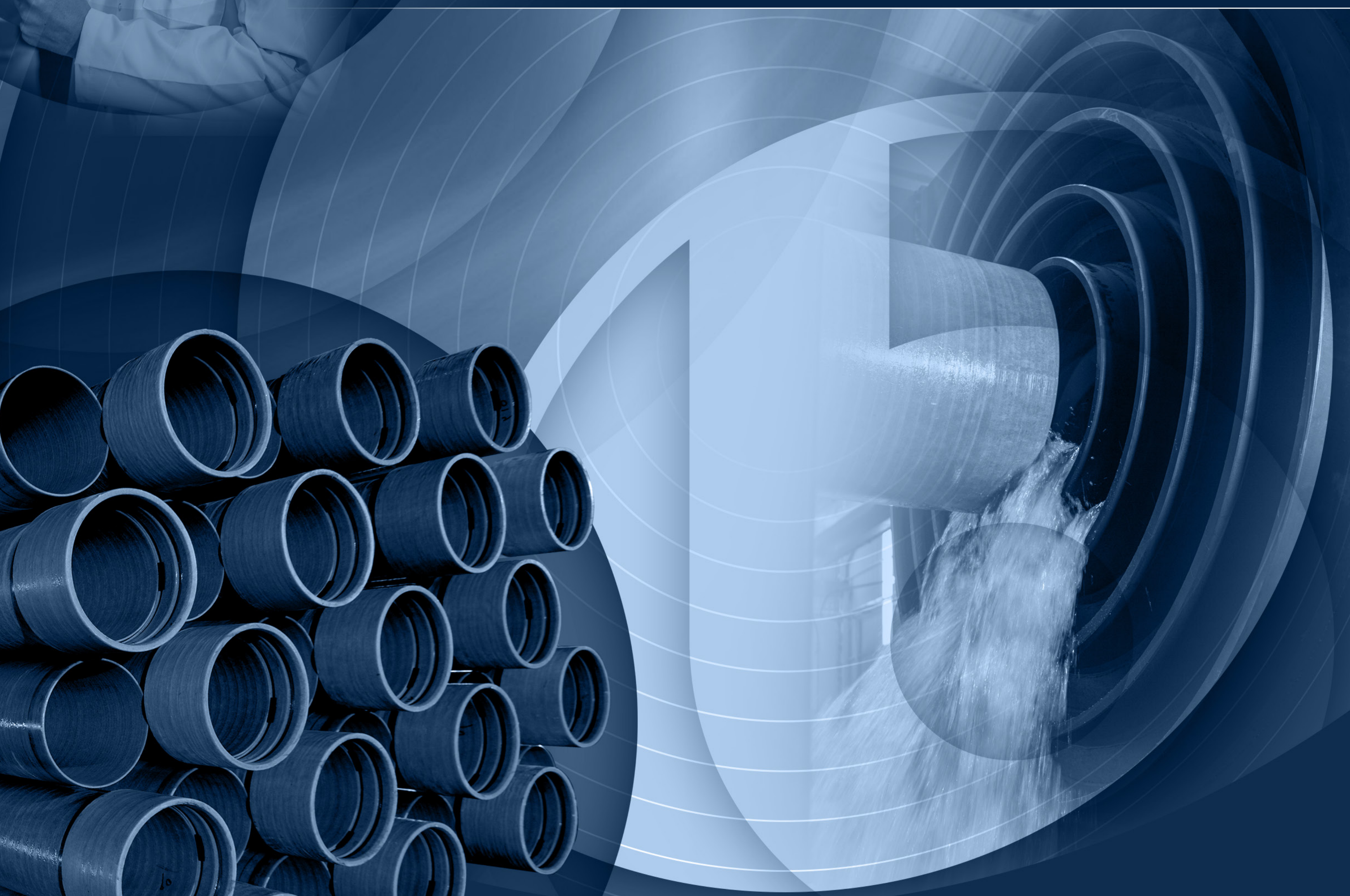
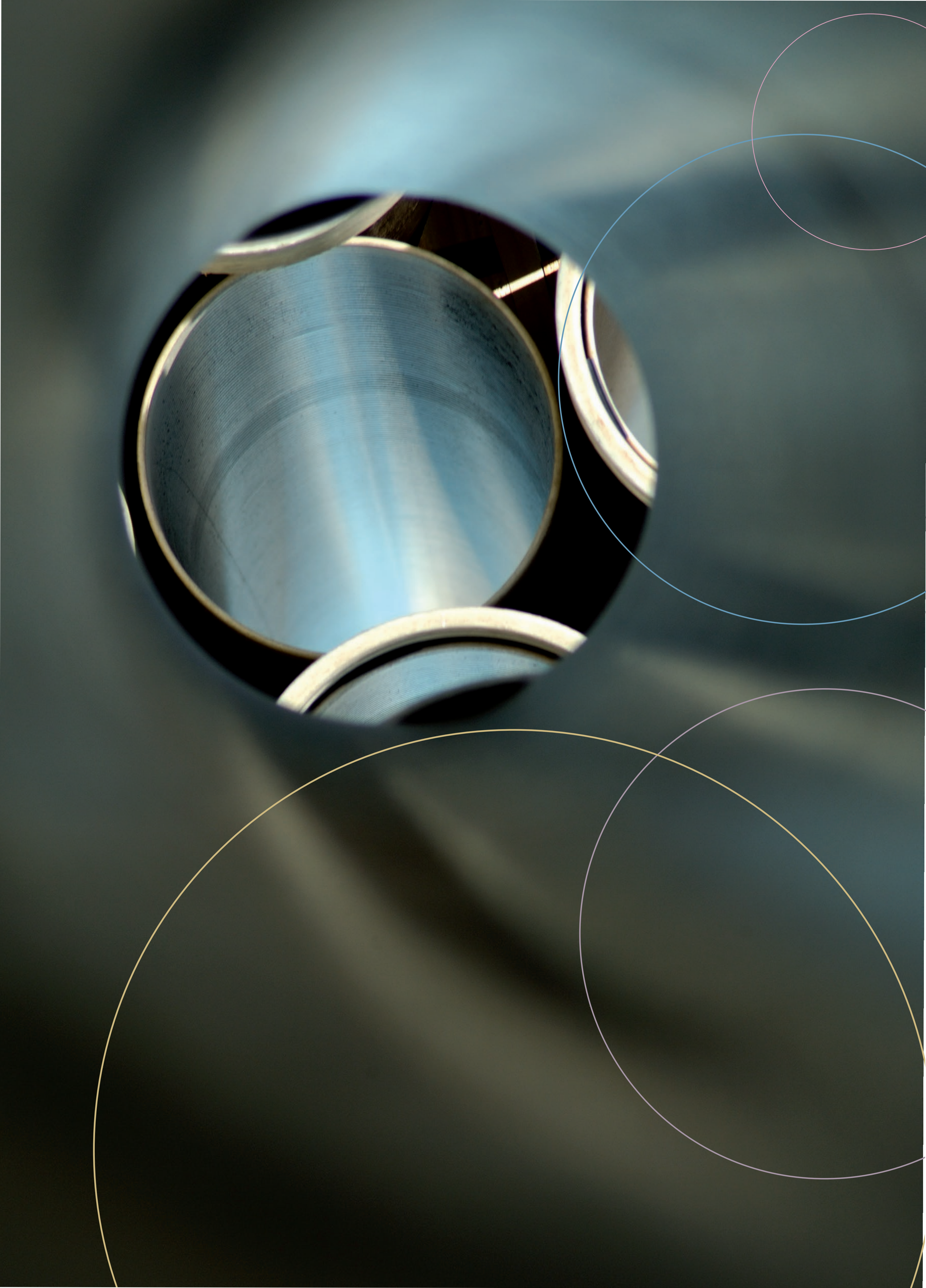
alfebor
GRP PIPES





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PREFACE

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- **Alfebor Pipes®** reserves the right to modify the data available in this manual without any prior notice. Published information can be changed by Alfebor Pipes® for particular project requirements.
- For any technical inquiry, kindly consult **Alfebor Pipes®**.

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1 INTRODUCTION

1.1 FOREWORD

This manual provides guidelines for the handling and underground installation of GRP and GRV piping materials manufactured by Alfebor Pipes® and attempts to cover all standard direct bury applications. Pipe diameter 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 Alfebor Pipes®.

Nominal Diameter ND (mm)	Standard Pipe Length L (m)
80 - 250	6
300 - 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 such as subaqueous installations or aboveground on cradles for which special procedures will be developed. It 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 Alfebor 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

Alfebor Pipes may provide a Field Service Representative to advise the contractor on the proper handling, storage, bedding, laying, jointing, backfilling and testing procedures.

