WAVISTRONG®

Assembly Instructions
Taper-Taper (TB-TS) Adhesive Bonded Joint

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TERMS OF USE

All information was correct at the time of going to press. However, we reserve the right to alter, amend and update any products, systems and services described in this brochure.
We accept no responsibility for the interpretation of statements made.

TABLE OF CONTENTS

1. GENERAL

This document describes the method to assemble Taper-Taper adhesive-bonded joints. To ensure that the performance of the installed joint complies with the requirements used for the design, it is essential that all personnel involved in the bonding procedure are familiar with and fully understand the techniques described in this document.

The instructions in this document are as complete as possible. However, it is not possible to describe all circumstances that might be encountered in the field. Therefore, our experienced supervisors may deviate from the described method to achieve an optimum solution using the latest bonding techniques and processing methods.

Besides, our supervisors may be consulted for clarification of statements made in this document and for advice about specific problems encountered in the field.

Annex A shows schemes of the complete assembly process; Annex A1 shows the spigot dimensioning process and Annex A2 shows the adhesive bonding process.

Definition of words used in these instructions:
- The word “shall” indicates a requirement
- The word “should” indicates a recommendation

2. REFERENCES

These instructions are completed with the following referenced documents:
- Wavistrong® Easy-Fit Adhesive Instructions

3. QUALITY

It is advised that the bonder possesses a valid Jointer/Bonder Qualification Certificate, issued by the pipe manufacturer or a Qualified Certifier.

After preparation of bell- and spigot end, the actual bonding and finishing of the adhesive joint shall be performed continuously and without any interruption or delay.

4. INSPECTION

All pipes, fittings or components used in the pipeline system shall be inspected for damages, prior to the actual bonding activity. Rejected items shall be separated and quarantined from undamaged materials to avoid unintentional use.

Adhesive kits shall be inspected prior to use. Do not use adhesive kits or containers showing evidence of damage or leakage. The adhesive shall be used before the expiry date, which is shown on the adhesive kit. Make sure that storage of adhesive kits complies with the storage requirements.

Ensure all necessary tools and materials are available. Take notice of the safety precautions stated in this document and those in the referenced instructions.

5. REQUIREMENTS FOR BONDING SURFACE AND AMBIENT CONDITIONS

This section gives descriptions of specific conditions of the pipe surfaces meant for adhesive bonding, as well as methods to obtain the required condition of the bonding surfaces.

5.1 Cleaning of a plain pipe end or an unprepared bell end

Both the outer surface of a plain cut (not machined) pipe end and the inner surface of an unprepared (see section 5.2) bell must be clean and dry before starting any operation.

If these unprepared surfaces of product ends have been in contact with oil or grease, they must be cleaned using clean cloth, which is soaked in clean acetone, M.E.K. (Methyl Ethyl Ketone) or M.I.B.K. (Methyl Iso Butyl Ketone).

Dry the cleaned surface with a clean, dry and non-fluffy cloth.

If there are no traces of oil or grease contamination on these pipe ends, clean the surfaces using clean, dry and non-fluffy cloth (see fig. 5.1.a).

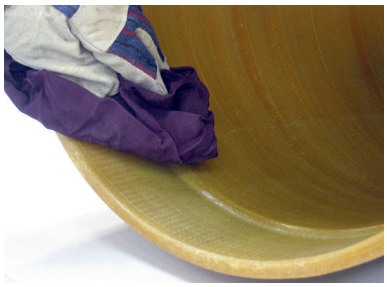


Fig. 5.1.a

5.2 Unprepared and prepared surface

An unprepared surface is a surface on the inside of a bell or on the outside of a pipe end, where the original resin rich coating is still intact as it were after completion of the manufacturing process. Any manual or mechanical abrasion process, such as sanding or sand blasting, has never reduced the original thickness of these resin rich layers.

A prepared surface is a surface on the inside of a bell or on the outside of a pipe end that has been abraded manually or mechanically. By the abrasion process, the reinforcement of the composite may come in direct contact with the environment and is therefore sensitive for contamination.

5.3 Ambient conditions and conditioning of bonding surfaces

If the bonding surfaces are visibly wet, these surfaces must be dried and heated.

If the temperature of the bonding surfaces is less than dew point plus 3 °C, these surfaces must be heated to avoid condensate on the bonding surface.

If the relative humidity of the environment is > 95 %, if it is foggy, or if there is any form of precipitation (e.g. rain, snow, hail), precautionary measures must be taken to create an environment where the bonding process can be performed under conditioned circumstances (e.g. a shelter). Drying of wet surfaces is performed using a clean, dry and non-fluffy cloth and is followed by heating of the bonding areas. Heating of surfaces that are wet or below dew point plus 3 °C is performed with a heating source such as a hot air blower or a heating blanket. The humidity of a (sheltered) bonding environment is reduced with e.g. a hot air blower.

Raise the temperature of the bonding surfaces during the heating process up to maximum 80 °C or set the temperature of the heating blanket at maximum 80 °C. If the environment heats the bonding surface above 40 °C, protect it from direct radiation by sunlight.

The temperature of the bonding surfaces of spigot and bell during the bonding procedure should be kept between 15 °C and 40 °C, but also at least 3 °C above dew point. Precautionary measures shall be taken to guarantee the compliance with the required humidity and temperature conditions during the complete bonding procedure.

5.4 Cleaning of a machined spigot end or a sanded bell end

A machined, prepared or sanded bonding surface that has been in contact with oil or grease shall not be used and must be cut. Machined, prepared or sanded bonding surfaces that are contaminated by other means than oil or grease can be cleaned by sanding (see section 5.5).

In case of doubt about the nature of the contamination cut the concerned spigot or bell. If there are no traces of contamination on these pipe ends, clean the surfaces using a clean, dry and non-fluffy cloth. Do not touch the cleaned surface, nor allow it to be contaminated.

5.5 Sanding of spigot and bell end

The sanding operation of the bonding surfaces of both, spigot- and bell end, shall be performed within 2 hours from the actual bonding.

Fig. 5.5.a

Bonding surfaces must be clean and dry at the start of the sanding operation (see sections 5.1, 5.3 and 5.4).

Sanding of unprepared bell ends is performed mechanically, using an emery cup with a grid of grade P40 to P60 (see fig. 5.5.a).

Sanding of factory prepared bell ends and machined spigot ends is performed mechanically using an emery cup, a flapper wheel or emery cloth with a grid of grade P40 to P60.

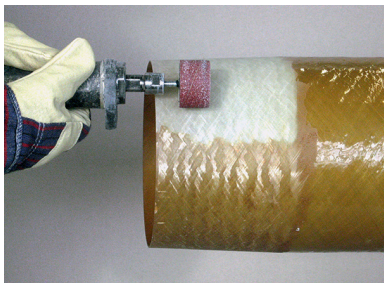


Fig. 5.5.b

A correctly sanded surface does not change in colour when continuing sanding (see fig. 5.5.b).

