Introductory information

1.1 Foreword

This manual is intended to assist the installer in understanding the requirements and procedures for the successful handling and installation of Flowtite® pipes above ground. It may also be a helpful source of data for project engineers, although it is *not* a design guide or system-engineering manual.

We have tried to address the unusual, as well as usual, circumstances that may be encountered in the field; however, it is certain that unique situations requiring special consideration will occur. When this happens, ask the supplier for help.

Also, installations other than aboveground on cradles, such as direct bury or subaqueous are not discussed herein. For direct bury use "Owens Corning Pipe Installation and Handling Instructions For Buried Pipe". Otherwise, consult the supplier for suggested procedures and limitations in these cases.

Most importantly, this booklet is not meant to replace common sense, good engineering judgement, safety regulations, local ordinances or the specifications and instructions of the owner's engineer, who is the final authority on all jobs. Should conflicts in any of this information arise that create doubts as how to proceed properly, please consult the supplier and the owner's engineer to obtain assistance.

1.2 Introduction

The excellent corrosion resistance and many other benefits of *Flowtite* pipe can be realized if the pipe is properly installed. *Flowtite* pipe is designed considering the support that will result from these recommended installation procedures.

Owens Corning Pipe Systems generally recommends the use of standard SN 5000 pipes for aboveground pipe installations. The recommended installation procedures are therefore based on the application of standard SN 5000 pipes.

The procedures also apply for pipes with higher stiffness, i.e. SN 10000. Aboveground installation of pipes with stiffness lower than SN 5000 requires special consideration.

The installation procedures outlined in this brochure and the suggestions of the Field Service Representatives, when carefully followed, will help assure a proper, long-lasting installation. Consult the supplier on any questions or when variations in these instructions are being considered.

1.3 Field Service Representative

The supplier can provide a Field Service Representative.

The Field Service Representative will advise the installer to help him achieve a satisfactory pipe installation. The "on the job" field service will be available early in the installation and may continue periodically throughout the project. The service will range from continuous (essentially full-time) to intermittent depending on the job schedule, complexity and installation results.

1.4 Fire Safety

Glass-reinforced polyester (GRP) pipe, like virtually all pipe made with petrochemicals, can burn and is, therefore, not recommended for use in applications which are exposed to intense heat or flames. During installation, care must be taken to avoid exposure of the pipe to welder's sparks, cutting-torch flames or other heat/flame/electrical sources which could ignite the pipe material.

This precaution is particularly important when working with volatile chemicals in making layup joints, repairing or modifying the pipe in the field.

Flowtite® Pipe
Installation and Handling
Instructions For Aboveground Pipe

Table of Contents:

Pre-installation

2.1 Inspecting Pipe

All pipe should be inspected 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 reinspect the pipe just prior to installation.

Inspect the shipment upon delivery, as follows:

1. Make an overall inspection of the load. If the load is intact, ordinary inspection while unloading will normally be sufficient to make sure the pipe has arrived without damage.
2. If the load has shifted or indicates 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 bill of lading.
4. Note on the bill of lading 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 of any damaged items. The carrier will notify you of proper disposal procedure.
6. If any imperfection or damage is found, immediately segregate the affected pipes and contact the supplier.

Do not use pipe that appears damaged or defective.

If the Field Service Representative is present at the time of your inspection(s), he will be glad to assist you.

2.2 Repairing Pipe

Normally, pipes with minor 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 determine whether repair is required and whether it is possible and practical. He can obtain the appropriate repair specification and arrange for the required materials and a trained repair technician, if desired. Repair designs can vary greatly 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. Improperly repaired pipes may not perform as intended.**

2.3 Unloading and Handling Pipe

Unloading the pipe is the responsibility of the customer. Be sure to maintain control of the pipe during unloading. Guide ropes attached to pipes or packages will enable easy manual control when lifting and handling. Spreader bars may be used when multiple support locations are necessary. Do not drop, impact or bump the pipe, particularly at pipe ends.

Unitized Loads

Generally, pipes 600 mm and smaller in diameter are packaged as a unit. Unitized loads may be handled using a pair of slings as shown in *Figure 2.1.* 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).**

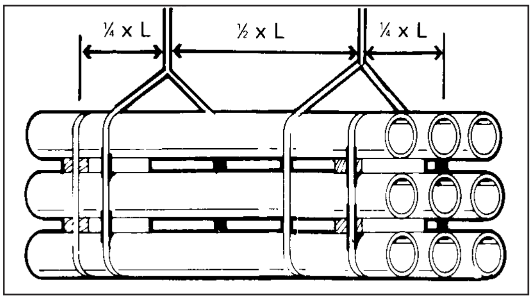

Figure 2.1
Lifting unitized package

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

See *Appendix A* for approximate weights of standard pipes and couplings.

If at any time during handling or installation of the pipe, any damage such as a gouge, crack or fracture occurs, the pipe should be repaired before the section is installed. **Contact the supplier for inspection of damage and for recommendation for repair method or disposal. See previous section on *Repairing Pipe*.**

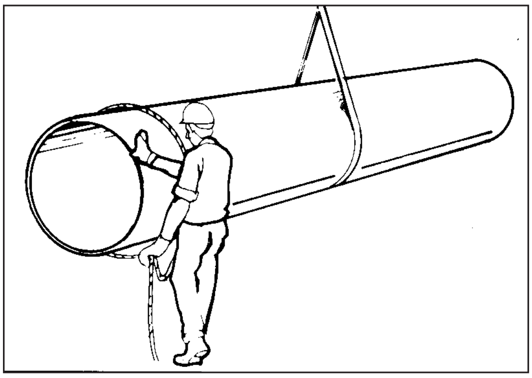

Figure 2.2
Lifting pipe at one support point

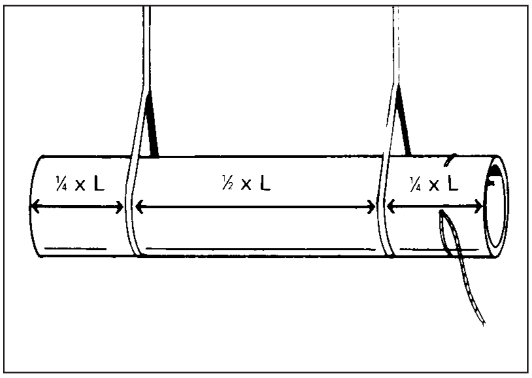

Figure 2.3
Lifting pipe at two support points

2.4 Storing Pipe

It is generally advantageous to store pipe on flat timber to facilitate placement and removal of lifting slings around the pipe.

When storing pipe directly on the ground, be sure that the area is relatively flat and free of rocks and other potentially damaging debris. All pipes should be chocked to prevent rolling in high winds.

If it is necessary to stack pipes, it is best to stack on flat timber supports at maximum 6 meter spacing with chocks *(See Figure 2.4)*. If it is available, use the original shipping dunnage.

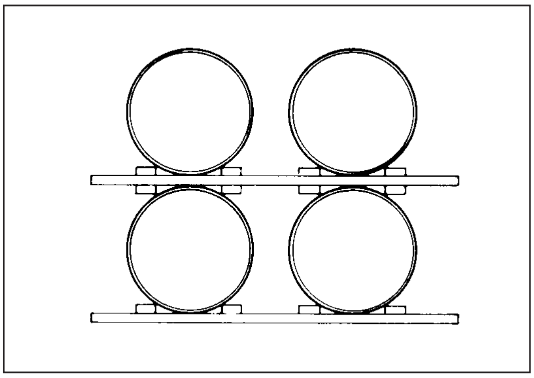

Figure 2.4
Storing pipe

Insure the stack will be stable for conditions such as high winds, unlevel storage area or other horizontal loads. Maximum stack height is approximately two meters. Stacking of pipes larger than 1400 mm diameter is not recommended.

Maximum diametrical deflection must not exceed the values in *Table 2.1*. Bulges, flat areas or other abrupt changes of curvature are not permitted. Storing of pipes outside of these limitations may result in damage to the pipes.

Table 2.1 Maximum Storage Deflection

Stiffness Class SN	Maximum Deflection (% of Diameter)
5000	2.0

2.5 Storing Gaskets and Lubricant

Rubber ring gaskets, if 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 deleterious substances.

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

2.6 Transporting Pipe

If it is necessary to transport pipes at the job site, it is best 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 centres with a maximum overhang of 2 meters. Chock the pipes to maintain stability and separation. Insure no pipes contact other pipes, so vibrations during transport will not cause abrasion *(Figure 2.5)*.

Maximum stack height is approximately 2 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 value 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.

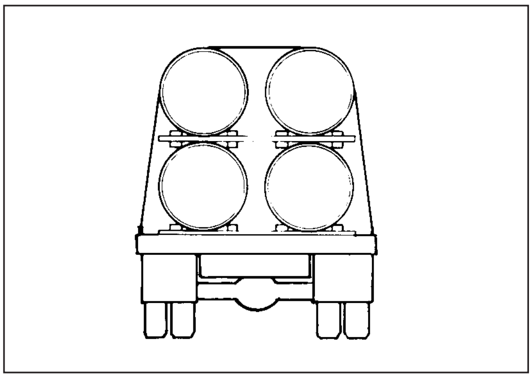

Figure 2.5
Transporting pipe

2.7 Handling Nested Pipes

Pipes to be shipped long distances may be nested (smaller diameter pipes inside of larger sizes) to reduce the transportation cost. These pipes generally have special packaging and may require non-standard procedures for unloading, handling, storing and transporting. Non-standard practices, if required, will be supplied prior to shipment. Regardless, the following general procedures should always be followed:

1. Always lift the nested bundle using at least two pliable straps *(Figure 2.6).* Limitations, if any, for spacing between straps and lifting locations will be specified for each project. Insure that the lifting slings have sufficient capacity for the bundle weight. This may be calculated from the approximate pipe weights given in *Appendix A.*

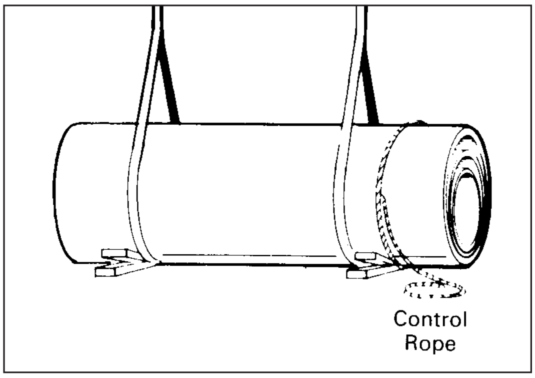

Figure 2.6
Double support point

2. Nested pipes are usually best stored in the transport packaging. Stacking of these packages should not occur unless specified otherwise.

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 to each project.

4. Package removal and denesting of the inside pipe(s) is best accomplished at a denesting 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 always 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 2.7).*

   When weight, length and/or equipment limitations preclude the use of this method, procedures for sliding the inside pipe(s) out of the bundle will be recommended for each project.

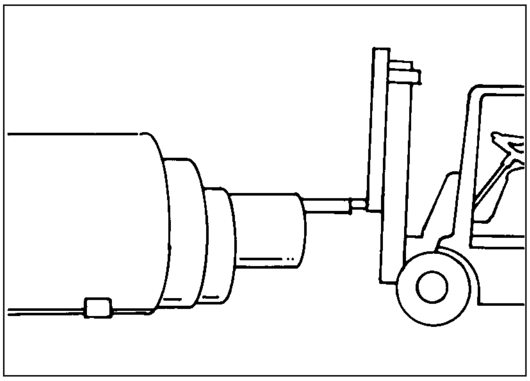

Figure 2.7
Denesting with padded boom on forklift truck

Joining pipes

Flowtite pipe sections are typically joined using GRP double bell couplings. Pipe and couplings may be supplied separately or the pipe may be supplied with a coupling installed on one end.

The couplings may be supplied with or without an elastomeric centre stop register. (Factory installed couplings utilize the register.)

Other joining systems such as flanges, mechanical couplings and layup joints may also be used with *Flowtite* pipe.

3.1 Double Bell Couplings

Cleaning and Gasket Installation

The following steps (1 to 4) 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 *(Figure 3.1)*.

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 3.2)*.

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 *(Figure 3.3)*. See *Appendix B* for normal amount of lubricant consumed per joint.