The responsibilities of the Field Service Representative include:

- 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 is 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.
- Alfebor 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.

1.3 SAFETY

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 TRANSPORT, UNLOADING & HANDLING, INSPECTION, AND STORAGE

2.1 TRANSPORT

Alfebor 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. Please check figure 2.1.

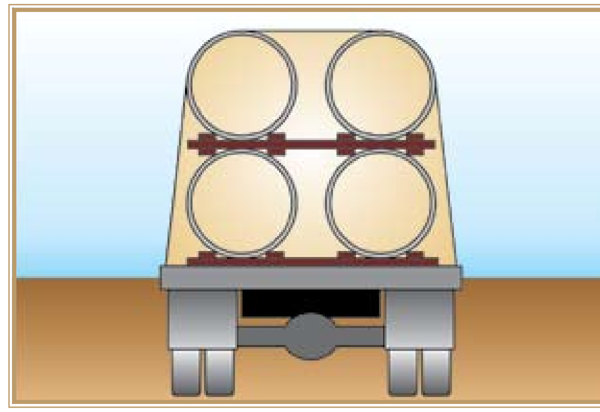


Figure 2.1 - Pipe Transport

Maximum stack height is approximately 3 meters. Strap pipe 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 2.1. 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.

2.2 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.

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 2.2. Larger diameters may be delivered in unitized packages also. Consult the supplier 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).

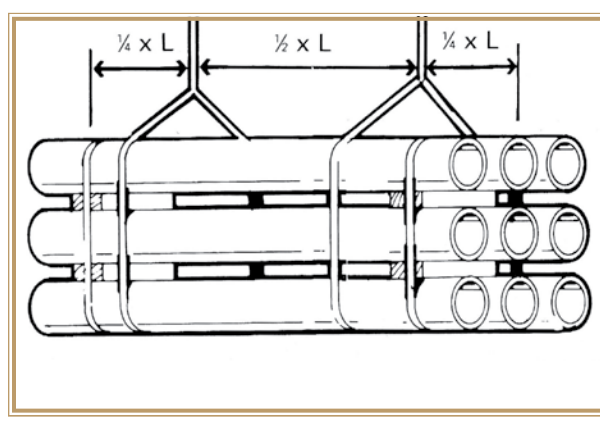


Figure 2.2 - Lifting bundled package

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 2.3) although two support points placed as in (Figure 2.4) make the pipe easier to control. **Do not lift pipes by passing a rope through the section end to end.**

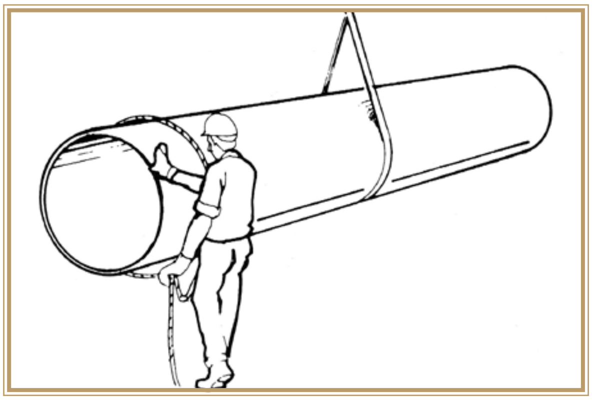


Figure 2.3 - Lifting at one support point

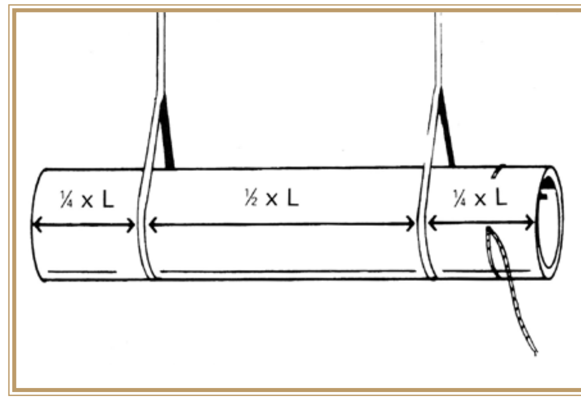


Figure 2.4 - Lifting at two support points

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 Alfebor Pipes® for inspection of damage and for recommendation for repair method or disposal. See section 2.5 on Repairing Pipe.

HANDLING NESTED PIPES

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

1. Always lift the nested bundle using at least two pliable straps (Figure 2.5). 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".
2. Nested pipes are usually best stored as received. Stacking of these packages is not recommended.
3. 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.
4. 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 2.6). Pipes smaller than 1200 mm do not require such stations.
5. Special procedure will be developed in case of larger pipes with weight, length, close sizes, and/or equipment limitations.

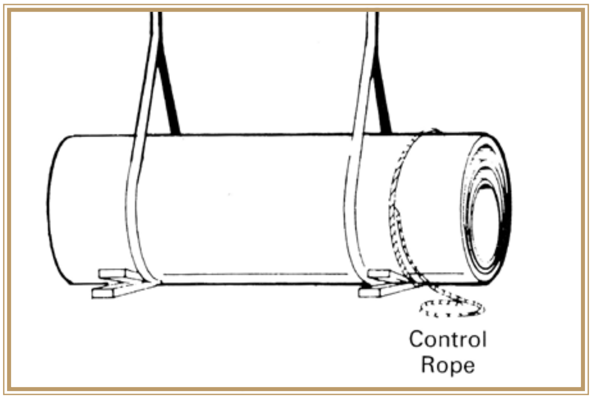


Figure 2.5 - Double support point

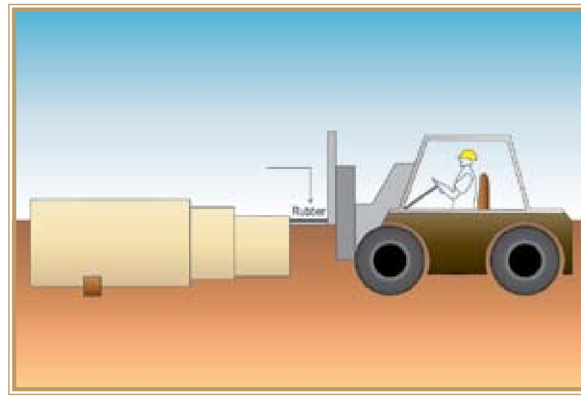


Figure 2.6 - De-nesting

2.3 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:

1. 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.
2. 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.
3. Check the quantity of each item against the delivery note.
4. 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.
5. Do not dispose damaged items.
6. If any deficiency or damage is found, immediately separate the affected pipes and contactAlfebor Pipes®.

Do not use pipes that appear damaged or defective.

2.4 STORAGE

2.4.1 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.

2.4.2 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.

Stack height should not exceed 2.5 meters 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 2.7 for typical storage.

It is important that pipe self deflection during storage does not exceed critical limits shown in Table 2.1. To insure this, bulges and abrupt changes in curvature must be avoided.

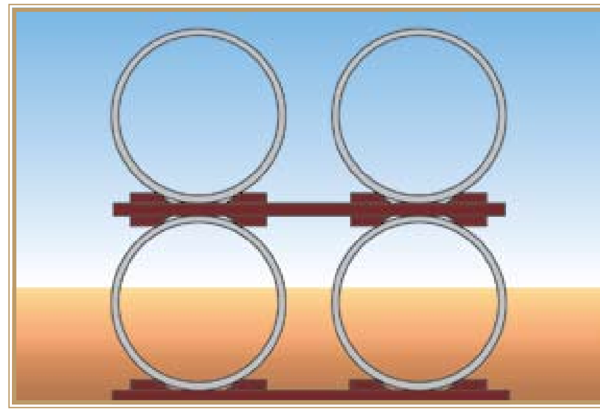


Figure 2.7 - Typical Pipe Storage

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

Table 2.1 – Maximum Allowable Storage Deflection

2.4.3 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.

2.5 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.

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 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 3.1 and Table 3.1.