Bonding surfaces must be sanded equally in circumferential direction. The bonding surface must stay smooth by applying an even pressure on the sanding equipment.

Break sharp edges of the tip of the machined spigot end.

Fig. 5.5.c

The bonding surface is cleaned using a dry and clean dust bristle (see fig. 5.5.c). Sanded surfaces must have a dull, fresh finish, not a polished look. Do not touch the cleaned surface, nor allow it to be contaminated.

6. DIMENSIONING OF TAPER SPIGOT END

In case a pipe with the correct length and (factory) shaved spigot end is available, then continue with section 7 of these instructions.

This section 6 is relevant in case the pipe length must be adjusted or a tapered spigot end must be shaved.

Make sure to comply with the relevant requirements stated in section 5 before starting a next step in the activities to complete the bonding procedure.

6.1 Cutting of pipe

a Contaminated pipe surfaces must be cleaned prior to perform any operation on the pipe (see relevant requirements stated in section 5).

b Ensure that the pipe is adequately supported or clamped on a pipe vice.
Use rubber padding having a minimum thickness of 2 mm or similar to protect the pipe from damage.

c Determine the required length from the product drawing or by measurement (see fig. 6.1.c).

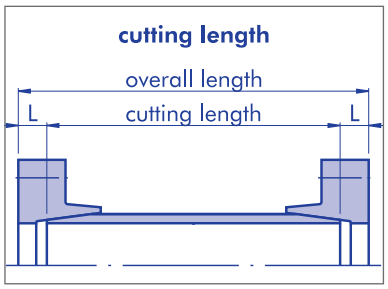


Fig. 6.1.c

d Scribe the pipe at the required length, using a pipe fitters' wrap-around (see fig. 6.1.d); take notice of the minimum cut length (see Annex B).


Fig. 6.1.d

e Cut the pipe square using a diamond or carbide coated hacksaw or an abrasive wheel.

f Ensure that the squareness of the cut end remains within required tolerance (A) (see fig. 6.1.f and table 6.1.f).

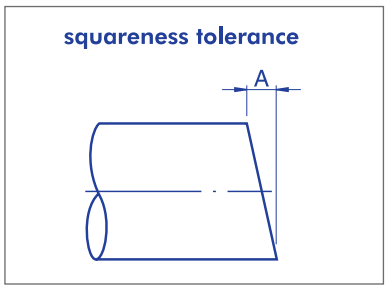


Fig. 6.1.f

Table 6.1.f Tolerance cut end

ID (mm)	A (mm)
25 - 600	± 3
700 - 900	± 4
1000 - 1200	± 6

6.2 Shaving of pipe end

a Various types of shavers are available (see fig. 6.2.a). To operate the shaver, carefully follow the applicable shaver instructions

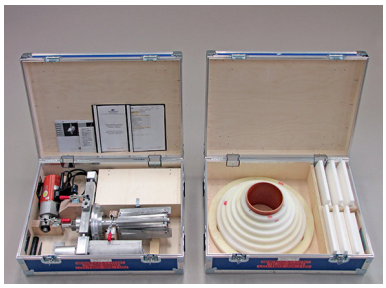


Fig. 6.2.a

b The pipe end to be shaved shall be clean (see relevant requirements in section 5) and must be adequately supported (see section 6.1.b and fig. 6.2.b).

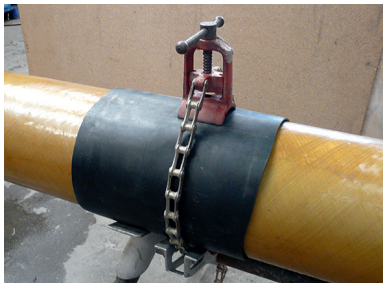


Fig. 6.2.b

c Start the shaving procedure (see fig. 6.2.c), using a maximum shaving feed of 2 mm. Be careful shaving the first layer as the pipe wall might have an unequal thickness over the circumference.

Fig.6.2.c

d Repeat the shaving action until the required spigot dimension (see Annex C) is achieved. Measurement of the nose thickness (T) at a number of spots (3 – 6) in the circumference of the head of the spigot (see fig. 6.2.d) can be used to obtain an indication of having achieved the required spigot diameter (S1).

Fig. 6.2.d

e Use an unprepared (dummy) bell to check the correctness of the shaved spigot end dimensions by determining the actual insert depth of the spigot in the bell.

Mark the actual insert depth of the spigot in the (dummy) bell on the section containing the spigot end (see fig. 6.2.e1).

The spigot diameter (S1) is checked by comparing the actual insert depth (see fig. 6.2.e2) with the allowable values of the insert depth (see Annex C).

Fig. 6.2.a

The actual insert depth shall comply with the following requirement:

- The actual insert depth shall be:
  - Equal to or smaller than the maximum insert depth, but also
  - Equal to or greater than the minimum insert depth.

  (Minimum insert depth <= Actual insert depth <= Maximum insert depth).

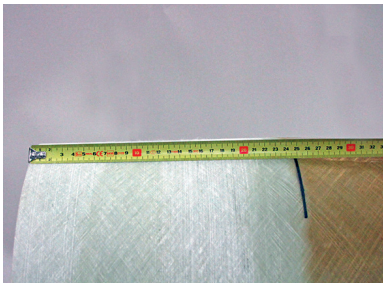


Fig. 6.2.b

- If the actual insert depth of the spigot in the (dummy) bell is too long (> maximum insert depth, see Annex C, tables C1), this means that the spigot diameter (S1) is too small. Choose for one of the following corrective actions:

- Cut the shaved length to comply with the required insert depth.
- Cut the shaved spigot at about 50 % of the shaved length and repeat dimensioning starting from section 6.1.

- If the actual depth of the spigot in the (dummy) bell is too short (< minimum insert depth, see Annex C, tables C1), this means that the spigot diameter (S1) is too big. Choose for the following corrective action:

- Cut the shaved spigot at about 50 % of the shaved length and repeat dimensioning starting from section 6.1.

f The eccentricity of the shaved spigot diameter (S1) relative to the inner diameter (ID) is determined from a number (>= 6) of measurements of the nose thickness (T) in the circumference of the spigot diameter (S1).

The maximum allowable difference between the measured nose thicknesses (Tolmax) is indicated in tables C1 of Annex C.

An explanation of a check of the eccentricity of the shaved spigot diameter is given in Annex D.

If the actual tolerance on the nose thickness (Tolact) is too big (> Tolmax, see Annex C, tables C1), this means that the eccentricity of the shaved spigot diameter (S1) relative to the inner diameter (ID) is too big. Choose for the following corrective action:

Cut the shaved spigot at about 50 % of the shaved length and repeat dimensioning starting from section 6.1.

