe layers number								
ND 250 - 500 600 - 800 900 - 1400 > 1500								
Number of Layers	9 - 4	4-3	2	1				
Total stack hight >2.4m >2.6m >2.8m ND								

Table 3.1 Pipe Stack Hight

Precautions

Should GRP pipes and components be stored at a room temperature or more than 50°C and for long periods, the stack height should not exceed 2 m in order to avoid ovalization of pipes in the bottom layers. It is also necessary to avoid any work with open flames in the immediate vicinity of the pipes.

3.5 Repairs

Normally, pipes with insignificant damage can be repaired quickly and easily at the job site by a qualified individual. If in doubt about the condition of a pipe, do not use the pipe.

Table 3.3 shows some common defects and corrective actions.

Defect Type	Description	Delivery Acceptance Cirteria	Corrective Action
Chip	Small piece broken from edge or surface. If fibres are broken, the damage is considered to be a crack.	If there are undamaged fibres exposed over any area; or no fibres are exposed but an area greater than 5 x 5mm lack resin. If there are no fibres exposed, and the area lacking resin is less than 5 x 5mm.	Minor repair. Accept
Crack	Actual separation of the laminate, visible on opposite surface, and often extending through the wall. Reinforcement fibres are often visible/broken.	None permitted	Reject
Crazing	Fine hairline cracks at or under the surface of the laminate. White areas are not visible as for cracks.	Cracks lengths greater than 25mm Cracks lengths less than 25mm	Minor repair. Accept
Fracture	Rupture of the laminate with complete penetration. Majority of fibres broken. Visible as lighter coloured area of interlaminar separation.	None permitted	Reject
Wear scratch	Shallow mark caused by improper transportation. If reinforcement fibres are broken, the damage is considered to be a crack.	If there are undamaged fibres exposed over any area: or no fibres are exposed but an area greater than 10x10mm lack resin. If there are no fibres exposed, and the area lacking resin is less than 10x10mm.	Minor repair. Accept

Table 3.3 – Some Common Deffects & Corrective Actions

The Field Service Representative can help you resolve whether repair is essential and whether it is possible and practical. He can obtain the suitable repair specification and arrange for the required materials and a qualified repair technician, if desired. Repair designs can vary significantly due to pipe thickness, wall composition, application, and the type and extent of the damage. Therefore, do not attempt to repair a damaged pipe without consulting the supplier first.

3.6 Storing of raw materials

Resin and glass:

- Resins and other chemicals shall be stored in the original drums and other packages, indoors, in a dry, dark and ventilated ambient at a temperature of approx. 25°C. In this case the average life is 6 months.
- Should the storage temperature be higher than 25°C, the standard life of resin and additives will be shortened and will be as lower as the room temperature is higher.
- On the contrary very low temperature can cause resin crystallization. The resin will look milky and thickened, but with no deterioration or reduction of the life. Heat up to 40-:50°C and stir thoroughly before the use.
- If resin is spilt accidentally, it should be picked up with sand or sawdust then the affected area should be cleaned with acetone or biodegradable detergent.
- ☐ In the event of fire, CO2, dry fire extinguishers or water can be used (In the proximity of electric cables only CO2 or dry fire extinguishers should be used).
- ☐ When handling resins, rubber gloves are recommended so as to avoid direct contact with the skin. In the event that resin comes into contact with skin, it should be removed with copious quantity of acetone followed by rinsing with water.
- ☐ Glass fibres shall be kept indoor and left sealed inside the original plastic envelopes in order to be protected from humidity, but they are not temperature sensitive. Stored in these conditions fibreglass has an unlimited life.

3.7 Storing Gaskets and Lubricants:

Rubber ring gaskets, when shipped separate from the couplings, should be stored in the shade in their original packaging and should not be exposed to sunlight except during the pipe joining. Also, the gaskets must be protected from exposure to greases and oils which are petroleum derivatives, and from solvents and other toxic substances.

Gasket lubricant should be carefully stored to prevent damage to the container. Partially used buckets should be resealed to avoid contamination of the lubricant.



It is important that pipe self deflection during storage does not exceed critical limits shown in Table 3.2. To insure this, bulges and abrupt changes in curvature must be avoided.

Stiffness Class SN; N/M2	Allowable Self Deflection % of ND
2500	2.5
5000	2.0
10000	1.5
12500	1.0

Table 3.2 – Maximum Allowable Storage Deflection





Accelerators:

In the event of accidental spillage of an accelerator it should be soaked up with rags that can be later discarded.

The polluted area should be thereafter cleaned with acetone. In case of skin contact, the affected area should be repeatedly rinsed with soap and water.

Catalysts:

When handling peroxide catalysts, the utmost care should be taken to avoid eye and skin contact.

In case of accidental contamination the affected areas should be thoroughly rinsed with water, followed with a solution containing 2% Boric acid or 5% ascorbic acid.





4. TRENCH CONSTRUCTION

4.1 Trench Details

The trench should be excavated as close as possible to the actual pipe laying and installation to avoid accidents and possible hazards such as flooding due to rain water.

Place the excavated soil on one side of the trench leaving the other side clear for equipment and pipe handling.

The trench shall be wide enough to allow placement of the pipe and proper compaction of the pipe zone backfilling material. Minimum trench dimensions shall be according to Figure 4.1 and Table 4.1.

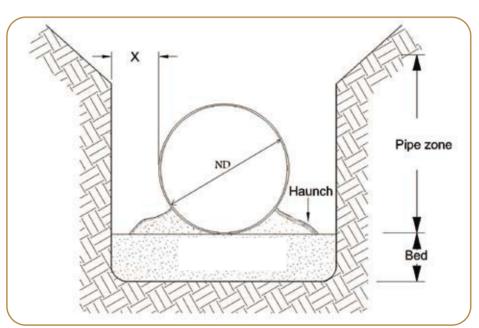


Figure 4.1- Standard Trench Details

ND (mm)	X (mm)
80 - 300	300
350 - 900	400
1000 - 1600	450
1800 - 2400	600
2500 - 3000	750
3000 - 4000	900

Table 4.1- Minimum Dimensions between Pipe and Trench wall

4. I. I Multple Pipes in Same Trench

When two or more GRP Pipes are installed in parallel in the same trench, a minimum space between the pipes shall be as per the following:

Cover of depth up to 4.0m: distance=(ND1+ND2)/6

Cover depth over 4.0m: distance=(ND1+ND2)/4

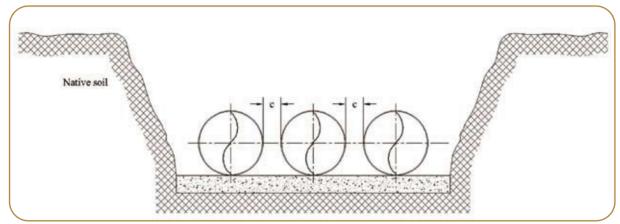


Figure 4.2 - Multple Pipes in Same Trench

ND (mm)	min c (mm)
50 - 300	300
300 - 900	400
1000 - 1600	500
1800 - 2400	600
2800 - 4000	900

Talbe 4.2 Spacing between pipes in the same trench

This distance should not be less than 150mm or sufficient room to place and compact backfill.

It is advisable when laying pipes of different diameters in the same trench, to lay with the same invert elevation.

When this is not possible, select backfill material must be used to fill all the space from the trench bottom to the invert of the higher pipe. Proper compaction must be achieved.



4.1.2 Cross-Overs

When two pipes cross, so that one passes over the other, vertical spacing between pipes and installation for the bottom pipe shall be as following:

Cover of depth up to 4.0m: spacing=(ND1+ND2)/6 Cover depth over 4.0m: spacing=(ND1+ND2)/4

In some cases, it is necessary to lay a pipe under an existing line. Extra care should be taken not to damage the existing pipe. It should be protected by fastening it to a steel beam crossing the trench. It is advisable also to wrap the pipe in order to protect it from impact damage. When the new pipe is laid, selected backfill material must be placed back into the trench and hand compacted in order to completely surround both pipes and also achieve the required density.

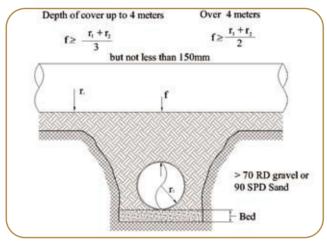


Figure 4.2 - Pipes Crosss Over

4.1.3 Unstable trench bottom

Where the trench bottom has soft, loose or highly expansive soils, it is regarded as unstable. An unstable trench bottom must be stabilized before laying pipe or a foundation must be constructed to minimize differential settlement of the trench bottom.

The depth of the gravel or crushed stone material used for foundation depends upon the severity of the trench bottom soil conditions, but should not be less than 150mm. the normal bedding must be placed on top of such foundation. The use of filter fabric cloth to completely surround the foundation material will prevent foundation and bedding materials from migration into one another that could cause loss of pipe bottom support. Additionally, the maximum pipe section length between flexible joints shall be 6 meters.

4.1.4 Flooded trench

When the ground water is above the trench bottom, the water level must be lowered to at least the trench bottom (preferably about 200mm below) prior the preparation of the bed. Different techniques may be used depending on the nature of the native soil material.

For sandy or silty soils, a system of well-points to a header pipe and a pump is recommended. The spacing between individual well-points and the depth at which they will be driven depends on the ground water table. It is important to use a filter around the suction point (coarse sand or gravel) to prevent clogging of the well-points by line grained native material.

When the native material consists of clay or bedrock, well-points will not work. Dewatering is more difficult to achieve in this case if the ground water table is high. The use of sumps and pumps is recommended.

If the water cannot be maintained below the top of the bedding, subdrains must be provided. The subdrains shall be made using single size aggregate (20 - 25 mm) totally embedded in filter cloth. This depth of the subdrain under the bed shall depend on the amount of water in the trench.

If the ground water can still not be maintained below the bed, filter cloth shall be used to surround the bed (and if necessary the pipe zone area as well) to prevent it from being contaminated by the native material. Gravel or crushed stone shall be used for bed and backfill.

The following cautions should be noted when dewatering:

- Avoid pumping long distances through the backfill materials or native soils, which could cause loss of support to previously installed pipes due to removal of materials or migration of soils.
- ☐ Do not turn off the dewatering system until sufficient cover depth has been reached to prevent pipe flotation.

4.1.5 Use of temporary trench shoring

If at all possible, the use of temporary trench shoring or sheeting at pipe level should be avoided. This is because it is important that the bedding and pipe zone backfill are compacted hard against the native trench wall. If the shoring or sheeting is pulled out after backfill, the pipe zone material will tend to move into the gap left by the sheeting, reducing support to the pipe, and in many cases, resulting in excessive deflections of the pipes.

In cases where temporary shoring and sheeting are necessary and cannot be avoided, the following requirements should be met:

- ☐ Install the shoring to a depth of 300mm above the top of pipe, leaving the native trench sides fully exposed at pipe level.
- Use a type of shoring which can be removed in stages either by pulling up individual sheets or by pulling up the bottom panel of a trench system independent of the upper panels. This lifting of sheets or panels must be done progressively so that pipe bedding and pipe zone material can be compacted hard against the native trench side up to 300mm above the pipe crown for installation type 1 and 2, to the pipe crown for installation type 3, and to 60% of the pipe diameter for installation type 4.
- Use trench boxes. It is fairly easy to pull them in stages using a crane or excavator.

Note: if water and/or native soil are seen to escape between sheets then there are certain to be voids. These must be filled with compacted bacfill.

4.1.6 Trench construction in rock

Minimum dimensions for pipe installation in a rock trench shall be per figure 4.2.A where the rock ends and the pipe passes into a soil trench area (or reverse), flexible joints shall be located as shown. Trench construction shall be according to the method applicable for the native soil condition.

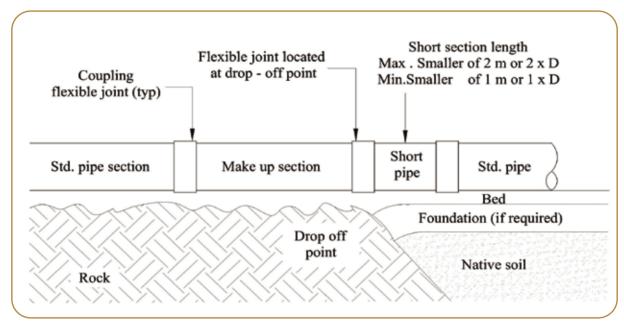


Figure 4.2.A - Trench Construction in Rock

4.1.7 Inadvertent over-excavation

Any inadvertent over-excavation of the trench walls or the trench bottom in the foundation, bed or pipe zone areas shall be filled with compacted backfill material. The native material shall not be returned into these areas regardless of the compaction level unless it qualifies as the backfill material.