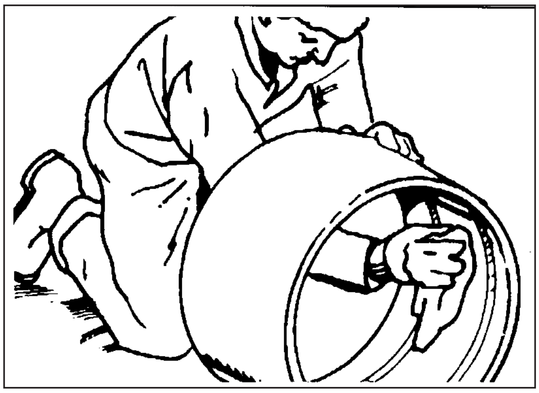

Figure 3.1
Cleaning coupling

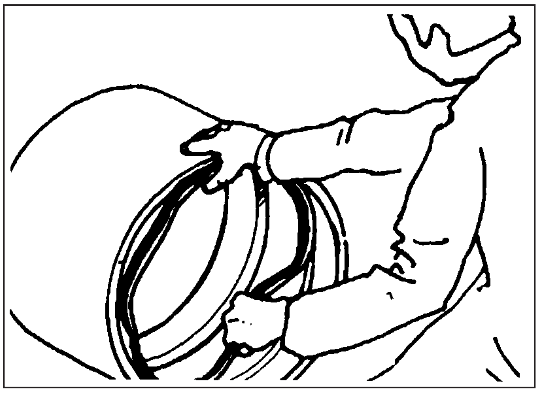

Figure 3.2
Installing gaskets

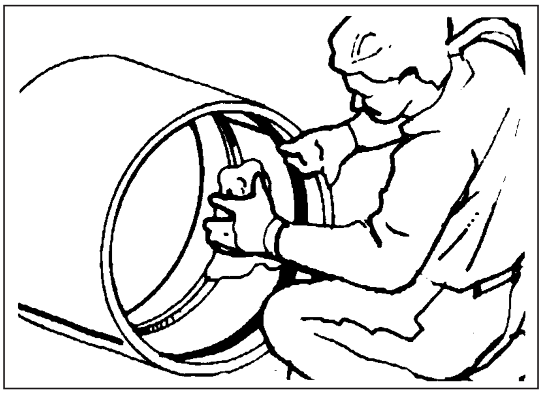

Figure 3.3
Lubricating gaskets

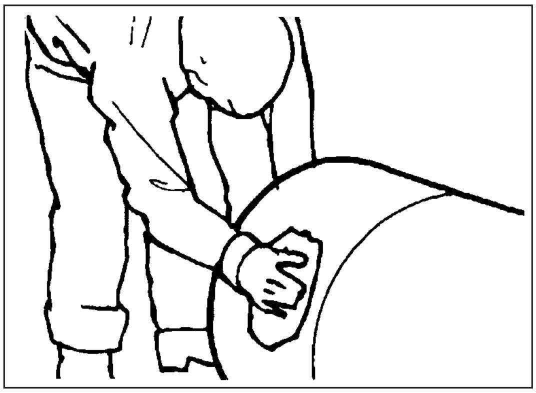

Figure 3.4
Cleaning spigot

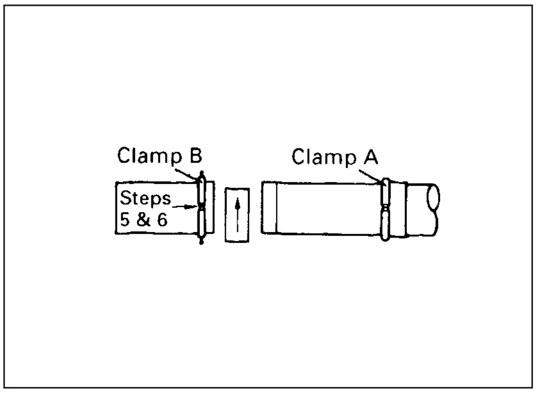

Figure 3.5
Clamp locations

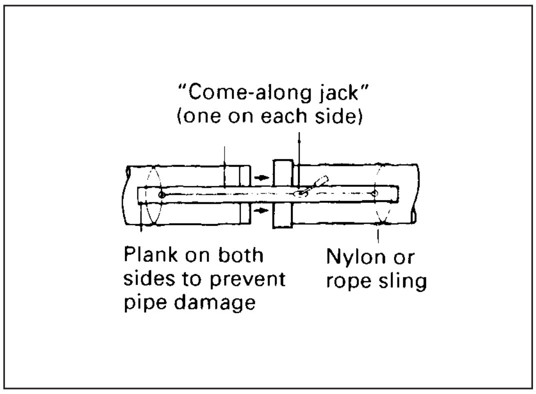

Figure 3.6
Pipe joining without clamps

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 black positioning stripe. After lubricating, take care to keep the coupling and spigots clean. *(Figure 3.4.)*

Caution: It is very important to use only the correct lubricant. The supplier provides sufficient lubricant with each delivery of couplings. If for some reason you run out, please contact the supplier for additional supply or advice on alternative lubricant. **Never** use a petroleum based lubricant.

Joining Without Centre Register

The following steps (5 to 8) apply to joining separate pipe and couplings without the elastomeric centre stop register.

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 3.5)*.

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 3.6*, but care must be taken in the alignment of the coupling. 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: Joint Coupling

Come-along jacks are installed to connect the pipe clamps and two 100 mm × 100 mm timbers or similar (large 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 a protective plank under it in order not to touch against the pipe *(Figure 3.7)*.

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

Note: For smaller diameter (100 mm-250 mm) 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 3.8)*. For appropriate gap between pipe ends, see the following section on *Gap Between Pipe Spigots*.

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.

Joining with Centre Register

The same basic joining procedures are followed except that the position of Clamp B does not need to be precisely located.

Joining the Prefixed Coupling

The factory installed coupling will have the centre stop register. Thus the joining step of first installing the coupling on the pipe is eliminated.

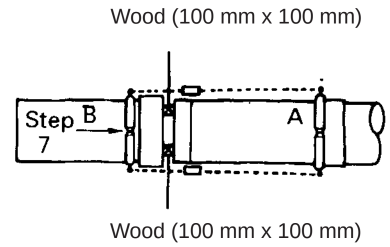

Figure 3.7
Join coupling

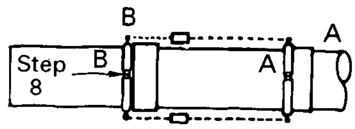

Figure 3.8
Pipe joining

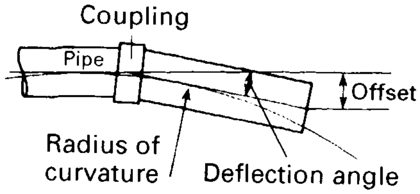

Figure 3.9
Double bell coupling, angular joint deflection

Gap Between Pipe Spigots

Aboveground pipelines will, if exposed to direct sunlight, be warmed up by the sun and expand. This applies especially for pipelines that are empty during the installation phase or for other reasons. To avoid excessive loads on pipes and pipe supports, the pipes must be joined with sufficient gap between spigots so as to avoid contact between the spigots even at the highest possible temperatures.

The adequate gap depends on the highest possible temperature rise that can be expected for the pipe and the length of pipe between anchors that can expand into the joint. For evaluation of minimum gap between spigots, a linear coefficient of thermal expansion of $30 \times 10^{-6}/°C$ can be assumed for *Flowtite* pipes in the longitudinal direction. The minimum gap can be calculated as:

$$g_{min} = (T_{max} - T_{inst.})L \times 30 \times 10^{-6}$$

where:

- T_{max} is the maximum expected pipe temperature in °C.
- $T_{inst.}$ is the pipe installation temperature in °C.
- L is the pipe length (anchor to anchor) expanding into the joint in mm.

A gap of 25 mm between spigots will be sufficient for most installations with pipe length up to and including 12 m.

The gap between pipe ends should not exceed 30 mm.

For joints with angular deflection, the gap will vary around the circumference of the pipe. In such cases the minimum gap shall be within the limitations stated above while the maximum gap should under no circumstances exceed 60 mm.

The gap requirements above apply for non-pressurized pipe.

Angular Deflection at Double Bell Couplings

The angular deflection at coupling joints must be limited in order to avoid excessive loads on pipeline and supports. Pressurized aboveground *Flowtite* pipes shall be installed in straight alignment while changes in line direction are achieved by bends and thrust restraints.

Unintended angular deflection at coupling joints for pipes installed in straight alignment, shall not exceed 20% of the values in *Table 3.1*.

Slight changes in line direction of low pressure pipelines, PN ≤ 6 can however, on special occasions, be achieved by angular deflections at joints. Such installations require special consideration and it must be assured that supports at joints with angular deflection have adequate thrust restraint.

Note: The pipe supplier shall be consulted prior to installing pipes with angular deflection.

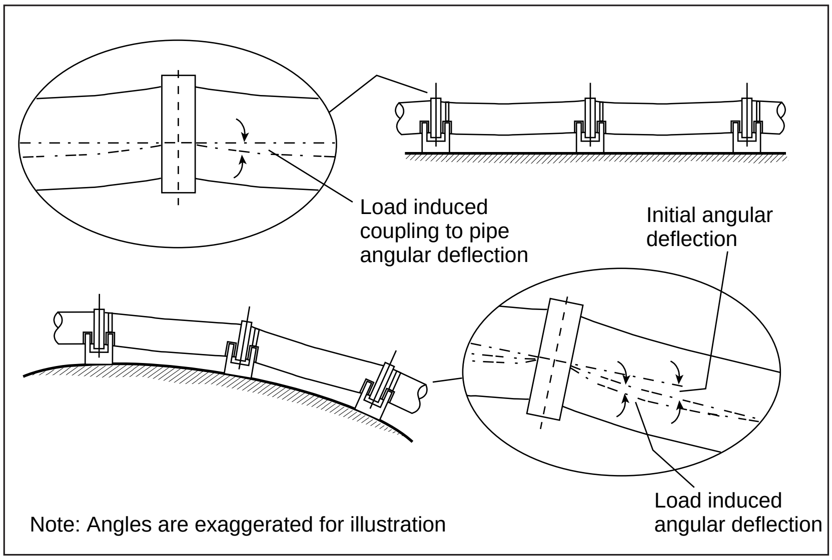

Figure 3.10
Pipe deflection

Table 3.1
Angular Deflection at Double Bell Coupling Joint
(See *Figure 3.9*)

Nominal Pipe Diameter	Nominal Angle of Deflection	Nominal Joint/Coupling Offset
(mm)	(°)	(mm)
300	3	17
350	3	20
400	3	22
450	3	25
500	3	28
600	2	21
700	2	25
800	2	29
900	2	32
1000	1	18
1200	1	21
1400	1	25
1600	1	29
1800	1	32
2000	0,5	18
2400	0,5	21

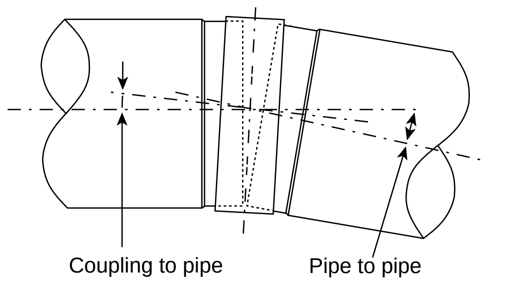

Figure 3.11
Angular deflection

If pipes are installed with angular deflection at joints, it must be ensured that the total angular deflection does not exceed the nominal values given in *Table 3.1*. In that regard, normal installation tolerances and the load induced angular deflections, explained below, have to be accounted for. The angular deflection of a joint shall be distributed on both sides of the coupling, see *Figure 3.11*. The coupling to pipe angular deflection shall under no circumstances exceed the values given in *Table 3.1*.

For aboveground pipelines, the loads acting on the pipeline will create angular deflection at joints although the pipes are installed in straight alignment. Normally most of the loads are gravitational forces causing angular deflection in the vertical convex direction, see *Figure 3.10*. The magnitude of this angular deflection depends on the pipe diameter and class as well as the supporting and loading conditions. For pipes installed in two cradles, with maximum support spacing and loading according to *Table 4.5*, this load induced angular deflection can on special occasions reach 70% of the nominal values given in *Table 3.1*. For pipes installed in multiple cradles, according to *Table 4.6*, this effect is limited to maximum 30% of the values from *Table 3.1*.

Anchoring of Pipes

Joined pipes shall not be left unanchored. Extreme temperature variations, e.g. caused by exposure to sunlight, will result in expansions and contractions in the pipes. If a string of several pipes is exposed to such conditions prior to anchoring of the individual pipes, couplings and pipes can be forced out of position.

Checking the Installed Joint

The quality of the joining operation is of utmost importance for the performance of the pipeline. Therefore a thorough checking of the installed joint is strongly recommended. Angular deflection, coupling position, joint misalignment and gap between pipe ends should be checked.

The quality of the joints should be checked as soon as possible after joining as the joint might be difficult to correct when the coupling gaskets have settled. The quality of the joint should also be checked after filling and pressurizing the pipeline, see *Section 5*.

Note: The installed joint should be checked at normal temperatures. High and/or uneven pipe temperatures, caused by e.g. direct sunlight, will affect the results of the check.

Angular Deflection

Both pipe to pipe and coupling to pipe angular deflection should be checked, see *Figure 3.11.*

The angular deflection is easiest checked with reference to the alignment stripes, see *Figures 3.12* and *3.14*.

The pipe to pipe angular deflection is for a given pipe dimension, approximately proportional to the joint offset which is the difference between the maximum and minimum distance between the alignment stripes, $d_{max} - d_{min}$, see *Figure 3.14*.

The coupling to pipe angular deflection is in a similar way approximately proportional to the coupling offset, $a_{max} - a_{min}$ for the left side and $b_{max} - b_{min}$ for the right side, see *Figure 3.12*.