Note 1
Shaving the spigot diameter (S1) 1 mm smaller (nose thickness 0.5 mm less) results in an additional insert depth of the spigot in the bell depending on the taper angle (see fig. N1):

For taper angle a= 1.75°, additional insert depth= 16.4 mm
For taper angle a= 2.50°, additional insert depth= 11.5 mm
For taper angle a= 3.25°, additional insert depth= 9.0 mm

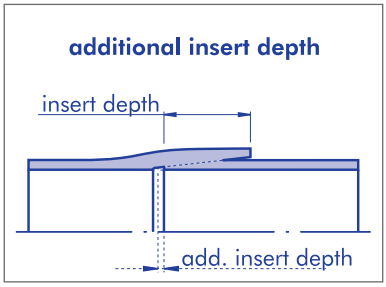


Fig. N1

7. PREPARING FOR BONDING

Before any actual bonding activity can start, the spigot- and bell end to be joined shall be prepared as described below.

Especially in the small diameter range, more joints may have to be prepared, as more joints can be made with one adhesive kit; in some cases, it may be advantageous to assemble more joints at the same time (see section 2).

7.1 Sanding and conditioning of both bonding surfaces

a Make sure to comply with the relevant requirements stated in section 5.

Note 2
The maximum number of sanding operations for each of the bonding surfaces, either the bell or the spigot, is two. In case a bonding surface is subjected to more than two sanding operations the dimensions shall be checked by determination of the insert depth of the spigot in the bell to be bonded. In this situation, the check of the insert depth shall be performed with the actual bell of the joint to be made, instead of using a dummy bell end.

7.2 Dry fit and marking

a A joint of two pipe sections is marked with an insertion mark. A joint of a pipe and a fitting is marked with an insertion mark as well as an alignment mark.

b In order to be able to check the required final position of the spigot relative to the bell a marking shall be made on the outer surface:

- An insertion mark is made on the pipe containing the spigot end in order to check the insert depth of the spigot in the bell

- An alignment mark is made on both, the bell and the pipe containing the spigot, in order to check the required orientation.

c For an insertion mark:
Measure distance Y (see Annex E, table E1) back from the head of the spigot and scribe a line in circumferential direction on the outer surface of the pipe (see fig. 7.2.c). An explanation of the check of the actual insert depth of the spigot in the bell after assembly is given in Annex E.

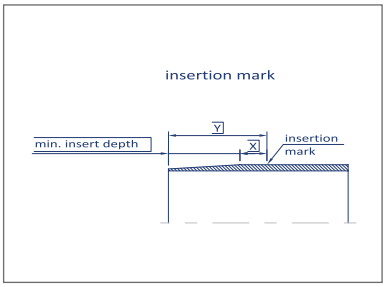


Fig. 7.2.c

Note 3
Y is derived from the following equation:

Y= Minimum insert depth + X (Eq. 1)

Where:

- *For Minimum insert depth see Annex C, tables C1.*
- *X is taken as a default value of 50 mm in Annex E, table E1.*

In case the value of X= 50 mm is not workable, choose another practical value of X and determine Y using equation (Eq. 1).

d For an alignment mark:
Scribe a longitudinal line on the outer surface of the bell, continuing on the outer surface of the pipe containing the shaved spigot end (see fig. 7.2.d).

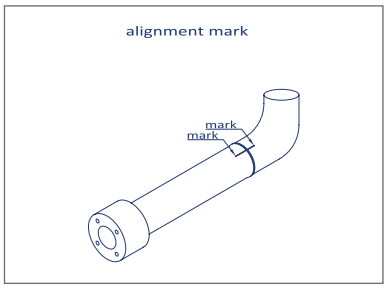


Fig. 7.2.d

7.3 Installation of pulling equipment

a The mechanical equipment to pull the spigot centrically in the bell is installed on both sides of the joint (see fig. 7.3.a). Normally two winches will suffice; if needed more winches can be used. The position of the winches is equally spaced over the circumference of the parts to be jointed in order to realise centric entrance of the spigot in the bell.

Make sure that there will be sufficient space to apply adhesive on the bonding surfaces.

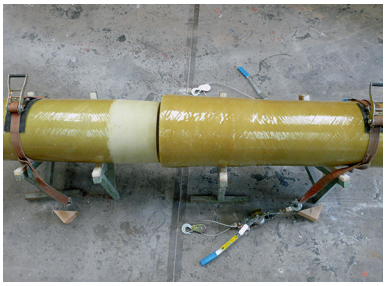


Fig. 7.3.a

b Respect the required alignment of the parts to be jointed as well as the support during the bonding operation.

8. BONDING

The actual bonding starts with the preparation of the adhesive and finishes when the adhesive between the jointed parts is cooled down to ambient temperature, after completion of curing of the adhesive.

The adhesive shall be supplied by the pipe manufacturer.

Be aware that the bonding procedure shall be performed continuously and without any interruption or delay, within the pot-life/working time of the adhesive. This means that the period within mixing of the adhesive components until the spigot has been pulled into the bell shall fall within the pot-life/working time.

8.1 Preparation of adhesive

a Select the proper type and kit size of adhesive, if applicable. Determine the number of adhesive kits required for one joint, or the number of joints which can be made with one kit. For detailed information about the adhesive, reference is made to the relevant document (see section 2).

b The temperature of the adhesive shall comply with the requirements stated in the relevant document (see section 2).

c Apply the adhesive immediately after finishing the mix procedure.

d Never use adhesive that has started to cure; this is the case when the mixture gets clotted, toughens and the temperature rises significantly.

8.2 Application of adhesive

a Use a fresh spatula or adhesive scraper for the application of adhesive on the freshly prepared bonding surfaces. In case the spatula used for mixing is also used for the application of the adhesive, the spatula must be cleaned first.

b Wet the sanded surfaces of bell- and spigot end with some force with a thin, uniform coating of adhesive (hardly any thickness).

c Apply a thin (≈ 0.5 mm) and uniform layer of adhesive on the adhesive coated bonding surface of the spigot end.
Do not apply more adhesive than strictly necessary to avoid an excessive resin bead on the inside of the joint, resulting in flow restrictions.

Make sure to apply an adhesive layer on the cut end of the spigot (see fig. 8.2.c and fig. 8.2.d).

d Make sure to apply sufficient adhesive on the cylindrical end of the spigot that will be covered by the bell
(see fig. 8.2.c and fig. 8.2.d).

e Protect the adhesive coatings on the bonding surfaces and prevent any contamination.

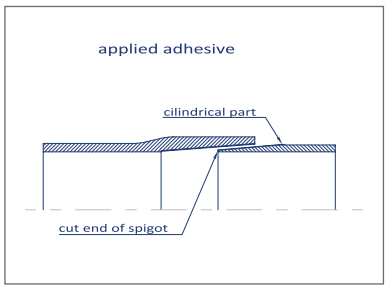


Fig. 8.2.c

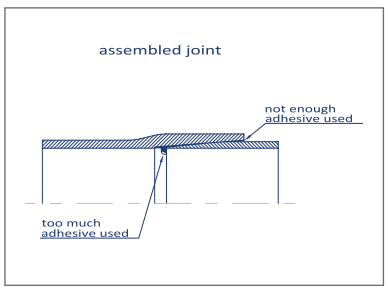


Fig. 8.2.d

8.3 Assembly of the spigot in the bell

a Parts to be jointed shall be aligned as true as possible. Any visual misalignment is unacceptable.

b Insert the spigot in the bell and pay attention to the alignment mark on the outer surface with regard to the orientation of the parts to be jointed.

c Hook the winches, apply an equal load on each winch and pull the sections to be bonded in a smooth movement together until the spigot does not enter anymore into the bell (see fig. 8.3.c); respect the marking on the outer surface.