4.1.8 Installation of pipes on slopes

When pipes are to be installed on a slope care must be taken to prevent movement or sliding of the ipes down the slope. Installation should proceed from the bottom to the top of the slope, compacting the backfill as the pipe is laid. On slopes steeper than 20 degrees (from horizontal) the pipe should be anchored to prevent downward movement. Consult Tamdid pipes® for advice on anchoring methods

4.2 Installation and Backfilling

4.2.1 General

The installation type and choice of backfill material is normally specified by the design engineer based on the selected pipe stiffness class, burial depth, native soil conditions and required vacuum level.

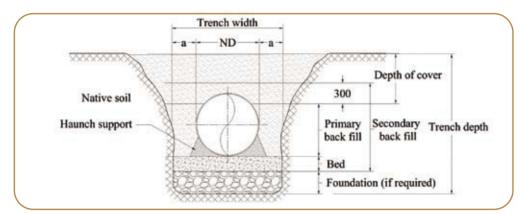


Figure 4.3 - Installation Details

The native material must effectively confine the pipe zone backfill (see Figure 4.3) to achieve proper pipe support. The following installation procedures are intended to assist the installer in achieving an acceptable pipe installation. However, regardless of soil conditions and installation method, it is suggested that the initial deflections must not exceed the values given in Table 4.3 while long term deflection should not exceed 5% of the pipe diameter. Native soil groups are described in Table 4.4.

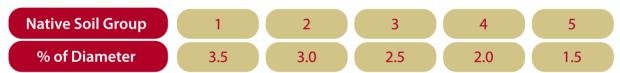


Table 4.3 Allowable Initial Vertical Deflections

Appendix II provides more detailed definitions for the native soil groups. Testing of native soil should be done regularly and particularly where changes are suspected. Properties of importance are those obtained at the bed and pipe zone elevation. The blow counts or soil strengths must represent the most severe (weakest) condition expected to exist for any significant period of time. (Normally this occurs when the water table is at its highest elevation). Appendix IV relates the consistency of cohesive soils and compactness of granular soils to various engineering properties characteristic of these soil types.



Table 4.4 Natvie Soil Groups Classification

4.2.2 Backfill Materials

Most coarse grained soils (gravel, crushed stone, and sand) are good pipe zone backfill materials. Gravel is easier to compact than sand and allows the pipe to be installed deeper.

Use of Native Soils

Where native soil is used as pipe zone backfill, the following restrictions apply:

- 1. No rocks greater than maximum gravel size given in Table 4.6.
- 2. No soil clumps greater than 2 times the maximum gravel size.
- 3. No organic or frozen material.
- 4. No debris (tires, bottles, metals, etc.).
- 5. Where compaction is specified: the native soil must be granular in nature (classification).

SOIL CATEGORY	SYMBOL (as ASTM 2487)
Crushed Rock / Gravel	GW, GP, GW-GC, GW-GM, GP-GC, GP-GM, GM, GC
Sand	SW, SP, SW-SC, SW-SM, SP-SC, SP-SM, SM, SC

Table 4.5 - Acceptable Pipe Zone Backfill Materials Gradation

PIPE DIAMETER	MAXIMUM PARTICLE SIZE
ND < 600mm	13 mm
600 mm < ND < 1600 mm	19 mm
ND > 1600mm	25 mm

Table 4.6 - Maximum Particle Size allowed as backfill in Pipe Zone

4.2.3 Backfill Migration

When selecting the backfill materials, it is essential to check its compatibility with the native soil. It is very important that the pipe zone backfill material not wash away or migrate into the native soil. Likewise, potential migration of the native soil into the pipe zone backfill must be prevented. Should this happen, the pipe may lose its side support, deflect excessively, and not perform as specified.

The gradation and relative size of the embedment and adjacent native soil must be compatible in order to minimize migration. In general, where the ground water table is above the foundation level and the native soil is finer than the backfill, avoid using open graded materials such as crushed rocks and gravel unless a geotextile filter fabric is used to line the trench bottom and sides.

Typically, migration can only occurs if there is movement of water in the pipe zone and the following relationship exists between the two adjacent soils:

D85 finer <= 0.2 D15 coarser

Where:

D85 finer = sieve opening passing 85% of the finer material

D15 coarser = sieve opening passing 15% of the coarser material (Figure 4.4)

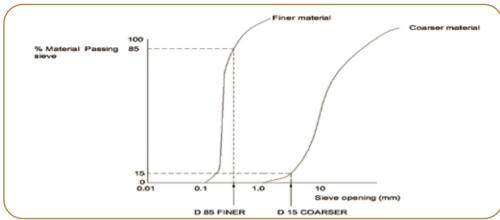


Figure 4.4 - Backfill Migration Criteria

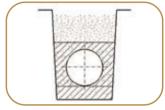
4.2.4 Standard Installation Methods

Due to its flexibility, GRP/GRV pipes by Tamdid Pipes® must be supported by the surrounding soil to carry the overburden loads. The allowable cover depths are related to the type of pipe zone backfill material and its compaction (density), trench construction, pipe stiffness, and native soil characteristics.

Four standard installation methods can be implemented. Selection depends on pipe stiffness, native soil, and required burial depth. Table 4.7 gives general guidelines for the four installation types without traffic load and Table 4.8 gives maximum burial depths with traffic loads (based on AASHTO H20 wheel loads).

Installation Method 1

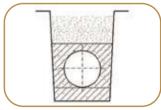
- □ Carefully constructed bed
- ☐ Backfill 70% Relative Density Gravel
- ☐ Backfill compacted to 300mm over pipe crown



Installation Method 1

Installation Method 2

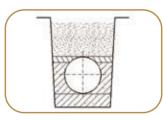
- ☐ Carefully constructed bed
- ☐ Backfill with 90% Standard Proctor Sand
- ☐ Backfill compacted to 300mm over pipe crown



Installation Method 2

Installation Method 3

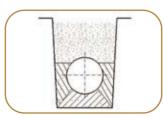
- □ Backfill to 60% of pipe diameter with gravel or sand (primary pipe zone).
- ☐ Backfill from 60% to pipe crown with compactable native compacted to 90% Standard Proctor



Installation Method 3

Installation Method 4

- ☐ Pipe bed and haunching with sand or gravel compacted to 90% Standard Proctor
- ☐ Backfill to 60% of pipe diameter with compactable native compacted to 90% Standard Proctor



Installation Method 4

		Native Soil Groups							
Installation Method	1		2		3		4		5
2500 STIS									
1	14		8		6		5		NR
2	9		5		4		3		NR
3	6		4		3		NR		NR
4	NR		NR		NR		NR		NR
		5	000 STIS						
1	16		10		8		6		2.5
2	10		6		5		4		1.5
3	8		5		4		3		NR
4	6		4		2		NR		NR
		10	0000 STIS	;					
1	18		12		11		9		4
2	15		9		7		6		2.5
3	12		8		6		5		2
4	10		7		5		4		1.5
		12	2500 STIS	;					
1	20		14		12		10		5
2	16		10		8		7		4
3	14		9		7		6		3
4	12		8		6		5		2

Table 4.7 - Standard Installation Maximum Burial Depth – Meters Without Traffic Load

	Native Soil Groups									
Installation Method	1	2	3	4	5					
2500 STIS										
1	14	8	6	5	NR					
2	9	4	3	2.5	NR					
3	6	4	2	NR	NR					
4	NR	NR	NR	NR	NR					
	5000 STIS									
1	16	10	8	6	2					
2	10	5	4	3	1.5					
3	8	4	3	2	NR					
4	6	3	2	NR	NR					
		10000 ST	IS							
1	18	12	11	9	4					
2	15	9	7	5	2					
3	12	8	6	4	1.5					
4	10	7	5	3	1					
		12500 ST	IS							
1	20	14	12	10	5					
2	16	10	8	7	3					
3	14	9	7	6	2					
4	12	8	6	4	1.5					

Table 4.8 - Standard Installation Maximum Burial Depth - Meters With Traffic Load (AASHTO H20)

4.2.5 Minimum Cover Depth

4.2.5.1 Traffic

Traffic effects decrease as cover depth increases thus minimum cover depths should be defined for different traffic loads based on standard installations as illustrated in Table 4.9. All backfill to grade must be compacted when traffic loads are to be present. Minimum cover restrictions may be reduced with special installations such as concrete encasement, concrete cover slabs, casings, etc...

	Wheel Load	Minimum Cover Depth
Load Type	KN	Meters
AASHTO H20 (C)	72	1.0
BS 153 HA (C)	90	1.5
ATV LKW 12 (C)	40	1.0
ATV SLW 30 (C)	50	1.0
ATV SLW 60 (C)	100	1.5

Table 4.9 Minimum Cover for Standard Installation and Wheel Loads

Note: The Burial Depth of Pipes with high pressures $PN \ge 16$ bars should be designed to prevent uplift. Kindly consult the owner Engineer or Tamdid Pipes[®].

4.2.5.2 High Water Table

A minimum of 0.8 diameter of earth cover (minimum dry soil bulk density of 1900kg/m3) is required to prevent an empty submerged pipe from floating. Alternatively, the installation may proceed by anchoring the pipes. If anchoring is proposed, restraining straps must be a flat material, minimum 25mm wide, placed at maximum 4.0 meter intervals. For more details, refer to "4.1.4 - flooded trench". Consult Tamdid Pipes® for details on anchoring and minimum cover depths with anchors.





4.2.5.3 - Negative Pressure

Allowable negative pressure is a function of pipe stiffness, burial depth, and type of installation. Table 4.10 provides maximum allowable negative pressures in bars provided no wheel load exists.

Installation Method	SN 2500	SN 5000	SN 10000	SN 12500
1	-1.00	-1.00	-1.00	-1.00
2	-0.25	-0.75	-1.00	-1.00
3	NR	-0.5	-1.00	-1.00
4	NR	-0.25	-1.00	-1.00

Table 4.10 Allowable Negative Pressure at minimum cover depth of 0.6 ND

4.2.6 Pipe Bedding

Pipe bedding material shall be in accordance to the requirements of the selected installation method. The bedding shall be placed after the trench bottom is compacted so as to provide proper support. Minimum compaction of the bed shall be a minimum of 90% Standard Proctor Density.

The finished bed shall be plane, having a minimum depth equal to DN/4 (maximum 150mm required) and must provide uniform and continuous support to the pipe. The bed must be over-excavated at each joint location to ensure that the pipe will have a continuous support and does not rest on the couplings. However, this area must be properly bedded and backfilled after the joint assembly is completed. See Figures 4.5 and 4.6 for proper and improper bedding support.

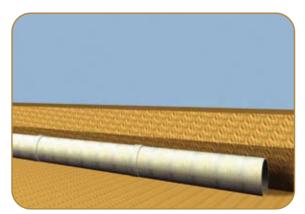


Figure 4.5 – Proper Bedding Support

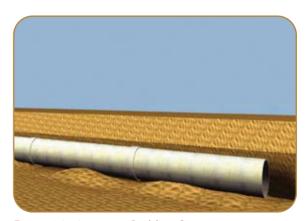


Figure 4.6 – Improper Bedding Support

4.2.7 Backfilling

It is desirable to perform immediate backfilling after joining of pipes in order to prevent from floating of GRP pipes and thermal movements.

Proper selection, placement and compaction of pipe zone backfill are important for controlling the vertical deflection and are critical for pipe performance. Attention must be paid so that the backfill material is not polluted with debris or other strange materials that could damage the pipe or cause loss of side support. During backfilling, the granular material should flow completely under the pipe to provide full support. A wooden board tool may be used to push and compact the backfill under the pipe, without raising the pipe up. (See Figures 4.7 and 4.8)

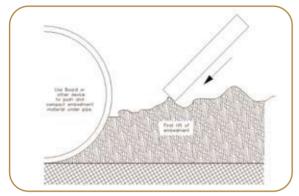


Figure 4.7 – Proper Haunching

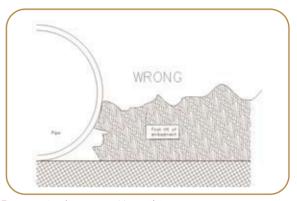


Figure 4.8 – Improper Haunching

Proper backfilling should be done in 150mm to 300mm lifts depending on backfill material and compaction method. When gravel or crushed stone is used as backfill material, 300mm lifts will be sufficient since gravel is relatively easy to compact. Sand needs more effort to compact and the lift height should be limited to 150mm. It is worth noting that it is important to achieve proper compaction of each lift to ensure that the pipe will have adequate support.