The pipe to pipe and the coupling to pipe angular deflection can then be calculated based on the measured offset and the pipe's outer diameter. Alternatively, the angular deflection can be estimated by proportioning the nominal joint/coupling offset given in *Table 3.1*.

$$\text{Angular Deflection} = \text{Nominal Angular Deflection} \times \frac{\text{Measured Offset}}{\text{Nominal Offset}}$$

For allowable angular deflection see the section on Angular Deflection of Double Bell Couplings.

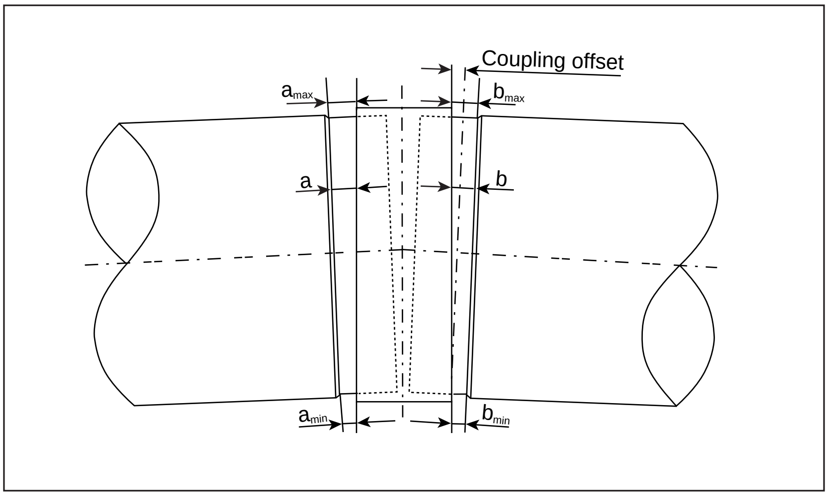

Figure 3.12
Measuring of coupling angular offset and position

Coupling Position

The coupling shall be mounted centric relative to the joint within a tolerance of +/– 10 mm.

The coupling position is easiest measured with reference to the alignment stripes. The average distance from the alignment stripe to the coupling edge is estimated for both sides of the coupling as:

$$a_{ave} = \frac{a_{max} - a_{min}}{2}$$

$$b_{ave} = \frac{b_{max} - b_{min}}{2}$$

See *Figure 3.12* for definitions. The coupling position relative to the centre of the joint is then calculated as:

$$-10\,\text{mm} \leq \frac{a_{ave} - b_{ave}}{2} \leq 10\,\text{mm}$$

Joint misalignment

Maximum misalignment of pipe ends shall not exceed the less of 0,5% of pipe diameter or 3 mm. The misalignment can be measured with two identical knotched rulers pressed against the pipe at both sides of the coupling, see *Figure 3.13*. If the depth of the machined spigot surface is different for the two pipes, the measured misalignment shall be corrected accordingly. For pipes 700 mm and larger the misalignment can be measured with a ruler from the inside of the pipe, see *Figure 3.13*.

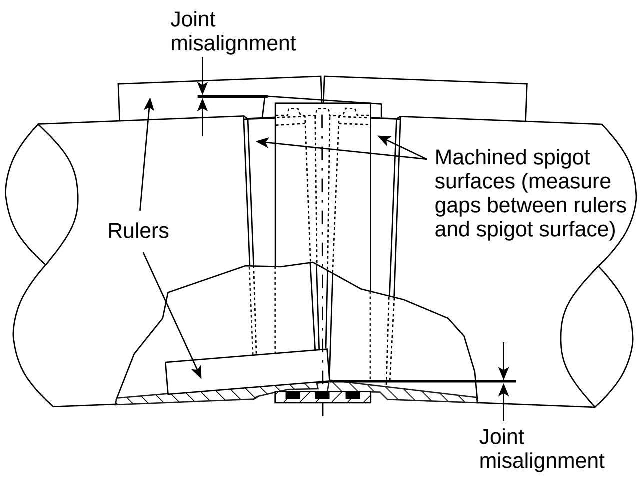

Figure 3.13
Misalignment

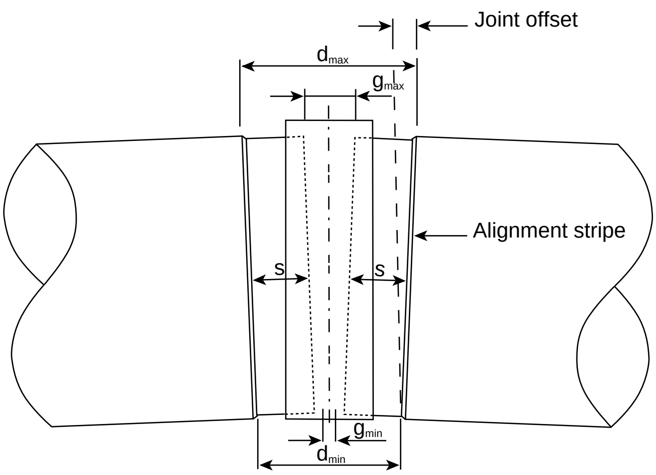

Figure 3.14
Gap between pipe ends

Gap Between Pipe Spigots

The gap between pipe spigots is easiest checked by measuring the distance between the alignment stripes, see *Figure 3.13*. The gap, g, is then calculated as:

$$g = d - 2s$$

The distance from the pipe end to the alignment stripes, s, can be found in the pipe specification or measured prior to installation. For pipes DN 700 and larger the gap can be measured directly from the inside of the pipe.

For joints with angular deflection, both maximum and minimum gap shall be measured.

For requirements for gap between pipe spigots, see the section on *Gap Between Pipe Spigots*.

Adjusting Joints

The joint shall be adjusted if any of the checks described in the preceding section falls outside the specified limits. The necessary adjustments of coupling or pipe position shall be made carefully, avoiding concentrated loads or impact loads that might damage pipe or coupling.

3.2 Other Coupling Joints

Flowtite aboveground pipe may also be joined by flexible steel and mechanical steel couplings. Following are some general guidelines but consult the supplier for specific details and recommendations.

Flexible Steel Couplings

(Straub, Tee Kay, etc. – See *Figure 3.15*)

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.

Three grades are available:

A. Polyamide or Epoxy coated steel mantle

B. Stainless steel mantle

C. Hot dip galvanized steel mantle

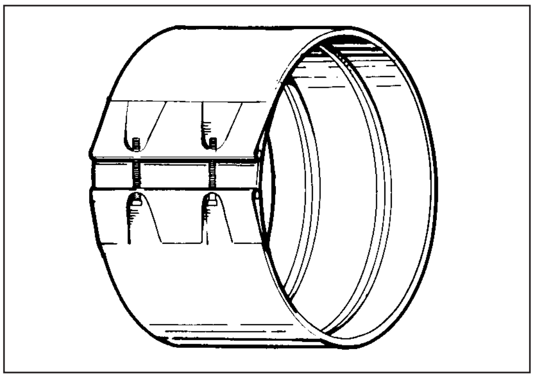

Figure 3.15
Flexible steel coupling

Control of bolting torque with these couplings is most important. After initial bolt up the coupling should be rapped with a rubber mallet to help seat and flow the gasket. Bolt torque should then be adjusted up to proper levels. Depending on coupling size, this procedure may need to be repeated several times. Do not over torque as this may over stress the bolts. Follow the manufacturer's recommended assembly instructions. Pressure and angular deflection limits will be specified by the supplier.

Mechanical Steel Couplings

(Viking Johnson, Dresser, etc.)

These couplings can be used for joining, typically to other types of pipe or to rigid items (*Figure 3.16*).

Bolting torque must be controlled to not exceed the manufacturer's maximum recommended values. Excessive torque could damage the pipe.

1. Manufacturer's assembly instructions will be provided for the type supplied.
2. Pressure and angular deflection limits will be specified.

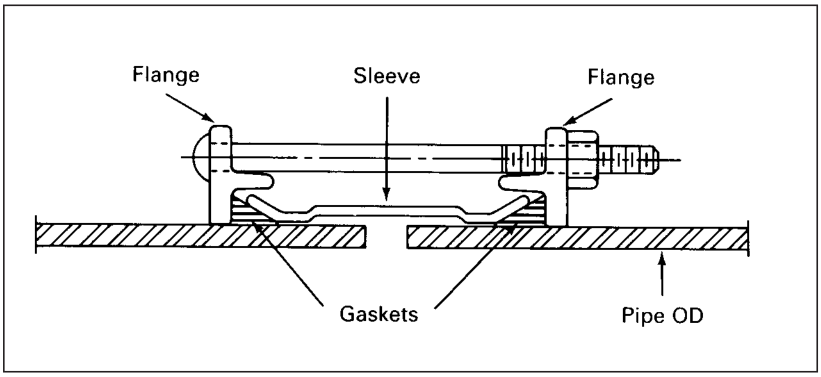

Figure 3.16
Mechanical steel coupling

Installation of aboveground pipes

4.1. Introduction

This section of the manual describes the requirements for installation of *Flowtite* pipes above ground.

It applies for pipes joined by non-restrained couplings as the double bell GRP coupling or flexible steel couplings.

When designing an aboveground pipe installation it is important to be aware of the forces that act on the pipe system and particularly for high pressure systems.

When a component in a pressurized pipeline has a change in cross-sectional area or direction, a resultant force is induced. All such components, as e.g. bends, reducers, tees, wyes or valves, must be anchored to withstand these loads.

For a buried pipeline, adequate resistance is provided by the pipe embedment and thrust blocks. Such resistance may not be provided at the supports of an aboveground pipeline. Care must be exercised to minimize misalignments and all components must be properly supported to ensure the stability of the pipeline.

4.2 Supporting of Pipes

Flowtite pipes are joined with couplings that do not restrain longitudinal expansion and contraction of the pipes.

To minimize the loads induced in pipes and supports, the supports shall not restrain longitudinal expansion of the pipes. It is, however, essential that the pipe movements are guided and controlled in such a way that all pipe sections are stable and that the coupling's ability to accept longitudinal movement is not exceeded.

The non-restrained couplings are flexible and it is very important that the stability of every pipe component is ensured by the supports. Every pipe shall therefore be supported by at least two cradles and anchored at one of these cradles while the remaining cradles shall be designed as a guide, allowing longitudinal expansion of the pipe but restraining lateral movements.

For pipes supported in more than two cradles, the cradle closest to the middle of the pipe should be used as an anchor.

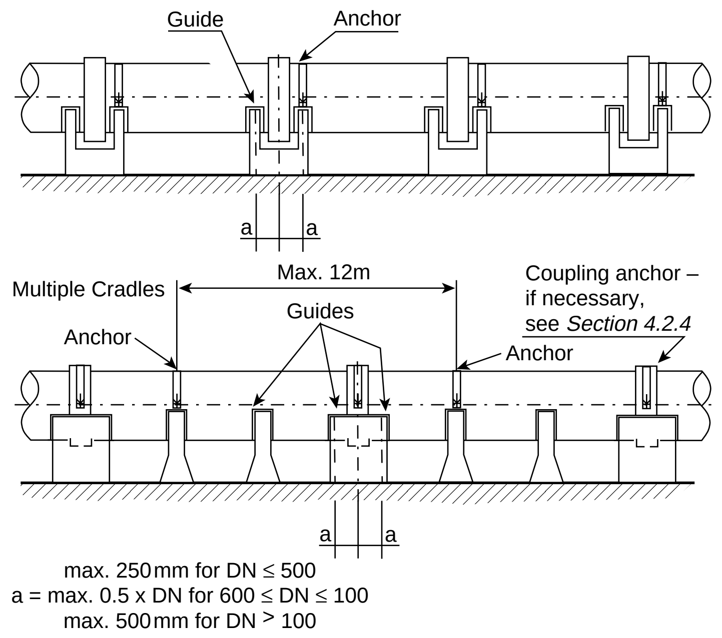

Figure 4.1
Flowtite® pipes. Typical support arrangement

The anchors shall be located with regular spacing in order to ensure even distribution of longitudinal pipe expansion on the joints. However, the distance between two anchors shall not exceed 12 m.

Figure 4.1 shows typical supporting of pipes.

Note: When a pipe is supported on more than two supports, the pipe supports shall be in straight alignment. Maximum deviation from straight alignment is 0,1% of the span length.

Supports shall limit displacement of pipes, in all of the restrained directions, to 0,5% of the diameter or 6 mm, whichever is less.

Note: It is important that support displacement does not result in misalignment of pipe ends in joints. Maximum allowable pipe end misalignment is the lesser of 0,5% of the diameter or 3 mm.

Pipes shall be installed in straight alignment in order to avoid reaction forces caused by angular deflection at joints. See *Section 3*.

The pipes must be supported adjacent to the joints in order to ensure the stability of the couplings. Maximum distance from the centerline of the joint to centerline of a support shall be 250 mm for pipes with DN 500 or less and the lesser of 0,5 x DN or 500 mm for pipes with DN 600 or larger *(Figure 4.1)*.