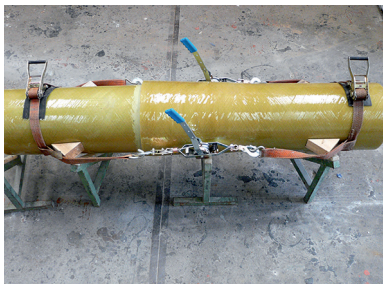


Fig. 8.3.c

Make sure that the spigot is inserted centrically into the bell until the joint is firmly fixed together.

d Determine the distance (Dist) measured from the head of the bell to the insertion mark (see fig. 8.3.d); this distance (Dist) shall comply with the requirement stated in Annex E. The distance (Dist) may depend on the type of adhesive.

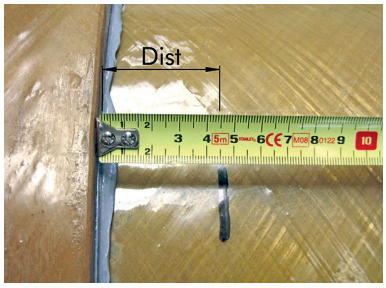


Fig. 8.3.d

e It may be necessary to create some space between the winch cables and the pipe outside to ease positioning of the heating blanket.

The load on the pulling equipment may only be changed within the pot-life/working time of the adhesive.

Note 4
Continuation of activities on the pipeline system may never influence the load on the pulling equipment in either positive or negative sense.

Fig. 8.3.h1

g Keep the tension load on the pulling equipment until the adhesive is fully cured.

If the load on the jointed parts is released within the pot-life/ working time of the adhesive, the bonding procedure shall be repeated starting from section 8.2.
If the load on the jointed parts is released after the pot-life/ working time of the adhesive, but before completion of the curing cycle, then the joint is rejected and the bonding procedure shall be repeated starting from section 7.

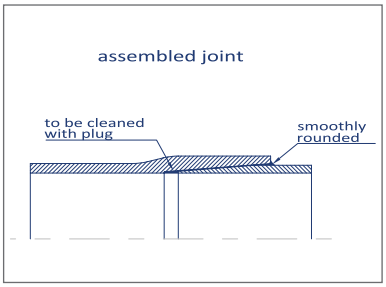


Fig. 8.3.h2

h Remove the excessive adhesive from the outer surface (see fig. 8.3.h1) and if possible from the inside of the joint.
The fillet on the head of the bell should be smoothly rounded; the inside might be cleaned with a plug (see fig. 8.3.h2).

8.4 Curing of the adhesive

a The tension on the pulling equipment shall not be changed until completion of the cure of the adhesive. Until completion of the cure of the adhesive the joint shall not be moved, vibrated or otherwise disturbed.

b Wrap the required size and voltage heating blanket around the joint, ensuring full coverage of the bond area and keeping the power supply cable free from the blanket.

Tie the heating blanket down using e.g. a string or steel wire and assuring an optimal surface contact with the bell (see fig. 8.4.b).

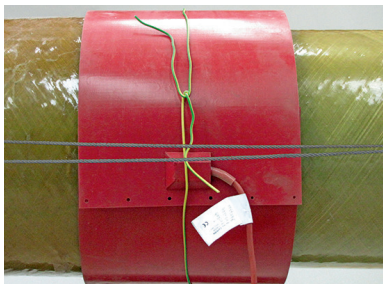


Fig. 8.4.b

c Overlapping ends of oversized blankets risk to be over-heated.

Insulate overlapping ends and position the overlap outside the insulation.

d Insulate the heating blanket with suitable insulating material (by preference a fire blanket or equivalent).

Close at least one open end of the jointed pipeline sections in order to avoid cooling down by draught. Insulating material should overlap the sides of the blanket with at least 100 mm and should match the pipe (see fig. 8.4.d).

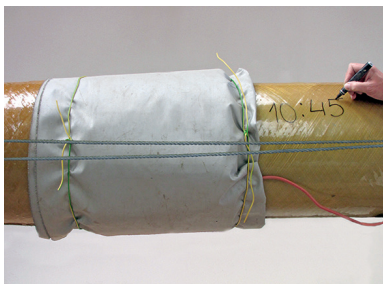


Fig. 8.4.d

e Apply electric power to the heating blanket.

If applicable, adjust the temperature of the blanket such that the surface temperature of the jointed parts complies with the requirements stated in the relevant adhesive instructions (see section 2).

Check the functioning of the heating blanket at least at the start and at the end of the curing process by measuring the surface temperature of the bell using a (digital) thermometer.

f The curing time starts when the required surface temperature of the jointed components is reached. Write the starting time of the curing on the pipe, next to the heating blanket (see fig. 8.4.d).

For the required curing time reference is made to the relevant adhesive instructions (see section 2).

g Adhesive bonded flanges shall be cured by placing the heating blanket against the inner surface of the flange. For an optimal heat transfer the blanket shall be pressed against the inner surface of the jointed parts, after the excess adhesive has been removed from the inside of the joint (see fig. 8.4.g).

h If the curing time or the curing temperature does not comply with the requirements of the curing cycle, the complete curing cycle shall be repeated.

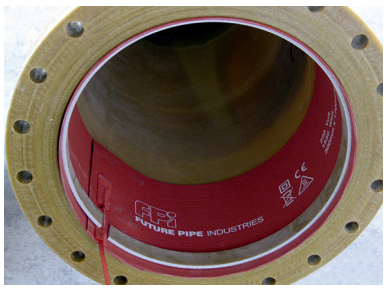


Fig. 8.4.g

i The electrical power to the heating blanket shall be switched off after completion of the curing time and after having checked the surface temperature for the last time. Indicate the end time of the curing cycle on the pipe. It is advised to mark the joint, indicating that the adhesive is cured. Allow the joint to cool down before loading mechanically or hydrostatically.

9. MATERIALS, TOOLS AND CONSUMABLES

9.1 Materials

- Adhesive *

9.2 Tools

- Shaver *
- Heating blanket (plus temperature controller, if applicable) *
- Measuring tape and/or folding rule
- Vernier calliper
- Pipe fitters' wrap-around
- Level and marker
- Pipe vice or stable supports (brackets) with rubber coated clamping device
- Hacksaw, disc grinder or power jigsaw
- Small electrical or air driven grinding machine
- Pairs of winches or come-along
- Pairs of band clamps with puller rings
- Insulation material or blankets
- Digital temperature gauge for surface temperature measurement
- Dew point meter
- Thermometer
- Relative humidity meter
- Infra-red thermometer
- Hot air blower
- Tenting (subject to weather conditions)
- Dummy bell end*

* To be supplied by the pipe manufacturer.