The compaction of sandy backfill is most easily accomplished when the material is at or near its optimum moisture content. When backfilling reaches pipe spring line, all compaction should be done first near the trench sides and proceed towards the pipe.

It is recommended that placing and compacting of the pipe zone backfill is done in such a way as to cause the pipe to ovalize a little in the vertical direction. When backfill reaches the pipe crown, the initial vertical ovalization should not exceed 1.5% of pipe diameter.

Table 4.11 shows the minimum cover height over the pipe necessary before certain compaction equipment may be used directly above the pipe. Care must be taken to avoid excessive compaction loads above the pipe crown which may cause bulges or flat areas. However, the material in this area must not be left loose and the desired specific density should be achieved.

In case of the maximum covering depth cannot be reached, and a high dynamic loads are applied (road crossing), the following options may be applied to protect the pipe:

- ☐ Make a concrete encasement around the pipe.
- ☐ Using a concrete or steel sleeve pipe. (see figure 4.9)
- ☐ Make a concrete protection slab over the loaded pipe section. (see figure 4.10)

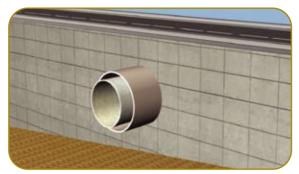


Figure 4.9 – RC or Steel Pipe Sleeve

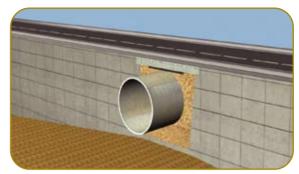


Figure 4.10 – Concrete Protection Slab

	Minimum Pipe Cover* (mm)		
Equipment Weight (Kg)	Tamped	Vibrated	
Less than 100	300	200	
100 to 200	400	250	
200 to 500	500	350	
500 to 1000	750	500	
1000 to 2000	1000	700	
2000 to 4000	1250	900	
4000 to 8000	1600	1200	
8000 to 12000	2000	1400	
12000 to 18000	2500	1800	

^{*} It may be necessary to begin with higher cover so that, as compact ion is achieved, the cover will not be less than the minimum.

Table 4.11 Minimum Cover for Compaction above Pipe



4.3 Other Types of Installations

4.3.1 Micro Tunneling Installations - Jacking Pipes

Micro Tunneling installations are utilized when the ground above or around the pipe cannot be disturbed. Crossings under highways, railways, airport runways, rivers, etc... are cases for using this installation method. This method also may be cost-effective for very deep sewer lines where the cost of opened trench excavations may become too much due to the ground conditions where extensive sheet pilings and dewatering might be required.

Two types of GRP pipes are suitable for this kind of application. Special GRP jacking pipe with flush GRP REKA couplings are available for direct jacking. Also, standard GRP pipes can be provided in short lengths to be encased in a concrete jacket. In this case, the outer concrete pipe takes the jacking load while the inner GRP pipe provides the corrosion resistance and the required joint tightness. When GRP pipes are "jacked", an 18 - 20 mm thick plywood or similar compressible material must be placed between the pipe and joint ends to avoid point loads during the jacking operations.

For Further information on GRP Jacking Pipes, please contact Tamdid Pipes®.

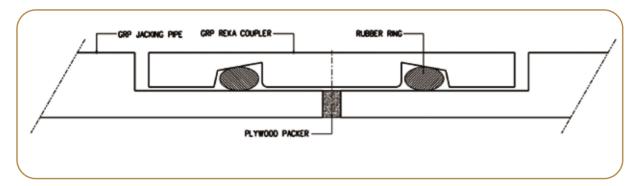


Figure 4.11 – Typical Jacking Pipe

4.3.2 Sub-Aqueous Installations

This installation method is used for the offshore portion of GRP pipes. The pipe joints are assembled under the water. Steel angle irons lugs will be provided on the two ends of pipe to permit divers to assemble the standard GRP double bell coupling joints under water. It may be possible to join on the barge up to 3 standard lengths of pipes and to lower the assembled segment (total length of 36 m) into the excavated sea bed trench. It is worth noting that GRP pipes are not designed to be assembled on-shore in long lengths and then dragged out to the sea.

Installing GRP pipes under water require a trench like the onshore trench, however; the trench width is larger. The typical underwater trench width is equal to 2 x Nominal Diameter, but in no case less than Nominal Diameter + 1 meter. The cover over the pipes shall be not less than 1 meter above the crown of pipe to the normal sea bed.

The divers should do Backfilling with excavated granular seabed material in maximum 300cm lifts where particular attention to the backfilling and compaction of the backfill under the pipe haunches should be made. Backfilling should be made evenly on both sides of the pipe to avoid pipe displacement. Protection shall be allowed for the backfilled seabed over the pipe trench. Large stones or rocks (rip-rap) may be used for this purpose.

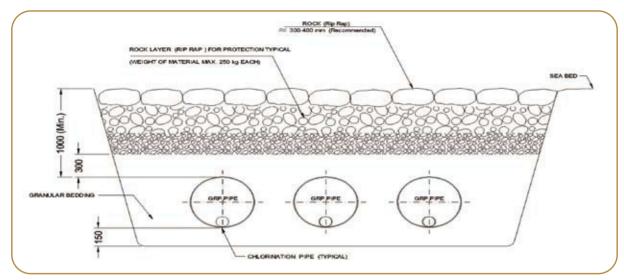


Figure 4.12 – Sub-Aqueous Installations

The following paragraph explains the typical details for sub-aqueous installation:

Pipes Preparation and Assembly Prior to Placing

All pipes' spigot ends and coupling will be thoroughly cleaned from dirt, grit grease or any other foreign materials. The rubber gaskets will be installed into the couplings and lubricated prior to fixing with Tamdid Pipes® recommended lubricant. One coupling will be fitted on each pipe on land with the aid or marine harness lugs and tie rods. Pipes will be loaded on the transportation barge at the jetty. Each two / three pipes will be assembled together forming 24m / 36m pipe.

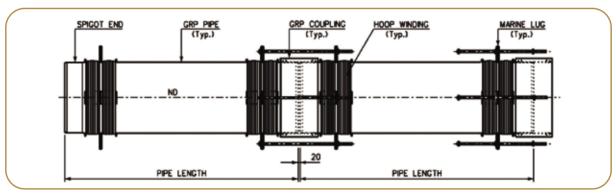


Figure 4.13 – Pipe Assemply (Before Placing)

Pipe Laying Sequence

After the pipes have been assembled, a pipe laying steel structure will be used to install the pipes. The pipe laying sequence can be summarized as follows:

- 01. Clean the rubber rings in coupling and apply lubricant.
- 02. Join the coupling to the pipe and secure them. Apply lubricant in spigot end and in free coupling.
- 03. Attach crane to the steel structure.
- 04. Adjust the steel structure on pipe and clamp around.
- 05. Lower the steel structure and align by buoys.
- 06. Final lowering of steel structure and make loose lifting slings.

- 07. Making of joint by divers.
- 08. Joint gab must be taken by the divers after complete fit and has to be within the allowable range.
- 09. Tie rods to be placed and tighten in marine lugs.
- 10. Place backfilling material using clamshell bucket or any other means.
- 11. Sufficient compacting and hunching of backfilling material to be done by using the lance water jet directed to the pipe inverts.
- 12. Reposition alignment buoy to new pipe end.
- 13. A suitable mean for survey check to be used to assure the pipe location (usually Differential Global Positioning System (DGPS) and Echo Sounding System) will be used.

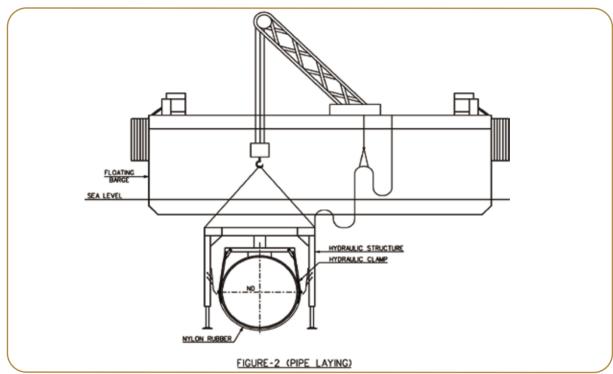


Figure 4.14 – Pipe Laying

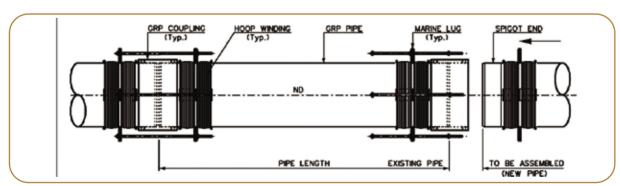


Figure 4.15 – Pipe Assembly (Under Water)

Placing of Backfilling Material

After three pipe lengths (3 X 24m), the cargo barge for backfilling material will be loaded with 30 mm aggregate. The pipes will initially be covered to a level of about 50% of the diameter. As per Tamdid Pipes® recommendations, pipes to be covered with aggregate material at least up to 30 mm above the pipe crown. The next phase will be to cover the pipes and fill the trench.

As soon as the trench filling process is completed, RIP RAP rock will be placed on top of it. Armor rocks will be placed using the floating crane.

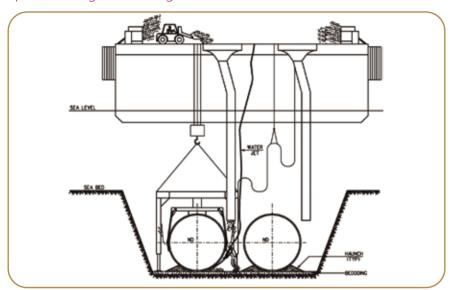


Figure 4.16 – Haunching By Water Jet

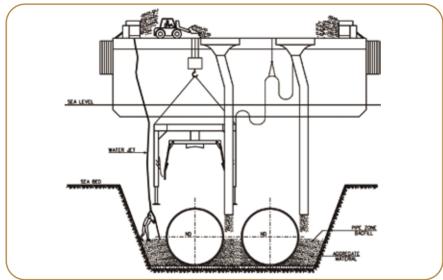


Figure 4.17 – Backfilling Process

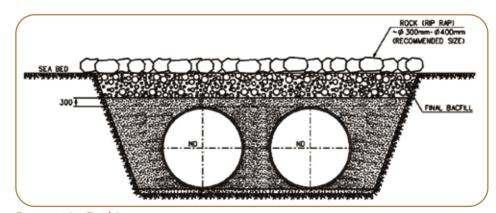


Figure 4.18 – Final Arrangement

4.4 Alternate Installations

Alternative installation procedures must be considered when the burial depth requirement for the selected pipe stiffness, installation method and native soil group are not within the limits of tables 4.4 & 4.5.

Available alternative installation methods are:

- Wider Trench
- ☐ Permanent Sheeting
- ☐ Stabilized Backfill (Cement)

4.4.1 Wider Trench

Increasing the trench width allows a deeper installation by distancing the poor native soil farther from the pipe. Tables 4.12 and 4.13 specify the maximum cover depth allowed with and without traffic loads respectively.

Trench Width		3 x ND					4 x ND		
Installation		Native Soil Groups							
Туре		3		4		5		4	5
2500 STIS									
1		8		6		NR		12	NR
2		5		4		NR		5	NR
3		4		3		NR		4	NR
4		2.5		2		NR		2.5	NR
5000 STIS									
1		10		8		4		14	6
2		6		5		2.5		6	3.5
3		5		4		2		5	3
4		3		2.5		1		2	1.5
1000 STIS									
1		16		12		6		18	10
2		9		8		4		10	6
3		7		5		3		6	4
4		3.5		3		1.5		3.5	2
12500 STIS									
1		18		14		7		20	12
2		10		9		6		12	8
3		8		6		3.5		7	4.5
4		4		3.5		1.75		4	2.25

Table 4.12 – Wider Trench - Maximum Burial Depth – Meters Without Traffic Load





Trench Width		3 x ND 4 x ND					
Installation		Native Soil Groups					
Type	3	4	5	4	5		
2500 STIS							
1	8	6	NR	12	NR		
2	4	3	NR	4	NR		
3	3.5	1.5	NR	3	NR		
4	2.5	NR	NR	1	NR		
	5000 STIS						
1	10	8	4	14	6		
2	6	5	2	6	3.5		
3	5	4	1	5	2		
4	3	2	NR	2	NR		
		1000	0 STIS				
1	16	12	6	18	10		
2	9	7	4	10	5		
3	7	5	2	6	3		
4	3.5	2.5	1	3	1.5		
12500 STIS							
1	18	14	7	20	12		
2	10	8	5	12	6		
3	8	6	2.5	7	3.5		
4	4	3	1.5	3.5	2		

Table 4.13 - Wider Trench - Maximum Burial Depth - Meters with Traffic Load

4.4.2 Permanent Sheeting

Permanent sheeting can be utilized to distribute the pipe's lateral loads appropriately. The sheeting should be at least 300mm higher than the pipe crown level and driven below the foundation level. The sheeting system is to be designed by a specialist and the material to be of quality to last the design lifetime of the pipe.