ND (mm)	X (mm)
80 - 300	150
350 - 500	200
600 - 900	300
1000 - 1600	450
1800 - 2400	600
2500 - 3000	750
3100 - 4000	900

Table 3.1 – Minimum Dimensions between Pipe and Trench wall

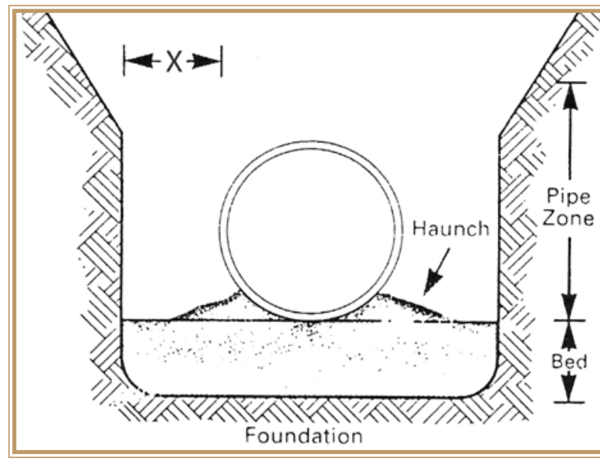


Figure 3.1 - Standard Trench Details

When two or more GRP Pipes are installed in parallel in the same trench, a minimum space equal to the larger of (ND1+ND2)/4 or 300mm is required between the two pipes.

4 INSTALLATION AND BACKFILLING

4.1 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.

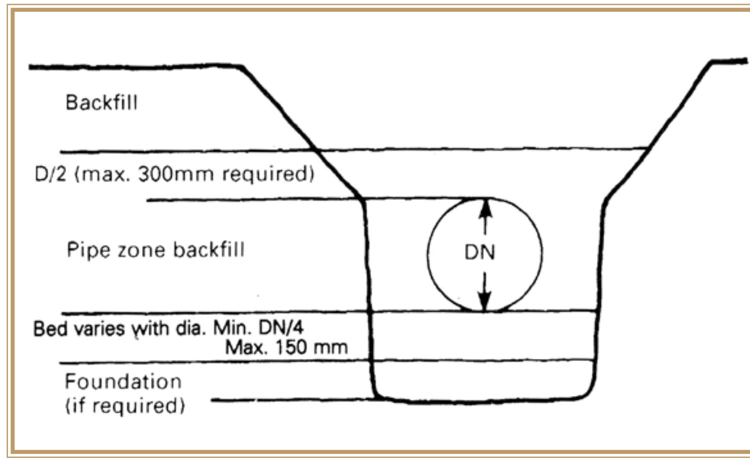


Figure 4.1 - Installation Details

The native material must effectively confine the pipe zone backfill (see Figure 4.1) 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 4.1 while long term deflection should not exceed 5% of the pipe diameter. Native soil groups are described in Table 4.2.

Native Soil Group	1	2	3	4	5
% of Diameter	3.5	3.0	2.5	2.0	1.5

Table 4.1 –Allowable Initial Vertical Deflections

Appendix III 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.

Soil Group	1	2	3	4	5
Cohesive (Fine Grained)	Hard and Very Stiff	Stiff	Medium	Soft	Very Soft
Granular (Coarse Grained)	Very Dense	Dense	Medium	Loose	Very Loose
Blow counts	> 30	16 - 30	6 – 15	3 – 5	0 – 3

Table 4.2 – Native Soil Group Classification

4.2 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 4.4.
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 4.3 – Acceptable Pipe Zone Backfill Materials Gradation

Pipe Diameter	Maximum particle Size
ND < 600 mm	13 mm
600 mm ≤ ND ≤ 1600 mm	19 mm
ND > 1600	25 mm

Table 4.4 – Maximum Particle Size allowed as backfill in Pipe Zone

4.3 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

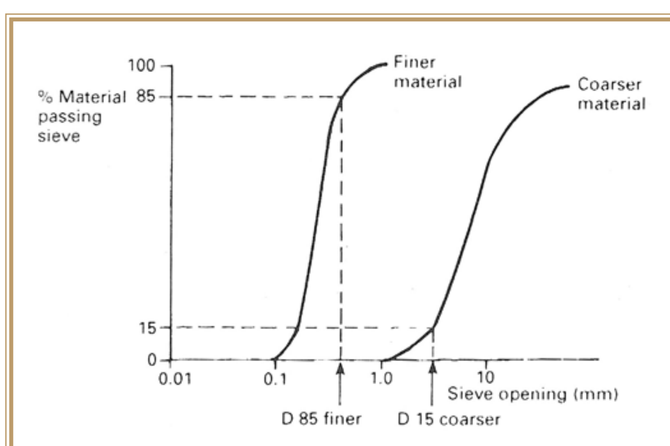


Figure 4.2 - Backfill Migration Criteria

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 occur if there is movement of water in the pipe zone and the following relationship exists between the two adjacent soils:

D_{85} finer ≤ 0.2 D15 coarser

Where:

D_{85} finer = sieve opening passing 85% of the finer material

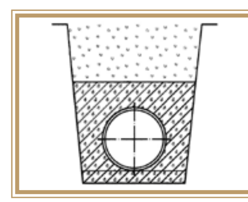
D_{15} coarser = sieve opening passing 15% of the coarser material (Figure 4.2)

Where incompatible materials must be used, they must be separated by filter fabric designed to last the life of the pipeline to prevent wash-away and migration. The filter fabric must completely surround the bedding and pipe zone backfill material and must be folded over the pipe on area in order to avoid contamination of the selected backfill material.

4.4 MAXIMUM COVER DEPTH

Due to their flexibility, GRP/GRV pipes by Alfebor 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.

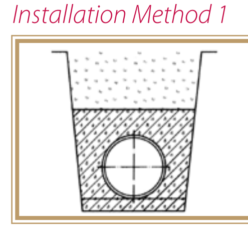
Four standard installation methods can be implemented. Selection depends on pipe stiffness, native soil, and required burial depth. Table 4.4 gives general guidelines for the four installation types without traffic load and Table 4.5 gives maximum burial depths with traffic loads (based on AASHTO H20 wheel loads).



Installation Method 1

INSTALLATION METHOD 1

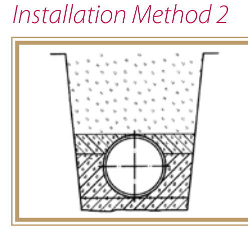
- Carefully constructed bed
- Backfill 70% Relative Density Gravel
- Backfill compacted to 300mm over pipe crown



Installation Method 2

INSTALLATION METHOD 2

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



Installation Method 3

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 4

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	Native Soil Group				
	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
5000 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
10000 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
12500 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 4.5 – Standard Installation Maximum Burial Depth – Meters (Without Traffic Load)

Installation Method	Native Soil Group				
	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	NR
3	8	4	3	2	NR
4	6	3	2	NR	NR
10000 STIS					
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 STIS					
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 4.6 – Standard Installation Maximum Burial Depth – Meters (With Traffic Load (AASHTO H20))

4.5 MINIMUM COVER DEPTH

4.5.1 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 4.6. 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…

Load Type	Wheel Load (KN)	Minimum Cover Depth
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 4.7 – Minimum Cover for Standard Installation and Wheel Loads

Note: The Burial Depth of Pipes with high pressures PN≥ 16 bars should be designed to prevent uplift. Kindly consult the owner Engineer or Alfebor Pipes®.

4.5.2 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. Consult Alfebor Pipes® for details on anchoring and minimum cover depths with anchors.

4.5.3 NEGATIVE PRESSURE

Allowable negative pressure is a function of pipe stiffness, burial depth, and type of installation. Table 4.7 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	-0.50	-1.00	-1.00
4	NR	-0.25	-1.00	-1.00

Table 4.8 – Allowable Negative Pressure at minimum cover depth of 0.6 ND

4.6 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 90% Standard Proctor Density.

The finished bed shall be plane, shall have 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 4.3 and 4.4 for proper and improper bedding support.