9.3 Consumables

- Cutting disks
- Emery disks, emery cups, emery cloth, flapper wheels (all grade P40 to P60)
- Spatula (rubber scraper plate, filling knife), marker pen, dust (paint) brush
- Rubber gloves, working gloves, dust masks, safety goggles
- Cleaning plug
- Overalls, safety shoes, safety helmet
- Cleaning rags, cleaning fluid such as acetone, Methyl Ethyl Ketone (MEK) or Methyl Iso Butyl Ketone (MIBK)

10. HEALTH AND SAFETY

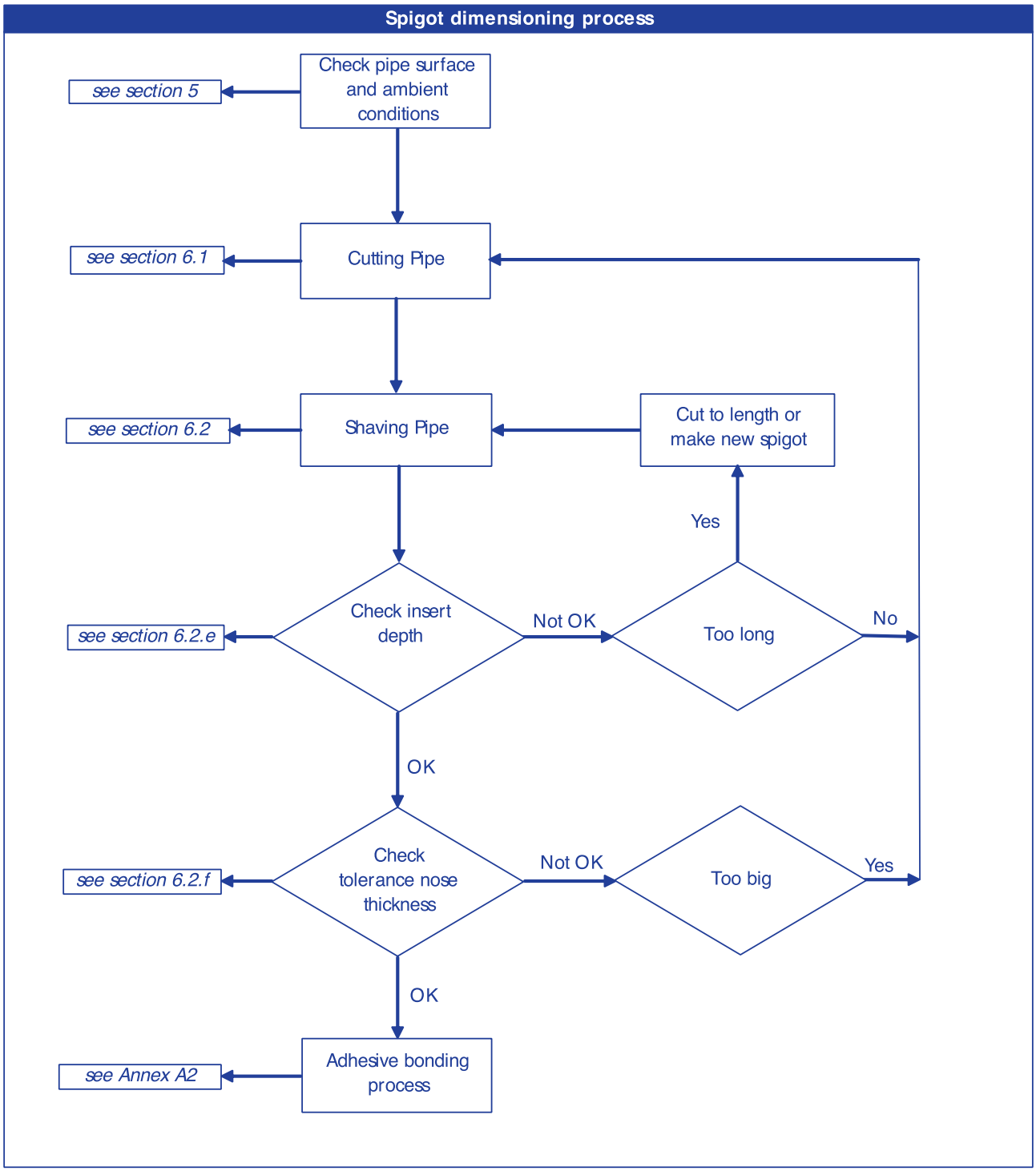
When working with GRE products, following safety precautions shall be taken:

Fig. 10

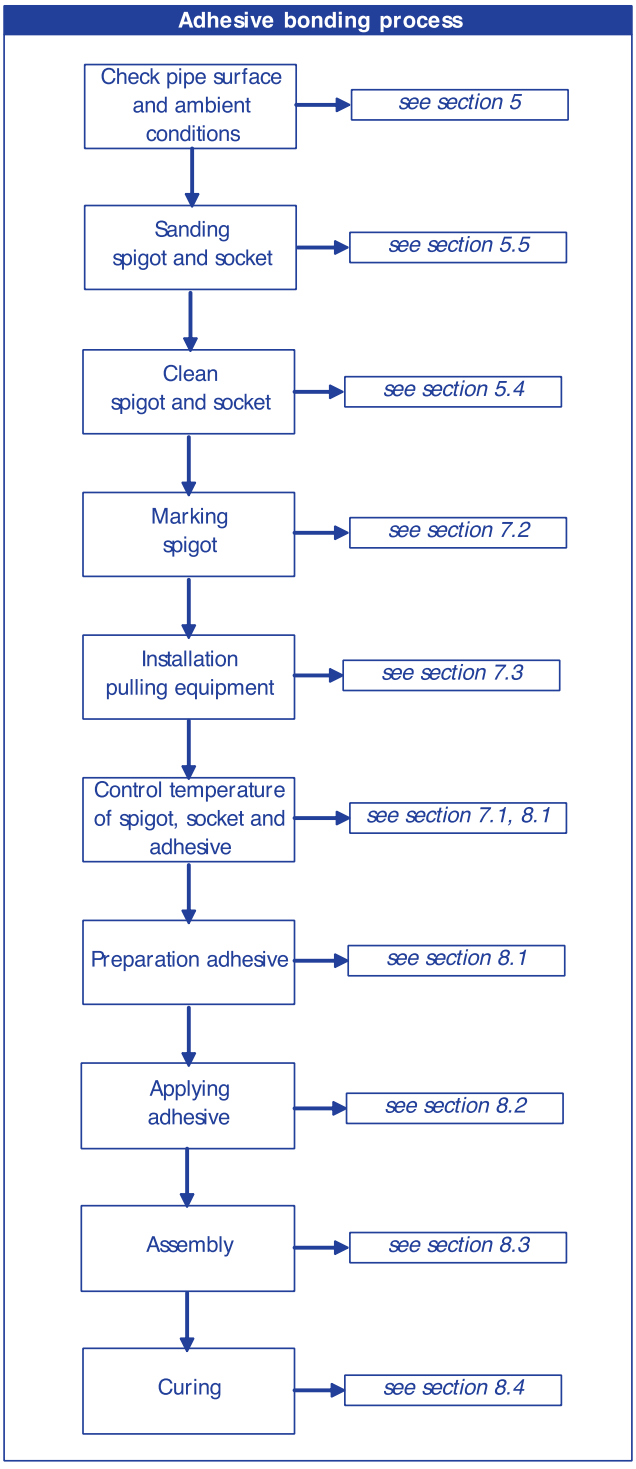
- Wear at all times suitable protective clothing.
- Use Personnel Protective Equipment (PPE), such as:
  - Long sleeves
  - Hard hat (if required by site conditions)
  - Safety shoes
  - Glasses
  - Gloves (for mechanical and chemical protection)
  - Dust mask (during machining and sanding)
  - Ear protection (during mechanical operations)
- For health and safety data reference is made to the applicable instructions (see section 2).