4.2.1 Support Design

Any excessive point or line loading shall be avoided when pipes are installed aboveground. Aboveground *Flowtite* pipes shall therefore be supported in cradles. Normally the cradles are made from concrete or steel. The cradles shall have a supporting angle of 150°. The diameter of the finished cradle with cradle liners shall be 0,5% larger that the outer diameter of the non-pressurized pipe *(Figure 4.2)*. The cradles shall have a minimum width of 150 mm for all pipes with DN ≤ 1000 mm and a minimum width of 200 mm for pipes with DN > 1000 mm *(Figure 4.2)*.

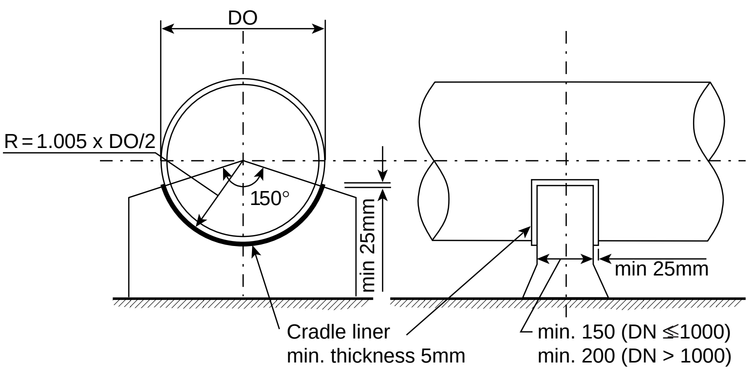

Figure 4.2
Cradle design

The inside of the cradles shall be covered with a 5 mm thick cradle liner to avoid direct contact between pipe and cradle. Liners must be made from materials that are resistant to the actual environment. High friction liners shall be applied at anchors while low friction liners shall be applied at guides. See *Section 4.2.3, Anchor design* and *Section 4.2.4, Guide design for liner specifications.*

Figure 4.2 shows the cradle design.

The pipe supports are designed as anchors or guides. Anchors are designed to restrain pipe movement. Guides are designed to allow the pipe to expand in the longitudinal direction but restrain it from any lateral displacement.

4.2.2 Loads on Supports

The supports shall be rigid and designed to withstand the actual loads caused by:

- External and environmental loads
- Weight of pipe and fluid
- Reaction forces caused by internal pressure
- Friction induced in couplings and against guides in case of temperature and/or pressure variations.

It is the responsibility of the owner's engineer to determine design loads for the supports.

Note: The reaction forces, caused by dead weight of water, act perpendicular to the pipe. For pipe installations with steep slope this results in a significant horizontal load on the pipe foundations.

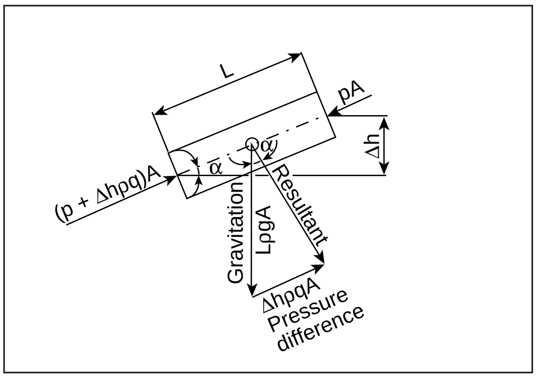

Figure 4.3
Forces

It is a common error to regard the reaction from water as vertical since it is a gravitational force, see *Figure 4.3*.

Table 4.1 provides approximate axial forces that should be considered in the design of support cradles. These loads result from contraction and elongation of pipe during operation and frictional resistance in the gasketed joint.

Table 4.1 is based on the assumption of simultaneous expansions and contractions of the neighboring pipes. If non-simultaneous expansions and contractions can be expected, contact the pipe supplier for adequate axial forces.

Frictional force between pipe and guide shall be determined based on total compression between pipe and cradle and the frictional coefficient between the pipe material and the cradle liner.

For the cradle liners suggested in *Section 4.2.4, Guide design,* the frictional coefficient can be assumed to be 0,3.

Table 4.1
SN 5000 *Flowtite* pipes. Axial loads due to frictional resistance in joints (kN)

DN	PN 1	PN 6	PN 10	PN 16
300	5	5	6	7
350	5	6	6	8
400	5	6	7	8
450	6	6	7	9
500	6	7	8	10
600	7	8	9	11
700	7	8	10	12
800	8	9	11	14
900	8	10	12	15
1000	9	11	13	16
1100	9	12	14	17
1200	10	12	15	19
1300	11	13	16	20
1400	11	14	17	21
1500	12	15	18	23
1600	12	15	19	24
1700	13	16	20	25
1800	14	17	21	27
1900	14	18	22	28
2000	15	18	23	29
2100	15	19	24	31
2200	16	20	25	32
2300	16	21	26	33
2400	17	22	27	35
2500	18	22	28	36

4.2.3 Anchor Design

Anchors shall be designed as cradles with high-friction cradle liners and a pretensioned steel clamp pressing the pipe against the cradle.

The pretension of the clamp shall be sufficient to prevent the pipe from moving in the cradle.

Note: GRP pipes have higher design strain and higher coefficient of thermal expansion than steel. The steel clamp shall therefore be designed with a spring element to compensate for this difference. The spring element shall be designed such that sufficient strap tension can be ensured at low temperatures without overloading the strap or the pipe in situations involving high temperatures and high working pressure.

The design of the steel clamp and the spring elements depends on the properties of the pipe and the loading conditions. *Figure 4.4* shows typical design of steel clamp with bracket and disk springs.

The key dimensions for six different standard clamp designs are shown in *Table 4.2.*

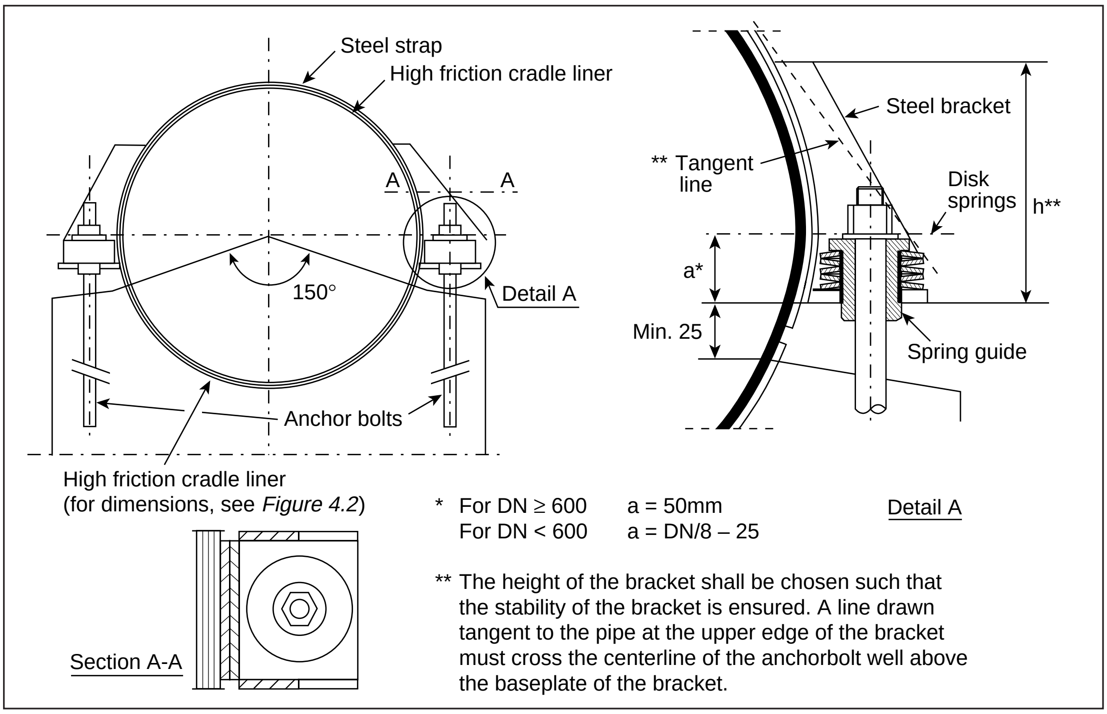

Figure 4.4
Clamp design

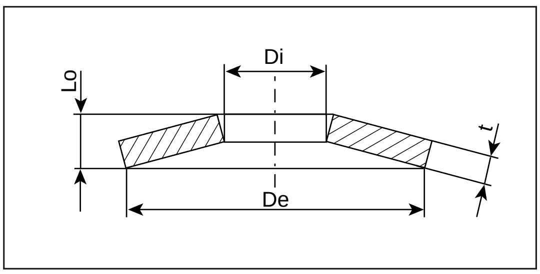

Figure 4.5
Disk spring dimensions

Table 4.2 Standard Clamp Design

Clamp Design	I	II	III	IV	V	VI
Design load	2 x 12 kN	2 x 22 kN	2 x 36 kN	2 x 50 kN	2 x 67 kN	2 x 95 kN
Steel strap**	100 x 5mm	100 x 5mm	120 x 5mm	120 x 5mm	140 x 6mm	140 x 8mm
Cradle liner*	100 x 5mm	100 x 5mm	120 x 5mm	120 x 5mm	140 x 5mm	140 x 5mm
Disk springs***	80 x 36 x 3; 5,7	80 x 36 x 4; 6,2	100 x 51 x 5; 7,8	100 x 51 x 6; 8,2	125 x 64 x 7;10	125 x 61 x 8; 10,6
Max. allowable single spring compression	2,03mm	1,65mm	2,10mm	1,65mm	2,25mm	2,18mm
Anchor bolts**	M20	M20	M25	M25	M30	M30

* The clamping specification in *Table 4.3* is based on high friction cradle liner with friction factor against pipe and cradle min 0,7 as i.e. 60-70 Shore A Thermoplastic Polyurethane.

** Dimensions are based on the following minimum steel qualities: Steel strap: ISO 630, Fe 360 (DIN 17100, St. 37)
Anchor bolt: ISO 630, Fe 510 (DIN 17100, St. 52)

*** The disk spring dimensions are given as follows: D_e x D_i x t; l_o
Where D_e is the spring external diameter in mm
D_i is the spring internal diameter in mm
t is the spring thickness in mm
l_o is the spring length in mm

Table 4.3 shows clamp design, number of spring elements, number of disk springs in spring element and precompression of spring elements for SN5000 *Flowtite* pipes.

Table 4.3 is worked out for *Flowtite* pipes on two supports as shown on *Figure 4.8* and maximum pipe length according to *Table 4.4.*

Table 4.3 is worked out based on the following loading conditions:

Maximum working pressure	=	Nominal pressure
Maximum surge pressure	=	1,4 x Nominal pressure
Maximum external load on pipe	=	2,5 kN/m² on projected area
Maximum slope of pipe		10, 20 and 30°, see table heading
Joint axial load		According to *Table 4.1*
Minimum temperature, empty pipe		50°C lower than installation temperature
Maximum temperature, empty pipe		50°C higher than installation temperature
Minimum temperature, filled pipe		20°C lower than installation temperature
Maximum temperature, filled pipe		20°C higher than installation temperature

The clamp design is specified in *Table 4.3* with the following nomenclature:

N x n/c

where N is the number of spring elements

N = 1 means spring element on one side of the clamp

N = 2 means spring elements on both sides of the clamp

n is the number of disk springs in each spring element

c is the required precompression of each spring element in mm. The values apply for non-pressurized, pipes

The applicable clamp design from *Table 4.2* is shown in the last column of the table. The clamp design applies for the area of the table marked with lines.