Note: The backfilling procedure and maximum cover depths are the same as for standard installations.

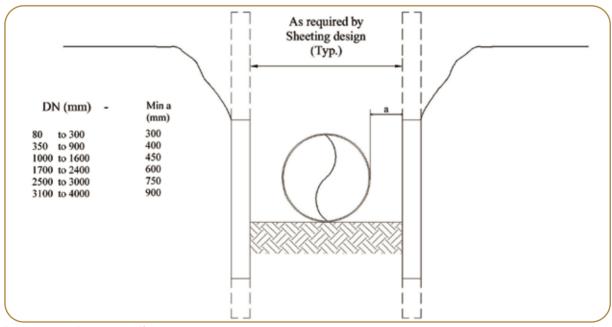


Figure 4.19 - Permanent Sheeting

4.4.3 Stabilized Backfill (Cement)

Cement stabilized sand is a mixture of one sack of cement (50 kg) and one ton of clean sand. This backfill material provides excellent support for GRP Pipes where native soil conditions are poor. The mixture should be placed in the foundation, bedding, haunches and pipe embedment zone in layers of 15 - 20 cm. Each layer should be wetted with clean water and compacted with plate vibrators before the cement sets.

The pipe must be surrounded in stabilized backfill where maximum pipe length is 6 meters and maximum initial cover of 1.5 meters. Please refer to figure 4.20.

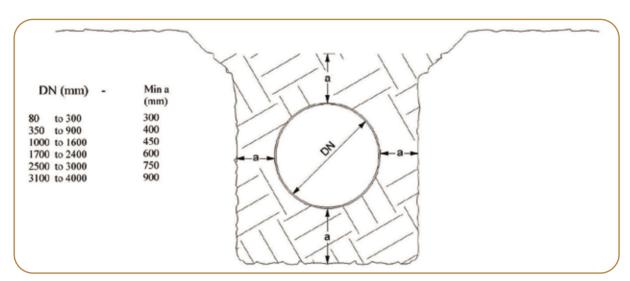


Figure 4.20 – Stabilized Backfill

Over excavation must be filled with compacted stabilized material and as trench boxes or temporary sheeting is pulled the stabilized backfill must be compacted against the native soil. Maximum total cover depth is 5 meters.



5. PIPE JOINING

Underground GRP Piping systems by Tamdid Pipes® are joined using GRP double bell couplings unless otherwise specified. Pipe and couplings may be supplied separately or with a coupling installed on one end.

Other joining systems such as flanges, mechanical couplings, and layup joints may also be used with GRP Pipes Systems by Tamdid Pipes®.

5.1 Joining of Double Bell Couplings

The following steps apply to all double bell coupling joining procedures.

Step 1: Clean Coupling

Thoroughly clean double bell coupling grooves and rubber gasket rings to make sure no dirt or oil is present.

Step 2: Install Gaskets



Figure 5.1 – Installing Gaskets

Insert the gasket into the groove leaving loops (typically two to four) of rubber extending out of the groove.

Do not use any lubricant in the groove or on the gasket at this stage of assembly. Water may be used to moisten the gasket and groove to ease positioning and insertion of the gasket.

With uniform pressure, push each loop of the rubber gasket into the gasket groove.

When installed, pull carefully on the gasket in the radial direction around the circumference to distribute compression of the gasket.

Check also that both sides of the gasket protrude equally above the top of the groove around the whole circumference.

Tapping with a rubber mallet will be helpful to accomplish the above.

Step 3: Lubricate Gaskets

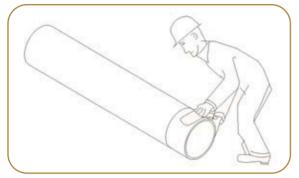
Next, using a clean cloth, apply a thin film of lubricant to the rubber gaskets.

Table 5.1 shows the recommended amount of lubricant required per joint.

ND (mm)	(kg)
< 100	0.05
125 - 350	0.10
400 - 800	0.15
900 - 1000	0.20
1100 - 1300	0.30
1400 - 1600	0.40
1700 - 1900	0.50
2000 - 2200	0.60
2200 - 2600	0.75
> 2600	1.00 - 1.50

Table 5.1 – Recommended Amount of Lubricate per Joint

Step 4: Clean and Lubricate Spigots



Thoroughly clean pipe spigots to remove any dirt, grit, grease, etc. Using a clean cloth, apply a thin film of lubricant to the spigots from the end of the pipe to the magenta positioning stripe.

Figure 5.2 – Spigot Cleaning & Lubrication

After lubricating, take care to keep the coupling and spigots clean. See Figure 5.2.

Use only the correct lubricant. Tamdid Pipes® provides sufficient lubricant with each delivery of couplings. If for some reason you run out, please contact Tamdid Pipes® for additional supply or advice on alternative lubricants. *Never use a petroleum based lubricant*.

Step 5: Fixing of Clamps

Clamp A is fixed anywhere on first pipe or left in position from previous joint. Fix Clamp B on the pipe to be connected in the correct position relative to the alignment stripe on the spigot-end so as also to act as a stopper (Figure 5.3).

Note: The mechanical installation clamp is to act both as a stop to position the coupling and as a device on which to attach the pulling (come-along jacks) equipment. Clamp contact with the pipe shall be padded or otherwise protected to prevent damage to the pipe and to have high friction resistance with the pipe surface. If clamps are not available, nylon slings or rope may be used as in Figure 5.4, but care must be taken in the alignment of the coupling.

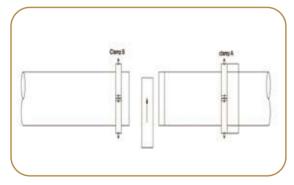


Figure 5.3 – Clamps Location

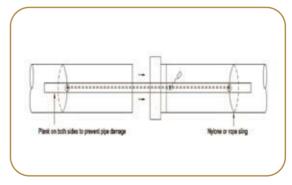


Figure 5.4 – Pipe Joining without Clamps

A pipe clamp has the advantage of acting as a stopper. However, if not available, insert the pipe spigots until the homeline (alignment stripe) aligns with the coupling edge.

Step 6: Pipe Placement

The pipe to be connected is placed on the bed with sufficient distance from previously joined pipe to allow lowering the coupling into position.

Step 7: Join Coupling

Come-along jacks are installed to connect the pipe clamps and two 10cm by 10 cm timbers or similar (larger diameters may require a bulkhead) are placed between the pipe previously connected and the coupling. While these are held in position the new pipe is entered into the coupling until it rests against the pipe clamp. Come-along jack might need protective plank under it in order not to touch against the pipe (Figure 5.5).

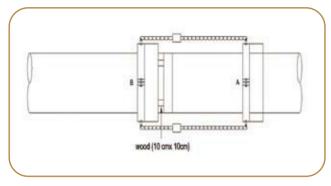


Figure 5.5 – Coupling Joining

Note: Approximate joining force 1 kg per mm of diameter.

Note: For smaller diameter (100mm - 250mm) it may be possible to join pipe and coupling without the use of come-along jacks. The use of levers is common to join small diameters.

Step 8: Join Pipes

Come-along jacks are loosened and the timbers removed before retightening the jacks for entering the coupling onto the previously connected pipe. Check for correct position of the edge of the coupling to the alignment stripe (Figure 5.6).

Note: When Step 8 has been completed, Clamp B is left in position while Clamp A is moved on to the next pipe to be joined.

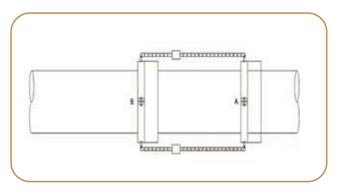


Figure 5.6 – Pipe Joining







5.2 Angular Deflection of Double Bell Couplings

Maximum angular deflection at each coupling joint must not exceed the values given in Table 5.2. The pipes should be joined in straight alignment and thereafter deflected angularly as required. See Figure 5.7 for details.

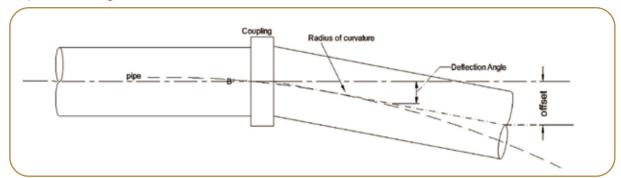


Figure 5.7 – Angular joint Deflection

ND	Maximum Angular Deflection	Nominal Offset(mm) Pipe Length		Nominal Radius of Curvature (m) Pipe Length			
(mm)	(deg)	3m	6m	12m	3m	6m	12m
ND < 500	3	157	314	628	57	115	229
500 <nd< 800<="" td=""><td>2</td><td>105</td><td>209</td><td>419</td><td>86</td><td>172</td><td>344</td></nd<>	2	105	209	419	86	172	344
900 <nd< 1800<="" td=""><td>1</td><td>52</td><td>105</td><td>209</td><td>172</td><td>344</td><td>688</td></nd<>	1	52	105	209	172	344	688
1900 <nd< 2600<="" td=""><td>0.5</td><td>26</td><td>52</td><td>104</td><td>344</td><td>688</td><td>1376</td></nd<>	0.5	26	52	104	344	688	1376
ND> 2600	Not Allowed*	For special cases, kindly contact Tamdid Pipes®			ipes®		

Table 5.2 – Maximum Angular Deflection at Double Bell Coupling Joints



5.3 Methods of insertion

5.3.1 Insertion by hand / using "crow bar"

Small diameter pipes (DN < 300) the joint can be made by hand or with a crow bar. Use timber block to protect the sleeve and force the joint into correct position (see figure 5.8).

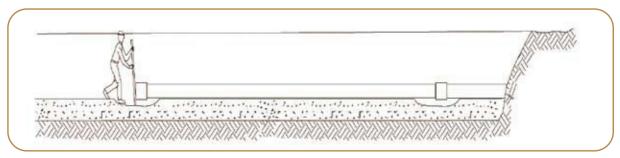


Figure 5.8 – Insertion by hand using crow bar

5.3.2 Insertion by hand / using "come along jacks"

Both for small and large diameter pipes, hand ratchet blocks / come along jacks of suitable size for the purpose, may be used for the insertion (See Pragraph 5.1).

5.3.3 Insertion using excavator or bulldozer bucket

Place in front of the end of the spigot a plug consisting of thick wooden boards crossed over each other and suitable for protecting the end of the pipe section from the bucket of the excavator, the bucket being then rested against the plug and being rotated so as to couple the joint.

Under no circumstances should the arm of the excavator be moved since this would cause too fast insertion of the coupling, not leaving the possibility to keep operations under control.

With pipes of medium diameter in shallow trenches which are wide enough for the purpose, the pipe sections can be inserted by making the excavator move alongside the trench with the pipe section slung at two points, care being taken to make the excavator bucket run as close as possible to the upper generating line of the pipe (see Figure 5.9) and thus to prevent the lifting of the pipe, which would cause misalignment of the joint.

Use nylon or canvas slings for such handling, never use chains or steel cables.

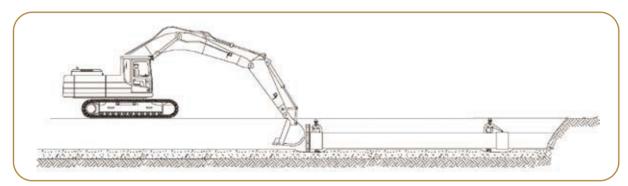


Figure 5.9 – Insertion Using Excavator

5.3.4 Pipe Laying to The Trench

Manual Laying

Pipe laying to the trench can be manually excuted by two men only. The reasonable wight is around 40 Kg for each man (figure 5.9a).