ANNEX A - SCHEMES ASSEMBLY PROCESS TAPER-TAPER BONDED JOINT

Annex A1 Scheme of spigot dimensioning process



Annex A2 Scheme of adhesive bonding process



ANNEX B - MINIMUM CUT LENGTH

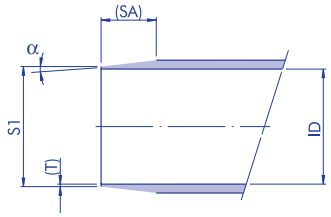


Fig. B1 Minimum cut length (Lo) for pipe Taper Bell – Taper Spigot

Table B1.1 Minimum cut length (Lo) (mm) for STD Pressure

ID (mm)	PN (bar)							
	8	12.5	16	20	25	32	40	50
25								405
40								405
50							405	425
65							425	455
80						425	445	495
100					675	695	735	795
125					685	735	795	865
150				685	725	775	845	935
200				665	705	755	815	905
250			665	705	755	815	895	995
300			685	725	785	865	965	1075
350		665	715	765	835	925	1035	1175
400		695	745	805	885	985	1115	1275
450	685	725	785	855	935	1055		
500	685	735	805	875	975	1115		
600	715	775	855	945	1055	1215		
700	755	815	915	1015	1145	1335		
750	755	815	915	1035	1175	1375		
800	765	845	945	1065	1215	1435		
900	805	885	1005					
1000	815	915	1045					

Table B1.2 Minimum cut length (Lo) (mm) for High Pressure

ID (mm)	PN (bar)			
	63	80	100	120
25	405			
40	425			
50	465			
65	495			
80	445	485	535	535
100	735	785	855	845
125	775	845	925	925
150	825	905	1005	995

Note: *The dimensions listed above are for reference only. Please contact Future Pipe Industries L.L.C for additional information and requirements.*

ANNEX C - SHAVING DIMENSIONS TAPER SPIGOT

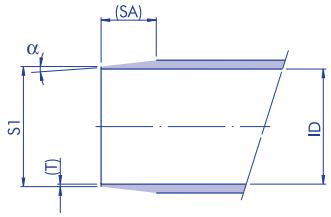


Fig. C1 Dimensions Taper Spigot

Table C1.1-a Dimensions Taper Spigot for STD Pressure

PN (bar)	ID (mm)	α (°)* 0 -0.25	Minimum insert depth (mm)	Maximum insert depth (mm)	(T_{nom})* (mm)	Tol_{max} (mm)	S1* +0.5 0 (mm)	(SA)* (mm)
8	450	2.50	63	79	1.50	1.40	453.0	55.0
	500	2.50	63	79	1.75	1.50	503.5	58.4
	600	2.50	78	94	2.00	1.80	604.0	71.0
	700	2.50	98	114	2.00	2.10	704.0	91.6
	750	2.50	98	114	2.50	2.30	755.0	89.3
	800	2.50	103	119	2.50	2.40	805.0	98.5
	900	2.50	123	139	2.50	2.70	905.0	116.8
	1000	2.50	128	144	3.00	3.00	1006.0	123.7
12.5	350	2.50	53	69	2.00	1.10	354.0	52.7
	400	2.50	68	84	2.00	1.20	404.0	66.4
	450	2.50	83	99	1.50	1.40	453.0	77.9
	500	2.50	88	104	1.75	1.50	503.5	83.6
	600	2.50	108	124	2.00	1.80	604.0	100.8
	700	2.50	128	144	2.00	2.10	704.0	123.7
	750	2.50	128	144	2.50	2.30	755.0	123.7
	800	2.50	143	159	2.50	2.40	805.0	135.1
	900	2.50	163	179	2.50	2.70	905.0	158.0
	1000	2.50	178	194	3.00	3.00	1006.0	169.5
16	250	2.50	53	69	1.75	0.80	253.5	53.8
	300	2.50	63	79	2.00	0.90	304.0	61.8
	350	2.50	78	94	2.00	1.10	354.0	77.9
	400	2.50	93	109	2.00	1.20	404.0	91.6
	450	2.50	113	129	1.50	1.40	453.0	105.4
	500	2.50	123	139	1.75	1.50	503.5	115.7
	600	2.50	148	164	2.00	1.80	604.0	139.7
	700	2.50	178	194	2.00	2.10	704.0	169.5
	750	2.50	178	194	2.50	2.30	755.0	171.8
	800	2.50	193	209	2.50	2.40	805.0	187.8
	900	2.50	223	239	2.50	2.70	905.0	217.6
	1000	2.50	243	259	3.00	3.00	1006.0	235.9

* α = Taper Angle
* (T_{nom}) = Nominal Nose Thickness (for reference only)
* S1 = Spigot Diameter
* (SA) = Nominal Spigot Length (for reference only)

Note: *The dimensions listed above are for reference only. Please contact Future Pipe Industries L.L.C for additional information and requirements.*

ANNEX C - SHAVING DIMENSIONS TAPER SPIGOT (CONTINUED)