Table 4.3a
SN 5000 *Flowtite* Pipes on Two Supports. Clamping of Pipes on Anchors. Maximum Slope 10⁰

DN	PN 1	PN 6	PN 10	PN 16	Clamp Design
300	1 x 3/2,5	1 x 3/2,5	1 x 3/2,4	1 x 3/2,4	
350	1 x 3/2,9	1 x 3/2,7	1 x 3/2,7	1 x 3/2,7	
400	1 x 3/3,1	1 x 3/3,0	1 x 3/2,9	1 x 3/3,0	
450	1 x 3/3,3	1 x 3/3,3	1 x 3/3,1	1 x 5/4,2	I
500	1 x 3/3,4	1 x 3/3,5	1 x 3/3,3	1 x 5/4,4	
600	1 x 3/3,6	1 x 5/5,0	1 x 5/4,9	1 x 7/7,6	
700	1 x 3/3,8	1 x 5/5,5	1 x 7/7,5	1 x 7/7,6	
800	1 x 5/6,3	1 x 5/3,1	1 x 5/3,0	1 x 7/4,0	
900	2 x 5/6,9	1 x 5/3,4	2 x 3/1,9	2 x 5/3,1	
1000	2 x 5/7,0	2 x 3/2,2	2 x 5/3,3	2 x 5/3,4	II
1100	2 x 5/7,6	2 x 5/3,7	2 x 5/3,6	2 x 5/3,7	
1200	2 x 3/2,7	2 x 5/4,0	2 x 5/3,9	2 x 7/5,4	
1300	2 x 5/4,5	2 x 5/4,3	2 x 7/5,7	2 x 7/5,8	
1400	2 x 5/4,8	2 x 7/6,2	2 x 7/6,1	2 x 5/3,5	
1500	2 x 5/5,1	2 x 7/6,6	2 x 5/3,8	2 x 5/3,8	
1600	2 x 5/5,4	2 x 5/4,1	2 x 5/4,0	2 x 5/4,0	
1700	2 x 7/7,7	2 x 5/4,4	2 x 5/4,3	2 x 7/5,8	
1800	2 x 7/8,2	2 x 5/4,6	2 x 7/6,1	2 x 7/6,2	III
1900	2 x 5/5,2	2 x 5/4,9	2 x 7/6,4	2 x 7/6,5	
2000	2 x 5/5,5	2 x 7/6,9	2 x 7/6,8	2 x 9/8,7	
2100	2 x 5/5,8	2 x 7/7,3	2 x 9/9,0	2 x 9/9,1	
2200	2 x 5/6,1	2 x 7/7,6	2 x 9/9,4	2 x 11/11,6	
2300	2 x 5/6,4	2 x 9/10,0	2 x 9/9,9	2 x 11/12,2	
2400	2 x 7/8,8	2 x 9/10,4	2 x 11/12,5	2 x 7/5,0	IV
2500	2 x 7/9,1	2 x 9/10,9	2 x 11/13,1	2 x 7/5,3	

Table 4.3b
SN 5000 *Flowtite* Pipes on Two Supports. Clamping of Pipes on Anchors. Maximum Slope 20^0

DN	PN 1	PN 6	PN 10	PN 16	Clamp Design
300	1 x 3/2,5	1 x 3/2,5	1 x 3/2,4	1 x 3/2,4	
350	1 x 3/2,9	1 x 3/2,7	1 x 3/2,7	1 x 3/2,7	
400	1 x 3/3,1	1 x 3/3,0	1 x 5/4,8	1 x 3/2,7	
450	1 x 3/3,5	1 x 3/3,3	1 x 3/2,9	1 x 5/4,7	I
500	1 x 3/3,8	1 x 5/5,8	1 x 5/5,1	1 x 5/5,1	
600	1 x 3/3,9	1 x 5/6,0	1 x 7/8,2	1 x 7/8,3	
700	1 x 5/7,1	1 x 7/9,5	1 x 5/3,3	1 x 7/4,5	
800	1 x 7/11	1 x 5/3,9	1 x 7/5,1	1 x 7/4,5	II
900	1 x 5/4,6	1 x 7/5,9	2 x 5/4,1	2 x 5/4,1	
1000	2 x 3/3,2	2 x 5/4,6	2 x 5/4,6	2 x 5/2,2	
1100	2 x 5/5,3	2 x 5/5,2	2 x 7/7,0	2 x 5/4,0	
1200	2 x 5/5,9	2 x 3/2,8	2 x 5/4,4	2 x 5/4,4	III
1300	2 x 3/3,3	2 x 5/4,9	2 x 5/4,8	2 x 5/4,9	
1400	2 x 3/3,6	2 x 5/5,4	2 x 5/5,3	2 x 7/7,3	
1500	2 x 3/4,1	2 x 5/5,9	2 x 7/7,8	2 x 7/8,0	
1600	2 x 5/6,0	2 x 7/8,6	2 x 7/8,5	2 x 7/5,2	
1700	2 x 5/7,2	2 x 7/9,3	2 x 7/5,6	2 x 9/7,2	IV
1800	2 x 7/10,4	2 x 7/6,2	2 x 9/7,6	2 x 9/7,7	
1900	2 x 7/11,2	2 x 9/8,2	2 x 8/8,2	2 x 7/6,4	
2000	2 x 7/7,5	2 x 9/8,9	2 x 7/6,8	2 x 7/6,8	
2100	2 x 7/8,0	2 x 5/5,5	2 x 7/7,3	2 x 7/7,3	V
2200	2 x 5/6,3	2 x 7/7,9	2 x 7/7,7	2 x 9/9,9	
2300	2 x 5/6,7	2 x 7/8,4	2 x 9/10,3	2 x 9/10,5	
2400	2 x 5/7,1	2 x 7/8,9	2 x 9/11,0	2 x 9/8,0	VI
2500	2 x 5/7,3	2 x 9/11,9	2 x 7/6,7	2 x 9/8,4	

Table 4.3c
SN 5000 *Flowtite* Pipes on Two Supports. Clamping of Pipes on Anchors. Maximum Slope 30^0

DN	PN 1	PN 6	PN 10	PN 16	Clamp Design
300	1 x 3/2,5	1 x 3/2,5	1 x 3/2,4	1 x 3/2,4	
350	1 x 3/2,9	1 x 3/2,7	1 x 3/2,7	1 x 3/2,7	
400	1 x 3/3,1	1 x 3/3,0	1 x 3/2,9	1 x 5/4,8	
450	1 x 3/3,5	1 x 3/3,3	1 x 5/5,2	1 x 5/5,2	I
500	1 x 3/3,8	1 x 5/5,8	1 x 5/5,8	1 x 7/8,0	
600	1 x 5/7,2	1 x 7/9,6	2 x 5/6,7	2 x 5/6,8	
700	1 x 7/11,6	2 x 5/8,0	1 x 7/5,3	1 x 7/5,3	
800	1 x 5/4,8	1 x 7/6,3	2 x 5/4,4	2 x 5/4,4	II
900	1 x 5/5,6	2 x 5/5,1	2 x 5/5,0	2 x 7/7,0	
1000	2 x 5/6,0	2 x 7/7,9	2 x 5/4,4	2 x 5/4,5	
1100	2 x 3/3,3	2 x 5/5,1	2 x 5/5,0	2 x 5/5,1	III
1200	2 x 3/3,8	2 x 5/5,7	2 x 5/5,6	2 x 7/7,9	
1300	2 x 3/4,2	2 x 5/6,4	2 x 7/8,7	2 x 7/8,8	
1400	2 x 5/7,3	2 x 7/9,7	2 x 7/6,8	2 x 7/6,9	IV
1500	2 x 3/8,1	2 x 7/6,5	2 x 7/6,8	2 x 9/8,2	
1600	2 x 5/5,5	2 x 7/7,1	2 x 9/8,8	2 x 5/5,0	
1700	2 x 7/8,1	2 x 9/9,7	2 x 5/5,4	2 x 7/7,5	V
1800	2 x 7/8,7	2 x 5/6,0	2 x 7/8,0	2 x 7/8,1	
1900	2 x 5/6,9	2 x 5/6,5	2 x 7/8,6	2 x 9/11,1	
2000	2 x 5/7,9	2 x 7/9,5	2 x 9/11,8	2 x 7/6,7	
2100	2 x 5/8,0	2 x 9/12,9	2 x 7/7,2	2 x 7/7,2	
2200	2 x 7/11,5	2 x 9/13,8	2 x 7/7,7	2 x 9/9,8	VI
2300	2 x 5/6,7	2 x 7/8,4	2 x 9/10,4	2 x 11/12,7	
2400	2 x 5/7,1	2 x 7/9,0	2 x 9/11,1	2 x 11/13,6	
2500	2 x 7/9,9	2 x 9/12,0	2 x 11/14,2	2 x 11/14,4	

Table 4.3 applies also for pipes supported in more than two cradles, provided that the cradle closest to the middle of the pipe is used as the anchor *(Figure 4.1)*.

For other installation and loading conditions, contact pipe supplier.

The specified precompression of spring elements is achieved by marking the spring guide relative to the clamp after having finger tightened the anchor nut. The marking shall be made as permanent as possible in order to enable checks at a later stage. Then the nut shall be tightened until the mark on the guide has been displaced to the specified precompression +/- 10% *(Figure 4.6)*.

Note: The tension in the steel strap tends to be uneven due to the friction against the protective liner. The tension shall be distributed by tapping the steel strap with a rubber mallet while the anchor nuts are being tightened.

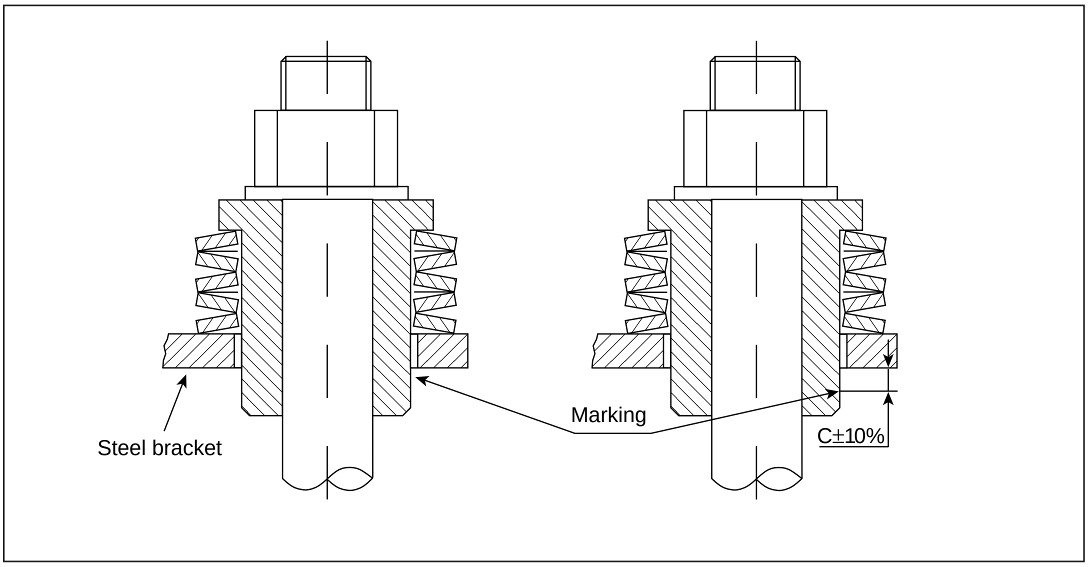

Figure 4.6
Adjusting precompression of disk springs

4.2.4 Guide Design

Guides shall be designed as cradles with low-friction cradle liners *(Figure 4.2)*. The friction factor between *Flowtite* pipes and the liner shall be less than 0,3. This requirement is fulfilled by e.g. ultrahigh-molecular polyethylene and polytetrafluorethylene liners. It must be ensured that the liner material is resistant to the actual environment. The cradle liner shall be permanently attached to the guide cradle to ensure its stability.

In many situations, the weight of pipe and fluid is sufficient to ensure the lateral stability of a pipe in a guide. The ends of short high-pressure pipes can, however, lift up from guides as a result of an unfavourable combination of high pressure forces in the fluid and pipe to coupling angular deflection. The need for securing of pipe ends depends on the combination of internal pressure, pipe to coupling angular deflection and the supporting conditions.

Vertical convex angular pipe to coupling deflection and internal pressure creates a force that tends to lift the pipe end *(Figure 4.7)*.

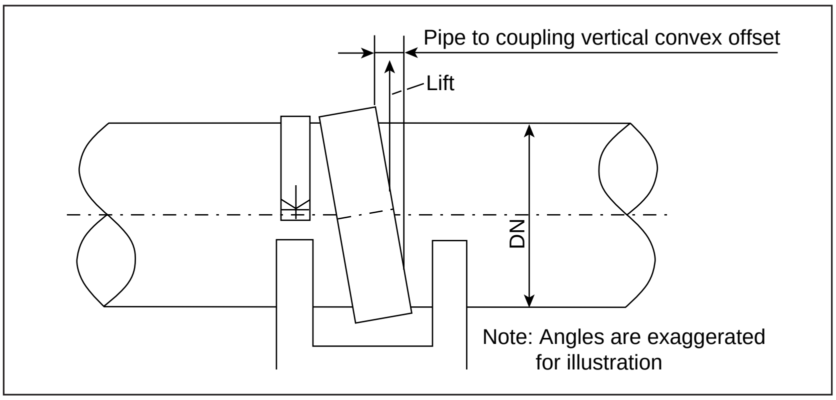

Figure 4.7
Stability of pipe ends on guides

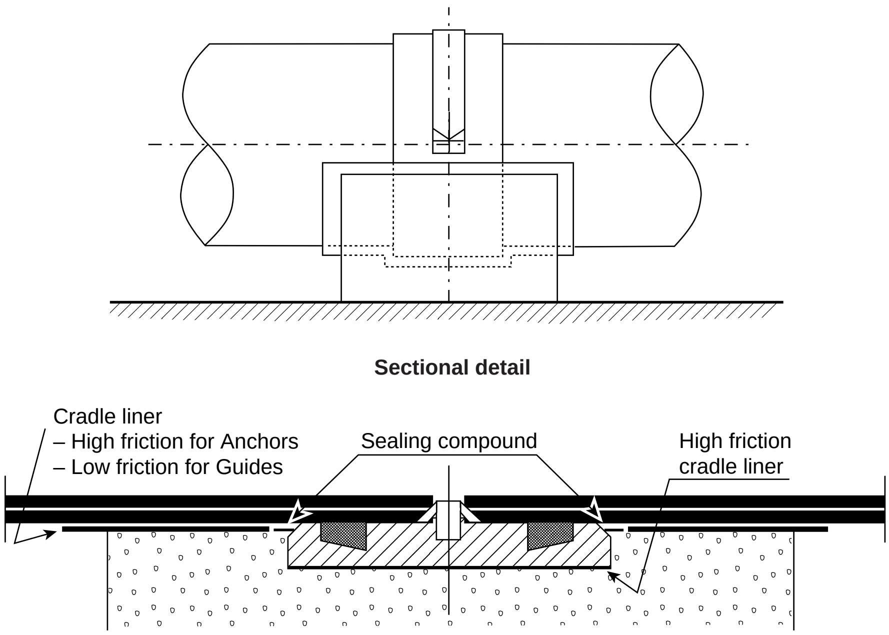

Figure 4.8
Anchoring of couplings to concrete supports

If such a lifting force can become large enough to lift up pipe end, the pipe ends must be secured. The securing of pipe ends is best achieved by clamping the coupling to the foundation supporting the joint. For in situ cast concrete supports, see *Figure 4.8*. The clamps used for anchoring of pipes, see *Section 4.2.3*, can be used for clamping of couplings to foundations. See *Section 4.2.3* for selection and mounting of clamps.