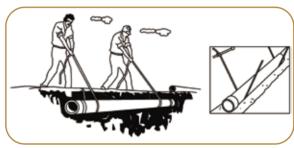


Figure 5.9a – Manual Laying of Pipes

Mechanical Laying

Usually mechanical laying of pipes by excavator is recommended as it makes the installation process very efficient (figure 5.9b)

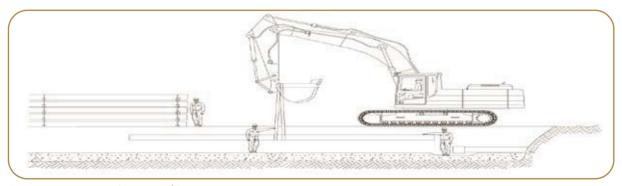


Figure 5.9a – Manual Laying of Pipes

5.4 Flanged joint

Tamdid Pipes® flanges are produced by hand lay-up technique. Project conditions often dictate mating a fiberglass flange with a pre-existing metallic flange on a pump, valve or metallic pipe. Flanges should be flat faced. Raised face flanges require an adapter to prevent over-stressing. Bolt holes and bolt circle pitches are available in all standard dimensions.

5.4. I Bolts installation

For proper installation of the flange bolts observe the following procedure:

- a) Prior to fit-up, lubricate bolts, nuts and washers using a non-fluid thread lubricant.
- b) Install bolts, nuts and washers and tighten the nuts by hand until they are snug.
- c) Following the nuts tightening sequence reported on the schemes (see figure 5.10), establish uniform pressure over the flange face until reaching the torque relevant to the proper diameter.
- d) Before starting with the hydrostatic test the torque of all bolts shall be verified following the sequence and using the dynamometric key.
- e) If during hydrotest leakage should occur an increase of bolt tightening is allowed. Maximum allowable torque value must not be more than 2.5 times the tabled value.

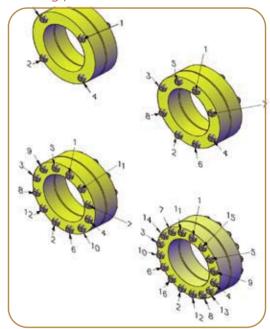


Figure 5.10 – Bolts Tightening Sequence

If the above mentioned procedures have been followed, no difficulty should be experienced. If any problems occur, try the following suggestion:

- a) Loosen and remove all bolts, nuts, washers and gaskets.
- b) Check for alignment of assembly. Rebuild to correct alignment if out alignment.
- ^{C)} Check the gasket for damage and, if necessary, replace damaged gasket.
- d) Check the surfaces on the raised-face flanges, valve flanges or lined pipe and fittings flanges as the case may be. Clean or repair as needed.
- e) Retrace the assembly procedure and sealing should be effected.

5.4.2 Torque table

Assumptions:

- bolt / nut friction =0.12
- flat gasket sealing: the outside diameter has to be less than the bolt circle diameter;
- bolt torque is based on 1.5xPN

Note: Washers must be interposed between nuts and GRP flange.

Caution: Excess torque can defeat sealing and, if carried high enough, can damage flanges.

Bolt Size (mm)	Torque Value Dry (kg.m)	Torque Value Lubricated (kg.m)
14 - 16	7	5.2
18 - 20	12	9
22	12.7	9.6
26	12.7	9.6
28	16	12.4
32	23	13

Table 5.3 – Bolts Torque for GRP Flange

FOR MORE DETAILS SEE APPENDIX IV

5.4.3 Flange gaskets

Flanges should be flat faced (recommended only for low pressure) or flat faced with a confined gasket.

Generally three types of gaskets can be used:

- \square Standard flat gasket with thickness 3mm (DN < 350mm) and 5mm (DN > 350mm). Gasket has the external diameter inside the bolts.
- ☐ Flat gasket with the bulb and steel ring incorporated
- O-Ring gasket inside the groove made on one flange What regards the flange gaskets material, please refer to the chapter for sleeve gasket material, because they should be made of the same type of material.

5.5 Mechanical Couplings

There are basically two kinds of mechanical couplers:

- ☐ Flexible Steel Couplings (Like Straub, Tee Kay, etc...): These couplingscan be used for joining as well as for repair. The coupling consists of a steel mantle with and interior rubber sealing sleeve. (Figure 5.11)
- ☐ Mechanical Steel Couplings (like Viking Johnson, Dresser, etc...): These couplings are typically used for joining to other types of pipe or to rigid items. (Figure 5.12)

Kindly consult the Mechanical Coupling Manufacturer or Tamdid Pipes® prior to using these kinds of couplers.



Figure 5.11 – Flexible Steel Coupling

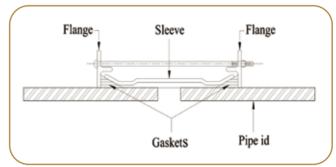


Figure 5.12 – Mechanical Steel Coupling

5.6 Butt & Strap joint / site laminations

This section describes the instructions for making site laminated joints. The joints obtained by lamination provide the same degree of corrosion resistance and strength as that of any other piping component (i.e.: the resulting system can be considered as monolithic – see figure 5.13).

Only workers that have successfully attended a training course for pipe installation can excute the lamination work.

Tamdid Pipes® qualified engineer / supervisor will control the performance of the different teams at work.

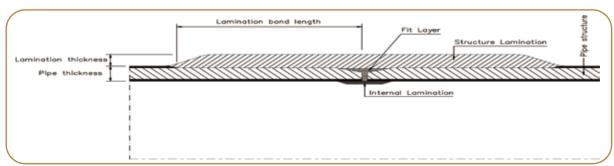


Figure 5.13 - Butt & Strap Joint Lamination

1.2 Connection to Raised Face Flanges:

DIA (mm)	Max . Torque (N.m) (All Pressure Classes)
25 - 80	25
100 - 150	50
200 - 250	75
300	100

Maximum Torque For Raised Face Flanges Using (C.A.F) Gasket

2. (C.A.F) Gasket with rubber O-Ring:

Range of use: From DN 350mm up to DN 800mm (PN 16) From DN 900mm up to DN 1200mm (PN10)

DIA (mm)	Max . Torque (N.m) (All Pressure Classes)
350 - 450	400
500 - 600	500
> 700	700

Maximum Torque For Flat Face Flanges Using (C.A.F) Gasket with Rubber O-Ring

3. Rubber Gasket with steel inner layer (Kroll & Ziller):

Range of use: From DN 25mm up to DN 300mm (PN 25) From DN 350mm up to DN 1200mm (PN10)

DIA (mm)	Max . Torque (N.m) (All Pressure Classes)
25 - 80	25
100 - 150	50
200 - 300	100
> 350	150

Maximum Torque For Flat Face Flanges Using (Kroll & Ziller) Gasket

4. Neoprene Rubber Gasket:

Supplied for Full Faced with a Shore A durometer of 60 ± 5 **Range of use:** From DN 25mm up to DN 350mm (PN 10)

DIA (mm)	Max . Torque (N.m) (All Pressure Classes)
25 - 80	55
100 - 150	55
200 - 250	100
300 - 350	125

Maximum Torque For Flat Face Flanges Using Neoprene Rubber Gasket

Appendix IV- FLANGE INSTALLATION INSTRUCTIONS

SCOPE:

This Appendix explains the details and the proper way for flanged connection installation of GRP and other flanges types.

TOOLS:

- ☐ Ring Spanner.
- Torque Wrench.

Usually the GRP flange thickness is more than steel one. Contact Tamdid Pipes® to advice for flange thickness in order to calculate the required bolts length.

Connecting of GRP Flanges with Raised Face Flanges:

GRP flanges are Flat Face and it should be connected with a Flat Face flanges. In case of using Raised Face flanges, the gap between flat and raised faces to be filled with either steel washer or flat gasket –Asbestos (C.A.F).

Torque Values:

Different types of gaskets may be used for flanged connection sealing depending on Diameter, Pressure and client requirements. Torque value for tightening the flanges varies from gasket type to another as follows *(see Important not for maximum torque value)*:

1. (C.A.F) Gasket:

Range of use: From DN 25mm up to DN 300mm (Up to PN 25).

1.1 Connection to Flat Face Flanges:

DIA (mm)	Max . Torque (N.m) DIN 2501 PN 10	Max . Torque (N.m) DIN 2501 PN 16 ASA 250	Max . Torque (N.m) DIN 2501 PN 25 ASA 300
25	70	70	100
40	100	100	150
50	100	100	150
80	100	100	150
100	100	100	250
150	150	150	250
200	150	150	300
250	150	300	500
300	150	300	500

Maximum Torque For Flat Face Flanges Using (C.A.F) Gasket

Simple Field Test for Determining Soil Group*

Soil Group	Measurable Characteristic
1	Can barely penetrate to readily penetrate with thumbnail
2	Can barely penetrate with thumb
3	Can penetrate to 50mm with thumb with significant effort
4	Can easily penetrate 50mm with thumb
5	Can penetrate with moderate effort 50mm with fist

^{*} Peck, Hanson and Thornburn, Foundation Engineering, 2nd ed., John Wiley and Stones, Inc., 1974.

Appendix III - SOLI CHARACTERISTICS

Cohesive Soils**

Concaive Sons			
Cohesive Soils**	Blows* Per	qu****	Identification
Consistency	Foot (N)	(kN/m2)	Characteristics
Very soft	0 - 3	0 to 25	Sample tends to lose shape under own weight
Soft	3 - 5	26 to 50	Molded with slight finger pressure
Medium	6 - 15	51 to 150	Molded with moderate finger pressure
Stiff	6 - 30	151 to 300	Molded with substantial finger pressure
Very stiff	> 30	301 to 500	Not molded by finger pressure; requires picking to remove
Hard	> 30	> 500	Difficult to remove by picking

Granular Soils***	Blows* Per	Relative	Moist Unit Weight
Compactness	Foot (N)	Density	(kN/m3)
Very loose	0 - 3	0 to 15%	11 - 16
Loose	3 - 5	16 to 40%	14 - 18
Medium	6 - 15	41 to 65%	17 - 20
Dense	6 - 30	66 to 85%	18 - 22
Very dense	> 30	>85%	20 - 23

^{*} Blows as measured with 2 in. O.D. 18/3- in. I.D. sampler driven 1 ft. by 140 lb. hammer falling 30 in. See Standard Method for Penetration Test and Split Barrel Sampling of Soils (SPT). ASTM Designation D1586.

^{**} Soils containing a large portion of fine particles (clay and colloidal size). Shear strength is largely or entirely derived from cohesion (natural attraction of particles). Includes clays, silly clays and clays mixed with sand or gravel.

^{***} Soils not exhibiting a natural particle attraction. Shear strength is most related to compactness (density) of the confined grains. Includes sand, gravel, cobbles, stones, etc.

^{****} Unconfined compressive strength.

Appendix II - CLASSIFICATION OF NATIVE SOILS

Native soils are classified into five main groups, ranging from very stable, dense granular soils and relatively hard cohesive soils to relatively poor organic and fine grained soils. The soil groups are a function of both soil types (classification) and soil density, which together determines the modulus of the soil and its ability to support the pipe and backfill material. Relative quantification of densities may be determined from blow counts measurements as given in Table CT. The blow counts must represent the most severe (weakest) conditions expected to exist for any significant period of time. (Normally this condition occurs when the water table is at its highest elevation.)

Group 1 - Very Stable Soils

1A Very dense (per Table CT) gravels or sands, according to ASTM1 GW, GP, SW and SP containing less than 5% fines (or ATV Type 1).

1B Hard or very stiff cohesive soils per Table CT.

Group 2 - Stable Soils

2A Dense consistency (per Table CT) slightly silty or clayey gravels or sands, according to ASTM1 GM, GC, SM and SC containing less than 15% fines (or ATV Type 2).

2B Stiff cohesive soils per Table CT.

Group 3 - Soil Mixtures

Typically medium consistency cohesive and/or loose granular soils, (per Table CT), according to ASTM1 ML or CL with liquid limit less than 50 and GM, GC, SM and SC (or ATV Type 3).

Group 4 - Cohesive Soils

Soft and loose consistency soils (per Table CT), according to ASTM1 MH, CH, OL and OH (or ATV Type 4).

Group 5 - Very Poor Soils

Very soft and very loose consistency soils (per Table CT), according to ASTM1 MH, CH, OL and OH. These soils are off the ATV scale for soil quality.

1 ASTM 2487 "Standard Test Method for Classification of Soils for Engineering Purposes"

Use of Filter Fabric (Geo Textile) Membrane

The filter fabric could be used / recommended for the belowmentioned type of unstable soils:

- Blows as measured with 2 in. 0.0. 18/3- in. 1.0. sampler driven 1 ft. by 140 lb. hammer falling 30 in. See Standard Method for Penetration Test and Split Barrel Sampling of Soils (SPT). ASTM Designation 01586.
- Soils containing a large portion of fine particles (clay and colloidal size). Shear strength is already or entirely derived from cohesion (natural attraction of particles). Includes clays, silty clays and clays mixed with sand or gravel.
- □ Soils not exhibiting a natural particle attraction. Shear strength is mostly related to compactness (density) of the confined grains. Includes sand, gravel, cobbles, stones, etc.