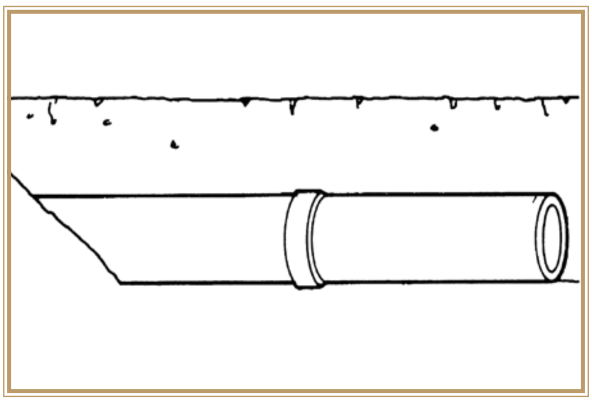


Figure 4.3 - Proper Bedding Support

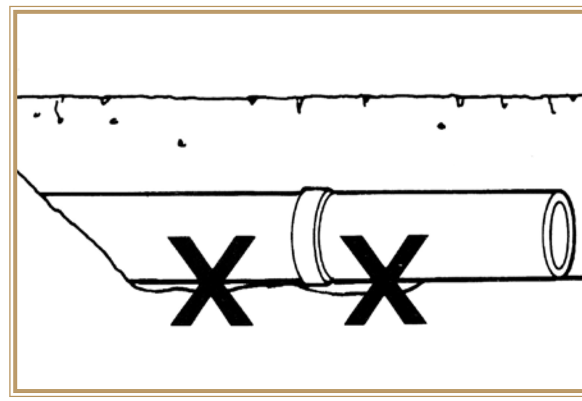


Figure 4.4 - Improper Bedding Support

4.7 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 4.5 and 4.6)

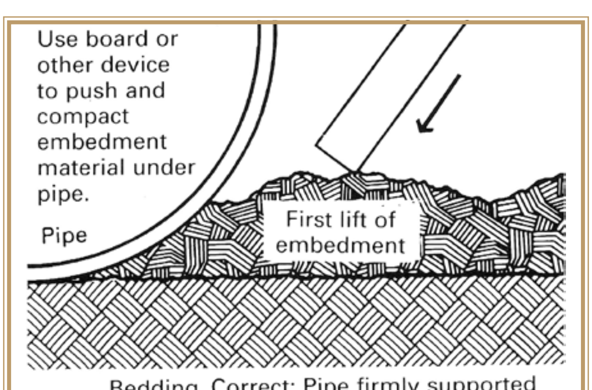


Figure 4.5 - Proper Haunching

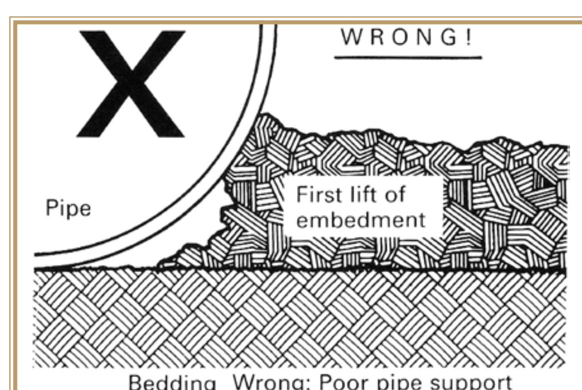


Figure 4.6 - Improper Haunching

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 4.8 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.

	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 4.9 – Minimum Cover for Compaction above Pipe

4.8 MICRO TUNNELING INSTALLATIONS – JACKING PIP

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 Alfebor Pipes®.

4.9 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.

For more information on Subaqueous installations, please contact Alfebor Pipes®

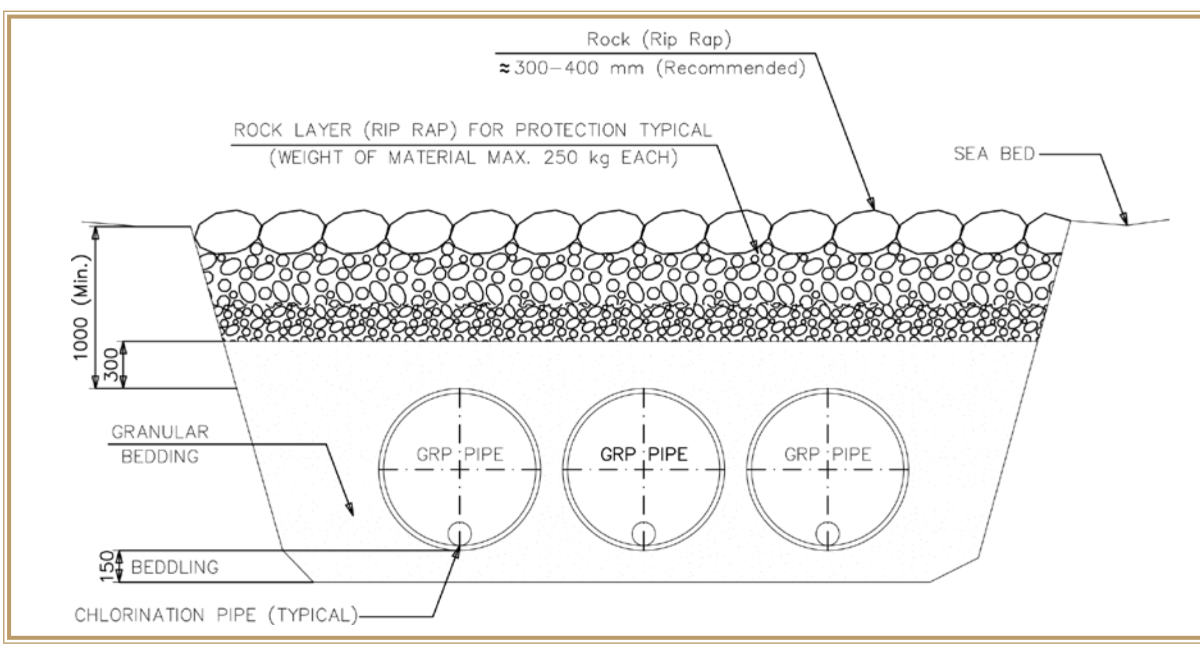


Figure 4.9 - Sub-aqueous Installation

5 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)

5.1 WIDER TRENCH

Increasing the trench width allows a deeper installation by distancing the poor native soil farther from the pipe. Tables 5.1 and 5.2 specify the maximum cover depth allowed with and without traffic loads respectively.

Trench Width	3 x DN			4 x DN	
Installation Type	Native Soil Group				
	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	3	1.5
10000 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 5.1 – WIDER TRENCH - Maximum Burial Depth – Meters (Without Traffic Load)

Trench Width	3 x DN			4 x DN	
Installation Type	Native Soil Group				
	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
10000 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 5.2 – WIDER TRENCH - Maximum Burial Depth – Meters (With Traffic Load)

5.2 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.

5.3 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 15-20cm. Each layer should be wetted with clean water and compacted with plate vibrators before the cement sets.

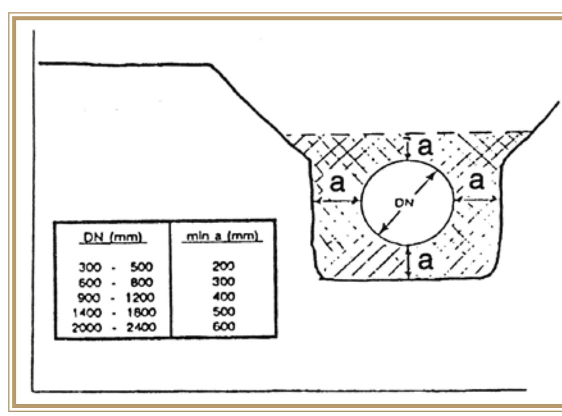


Figure 5.1 - Stabilized Backfill

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 5.1.

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.

6 PIPE JOINING

Underground GRP Piping systems by Alfebor 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®.

6.1 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

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. (Figure 6.1).

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.

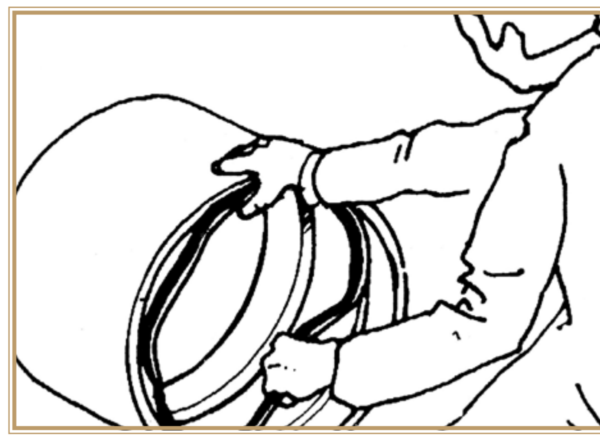


Figure 6.1 - Installing Gaskets

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. See Appendix II for normal amount of lubricant consumed 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.

After lubricating, take care to keep the coupling

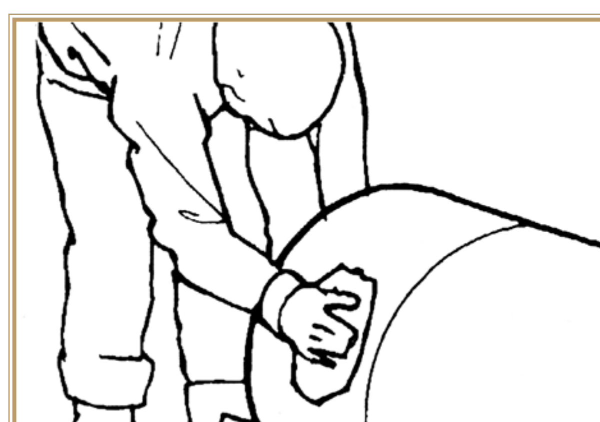


Figure 6.2 - Cleaning Spigot

and spigots clean. See Figure 6.2.