The need for securing pipe ends depends on the angular deflection at joints, the pressure in the pipes and the supporting conditions. Both pipe to pipe and coupling to pipe angular deflection must be considered.

Tables 4.4a and *4.4b* show the minimum support spacing needed to ensure sufficient reaction from the dead weight of pipe and fluid to counteract the lifting force created. A vertical convex angular deflection corresponding to the values given in *Table 3.1* is assumed together with working pressure equal to the nominal pressure of the pipe, surge pressure equal to 1,4 x nominal pressure and maximum field test pressure as given in *Table 5.1*. The tables are worked out for pipe installations in different slopes.

Table 4.4a
Water Filled Pipes on Two Cradles. Minimum Pipe Length for Stable Ends

Minimum Pipe Length for Stable Pipe Ends

Nominal Pipe Diameter	Vertical Convex Angle of Deflection	PN1			PN6			PN10			PN16		
		Slope			Slope			Slope			Slope		
		10°	20°	30°	10°	20°	30°	10°	20°	30°	10°	20°	30°
(mm)	(°)	m	m	m	m	m	m	m	m	m	m	m	m
300≤DN<500	3	1,2	1,3	1,4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
500<DN≤900	2	0,8	0,8	0,9	4,8	5,0	5,4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
900<DN≤1800	1	0,4	0,4	0,5	2,4	2,5	2,7	4,0	4,2	4,5	6,4	6,7	7,2
1800<DN	0,5	0,2	0,2	0,2	1,2	1,3	1,4	2,0	2,1	2,3	3,2	3,3	3,6

* n.a. = not applicable clamp couplings

Table 4.4b
Water Filled Pipes on Multiple Cradles. Minimum Support Spacing for Stable Ends

Minimum Support Spacing for Stable Pipe Ends

Nominal Pipe Diameter	Vertical Convex Angle of Deflection	PN1			PN6			PN10			PN16		
		Slope			Slope			Slope			Slope		
		10°	20°	30°	10°	20°	30°	10°	20°	30°	10°	20°	30°
(mm)	(°)	m	m	m	m	m	m	m	m	m	m	m	m
300≤DN<500	3	1,6	1,7	1,8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
500<DN≤900	2	1,1	1,1	1,2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
900<DN≤1800	1	0,5	0,6	0,6	3,2	3,3	3,6	5,3	5,6	6,0	n.a.	n.a.	n.a.
1800<DN	0,5	0,3	0,3	0,3	1,6	1,7	1,8	2,7	2,8	3,0	4,2	4,4	4,8

* n.a. = not applicable clamp couplings

4.3 Maximum Supporting Spacing

The maximum support spacing is determined based on the properties of the pipe and the loading conditions.

Stresses in the pipe wall must be kept within allowable limits and excessive pipe deflections must be avoided.

Table 4.5 shows maximum pipe lengths for *Flowtite* pipes supported on two cradles.

The table is based on the following loading conditions and pipe support as shown in *Figure 4.9.*

Density of fluid	1000 kg/m^3
Maximum working pressure	Nominal pressure
Maximum field test pressure	According to *Table 5.1*
Maximum surge pressure	1,4 x nominal
Maximum external load on pipe	2,5 kN/m^2 proj. area

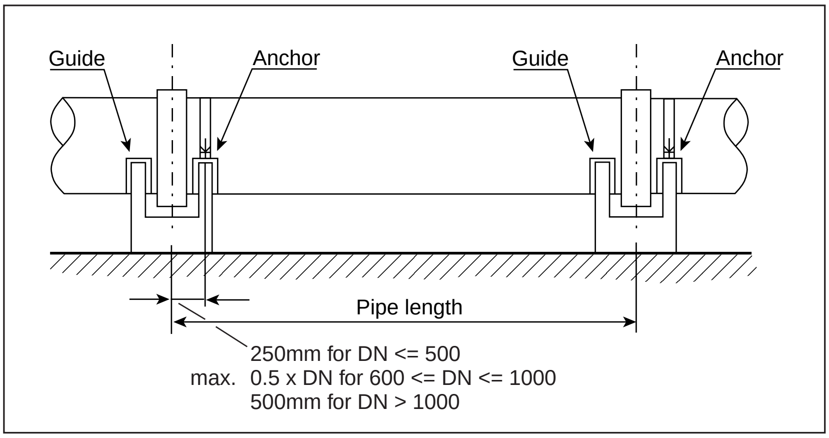

Figure 4.9
Pipes supported on two cradles

Table 4.5
SN 5000 Maximum Pipe Length on Two Cradles [m]

DN	PN 1	PN 6	PN 10	PN 16
300	2,8	2,6	2,6	2,6
350	3,3	3,1	3,1	2,9
400	3,5	3,3	3,3	3,2
450	3,9	3,7	3,7	3,6
500	4,3	4,1	4,1	4,0
600	4,9	4,8	4,7	4,7
700	5,4	5,4	5,3	5,4
800	5,8	5,8	5,9	6,0
900	6,3	6,3	6,4	6,6
1000	6,7	6,7	6,9	7,1
1100	7,1	7,1	7,3	7,7
1200	7,5	7,5	7,7	8,1
1300	7,8	7,9	8,1	8,5
1400	8,1	8,2	8,4	8,8
1500	8,4	8,5	8,7	9,1
1600	8,6	8,7	8,9	9,4
1700	8,8	8,9	9,2	9,6
1800	9,0	9,1	9,4	9,9
1900	9,2	9,3	9,6	10,1
2000	9,4	9,5	9,8	10,3
2100	9,6	9,7	10,0	10,5
2200	9,7	9,9	10,2	10,7
2300	9,9	10,0	10,4	10,9
2400	10,0	10,2	10,5	11,1
2500	10,1	10,4	10,7	11,3

Table 4.6 shows maximum support spacing for *Flowtite* pipes supported on three or more cradles.

Maximum standard *Flowtite* pipe length is 12 m and the table covers only support spacing lower than 6 m.

The table is worked out based on the following loading conditions and supporting as shown in *Figure 4.10.*

Density of fluid	1000 kg/m^3
Maximum working pressure	Nominal pressure
Maximum field test pressure	According to *Table 5.1*
Maximum surge pressure	1,4 x nominal
Maximum external load on pipe	2,5 kN/m^2 proj. area

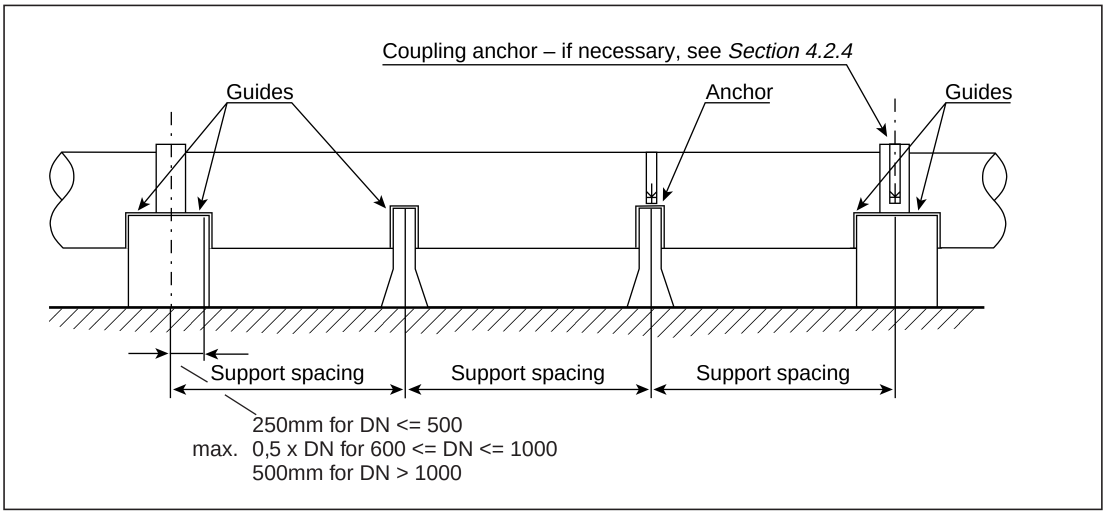

Figure 4.10
Pipes supported in multiple cradles

Table 4.6
SN 5000 Maximum Support Spacing, Multiple Cradle Installations [m]

DN	PN 1	PN 6	PN 10	PN 16
300	2,7	2,6	2,8	2,6
350	3,2	3,2	3,3	2,9
400	3,5	3,4	3,6	3,2
450	3,9	3,9	4,1	3,6
500	4,2	4,3	4,4	4,0
600	4,7	4,9	5,1	4,8
700	5,3	5,4	5,6	5,6
800	5,7	5,8	6,0	6,0
900	6,0	6,0	6,0	6,0

For other loading conditions, please consult the supplier.

4.4 Negative Pressure

The allowable negative pressure (vacuum) is -0,5 bar for SN 5000 and -1,0 bar for SN 10,000.

Checking the installed pipe

5.1 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 permit 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. 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:
   - Joints assembled correctly.
   - System restraints (i.e. thrust blocks, and other anchors) in place and properly cured
   - Flange bolting torqued per instructions
   - Valves and pumps anchored

   See *Section 5.2*.

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.

   When the pipeline has been filled it shall be inspected. See *Section 5.3*.

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. Insure the maximum test pressure is *not* exceeded (See *Table 5.1*). 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) 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
   - Check joints for leakage

Table 5.1 Maximum Field Test Pressures

Pressure Class	Maximum Field Test Pressure
100 kPa	150 kPa
600 kPa	900 kPa
1000 kPa	1500 kPa
1600 kPa	2400 kPa

5.2 Inspection Prior to Filling of Pipe

The pipe shall not be filled with water until the complete installation has been inspected in order to assure that all work has been finished properly.

Special attention shall be paid to the following aspects:

(1) Joints

- The joints shall be checked as described in *Section 3* in regard to:
  - angular deflection
  - coupling position
  - joint alignment and
  - the gap between the pipe ends
- The coupling position relative to both of the pipes shall be marked at 4 points around the circumference *(Figure 5.1)* as reference for later checks.
- It shall be checked that the gaskets are correctly seated and that the gap between pipe spigot and coupling sleeve is free of concrete or other foreign inclusions.

(2) Supports

- Check that the cradle gives even and continuous support to the pipe and that the cradle diameter is 0,5 ±0,25% larger than the pipe. Check the support angle to be 150 ± 5°.
- For pipes supported on more than two supports, the alignment of pipe supports shall be checked. Maximum deviation from straight alignment is 0,1% of the span length.
- Check that the cradle liner is in place between the pipe and the cradle and ensure that there is no direct contact between cradle and pipe. Check that there is no concrete or other foreign inclusion between the pipe and the cradle liner.
- Check that there are high-friction liners at anchors and low-friction liners at guides.
- Check the structural integrity of the supports.
- Mark the position of the pipe relative to the anchors, as reference for later inspection.

(3) Clamps

- Check that the liner is correctly positioned between the clamp and the pipe or coupling.
- Check the number and compression of disk springs against the specification.
- Check structural integrity of the steel clamp and anchor bolts.
- Check that the steel clamp is positioned perpendicular to the pipe axis.

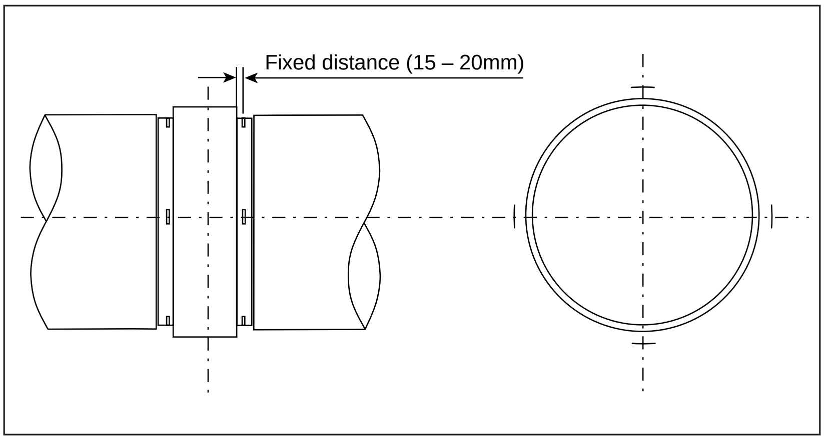

Figure 5.1
Marking coupling position

(4) Pipes

- Inspect the pipes to ensure that they have not been damaged in the installation phase.
- Check the support spacing against specifications.