Appendix I - APPROXIMATE WEIGHTS FOR PIPES AND COUPLINGS

Nominal	Pipe Weight (kg/M)				Weight Per
Diameter (mm)	SN2500	SN5000	SN10000	SN12500	Coupling (kg)
100	-	2.0	2.5	3	2
150	-	5	5	6	3
200	-	7.5	7.5	8	4
250	-	11	11	12	6
300	10	13	15	16	10
350	13	16	18	19	12
400	15	19	22	29	13
500	23	29	33	35	17
600	32	41	46	48	21
700	42	54	62	65	26
800	53	70	80	85	31
900	67	88	101	105	36
1000	82	108	123	130	42
1200	117	153	176	185	54
1400	158	207	238	250	68
1600	204	268	309	350	69
1800	256	337	389	420	66
2000	316	410	420	500	75

For larger pipe diameters, please consult Tamdid Pipes®



8.5 Pipe Line Commissioning

8.5. I Cleaning of Tamdid pipes® sewer pipe

There are several methods used to clean gravity sewer lines, depending on diameter and the degree and the nature of blockage. All of these methods use either mechanical or hydropneumatic force to clean the interior of the pipe. When mechanical means employed, we recommend the use of plastic scrappers to avoid damage to the pipe surface.

The use of high pressure water, emitted through jet nozzles, is a practice followed in some countries for cleaning sewer pipes. However, water emitted under high pressure through a jet nozzle can cause damage to most materials if not properly controlled. Based on experience gained with water jet cleaning of GRP sewer pipes, the following guidelines must be adhered to in order to avoid damage to the installed pipes:

- ☐ Maximum input pressure at the jetting nozzle must be limited to 120 bars (1750 psig). Due to the smooth interior surface of GRP pipe, adequate cleaning and removal of blockages can normally be achieved below this pressure.
- ☐ Jetting/swabbing sleds with several runners are to be used to elevate the jet nozzle off the pipe;s invert .
- ☐ The water discharge angle at the outlet nozzle must be between 6° to 15° relative to the pipe axis.
- ☐ The number of jet hole in the nozzle head should be 8 or more, and the bore hole size must be greater than 2.0mm (0.08 inch)

Please contact Tamdid pipes® for the names of water jet nozzle and sled manufacturers whose equipment meets the above criteria if uncertain. The use of equipment or pressures that do not meet the above criteria could cause damage to the installed pipe.

8.5.2 Flushing & Disinfecting for Potable Waterlines

After completing the hydraulic test, the line must be thoroughly flushed out and disinfected, as specified by the engineer or local regulations. The following guidelines may be followed:

- ☐ Disinfecting potable water lines is normally performed using either of the following chemical mediums:
- ◆ Liquid Chlorine.
- Sodium Hypochlorite solution.
- Calcium Hypochlorite granules or tablets.
- This application gives a solution containing at least 20 to 25 mg/l of free chlorine initially. The disinfecting period is normally 24 hours after which the residual chlorine should not be less than 10mg/l. After the 24 hours disinfecting period, the line is flushed and filled with potable water.
- When commissioning a pipeline, first ensure that all air valves are fully opened to release entrapped air. Fill the line very slowly and evenly at velocities not exceeding 0.3 m/s. Do not open valves quickly and fully during filling. After releasing all air, close air valves and hydrants and open inlet valve fully. If the line is coupled to a pump, the inlet valve should be closed when the pump starts running. Later on, the inlet valve shall be opened slowly. The discharge valve should be closed slowly before shutting down the pump.

8.4.2 Field Air Test

An alternate leak test for gravity pipe systems may be conducted with air pressure instead of water. In addition to regular care, standard precautions, and typical procedures used in this work, the following suggestions and criteria should be noted:

- 1. As with the hydrotest, the line should be tested in small segments, usually the pipe contained between adjacent manholes.
- 2. Assure the pipeline and all laterals, stubs, accesses, drops, etc... are effectively capped or plugged and braced against the internal pressure.
- 3. Slowly pressurize the system to 24kPa. The pressure must be regulated to prevent over pressurization (maximum 35kPa).
- 4. Allow the air temperature to stabilize for several minutes while maintaining the pressure at 24kPa.
- 5. During this stabilization period, it is advisable to check all plugged and capped outlets with a soap solution to detect leakage. If leakage is found at any connection, release the system pressure, seal the leaky cap(s) or plug(s) and begin the procedure again at Step 3.
- 6. After the stabilization period, adjust the air pressure to 24kPa and shut-off or disconnect the air supply.
- 7. The pipe system passes this test if the pressure drop is 3.5kPa or less during the time periods given in Table 8.2.
- 8. Should the section of line under test fail the air test acceptance requirements, the pneumatic plugs can be coupled fairly close together and moved up or down the line, repeating the air test at each location, until the leak is found. This leak location method is very accurate, pinpointing the location of the leak to within one or two meters. Accordingly, the area that must be excavated to make repairs is minimized, resulting in lower repair costs and considerable saved time.

Caution: Considerable potential energy is stored in a pipeline under pressure. This is particularly true when air (even at low pressures) is the test medium. Take great care to be sure the pipeline is adequately restrained at changes in line direction and follow manufacturers' safety precautions for devices such as pneumatic plugs.

Tamdid Pipes[®] does not recommend using pressure air test for Pressure Pipes.

Notes:

- 1. This test will determine the rate at which air under pressure escapes from an isolated section of the pipeline. It is suited to determine the presence or absence of pipe damage and/or improperly assembled joints.
- 2. This test is not intended to indicate water leakage limits. If the pipeline fails this air test, it should not be rejected until a hydrotest is conducted.

ND (mm)	Time (minutes)	ND (mm)	Time (minutes)
80	2.5	1000	25
100	2.5	1100	27.5
150	3.75	1200	30
200	5	1300	32.5
250	6.25	1400	35
300	7.75	1500	37.5
350	8.75	1600	40
400	10	1800	45
450	11.25	2000	50
500	12.5	2200	55
600	15	2400	60
700	17.5	2600	60
800	20	2800	60
900	22.5	3000 up to 4000	60

Table 8.2 – Test Time for Low Pressure Air Test

8.3 Field Joint Tester

Portable hydraulic field joint test equipment can be supplied for diameters 700mm and above.

This equipment can be used to internally test pipe joints prior to or after backfilling. Additional details are available from Tamdid Pipes® Field Service Representative. (Figure 8.4)

Caution:

This equipment is designed to allow a test of the joint to verify that the joint has been assembled properly with gaskets in proper position. This equipment may be limited to a maximum pressure test level. Kindly consult the joint tester supplier or Tamdid Pipes®.

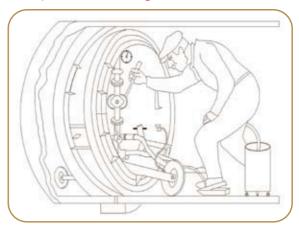


Figure 8.4 – Field Joint Tester

8.4 Pressure Testing for Gravity Lines

Two methods are available for testing gravity lines, a low head water test or a low pressure air test.

8.4.1 Low Head Water Test (Leak Test)

The contractor should plug both ends of the pipeline section (between two manholes) with suitable plugs. The test section should not exceed 200 meters. The plugs should have connections for a standpipe connected to the pipe plug with a 90° elbow. At the upstream manhole, the standpipe shall extend 1.2m above the crown of the gravity pipe, or 1.2m above the existing ground water level. This level is called the test level. The test section shall be filled slowly from the upstream manhole while releasing the air out. Allow the water to stand for about 1 hour for stabelization, then add water until the test level is again reached in the stand pipe at the upstream manhole. Start the test, and over the next 30 minutes, the amount of water necessary to maintain a constant test level water head shall be measured using graduated containers of water. The line shall pass the test if the ex-filtration amount does not exceed 15 Liters per 24 hours per mm of pipe line diameter per kilometer of pipe. A typical test setup is shown if figure 8.5

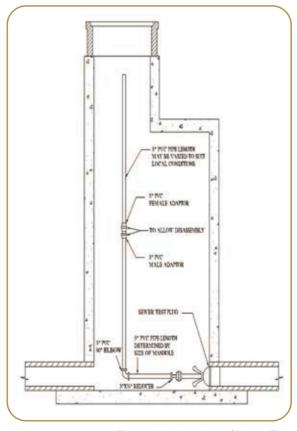


Figure 8.5 – Low Head Water Test

3. Pressurizing

- After the stablization period, the pressure shall be raised gradually untill the intended test pressure at the lowest pont is reached.
- □ Unless otherwise specified by the engineer, the test pressure shall be equal to 1.5 times the intended working pressure of the pipeline section. Once the required test pressure is reached, the pressure shuld be maintained for a holding period.
- During the pressure test, all joints should be exposed for visual inspection (where possible), and all visual leaks should be repaired. In case the test is not satisfactory, the locations of the leaks shall be determined and rectified, and the line to be re-testd in the same manner as specified above.
- ☐ Block all openings and increase the pressure until it reaches the operating value.
- ☐ The increase in pressure will be not more than 0,1 bar/s.
- ☐ Maintain the working pressure for not less than 2 hours in order to allow the complete stabilisation of the pipeline against the trench backfilling.
- ☐ If after a brief period for stabilization the line does not hold constant pressure, insure that thermal effect (a temperature change), pipe expansion* or entrapped air is not the cause. If the pipe is determined to be leaking and the location is not readily apparent, the following methods may aid discovery of the problem source:
 - Check flange and valve areas.
 - Check line tap locations.
 - Use sonic detection equipment.
 - Test the line in smaller segments to isolate the leak.

4. Acceptance criteria

The hydrostatic test will be considered as successful in case one of the following conditions will be effective:

- ☐ The testing pressure remained stable.
- ☐ The variation in testing pressure (start / end of test) is consequential to variations of the temperature.
- ☐ A combination of the above mentioned conditions.

The acceptable loss shoul be clearly specified and the test should be repeated until this achieved. The generally accepted loss for GRP is 0.02 L/mm of nominal diameter per kilometers of pipeline per 24 h per bar of applied pressure head.

The loss during the pressure test can be calculated by the following equation:

The Loss =
$$\frac{2 \text{ X dia (mm) X length (Km) X pressure (Kg/cm²) X time (hr)}}{24 \text{ X } 100}$$

Notes:

- Most projects will specify a maximum pressure loss or volume of water lost. These may vary by from project to another. Consult Tamdid Pipes® for more specific guidance or recommendations.
- The Contractor should note that while pressure testing large diameter GRP pipe on site at pressures generally above 10 bars, there is a possibility of a slight rotation/pivoting of the GRP coupling. This is the result of uneven pressure against the various parts of the coupling, and is inevitable during normal joint assembly where a perfectly centered and aligned joint can never be achieved. In the unlikely event that one or more joints start to rotate or to shift slightly during the pressure test, it is advisable to reduce the pressure, and to backfill the joints completely using selected, properly compacted backfill, prior to resumption of the pressure test. Any joint that has shifted significantly should be centered again before resuming the pressure test.
- Test pressure of pipelines are related to the intended working pressure (Pw) in the pipes and not to the rated pressure class of the pipes (PN)
- * Glass Reinforced Polyester Pipes will expand under pressure. Hence additional water will be required to make up for this expansion.