Use only the correct lubricant. Alfebor Pipes® provides sufficient lubricant with each delivery of couplings. If for some reason you run out, please contact Alfebor 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 6.3.

> **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 6.4, but care must be taken in the alignment of the coupling.

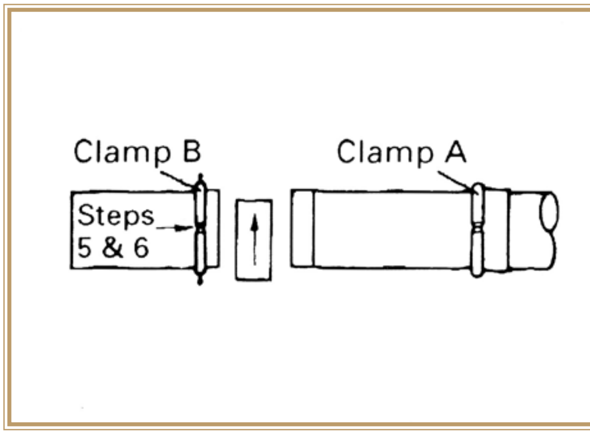


Figure 6.3 - Clamp Locations

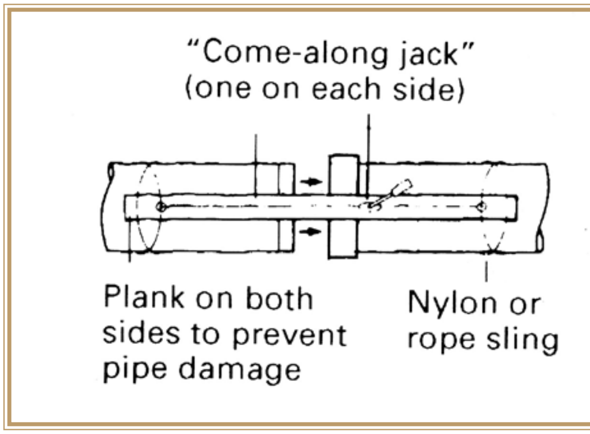


Figure 6.4 - Pipe Joining Without Clamps

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 6.5).

Note: Approximate joining force 1 kg per mm of diameter. Note: For smaller diameter (100mm-250mm) it may be possible to join

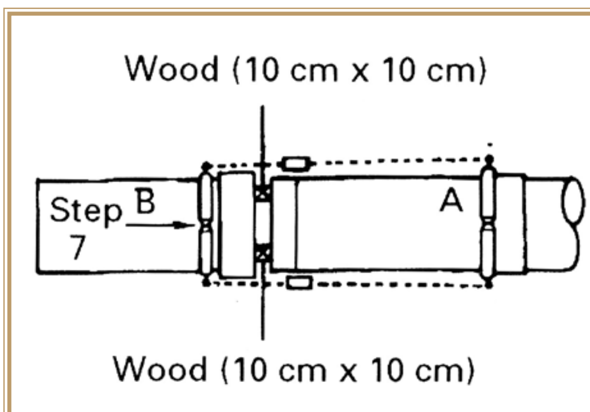


Figure 6.5 - Join Coupling

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 6.6).

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.

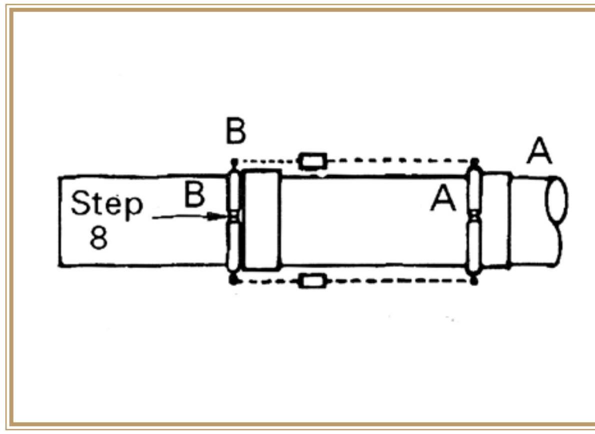


Figure 6.6 - Pipe Joining

6.2 ANGULAR DEFLECTION OF DOUBLE BELL COUPLINGS

Maximum angular deflection at each coupling joint must not exceed the values given in Table 6.1. The pipes should be joined in straight alignment and thereafter deflected angularly as required. See Figure 6.7 for details.

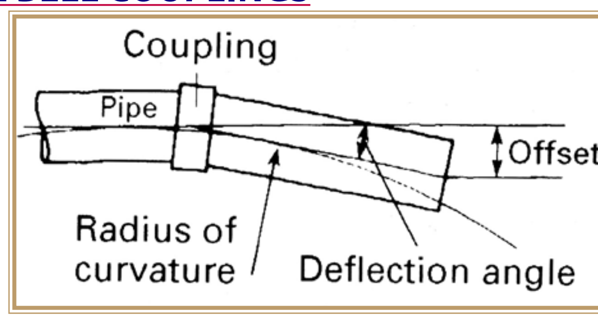


Figure 6.7 - Angular Joint Deflection

DN (mm)	Maximum Angular Deflection (degree)	Nominal Offset (mm) Pipe Length			Nominal Radius of Curvature (m) Pipe length		
		3 m	6 m	2 m	3 m	6 m	12 m
ND < 500	3	157	314	628	57	115	229
500 ≤ ND ≤ 800	2	105	209	419	86	172	344
900 ≤ ND ≤ 1800	1	52	105	209	172	344	688
1900 ≤ ND ≤ 2600	0.5	26	52	78	344	688	1376
ND > 2600	Not Allowed*	*For Special Cases, Kindly contact Alfebor Pipes®*					
***Caution:** For high pressure applications PN ≥ 16 bars, vertical angular deflections are not desirable since it may cause uplift in GRP pipelines.*							

Table 6.1 - Maximum Angular Deflection at Double Bell Coupling Joints

6.3 ANGULAR DEFLECTION OF DOUBLE BELL COUPLINGS

GRP flanges should be joined according to the following procedure: (Figure 6.8)

1. Thoroughly clean the flange face and the "O" ring groove (when applicable).
2. Ensure the "O" ring gasket is clean and undamaged. Do not use defective gaskets.
3. Position "O" ring in groove and secure in position with small strips of adhesive tape (when applicable).

4. Align flanges to be jointed.
5. Insert bolts, washers, and nuts. All hardware must be clean and lubricated to avoid incorrect tightening. Washers must be used on all GRP flanges.
6. Using a torque wrench, tighten all bolts to 35 N-m (25 lb.-ft.) torque for diameters larger then 1200mm, [20 N-m (15 lb.-ft.) for small diameter) following standard flange bolt tightening sequences.
7. Repeat this procedure, raising the bolt torque to 70 N-m (50 lb.-ft.) for diameters larger then 1200mm, [35 N-m (25 lb.-ft.) for small diameter) or until the flanges touch at their inside edges. Do not exceed this torque. To do so may cause permanent damage to GRP flanges.
8. Check bolt torques one hour later and adjust if necessary to 70 N-m [35 N-m for small diameter).

Notes:

- All flanges can be with or without groove pending on project requirements.
- When connecting a GRP flange with groove with another flange, only one flange should have a gasket groove in the face, while the other flange shall be flat face.

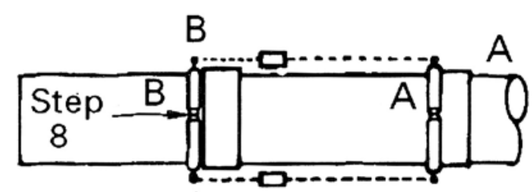


Figure 6.8 - Flange joint ≥ 1800 mm

6.4 MECHANICAL COUPLINGS

There are basically two kinds of mechanical couplers:

1. Flexible Steel Couplings (like Straub, Tee Kay, etc…): These couplings can be used for joining as well as for repair. The coupling consists of a steel mantle with an interior rubber sealing sleeve.
2. Mechanical Steel Couplings (like Viking Johnson, Dresser, etc…): These couplings are typically used for joining to other types of pipe or to rigid items.
   Kindly consult the Mechanical Coupling Manufacturer or Alfebor Pipes® prior to using these kinds of couplers.