(5) Other

- Check thrust blocks, anchors, valve pumps, etc.

5.3 Inspection of Filled Pipeline Prior to Pressurizing

When the pipe has been filled with water, it shall be inspected prior to pressurizing. Special attention shall be paid to the following aspects:

(1) Joints

- Inspect the joints for any sign of leakage.
- Check couplings' movement relative to the marks made prior to filling the pipe.

Note: The weight of fluid in the pipe will cause rotation of pipe ends *(Figure 5.2).*

- Check the coupling to pipe angular offset, see *Section 3.*
- If a coupling has moved, its new position relative to both of the pipes shall be marked at 4 points around the circumference *(Figure 5.1).*
- If there is any sign of coupling movement in excess of what can be explained by load induced pipe end rotation, the position of the coupling shall be checked. The stability of the coupling and the pipe end supports shall also be verified in an appropriate way.

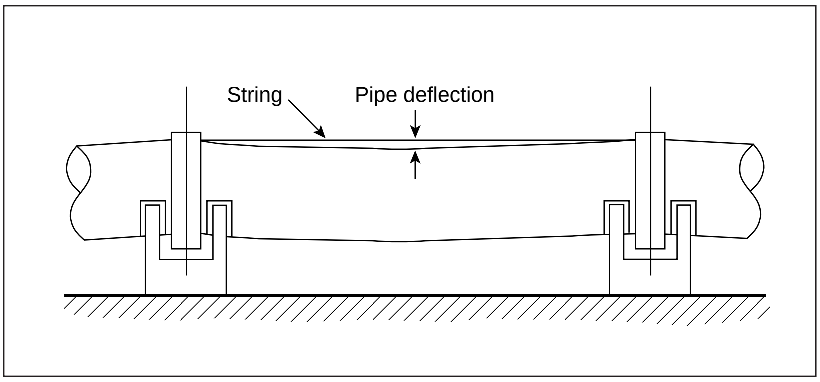

Figure 5.2
Pipe deflection

- If there is a reason to believe that supports might have settled due to the added weight, the pipe end misalignment shall be checked. Pipe end misalignment shall be less than 0,5% of pipe diameter and 3 mm.

(2) Supports

- Check the structural integrity and stability of the supports. Check if the added weight has caused settlement or deflection of supports.

3) Pipes

- Measure the maximum deflection of the pipes for each pipe span. The pipe deflection can be measured by using a tensioned string as a reference *(Figure 5.2).*
- If the maximum deflection at any pipe span exceeds the span length divided by 300, the pipe supplier shall be contacted prior to pressurizing the pipe.

5.4 Inspection of Pressurized Pipelines

When the pipe has been pressurized, the pipe shall be inspected. Special attention shall be paid to the following aspects:

(1) Joints

- Inspect the joints for any sign of leakage.
- It shall be checked if the couplings have moved relative to the marks made prior to pressurizing of the pipe.

Note: In addition to the Poisson's effect, the pressure increase in the pipe can cause slight rotation of pipe ends *(Figure 5.2).*

- Check the coupling to pipe angular offset, see *Section 3.*

  If there is any sign of coupling movement in excess of what can be explained by the Poisson's effect and pressure induced pipe end rotation, the stability of the coupling and the pipe end supports shall be verified in an appropriate way.

(2) Supports

- Check the structural integrity and stability of the supports. Check if the pressure increase has caused settlement or deflection of supports.
- Use the marks to check if the pipe has moved relative to the anchors. If a pipe has moved relative to anchor, the pipe shall be depressurized and the anchoring revised prior to repressurizing.

(3) Clamps

- Check the compression of disk springs and ensure that the compression does not exceed the maximum allowable spring compression *(Table 4.2)*. The spring compression can be measured using the marks on the spring guide *(Figure 4.4)*.
- Check structural integrity of the steel clamp and anchor bolts.

(4) Pipes

- Measure the maximum deflection of the pipes for each pipe span. The pipe deflection can be measured by using a tensioned string as a reference *(Figure 5.2)*.
- If the maximum deflection at any pipe span has increased by more than 50% compared to the deflection measured for filled and unpressurized pipe, the pipe shall be depressurized immediately and the pipe supplier shall be contacted.

Thrust blocks, concrete encasement, rigid connections

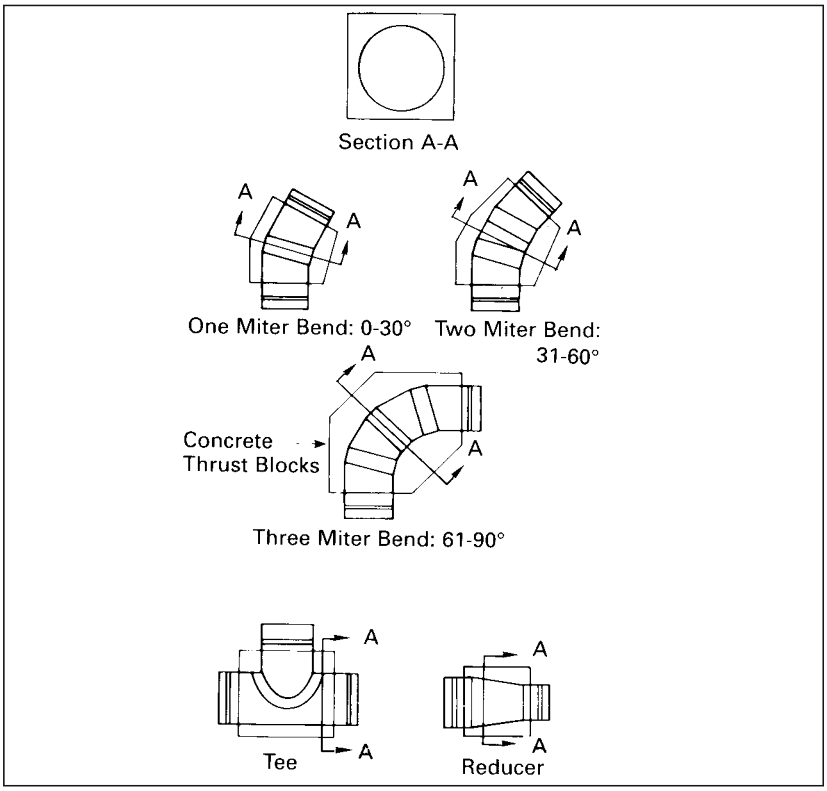

Figure 6.1
Thrust blocks

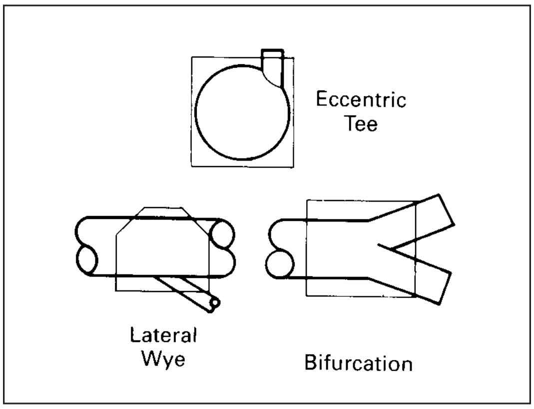

Figure 6.2
Stress blocked fittings

Note: It is important that support displacement does not result in misalignment of pipe ends in joints. Maximum allowable pipe end misalignment is the lesser of 0,5% of the diameter or 3 mm.

6.1 Thrust Restraints

When the pipeline is 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. Determination of need and design of these restraints is the responsibility of the owner's engineer subject to the following limitations:

Thrust Blocks

Thrust blocks must limit the displacement of the fitting to 0,5% of the diameter or 6 mm, whichever is less. The block must completely surround the fitting for its entire length and circumference *(Figure 6.1)* and must be built on sound foundation. See *Section 6.4* on *Rigid Connections* and *Section 6.2* on *Concrete Encasement* for details of pipe installation and system layout.

Note: It is important that support settlement does not result in misalignment of pipe ends in joints. Maximum allowable pipe end misalignment is the lesser of 0,5% of the diameter or 3 mm.

These blocks are applicable to the following components. These blocks are required for the following fittings when the line pressure exceeds 100 kPa.

1. All bends, reducers, bulkheads and blind flanges.
2. Tees, when the branch pipe is concentric to the header pipe centerline.

Thrust/Stress Blocks

Thrust/stress blocks must limit the displacement of the fitting to 0,5% of the diameter or 6 mm, whichever is less. They must also restrict the radial deformation of the fitting to 0,1% of the radius of the respective pipe sections. The block must completely surround the fitting for its entire length and circumference *(Figure 6.1)*. See sections on *Rigid Connections* and *Concrete Encasement* for details of pipe installation and system layout. These blocks are required for the following fittings when the line pressure exceeds 100 kPa (See *Figure 6.2*):

1. Tees, when the branch pipe is eccentric to the header pipe centerline.
2. Lateral wyes.
3. Bifurcations.
4. Custom fittings as noted by special instructions.

Valves

Valves must be anchored sufficiently to absorb the pressure thrust.

Nozzles

Nozzles are tee branches meeting all the following criteria:

1. Nozzle diameter ≤ 300 mm.
2. Header diameter ≥ 3 times nozzle diameter.
3. If the nozzle is not concentric and/or not perpendicular to the header pipe axis, the nozzle diameter shall be considered to be the longest chord distance on the header pipe wall at the nozzle/pipe intersection.

Note: It is not necessary to encase nozzle connections in concrete.

6.2 Concrete Encasement

When pipes must be encased in concrete, such as for thrust blocks, stress blocks, or to carry unusual loads, specific limitations in the installation procedures must be observed.

Pipe Anchoring

During the pouring of the concrete, the empty pipe will experience uplift (flotation) forces. The pipe must be restrained against movement that could be caused by these loads. This is normally accomplished by strapping over the pipe to a base slab or other anchor(s). Straps should be a flat material of minimum 25 mm width, strong enough to withstand flotation uplift forces, spaced not to exceed 4 meters, with a minimum of one strap per section length. The straps should be tightened to prevent pipe uplift, but not so tight that additional pipe deflection is caused *(Figure 6.3)*.

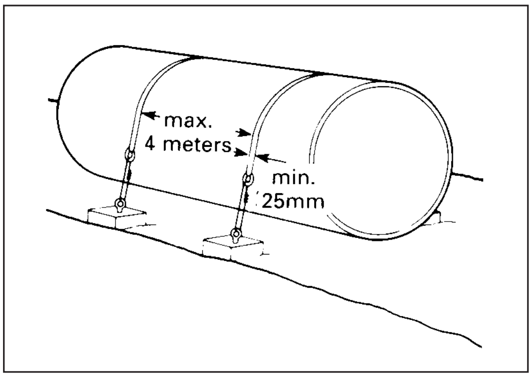

Figure 6.3
Pipe anchoring

Pipe Support

The pipe should be supported in such a way that the concrete can easily flow completely around and fully underneath the pipe. Also, the supports should result in an acceptable pipe shape *(less than 1% deflection and no bulges or flat areas),* and be a lifetime structural material. Supports are normally placed at strap locations (not exceeding 4 meter spacing) *(Figure 6.4).*

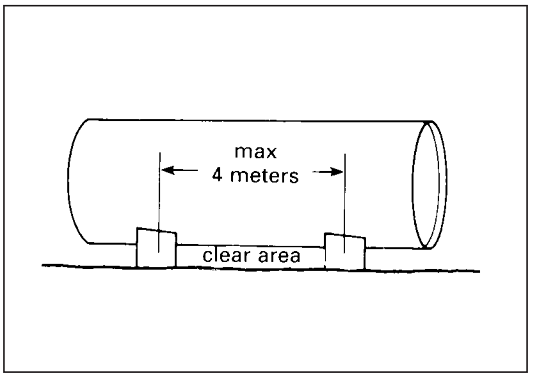

Figure 6.4
Pipe support

Concrete Pouring

The concrete surround must be placed in stages allowing sufficient time between layers for the cement to set (no longer exert buoyant forces). Maximum lift height is as shown on *Figure 6.5.*