8.2 Field Testing

8.2.1 Line Hydrostatic Testing

Some job specifications require the completed pipe installation to be hydrostatically tested prior to acceptance and service. This is good practice as it can allow early detection and correction of some installation flaws, damaged products, etc. If a field hydrotest is specified, it must be done regularly as installation proceeds. Installation should never exceed testing by more than approximately 1 km. In addition to routine care, normal precautions and typical procedures used in this work, the following suggestions should be noted:

1. Preparations

	and provide the second
	Prior to the hydrostatic test, several points must be checked in order to avoid failures:
	While the contractor tends to test long sections to increase his efficiency, the lenght of the test sections should be short enough to allow an easy detection of any possible leak. It is also difficult to fill a very long line without the risk of air entrapment.
	The backfilling must have been carried out properly and reached a level that would restrain the pipes to avoid movements during testing. The joints may be left exposed for visual inspection. The thrust blocks, which are part of the pressure test section, should be of permanent constructions and concrete should be poured at least 7days before testing.
	Check whether all testing apparatus are available and operational.
	The opened ends of a line must be sealed temporarily with GRP or steel/Cast iron end-caps. Tamdid Pipes® can provide a GRP testing end-caps upon request. All end-caps should have an inlet for water filling and an outler for venting. Check for damages caused by handling or installation prior to start the final test.
	Make proper feasible check the internal surface for any cracks, delaminations, joint pullout or misallignement which could be the result of wrong backfilling.
	Verify that the ovality of the buried pipes does not exceed 5% of the pipe ID.
	Double check the bolt torque of each flange and make sure it is within the specified range.
	Make sure the drain positioned at the lowermost level of each section of pipeline is accessible. So do for the vent which must be positioned at highest level of the same section.
	The vent must be open to the atmosphere during filling.
2.	Water Filling
	Connect the pump and check that all the air vents are opened.
	Fill the pipeline slowly, possibly from the bottom in order to facilitate the venting.
	When water starts to flow from the vent stop the filling, wait for 10 minutes, then pump again slowly until a clean flow of water flushes from the vent.

☐ Inspect the system for potential leakage; in case of any visible leakage empty the pipeline,

repair the source of leakage and repeat the filling up operation.

8.1.2 Correcting Over-Deflected Pipe

Pipes installed with initial diametrical deflections exceeding the values in Table 4.3 must be corrected to insure the long-term performance of the pipe.

Procedure:

For pipe deflected up to 8% of diameter:

- 1. Excavate to a level equal to approximately 85% of the pipe diameter. Excavation just above and at the sides of the pipe should be done utilizing hand tools to avoid impacting the pipe with heavy equipment (Figure 8.3).
- 2. Inspect the pipe for damage. Damaged pipe should be repaired or replaced.
- 3. Re-compact haunch backfill, insuring it is not contaminated with the native soil.
- 4. Re-backfill the pipe zone in lifts with the appropriate material, compacting each layer to limit the pipe deflection.
- 5. Backfill to grade and check the pipe deflections to verify they have not exceeded the values in Table 4.3.

Pipes with over 8% deflection should be replaced completely.

Caution: Do not attempt to jack or wedge the installed over deflected pipe into a round condition. This may cause damage to the pipe.

If excavating multiple pipes care must be taken to not mound the cover from one pipe over the adjacent. The extra cover and reduction of side support could magnify an over deflection situation.

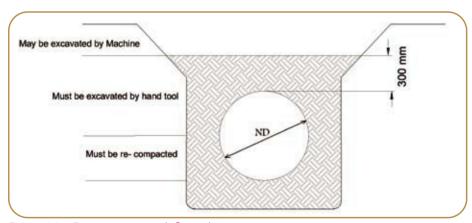


Figure 8.3 – Excavating over-deflected pipe



Deflection (% of Pipe Diameter) in a native soil of group							
Native Soil Group	1	2		3	4	5	
Large Diameter Pipes, DN > 250 - Water & Sewer							
Initial Deflection	4	3.5		3	2.5	2	
Long Term Deflection	5	5		5	5	5	
Small Diameter Pipes, DN < 300 - Water							
Initial Deflection	3	3		2.5	2	2	
Long Term Deflection	5	5		5	5	5	
Small Diameter Pipes, DN < 300 - Sewer							
Initial Deflection	2.5	2.5		2	1.5	1.5	
Long Term Deflection	4	4		4	4	4	

Table 8.1 – Maximum Allowable Deflection

Preliminary Deflection

This measurement should be taken when backfill reaches 30 cm above pipe crown. At this stage the measured deflection should be slightly negative, but not exceeding -2%. A negative deflection means the pipe vertical ID has increased becaus of the compaction forces / stresses coming from the side backfill.

A positive deflection at this stage indicates inadequate compaction in the Pipe Embedent Zone, hence improvement in the quality of installation and compaction s required. In such case, it is advisable to remove the bckfill to about 1 / 3 of the pipe ID from the pipe invert and to recompact the backfll in stages up to the top of the pipe zone, with special care to the compaction of the pipe hanches backfill area. After this rectification, the preliminary defletion shuld be measred again.

Intial defleciton

This measurement should be done immediately after backfilling reaches the final grade and after all temporary sheeting has been removed and all dewatering systems have been turned off for two days. The initial deflection limits are set to account for creep and soil consolidation with time (determined by deflection lag factor).

Final Deflection

This measurement should be done at least 6 months after the initial test is done. The maximum deflection at this stage shold not exceed the limits specified in table 8.1

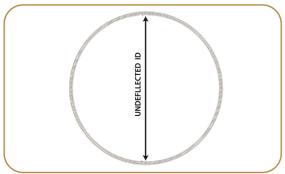


Figure 8.1 – Circular Cross Section of Pipe

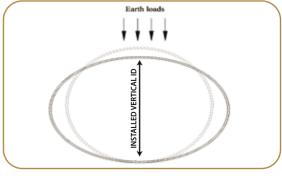


Figure 8.2 – Pipe Deflection Under Vertical Loads

8. POST-INSTALLATION

8.1 Checking Installed Pipe Deflection

Prior to handing over, contractor must perform certain checks to insure pipeline is properly installed. Maximum installed initial diametrical deflection must not exceed the values in Table 4.3. While long term deflections must not exceed 5%. Bulges, flat areas or other abrupt changes of pipe wall curvature are not permitted. Pipes installed outside of these limitations may not perform as intended.

Checking to insure that the initial requirements have been met is easy to do and should be done for each pipe immediately after completion of installation (typically within 24 hours after reaching maximum cover).

The expected initial pipe deflection is around 2% for most installations at the maximum cover given in Table 4.6 and is proportionally less at shallower depths. Therefore, while initial deflections in Table 4.3 are acceptable for the pipe performance, a value exceeding the expected amount indicates the installation intended has not been achieved and should be improved for upcoming pipes (i.e., increased pipe zone backfill compaction, coarser grained pipe zone backfill materials or wider trench, etc.).

Deflection checks should be done when the first installed pipes are backfilled to grade and continue periodically throughout the entire project. Never let pipe laying get too far ahead before verifying the installation quality. This will permit early detection and correction of inadequate installation methods.

Pipes installed with initial deflections exceeding the values in Table 4.3 must be reinstalled so the initial deflection is less than those values. See paragraph 8.1.2.

Procedure for checking the initial diametrical deflection for installed pipes:

- 1. Complete backfilling to grade.
- 2. Complete removal of temporary sheeting (if used).
- 3. Turn off the dewatering system (if used).
- 4. Measure and record the pipe's vertical diameter.

Measuring the pipe vertical deflection can be done either by manual or by using a DEFLECTOMETER or similar device.

- Manual method: for large pipe sizes (800 mm and above), measurement can be done manually by measuring the vertical diameter or the pipe by the technician by manual micrometer at 4m intervals and calculate the deflection accordingly. In case of smaller pipe sizes, a rope may be inserted during pipe laying attached with a wooden disc with an outside diameter equal to the maximum acceptable pipe ID. This disc will be pulled through the pipes. If it passes freely, it means the pipe deflection is within the allowable range.
- ☐ **Measuring by DEFLECTOMETER:** or similar by mounting the device inside the pipe while the device will measure the vertical pipe ID. Usually these devices are computerized (date can be processed through computer).

Note: for small diameter pipes, a deflectometer or similar device may be pulled through the pipes to measure the vertical diameter.

Construction Guidelines

- ☐ When the design of the concrete structure is considered, it should be noted that any excessive settlement of the structure relative to the pipe can be the cause of a pipe failure.
- ☐ The pipeline layout shall be such that the first pipe section near the rigid connection is a short length as follows: (See Figures 6.8 and 6.9)

Minimum: smallest of 1 meter or 1 diameter.

Maximum: smallest of 2 meters or 2 diameters.

For small diameter pipe (DN<=250mm) the length of the short piece is 300mm to 500mm.

Kindly consult Tamdid Pipes® for short pieces of Diameters ≥ 3000 mm.

Extra care and caution must be taken to replace and properly compact backfill adjacent to the concrete structure. Construction of the concrete structure will frequently require over excavation for formwork, etc... This extra excavated material must be restored to a density level compatible with surroundings or excess deformation or joint rotation adjacent to the structure may occur. Use of stabilized backfill (cement) adjacent to large concrete structures has been found to be very effective in preventing excess joint deformation in large diameters (DN>1600mm)

Rubber Wrap Placement

- 1. Position as shown in Figure. 6.8 & 6.9.
- 2. Tape all seams and edges to assure no cement can get between the rubber and the pipe or between the rubber wrap pipes edges.

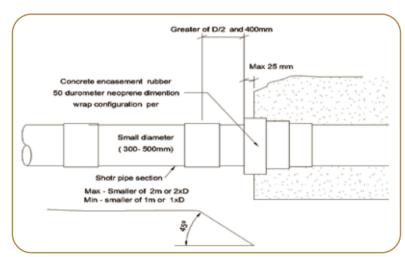


Caution:

- ☐ When casting a coupling in concrete be sure to maintain its roundness so later joint assembly may be accomplished easily. Alternatively, makeup the joint outside the encasement prior to pouring the concrete.
- ☐ Since the coupling cast in concrete is rigid, it is important to minimize the vertical deflection and deformation of the adjacent pipe.

Option B:

In case Option A is not possible, wrap rubber bands around the pipe prior to placement of any concrete such that the rubber slightly protrudes (25mm) from the concrete. Layout the pipeline so the first completely exposed coupling joint is located as shown in Figure 6.7 while the rubber wrap configuration is given in Table 6.2 and Figures 6.8 and 6.9.



All Pressure Classes (PN)
All SN

80 - 500 A

600 - 1000 B

1100 - 1400 C

1500 - 2400 D

2500 - 4000 E

Table 6.2 - Quantity and configuration of rubber wraps

Figure 6.7 – Option B

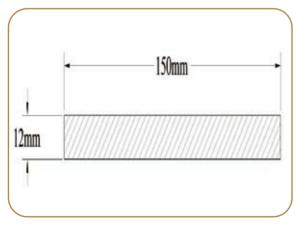


Figure 6.8 – Single wrap dimensions (cross-section)

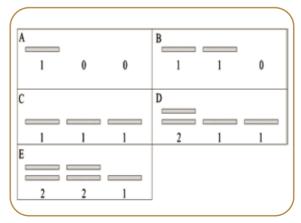


Figure 6.9 – Wrap Configurations

6.2.3 Concrete Pouring

The concrete surround must be placed in stages allowing adequate time between layers for the cement to set (no longer exert buoyant forces). Maximum lift height is variable with nominal pipe stiffness as shown in table 6.1:

STIFFNESS CLASS (SN)	MAXIMUM LIFT HEIGHT (MM)		
SN 2500	larger of 300mm or 14/ pipe diameter		
SN 5000	larger of 450mm or 13/ pipe diameter		
SN 10000	larger of 600mm or 12/ pipe diameter		
SN 12500	larger of 800mm or 34/ pipe diameter		

Table 6.1 – Maximum Lift Height

6.3 Rigid Connections

Excessive bending stresses may develop in a pipe passing through or connected to a rigid structure in case of differential settlement between the pipe and the rigid connection. Rigid connections could be pipes passing through walls, encased in concrete, connection to a manhole, thrust blocks, or flanged to a pump, valve, or other structures.

The contractor must minimize the development of high discontinuity stresses in the pipe by applying one of the two following options:

Option A:

A coupling joint is casted in the concrete at the interface followed by a short pipe known as "rocker pipe" as shown in Figure 6.6. In case differential settlement occurs, it can be absorbed by the angular deflection in the rocker pipe without inducing excessive bending stresses.

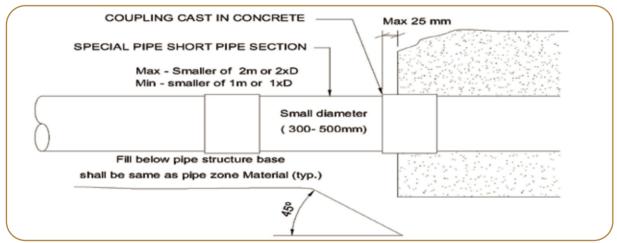


Figure 6.6 - Option A

6.2 Concrete Encasement

When pipes must be encased in concrete, such as for thrust blocks, stress blocks, or to carry unusual loads, specific additions to the installation procedures must be noted as follows:

6.2.1 Pipe Anchoring

During the pouring of the concrete, the empty pipe will experience large uplift forces. The pipe must be restrained against movement that could be caused by these loads. This is normally done by strapping over the pipe to a base slab or other anchor(s). Straps should be of flat material of minimum 25mm width, strong enough to withstand uplift forces, spaced not to exceed 4 meters, with a minimum of one strap per section length as shown in Figure 6.4. The straps should be tightened to prevent pipe uplift, but not so tight that additional pipe deflection is caused.