6.5 LAMINATION JOINTS

This joint is made from glass fiber reinforcements embedded in resin. It is typically used in situations where it is required to withstand axial forces from internal pressure or as a repair method. The length and thickness of the layup depends on diameter and pressure. Lamination joints require clean, controlled conditions and qualified personnel.

Kindly consult Alfebor Pipes® before performing such type of joint.

7 THRUST BLOCKS, CONCRETE ENCASEMENT, RIGID CONNECTIONS & SPECIAL REQUIREMENT S

7.1 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:

7.1.1 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 7.1 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)

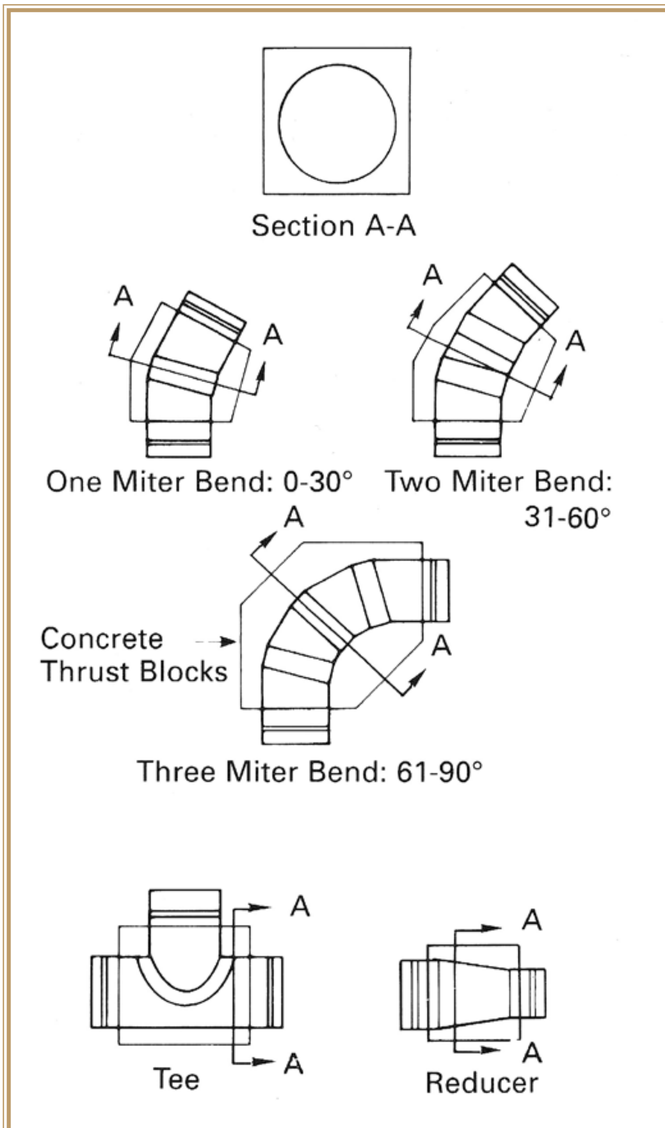


Figure 7.1 - Thrust Blocks

7.1.1 VALVES & VALVE CHAMBERS

Customized fittings are an advantage in GRP pipe systems manufactured by Alfebor Pipes®. Utilizing the GRP pipe system in valve chamber design greatly simplifies installation and eliminates redundant flanged joints as shown by comparing figure 7.2 & 7.3. Valves must be sufficiently anchored to absorb the pressure thrust.

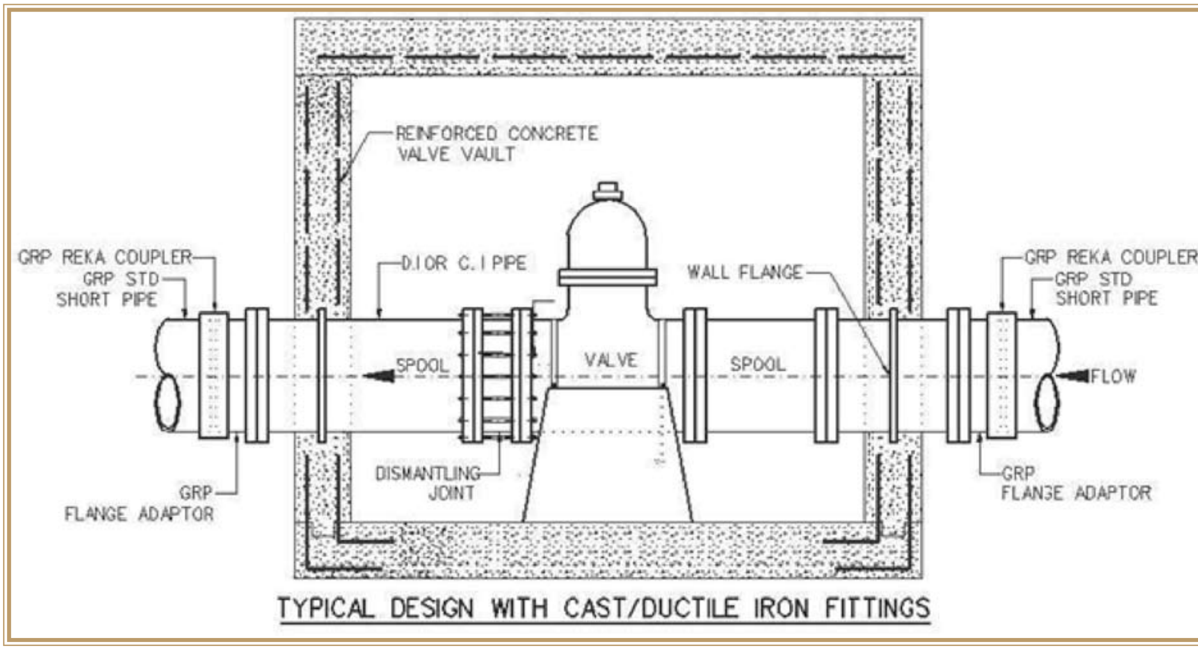


Figure 7.2 - Valve chamber with cast / Ductile iron fittings

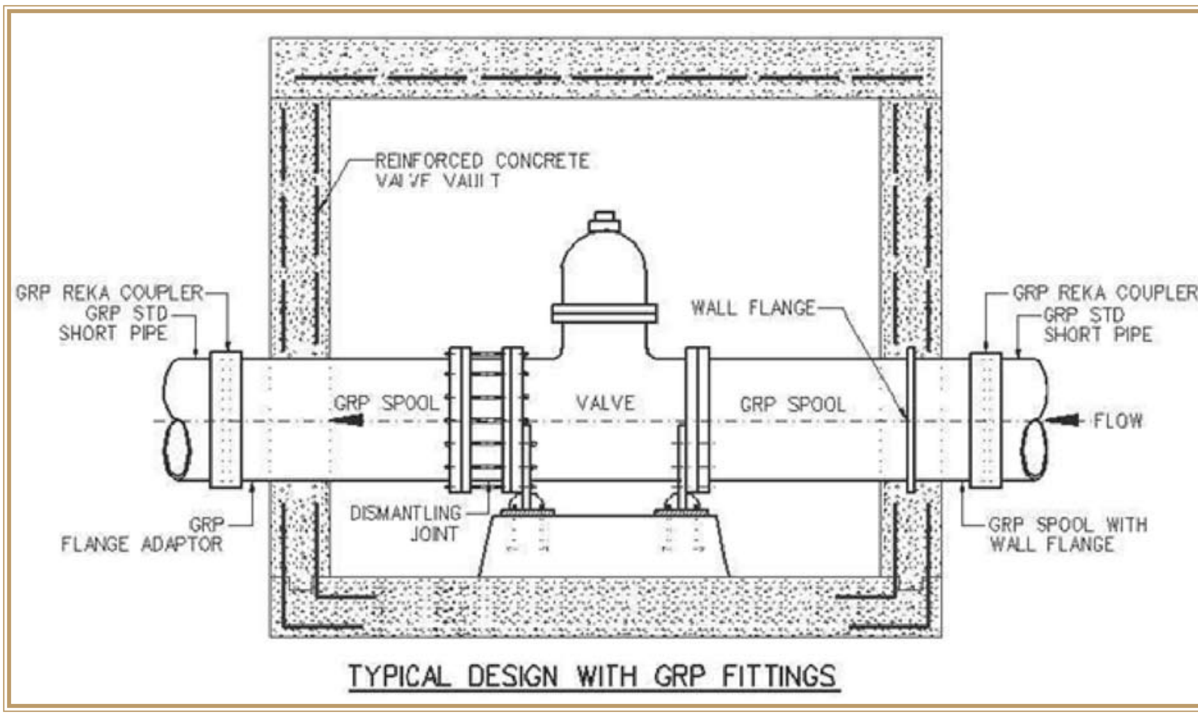


Figure 7.3 - Valve chamber with GRP Fittings

7.2 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.