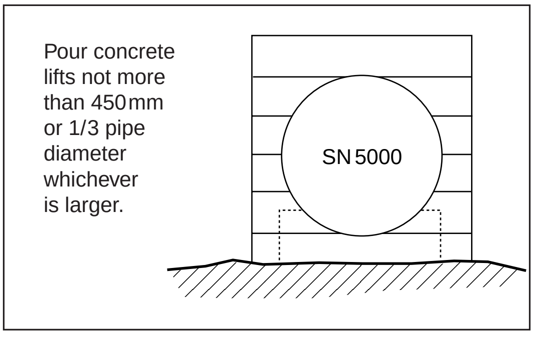

Figure 6.5
Concrete pouring SN 5000

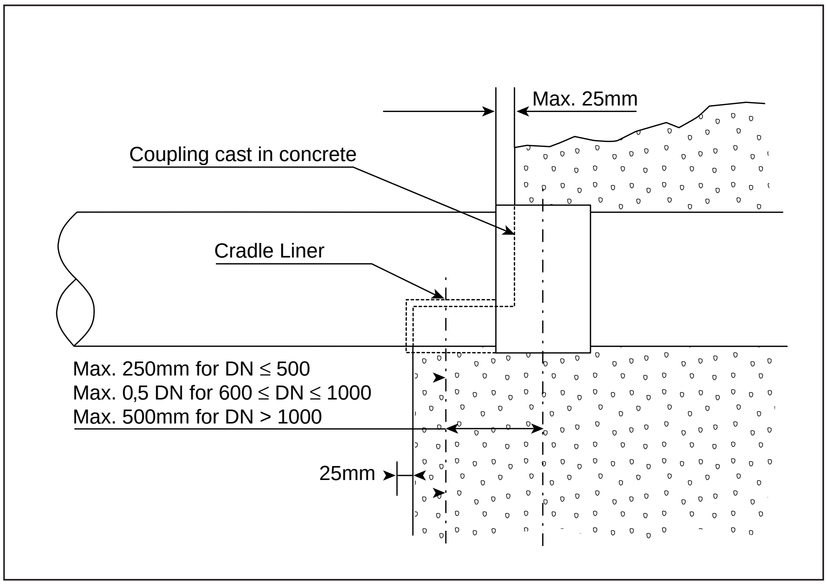

Figure 6.6
Alternate A

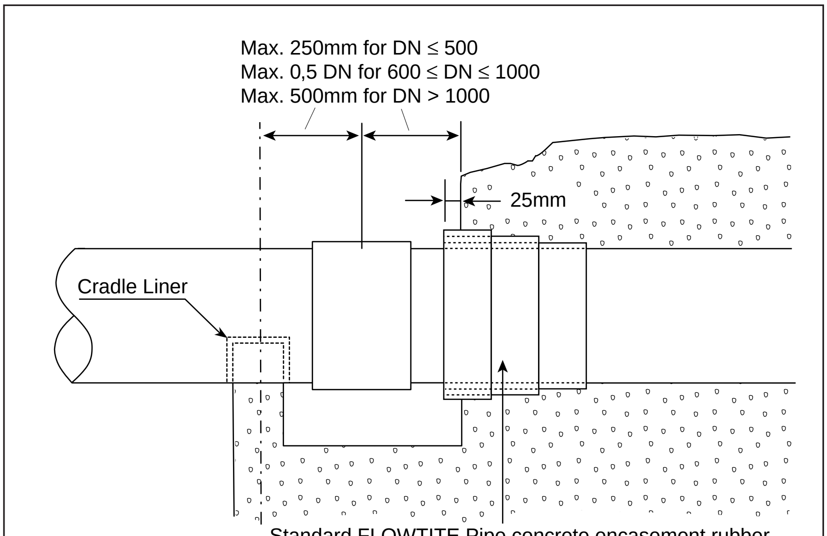

Figure 6.7
Alternate B

6.3 Rigid Connections

When a pipe passes through a wall, is encased in concrete, meets a junction with a manhole, or is flanged to a pump, valve, or other structure, excessive bending stresses may develop in the pipe if differential movement occurs between the pipe and the rigid connection.

For all rigid connections, action must be taken by the installer to minimize the development of high discontinuity stresses in the pipe.

Two options are available. *Alternate A* (preferred) uses a coupling joint cast into the concrete-pipe interface. *Alternate B* wraps the pipe in rubber to ease the transition.

Alternate A

Where possible, cast a coupling joint in the concrete at the interface (*Figure 6.6*) so that the first pipe outside the concrete has complete freedom of movement (within the limits of the joint).

Caution: When casting a coupling in concrete be sure to maintain its roundness so later joint assembly may be accomplished easily. Alternatively, make up the joint outside the encasement prior to pouring the concrete.

Alternate B

Where A is not possible, wrap (*Figure 6.7*) a band (or bands) of rubber (*Table 6.1* and *Figures 6.8* and *6.9*) around the pipe prior to placement of any concrete such that the rubber slightly protrudes (25 mm) from the concrete. Lay out the pipeline so the first completely exposed coupling joint is located as shown in *Figure 6.7*.

Precautions must be taken to minimize the settlement of the reinforced concrete structure or pipe by providing an adequate foundation. Differential settlement in excess of the lesser of 0,5% DN or 6 mm will cause excessive stress in the pipe and may cause pipe failure.

Table 6.1
Configuration of Rubber Bands

Diameter	Wrap configuration
300-700	A
800-1400	B
1500-2500	C

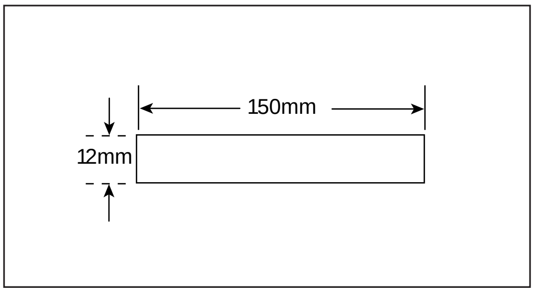

Figure 6.8
Single wrap dimensions (cross-section)

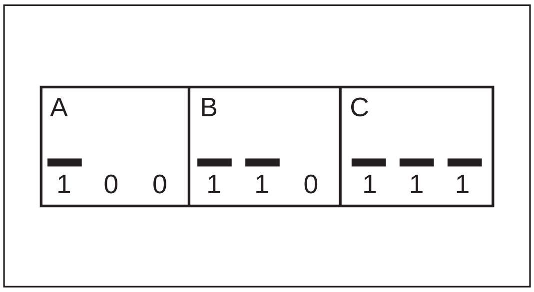

Figure 6.9
Wrap configurations

Rubber Wraps Placement

1. Position as shown in *Figures 6.7* and *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 plie's edges.

6.4 Casings (Tunnels)

When pipe is installed in a casing the following precautions should be observed.

1. Pipes may be placed into the casing by pulling (drawing) or pushing (jacking).
2. Pipes should be protected from sliding damage by the use of wooden skids attached to the pipe by strapping as shown in *Figure 6.10*. Skids must provide sufficient height to permit clearance between the coupling joints and the casing wall. (Also, see *Figure 6.11*)
3. Installation into the casing is made considerably easier by using lubricant between the skids and the casing wall. Do not use a petroleum based lubricant as it may cause harm to some gaskets.
4. The annular space between the casing and pipe may be filled with sand, gravel, or cement grout. Care must be taken to not overstress or collapse the pipe during this step, particularly when grouting. Maximum grouting pressure is in *Table 6.2*.

   Do not wedge or brace the pipe in a manner to cause concentrated or point loads on the pipe. Consult the supplier prior to this step for advice on suitability of the chosen method.

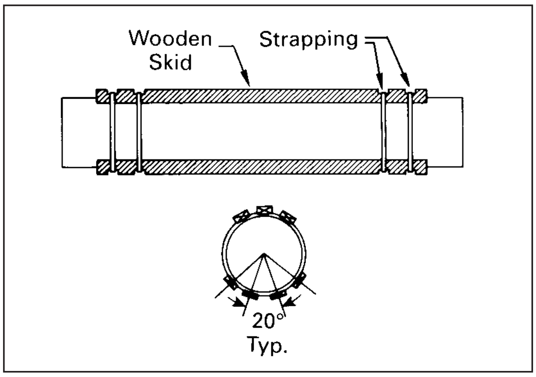

Figure 6.10
Typical skid arrangement

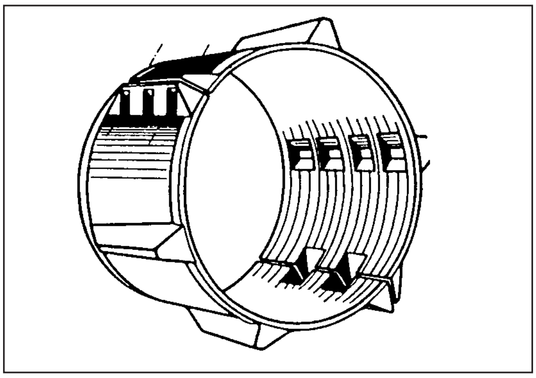

Figure 6.11
Plastic spacer unit

Table 6.2
Maximum Grouting Pressure

	Maximum Grout Pressure
SN	kPa
5000	54
10000	108

Field Adjustments

7.1 Length Adjustment

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.
3. Compare measurement with spigot tolerance range given in *Table 7.1*. (Note: manufacturers give the pipe a special marking [Adjustment Pipe] at the factory indicating the entire pipe barrel is within spigot tolerance range). Select one of these pipes (if available) for the field adjustment to avoid spigot machining.
4. Cut the pipe at the appropriate location using a circular saw with a masonry blade.
5. 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.
6. 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 tolerance as indicated in *Table 7.1*. Bevel pipe end (See *Figure 7.1*).

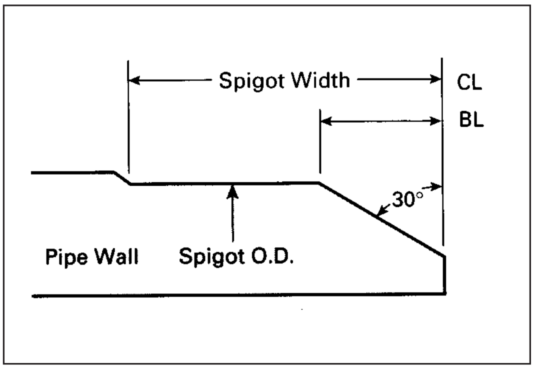

Figure 7.1
Pipe spigot and bevel dimensions definition for coupling joints. Note: For field closure section, double the spigot width (CL).

Table 7.1
Spigot Dimensions and Tolerances

Diam. Series	DN (mm)	Minimum (mm)	Maximum (mm)	CL (mm)	BL (mm)
B_2	300	323.4	324.5	159.0	6.6
	350	375.4	376.4	161.0	8.5
	400	426.3	427.3	162.0	10.4
	500	529.1	530.1	166.0	14.3
B_1	600	616.0	617.0	170.0	17.6
	700	718.0	719.0	172.0	20.0
	800	820.0	821.0	172.0	20.0
	900	922.0	923.0	172.0	20.0
	1000	1024.0	1025.0	172.0	20.0
	1200	1228.0	1229.0	172.0	20.0
	1400	1432.0	1433.0	172.0	20.0
	1600	1636.0	1637.0	172.0	20.0
	1800	1840.0	1841.0	172.0	20.0
	2000	2044.0	2045.0	172.0	20.0
	2400	2452.0	2453.0	172.0	20.0

Note:
1. Series B_2 matches with Ductile Iron spigot O.D.'s
2. Series B_1 is GRP O.D. series.
3. In some countries the Ductile Iron (B_2) series may not be used.

7.2 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 the pipe manufacturer. Please follow the mixing and application instructions furnished with each kit. Alternately, special short lengths of 1, 2 and 3 meters can be ordered from the pipe manufacturer thereby avoiding the need to make field cuts. These special lengths need to be ordered at the time the original order is placed.

The above is only necessary for gravity sewer pipes which will be subjected to high pressure (over 80 bar, but less than 120 bar) water jet cleaning. It is not necessary for pipes that are used to convey water or for pumped sewer mains, or where pipes are not cleaned by high pressure water jets.

7.3 Field Closures

1. Carefully measure the space where the closure pipe is to be placed. The closure piece must be 50 mm shorter than the length of the space. The piece must be centered with an equal clearance of 25 mm 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 7.2*, 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.

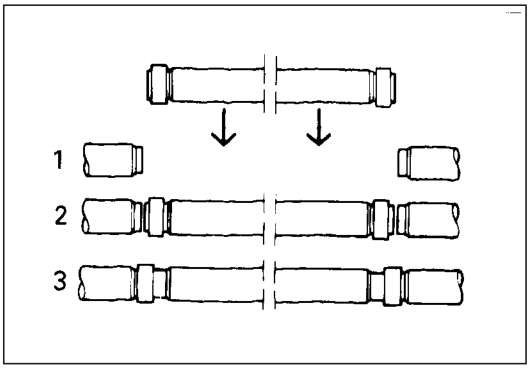

Figure 7.2
Closure section assembly

Appendix A

Approximate Weights for Pipes and Couplings

Nominal Diameter (mm)	Pipe Weight (kg/m) SN 5000	SN 10000	Weight Per Coupling (kg)
300	13	15	10
350	16	18	12
400	19	22	13
500	29	33	17
600	41	46	21
700	54	62	26
800	70	80	31
900	88	101	36
1000	108	123	42
1200	153	176	54
1400	207	238	68
1600	268	309	69†
1800	337	389	66‡
2000	416	417	75‡
2400	—	—	98‡

Coupling weights for PN 16, except where noted
†PN 10
‡PN 6

Appendix B

Joint Lubricant Requirements

Nominal Pipe Diameter (mm)	Nominal Amount of Lubricant (Kg) Required per Joint
300 to 500	.075
600 to 800	.100
900 to 1000	.150
1100 to 1200	.200
1300 to 1400	.250
1500 to 1600	.300
1800	.350
2000	.400
2200	.450
2400	.500

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