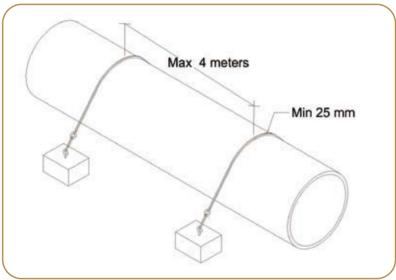


Figure 6.4 – Pipe Anchoring

6.2.2 Pipe Support

The pipe should be supported in a way that the concrete can easily flow completely around and fully below the pipe. Also, the supports should result in an acceptable pipe shape (less than 3% deflection and no bulges or flat area). Supports are normally placed at strap locations (not exceeding 4 meter spacing) as illustrated in Figure 6.5.

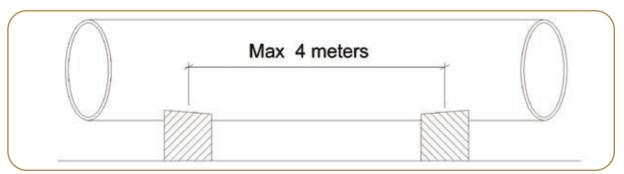


Figure 6.5 – Pipe Support

6.1.2 Valves & Valve Chambers

Customized fittings are an advantage in GRP pipe systems manufactured by Tamdid Pipes®. Utilizing the GRP pipe system in valve chamber design greatly simplifies installation and eliminates redundant flanged joints as shown by comparing figure 6.2 & 6.3. Valves must be sufficiently anchored to absorb the pressure thrust.

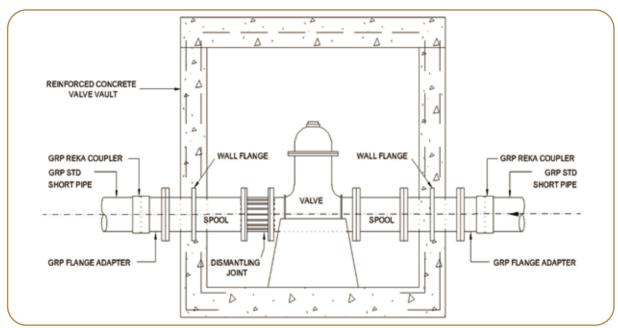


Figure 6.2 – Valve Chamber with Cast/Ductile Iron Fittings

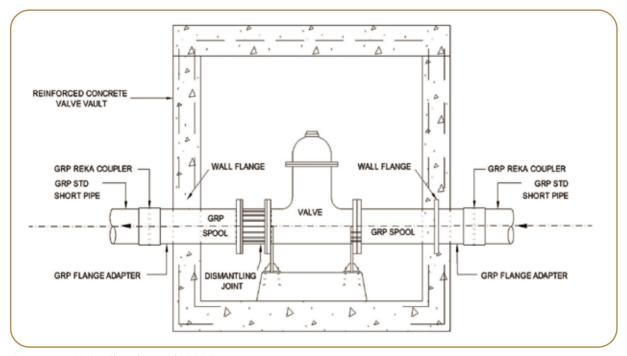


Figure 6.3 – Valve Chamber with GRP Fittings

6. THRUST BLOCKS, CONCRETE ENCASEMENT, RIGID CONNECTIONS & SPECIAL REQUIREMENTS

6.1 Thrust Restraints

When pipelines are pressurized, unbalanced thrust forces occur at bends, reducers, tees, wyes, bulkheads and other changes in line direction. These forces must be restrained in some manner to prevent joint separation. When the surrounding soil cannot provide this restraint, thrust blocks must be used. Determination of need and design of these restraints is the responsibility of the owner's engineer taking into account the following requirements:

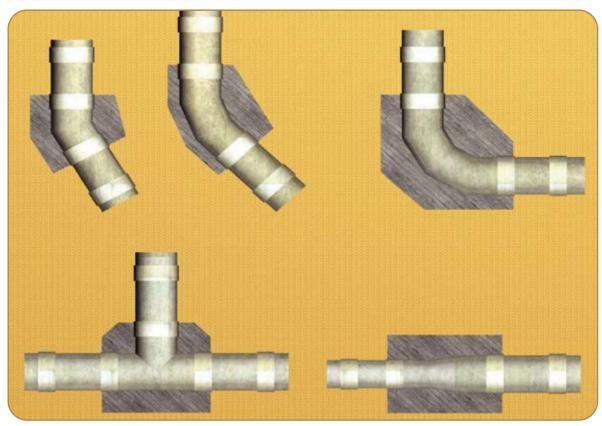


Figure 6.1 - Thrust Blocks

6.1.1 Thrust Blocks

Thrust blocks must limit the displacement of the fitting to 0.5% of the diameter or 6mm, whichever is less. The block must completely surround the fitting for its entire length and circumference as shown in Figure 6.1 and should be placed either against undisturbed earth or backfilled with pipe zone materials as appropriate for the native soil characteristics. For pipe installation and system layout, please check concrete encasement and rigid connections sections.

Thrust blocks are required when the actual pressure exceeds 1bar in the pipeline for the following cases:

- 1. Changes of direction (bends, tees, wyes).
- 2. Cross section changes (reducers).
- 3. Pipeline ends (End Caps or Blind Flanges)

5.7 Pipe Joining Using Socket / Spigot (RSJ - RSLJ) Joint

Some underground applications with small pipe sizes, and in case of deep slope installation or when thrust block cannot be used, TAMDID PIPES® can provide a pipe with a restrained mechanical gasket joint. These pipes are designed to resist the high longitudinal stresses. One locking strip is inserted into the joint to restrain the two pipe sections jointed as follows:

- ☐ Clean the spigot and socket properly.
- Position the O-Ring into the groove of the pipe spigot end. Both rubber and groove should be cleaned before fixing the O-Ring. Make sure that the tension is equally distributed around the rubber ring by passing a screwdriver radially underneath the ring.
- □ Lubricate the O-Ring and the socket inner surface. Avoid lubricant under the rubber ring in order to prevent slipping out of the groove.
- ☐ The two pipes should be kept aligned and leveled before and during assembly. The joint should be assembled in such a way that the position of the hole in the socket allows the locking strip to be inserted easily.
- ☐ Lubricate the first 15 20 cm section of the locking strip.
- The beveled end of the locking strip should be resting against the inside surface of the socket when inserted. The insertion should be made using a wooden hammer of a piece of wood to rap the strip or some power electrical hummer may be used until it rests against the first part or the strip.
- ☐ The contractor must insure that the locked joint is stretched after assembly and that both the spigot and socket are in contact with the locking strip.
- ☐ The maximum allowable joint deflection for locked socket joints is 1.5°. it is recommended not to reach this value during installation.

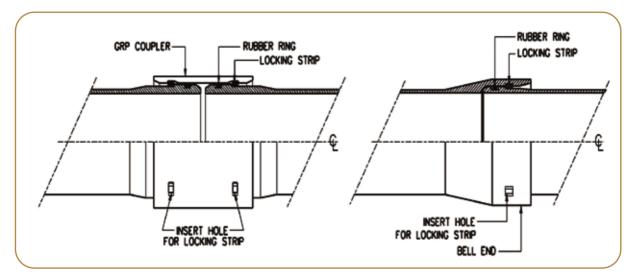


Figure 5.14 – RSJ-RSLJ Joint Details

5.6.4 General notes and information

The following notes & precautions to be consedered in butt & strap lamination:

I. Cleaning:

It is essential that the surfaces to be over laminated are clean and dry roughened ends of pipes left unprotected overnight should be thoroughly cleaned with rags soaked in isopropyl alcohol or acetone to eliminate moisture.

Arrange suitable protection so humidity, dust or sand do not come into contact with the uncured resin.

2. Uniformity and quality of the overlay:

The presence of air bubbles, unimpregnated zones, blisters and lack of the resin indicates that the overlay is of poor quality. The outer protective coating (top coat) should be smooth and the whole area of the joint should be free of rough zones.

The quality of welds also depends on the cleanliness of the tools employed. In particular, when the brushes and woollen rollers are not in use, they should be kept in a pot containing acetone.

Before being used these articles must be freed from the solvent. It should also be borne in mind that a brush or roller used with resin which already contains catalyst should not be put into contact with resin not containing catalyst.

3. Degree of curing:

Polymerization of the resin can be readily checked in the field with the acetone test: rub a rug soaked in acetone on the surface; if the resin is really cured it will not be sticky.

Do not move the pipeline for the next 4 hours from the time the laminate has reached ambient temperature after cure. Pressure testing shall not be done before 24 hours from when the joints were completed.

4. Brief considerations regarding temperature:

Temperature is a very important factor in all jointing processes, for two basic reasons:

- ☐ An increase in the ambient temperature speeds up the reaction and shortens the application time.
- □ A decrease in temperature slows down the reaction and sometimes does not allow a complete cure to be obtained.

Such effects caused by the temperature are compensated by adjusting the quantities of accelerator, inhibitor and catalyst, which are added during preparation of the resin and all of which affect the gel time.

Often it is sufficient to adjust only the catalyst to suit the ambient conditions, however, this should not be less than 1% otherwise complete polymerization will not take place, nor more than 2% to prevent violent reaction.

5.6.3 Lamination Steps

The process to carry out a laminated joint requires the following phases:

Step I: Putty

The putty is made with resin filled with a thixotropic agent like (Aerosil or Cap-O-Seal). It is added to the resin until the mixture becomes a semi solid gel.

The amount of thixotropic agent depends on the desired viscosity of the gel and normally ranges between 4% and 6% by weight of resin.

Increase slightly the quantity of Cobalt or DEAA accelerator in putties because the silica gel inhibits their activity.

Step 2: Preparing the Surfaces

- ☐ Mark the width of the laminate. Using a grinder remove about 2 mm from all the area on which to laminate will be applied and bevel the edges.
- Remove all dust carefully using compressed air or a dry cloth (avoid using solvents).
- ☐ To obtain a joint with an optimum strength the surfaces to be welded must be dry and clean.

Step 3: External Lamination

The following operations must be repeated until the full thickness of the lamination is reached:

- ☐ Slightly grind the surface to remove any sharpness or protrusion of cured resin, apply a layer of resin
- ☐ Apply a strip of "E" glass mat cut to suit the specified width and impregnate it with resin
- ☐ Remove the air bubbles with the roller
- Apply a strip of woven roving cut to size and impregnate it with resin
- ☐ Remove the air bubbles by rolling.
- Repeat the process until the total thickness is obtained.
- After the design thickness is reached and the hardening is completed, apply by means of a brush, a top coat of resin added with UV inhibitor end paraffin on the external surface of the joint.



5.6. I Safety precautions

The following precautions must be taken: ☐ Do not mix the catalyst directly with the accelerator ☐ Do not smoke or use naked flames near the joining area ☐ Safety glasses must be worn during grinding and when mixing the resin ☐ Tools must be kept clean by washing them in acetone or similar solvent ☐ Protective gloves must be used to handle resins and resin impregnated glass fibres ☐ Closed areas (inside the pipe) or areas protected from the inclemency of the weather, should be ventilated to avoid an excessive inhalation of styrene vapours and to eliminate the possibility of ignition of combustible vapours ☐ In areas with limited ventilation, wear breathing masks with suitable filter

5.6.2 List of tools and materials

Make sure that you have available all the tools and materials needed to make the joint directly

or	site. For this purpose follow this check-list:
	Working bench: a metal sheet or plywood can be used as surfaces
	Glass reinforcements (mat, woven roving, net and surfacing mat)
	Resin
	Catalyst, accelerator, inhibitor: to prepare the resin
	Putty based on the required resin
	Solvent (acetone or metilene chloride) and rags for personal and tool cleaning
	Electrical or air powered disk grinder with abrasive disks, 16 grit
	Hack saw or cutter with diamond plated disks for cutting the pipes
	Wool rollers resistant to solvents
	Grooved and lamellar plastic or aluminium rollers
	Mixing paddles & buckets
	50cc graduated dispensers for dosing accelerator and catalyst
	Paint brushes 70x30mm and 50x15mm
	Spatulas
	Scissors for cutting or shaping the glass reinforcements
	Mask with suitable filter
	Rubber gloves and safety glasses
	Equipment for aligning and securing pipe ends
	Elastic ring or inflatable tube