7.2.1 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 7.4. The straps should be tightened to prevent pipe uplift, but not so tight that additional pipe deflection is caused.

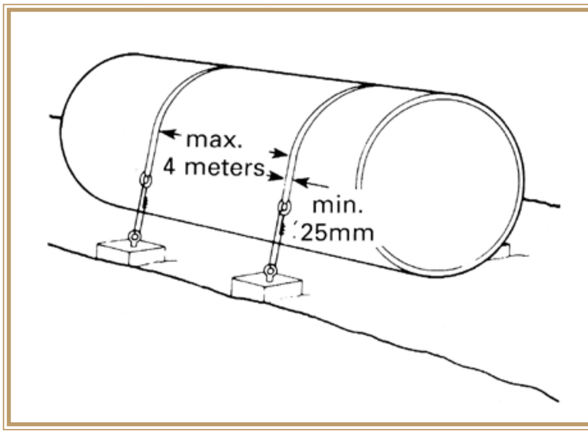


Figure 7.4 - Pipe Anchoring

7.2.2 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 7.5.

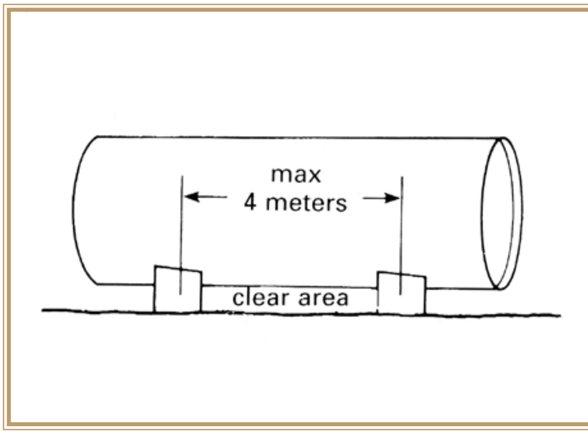


Figure 7.5 - Pipe Support

7.2.3 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 7.1:

Stiffness Class (SN)	Maximum Lift Heighrt (mm)
SN 2500	larger of 300mm or 1/4 pipe diameter
SN 5000	larger of 300mm or 1/3 pipe diameter
SN 10000	larger of 300mm or 1/2 pipe diameter
SN 12500	larger of 300mm or 3/4 pipe diameter

Table 7.1 – Maximum Lift Height

7.3 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 7.6. In case differential settlement occurs, it can be absorbed by the angular deflection in the rocker pipe without inducing excessive bending stresses.

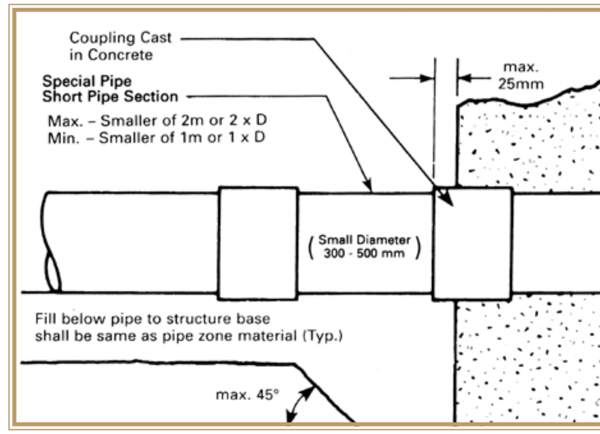


Figure 7.6 - Option A

CAUTION:

1. ***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.***
2. ***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 7.7 while the rubber wrap configuration is given in Table 7.2 and Figures 7.8 and 7.9.

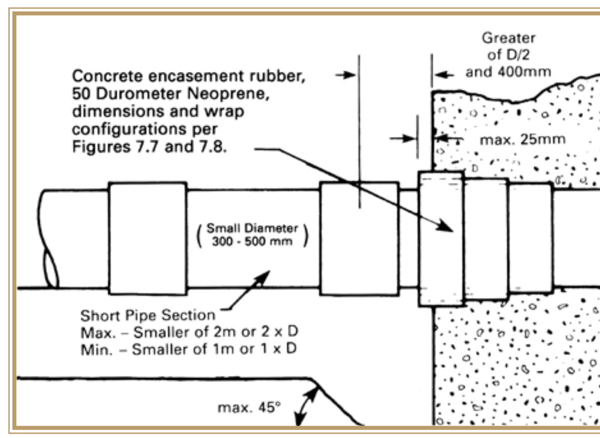


Figure 7.7 - Option B

Nominal Diameter ND (mm)	All Pressure Classs (PN)
80 - 500	A
600 - 1000	B
1100 - 1400	C
1500 - 2400	D
2500 - 4000	E

Table 7.2 – Quantity and configuration of rubber wraps

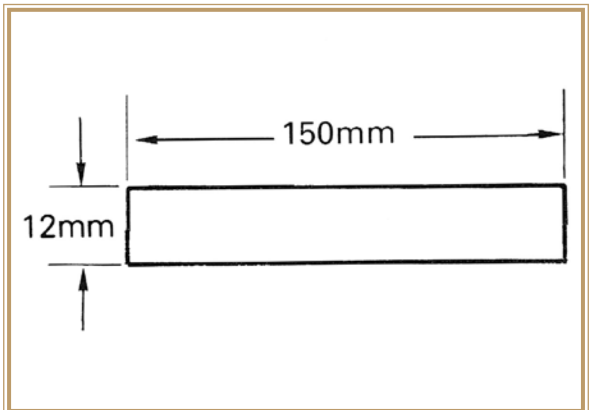


Figure 7.8 - Single wrap dimensions (cross-section)

Figure 7.9 - Wrap Configurations

CONSTRUCTION GUIDELINES

1. 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.
2. The pipeline layout shall be such that the first pipe section near the rigid connection is a short length as follows: (See Figures 7.8 and 7.9)

   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 Alfebor Pipes® for short pieces of Diameters ≥ 3000 mm.
3. 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. 7.8 & 7.9.
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.

8 FIELD ADJUSTMENTS

8.1 LENGTH ADJUSTMENT

Contractors may need to adjust pipe lengths during installation; Alfebor Pipes® may supply pipes with controlled outside diameter (OD) such that chamfering of the pipe end will be sufficient without the need to perform any grinding at site. Alfebor Pipes® will apply special marking to indicate pipes with controlled OD; contractor should try to use such pipes for site adjustment by performing the following steps:

1. Determine length required and mark a square cut location on the selected pipe.
2. Measure pipe diameter at point of cut with a circumferential PI tape to insure it is within spigot tolerances that Alfebor Pipes® will advise.
3. Cut the pipe at the appropriate location using a circular saw with a masonry blade.
4. If pipe diameter is within the spigot tolerance range, clean the surface in the jointing area, sand smooth any rough spots and with a grinder bevel cut pipe end to ease assembly. No further grinding is necessary.
5. If the pipe diameter is not in the spigot tolerance range use a field lathe or grinder and machine the jointing (spigot) surface to the tolerances as indicated on Pipe Data Sheets supplied by Alfebor Pipes®.
6. Bevel pipe ends as per Figure 8.1.
7. For field closure sections, double the spigot width (CL).

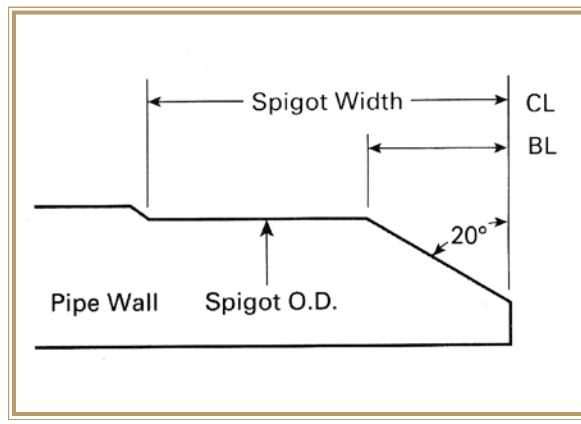


Figure 8.1

8.2 END COATING OF FIELD CUT SEWER PIPE

Sewer pipes that will be later subjected to high pressure water jet cleaning are supplied with a special protective end coating to enhance resistance to damage from high pressure water jets. It will be necessary for the installing contractor to similarly coat the ends of all field cut pipes. Kits containing the special coating are available from Alfebor Pipes®. Please follow the mixing and application instructions furnished with each kit. Alternatively, special short lengths of 1, 2 and 3 meters can be ordered from the Alfebor Pipes® thereby avoiding the need to make field cuts. These special lengths need to be ordered at the time the original purchase order is placed.