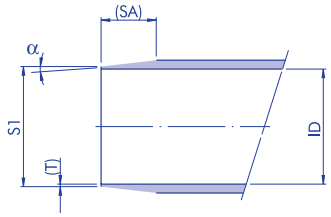


Fig. C1 Dimensions Taper Spigot

Table C1.1-b Dimensions Taper Spigot for STD Pressure

PN (bar)	ID (mm)	α (°)* 0 -0.25	Minimum insert depth (mm)	Maximum insert depth (mm)	(T_{nom})* (mm)	Tol_{max} (mm)	S1* +0.5 0 (mm)	(SA)* (mm)
20	150	1.75	48	69	1.75	0.60	153.5	50.7
	200	2.50	53	69	1.75	0.60	203.5	53.8
	250	2.50	73	89	1.75	0.80	253.5	72.1
	300	2.50	83	99	2.00	0.90	304.0	84.7
	350	2.50	103	119	2.00	1.10	354.0	103.1
	400	2.50	123	139	2.00	1.20	404.0	121.4
	450	2.50	148	164	1.50	1.40	453.0	139.7
	500	2.50	158	174	1.75	1.50	503.5	152.3
	600	2.50	193	209	2.00	1.80	604.0	185.5
	700	2.50	228	244	2.00	2.10	704.0	222.2
	750	2.50	238	254	2.50	2.30	755.0	229.0
	800	2.50	253	269	2.50	2.40	805.0	247.4
25	100	1.75	43	64	1.75	0.60	103.5	47.5
	125	1.75	48	69	1.75	0.60	128.5	54.0
	150	1.75	68	89	1.75	0.60	153.5	70.4
	200	2.50	73	89	1.75	0.60	203.5	72.1
	250	2.50	98	114	1.75	0.80	253.5	95.1
	300	2.50	113	129	2.00	0.90	304.0	112.2
	350	2.50	138	154	2.00	1.10	354.0	137.4
	400	2.50	163	179	2.00	1.20	404.0	160.3
	450	2.50	188	204	1.50	1.40	453.0	183.2
	500	2.50	208	224	1.75	1.50	503.5	200.4
	600	2.50	248	264	2.00	1.80	604.0	242.8
	700	2.50	293	309	2.00	2.10	704.0	288.6
	750	2.50	308	324	2.50	2.30	755.0	300.0
	800	2.50	328	344	2.50	2.40	805.0	322.9

* α = Taper Angle
* (T_{nom}) = Nominal Nose Thickness (for reference only)
* S1 = Spigot Diameter
* (SA) = Nominal Spigot Length (for reference only)

Note: *The dimensions listed above are for reference only. Please contact Future Pipe Industries L.L.C for additional information and requirements.*

ANNEX C - SHAVING DIMENSIONS TAPER SPIGOT (CONTINUED)

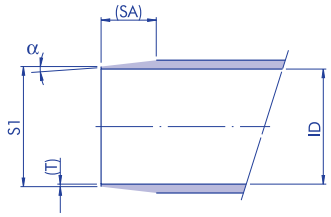


Fig. C1 Dimensions Taper Spigot

Table C1.1-c Dimensions Taper Spigot for STD Pressure

PN (bar)	ID (mm)	α (°)* 0 -0.25	Minimum insert depth (mm)	Maximum insert depth (mm)	(T_{nom})* (mm)	Tol_{max} (mm)	S1* +0.5 0 (mm)	(SA)* (mm)
32	80	1.75	43	64	1.75	0.60	83.5	47.5
	100	1.75	53	74	1.75	0.60	103.5	57.3
	125	1.75	73	94	1.75	0.60	128.5	76.9
	150	1.75	93	114	1.75	0.60	153.5	99.8
	200	2.50	98	114	1.75	0.60	203.5	99.6
	250	2.50	128	144	1.75	0.80	253.5	129.4
	300	2.50	153	169	2.00	0.90	304.0	153.5
	350	2.50	183	199	2.00	1.10	354.0	183.2
	400	2.50	213	229	2.00	1.20	404.0	213.0
	450	2.50	248	264	1.50	1.40	453.0	242.8
	500	2.50	278	294	1.75	1.50	503.5	269.1
	600	2.50	328	344	2.00	1.80	604.0	322.9
	700	2.50	388	404	2.00	2.10	704.0	382.5
	750	2.50	408	424	2.50	2.30	755.0	400.8
	800	2.50	438	454	2.50	2.40	805.0	430.6
40	50	1.75	385	399	1.50	0.60	53.0	36.0
	65	1.75	33	54	1.75	0.60	68.5	47.5
	80	1.75	43	64	1.75	0.60	83.5	57.3
	100	1.75	53	74	1.75	0.60	103.5	76.9
	125	1.75	73	94	1.75	0.60	128.5	106.4
	150	1.75	103	124	1.75	0.60	153.5	132.6
	200	2.50	128	149	1.75	0.60	203.5	129.4
	250	2.50	128	144	1.75	0.80	253.5	168.3
	300	2.50	168	184	2.00	0.90	304.0	201.6
	350	2.50	203	219	2.00	1.10	354.0	238.2
	400	2.50	238	254	2.00	1.20	404.0	277.1

* α = Taper Angle
* (T_{nom}) = Nominal Nose Thickness (for reference only)
* S1 = Spigot Diameter
* (SA) = Nominal Spigot Length (for reference only)

Note: *The dimensions listed above are for reference only. Please contact Future Pipe Industries L.L.C for additional information and requirements.*

ANNEX C - SHAVING DIMENSIONS TAPER SPIGOT (CONTINUED)

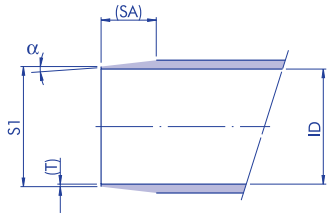


Fig. C1 Dimensions Taper Spigot

Table C1.1-d Dimensions Taper Spigot for STD Pressure

PN (bar)	ID (mm)	α (°)* 0 -0.25	Minimum insert depth (mm)	Maximum insert depth (mm)	(T_{nom})* (mm)	Tol_{max} (mm)	S1* +0.5 0 (mm)	(SA)* (mm)
50	25	1.75	33	54	1.50	0.60	28.0	36.0
	40	1.75	33	54	1.50	0.60	43.0	36.0
	50	1.75	43	64	1.50	0.60	53.0	45.8
	65	1.75	58	79	1.75	0.60	68.5	60.6
	80	1.75	78	99	1.75	0.60	83.5	80.2
	100	1.75	103	124	1.75	0.60	103.5	106.4
	125	1.75	138	159	1.75	0.60	128.5	142.4
	150	1.75	173	194	1.75	0.60	153.5	175.1
	200	2.50	173	189	1.75	0.60	203.5	170.6
	250	2.50	218	234	1.75	0.80	253.5	218.7
	300	2.50	258	274	2.00	0.90	304.0	258.8
	350	2.50	308	324	2.00	1.10	354.0	306.9
	400	2.50	358	374	2.00	1.20	404.0	355.0

* α = Taper Angle
* (T_{nom}) = Nominal Nose Thickness (for reference only)
* S1 = Spigot Diameter
* (SA) = Nominal Spigot Length (for reference only)

Note: *The dimensions listed above are for reference only. Please contact Future Pipe Industries L.L.C for additional information and requirements.*

ANNEX C - SHAVING DIMENSIONS TAPER SPIGOT (CONTINUED)