8.3 PIPELINE CLOSURES

For a closure in a line, it is required to order a special short pipe from the factory with double width calibration if controlled OD pipes are not available on site. The Contractor should clearly indicate in his order that a short pipe closure is required.

1. Carefully measure the space where the closure pipe is to be placed. The closure piece must be 50mm shorter than the length of the space. The piece must be centered with an equal clearance of 25mm left between the inserted pipe and the adjacent ones.

2. Use a special pipe with long machined ends ordered or prepared specifically for this purpose.
3. Use two double bell couplings without a center register or two wide type flexible steel couplings.
4. Pull the couplings onto the machined ends of the closure pipe after lubricating abundantly the ends and the rubber ring. It may be necessary to gently help the second ring over the chamfered end of the pipes.
5. Lubricate well the ends of the two adjacent pipes after they are cleaned thoroughly.
6. Place the closure pipe in its final position and pull the coupling over the adjacent pipes up to the home line (Figure 8.2, Steps 2 and 3).

Note: After the coupling is in final position a «feeler» gauge may be used to assure that gasket lips are properly oriented.

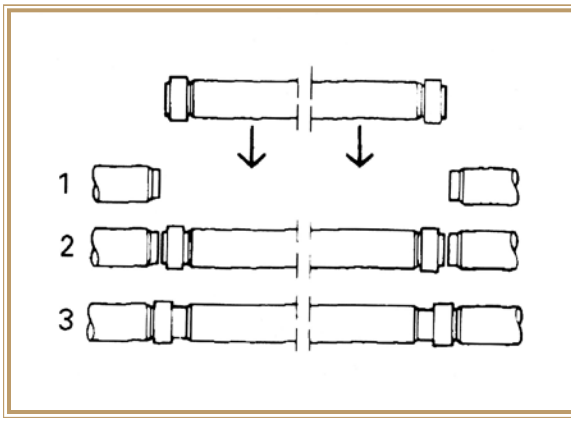


Figure 8.2

9 POST-INSTALLATION

9.1 CHECKING THE INSTALLED PIPE

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 4.1. 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 4.4 and is proportionally less at shallower depths. Therefore, while initial deflections in Table 4.1 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 4.1 must be reinstalled so the initial deflection is less than those values. See section, Correcting over Deflected Pipe, for limitations applicable to this work.

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.

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

$$\textbf{\% Deflection} = \frac{\textbf{Actual ID - Installed Vertical ID}}{\textbf{Actual ID}} \times 100$$

9.2 CORRECTING OVER-DEFLECTED PIPE

Pipes installed with initial diametrical deflections exceeding the values in Table 4.1 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 9.2).

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 4.1.

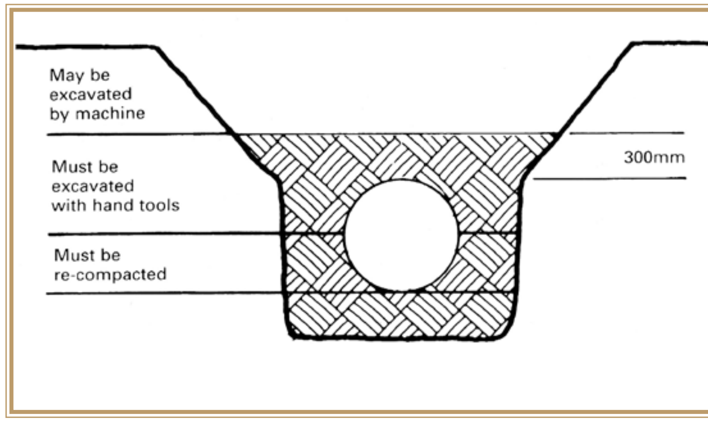


Figure 9.1 - Excavating over-deflected pipe

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.

9.3 FIELD HYDROTESTING

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. Preparation Prior to Test- Inspect the completed installation to assure that all work has been finished properly. Of critical importance are:
   - Pipe deflection limited to the values in Table 4.1.
   - Joints assembled correctly.
   - System restraints (i.e., thrust blocks, and other anchors) in place and properly cured.
   - Flange bolting torqued per instructions.
   - Backfilling completed. (It is permissible to leave joints of pressure class PN16 and below exposed if the line is restrained sufficiently to prevent movement and will not be subjected to a test pressure exceeding 2400kPa. All other joints should be completely backfilled to prevent coupling rotation or other instabilities.)
   - Valves and pumps anchored.
2. Filling the Line with Water: Open valves and vents, so that all air is expelled from the line during filling and avoid pressure surges.
3. Pressurize the line slowly. Considerable energy is stored in a pipe line under pressure and this power should be respected.

4. Insure the gauge location will read the highest line pressure or adjust accordingly. Locations lower in the line will have higher pressure due to additional head.
5. The maximum test pressure is normally 1.5xDesign Pressure. Insure the maximum test pressure is not exceeded as this may be dangerous and result in damage to the pipe system.
6. 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.

Notes:

- Most projects will specify a maximum pressure loss or volume of water lost. These may vary by from project to another. Consult Alfebor 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.

9.4 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 the supplier>s Field Service Representative.

***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 Alfebor Pipes®.**

9.5 FIELD JOINT TESTER

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 9.3.
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.**

Alfebor Pipes® does not recommend using pressure air test for Pressure Pipes.

ND (mm)	Time (minutes)
80	2.5
100	2.5
150	3.75
200	5
250	6.25
300	7.75
350	8.75
400	10
450	11.25
500	12.5
600	15
700	17.5
800	20
900	22.5

ND (mm)	Time (minutes)
1000	25
1100	27.5
1200	30
1300	32.5
1400	35
1500	37.5
1600	40
1800	45
2000	50
2200	55
2400	60
2600	60
2800	60
3000 up to 4000	60

Table 9.3 - Test time - Field Air Test

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.

APPENDIX I:
APPROXIMATE WEIGHTS FOR PIPES AND COUPLINGS

Nominal Diameter (mm)	Pipe Weight (kg/M)				Weight Per Coupling (kg)
	SN 2500	SN 5000	SN 10000	SN 12500	
100		2	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 Alfebor Pipes®

APPENDIX II

JOINT LUBRICANT REQUIREMENTS

Nominal Pipe Diameter	Nominal Amount of Lubricant (kg)
80 to 250	0.075
300 to 500	0.010
600 to 800	0.150
900 to 1000	0.200
1100 to 1200	0.250
1300 to 1400	0.300
1500 to 1600	0.350
1800	0.400
2000	0.500
2200	0.600
2400	0.800

For larger pipe diameters, please consult Alfebor Pipes®

APPENDIX III
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 ASTM[1] 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 ASTM[1] 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 ASTM[1] 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 ASTM[1] 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 ASTM[1] 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»**

Soil Group	1	2	3	4	5
Cohesive[2] (Fine Grained)	Hard and Very Stiff	Stiff	Medium	Soft	Very Soft
Granular[3] (Coarse Grained)	Very Dense	Dense	Medium	Loose	Very Loose
Blow counts[1]	> 30	16 - 30	6 – 15	3 – 5	0 – 3

Table III-1 – Native Soil Group Classification

1 *Blows as measured with 2 in. 0.0. 1-3/8 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.*

2 *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.*

3 *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.*

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.**	

*Table III-2 – Simple Field Test for Determining Soil Group**

APPENDIX IV
SOIL CHARACTERISTICS

Cohesive Soils** Consistency	Blows* Per Foot (N)	qu****	Identification
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 100	Molded with moderate finger pressure
Stiff	16 - 30	151 to 300	Molded with substantial finger pressure
Very Stiff	> 30	301 to 500	molded by finger pressure; requires picking to remove
Hard	> 30	? 500	Difficult to remove by picking

Table III-1 – Native Soil Group Classification

Granular Soils*** Compactness	Blows* Per Foot (N)	Relative Density	Moist Unit Weight (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	16 - 30	66 to 85 %	18 - 22
Very Dense	> 30	> 85 %	20 - 23

Table III-1 – Native Soil Group Classification

* *Blows as measured with 2 in. O.D. 1-3/8 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.*

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