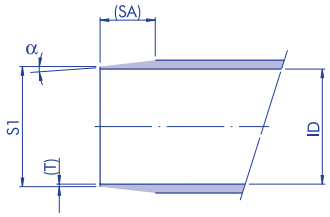


Fig. C1 Dimensions Taper Spigot

Table C1.2 Dimensions Taper Spigot for STD Pressure

PN (bar)	ID (mm)	α (°)* 0 -0.25	Minimum insert depth (mm)	Maximum insert depth (mm)	(T_{nom})* (mm)	Tol_{max} (mm)	S1* +0.5 0 (mm)	(SA)* (mm)
63	25	1.75	33	54	1.50	0.60	28.0	36.0
	40	1.75	43	64	1.50	0.60	43.0	49.1
	50	1.75	63	84	1.50	0.60	53.0	65.5
	65	1.75	78	99	1.75	0.60	68.5	83.5
	80	3.25	63	77	1.75	0.60	83.5	59.0
	100	3.25	83	97	1.75	0.60	103.5	78.4
	125	3.25	103	117	1.75	0.60	128.5	101.3
	150	3.25	128	142	1.75	0.60	153.5	124.2
80	80	3.25	83	97	1.75	0.60	83.5	80.1
	100	3.25	108	122	1.75	0.60	103.5	104.8
	125	3.25	138	152	1.75	0.60	128.5	134.7
	150	3.25	168	182	1.75	0.60	153.5	164.7
100	80	3.25	108	122	1.75	0.60	83.5	106.5
	100	3.25	143	157	1.75	0.60	103.5	138.2
	125	3.25	178	192	1.75	0.60	128.5	177.0
	150	3.25	218	232	1.75	0.60	153.5	214.0
120	80	4.00	114	126	1.75	0.60	83.5	109.4
	100	4.00	144	156	1.75	0.60	103.5	139.4
	125	4.00	184	196	1.75	0.60	128.5	178.0
	150	4.00	219	231	1.75	0.60	153.5	215.2

* α = Taper Angle
* (T_{nom}) = Nominal Nose Thickness (for reference only)
* S1 = Spigot Diameter
* (SA) = Nominal Spigot Length (for reference only)

Note: *The dimensions listed above are for reference only. Please contact Future Pipe Industries L.L.C for additional information and requirements.*

ANNEX D - ECCENTRICITY OF SPIGOT END

A check of the deviation on the nose thickness (Tdev) is an indirect method to check the eccentricity of the spigot diameter (S1) relative to the inner diameter (ID). The deviation of the nose thickness (Tdev) is obtained from measurements of the nose thickness (T) in the circumference of the spigot diameter (S1), (see fig. D1).

The minimum value of the deviation on the nose thickness ($Tdev_{min}$)= 0; in this case the spigot diameter (S1) is centric relative to the inner diameter (ID). The maximum allowable deviation on the nose thickness ($Tdev_{max}$) indicates the maximum allowable eccentricity of the spigot diameter (S1) relative to the inner diameter (ID).

The deviation of the nose thickness (Tdev) is determined from measurements of the actual nose thickness (T) and is compared with the maximum allowable tolerance (Tolmax), which is listed in Annex C, tables C1.

The deviation of the nose thickness (Tdev) is derived from following equation:

$$Tdev = T_{max} - T_{min} \qquad \text{(Eq. D1)}$$

T_{max} and T_{min} are respectively the maximum and minimum value of the measured nose thickness (T).

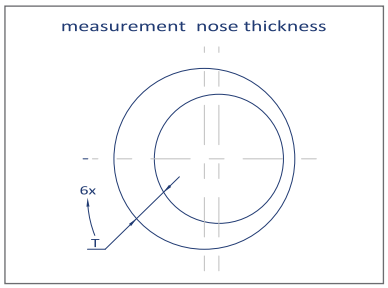


Fig. D1

The nose thickness (T) is measured at least 6 times, equally spaced over the circumference of the spigot diameter (S1), (see fig. D1).

The eccentricity of the spigot diameter (S1) relative to the inner diameter (ID) is correct if the deviation (Tdev) complies with the following requirement:

$$Tdev <= Tol_{max} \qquad \text{(Eq. D2)}$$

ANNEX E - INSERTION MARK AND INSERT DEPTH

In order to check the actual insert depth of the spigot in the bell after assembly of the joint, an insertion mark shall be scribed on the pipe section containing the spigot end before application of the adhesive on the bonding surfaces.

Note E1
The nominal Spigot Length (SA) is given in Annex C, tables C1, for reference only.

The Spigot Length (SA) shall not be used as quality criterion.

The insertion mark is scribed at a distance Y from the head of the spigot (see fig. E1).

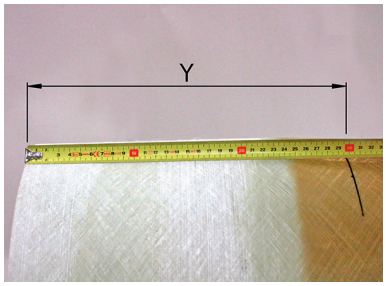


Fig. E1

Y is derived from the following equation:

Y = Minimum insert depth + X (Eq. E1)

Where:
- For Minimum insert depth see Annex C, tables C1
- X = chosen value (mm).

Normally X is taken as a default value of 50 mm.

In that case the insertion mark shall be scribed at a distance Y, which is given in table E1.

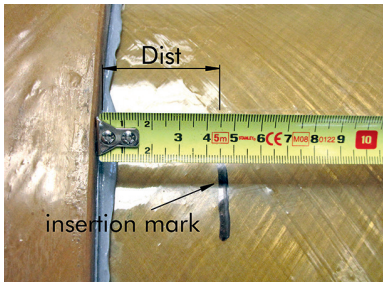


Fig. E2

After assembly of the spigot in the bell, a check of the required minimum insert depth of the spigot in the bell is performed by measurement of the distance (Dist) from the head of the bell to the insertion mark (see fig. E2).

The correct insertion depth shall comply with the following requirement:

Dist <= 50 mm (Eq. E2)

Occasionally, the insertion mark cannot be scribed at distance Y per table E1. In that case X is an appropriate value and the correct insertion depth then shall comply with following requirement:

Dist <= X mm (Eq. E3)

Table E1.1 Position of insertion mark at distance Y (mm) from the head of the spigot for STD Pressure

ID	PN (bar)							
(mm)	8	12.5	16	20	25	32	40	50
25								83
40								83
50							83	93
65							93	108
80						93	103	128
100					93	103	123	153
125					98	123	153	188
150				98	118	143	178	223
200				103	123	148	178	223
250			103	123	148	178	218	268
300			113	133	163	203	253	308
350		103	128	153	188	233	288	358
400		118	143	173	213	263	328	408
450	113	133	163	198	238	298		
500	113	138	173	208	258	328		
600	128	158	198	243	298	378		
700	148	178	228	278	343	438		
750	148	178	228	288	358	458		
800	153	193	243	303	378	488		
900	173	213	273					
1000	178	228	293					

Table E1.2 Position of insertion mark at distance Y (mm) from the head of the spigot for High Pressure

ID	PN (bar)			
(mm)	63	80	100	120
25	83			
40	93			
50	113			
65	128			
80	113	133	158	164
100	133	158	193	194
125	153	188	228	234
150	178	218	268	269

Note: *The dimensions listed above are for reference only. Please contact Future Pipe Industries L.L.C for additional information and requirements.*