WAVISTRONG™

Assembly Instructions
Conical-Cylindrical (CB-CS) Adhesive Bonded Joint

FUTURE PIPE INDUSTRIES

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Conical-Cylindrical (CB-CS)
Adhesive Bonded Joint

FPI-WSAICBCS-V03241

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Table of contents

1 General

This document describes the method to assemble Conical-Cylindrical 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 is familiar with and fully understands 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 in order 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:

- WS TCD 009 Wavistrong Easy-Fit Adhesive Instructions
- WS TCD 035 Wavistrong Cylindrical Spigot Shaver Instructions for ID80 – 250 mm
- WS TCD 036 Wavistrong Cylindrical Spigot Shaver Instructions for ID200 – 400 mm

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

4 Health and safety

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

- Wear at all time 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)

Fig. 4

For health and safety data reference is made to the applicable instructions (see section 2).

5 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.

6 Requirements for the 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.

6.1 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 6.2) 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 a 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 a clean, dry and non-fluffy cloth (see fig. 6.1).

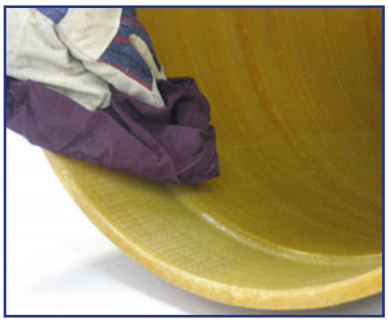


Fig. 6.1

6.2 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 was after completion of the manufacturing process. Not any manual or mechanical abrasion process, such as sanding or sand blasting, has ever 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 wall structure may come in direct contact with the environment and therefore this surface is sensitive for contamination.

6.3 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 ^{0}C, these surfaces must be heated in order 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 surfaces.
Heating of surfaces that are wet or below dew point plus 3 ^{0}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 ^{0}C, or set the temperature of the heating blanket at maximum 80 ^{0}C.
If the environment heats the bonding surface above 40 ^{0}C, protect it from direct radiation by sunlight.
The temperature of the bonding surfaces of spigot- and bell end during the bonding procedure should be kept between 15 ^{0}C and 40 ^{0}C, but also at least 3 ^{0}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.

6.4 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 6.5).
In case of doubt about the nature of the contamination cut the concerned spigot- or bell end.

If there are no traces of contamination on these pipe ends, clean these bonding surfaces using a clean, dry and non-fluffy cloth.
Do not touch the cleaned bonding surface, nor allow it to be contaminated.

6.5 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 operation.

Bonding surfaces must be clean and dry at the start of the sanding operation (see sections 6.1, 6.3 and 6.4).

Sanding of unprepared bell ends is performed mechanically, using an emery cup with a grid of grade P40 to P60 (see fig. 6.5.a).
Rotation speed of the emery cup shall be as low as possible.

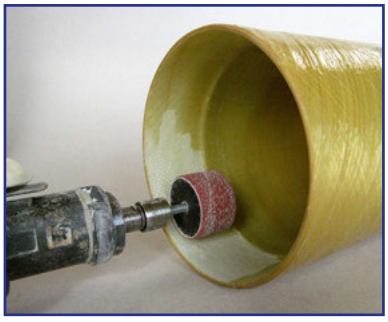


Fig. 6.5.a

Sanding of factory and/or field prepared spigot- and bell ends is performed mechanically using an emery cup, with a grid of grade P40 to P60.

A correctly sanded surface of a bell end does not change in colour when continuing sanding (see fig. 6.5.a). A factory prepared spigot end has been correctly sanded when the black ink has been removed completely and the surface does not change in colour when continuing sanding (see fig. 6.5.b.)

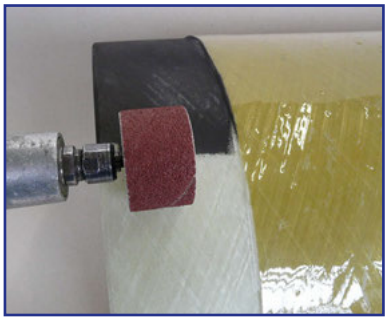


Fig. 6.5.b

Bonding surfaces must be sanded equally in circumferential direction.

The bonding surface must stay smooth by applying an even pressure on the sanding equipment.

Do not forget to sand the pipe stop shoulder in the bell end, nor the head of the bell end.

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

The bonding surface is cleaned using a dry and clean dust bristle (see fig. 6.5.c).

Fig. 6.5.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.

7 Dimensioning of a cylindrical spigot end

In case a pipe with the correct length and (factory) shaved spigot end is available, then continue with section 8 of these instructions.
This section 7 is relevant in case the pipe length has to be adjusted or a spigot end has to be shaved.
Make sure to comply with the relevant requirements stated in section 6 before starting a next step in the activities to complete the bonding procedure.

7.1 Cutting of pipe

a Contaminated pipe surfaces must be cleaned prior to perform any operation on the pipe (see relevant requirements stated in section 6).

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. 7.1.c).

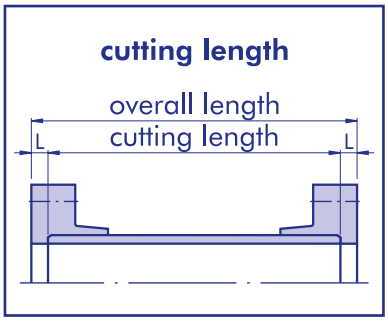


Fig. 7.1.c

d Scribe the pipe at the required length, using a pipe fitters' wrap-around (see fig. 7.1.d); take notice of the minimum cut length (see Annex B).

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

Fig. 7.1.d

f Ensure that the squareness of the cut end remains within required tolerance (A) (see fig. 7.1.f and table 7.1.f).

Table 7.1.f Tolerance cut end

ID (mm)	A (mm)
25 - 400	± 3

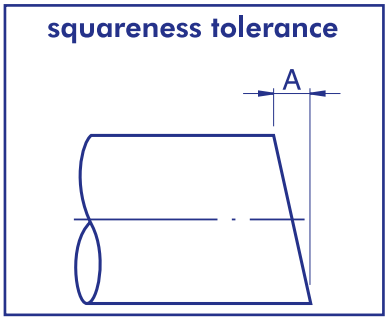


Fig. 7.1.f

7.2 Shaving of a pipe end

a Various types of shavers are available (see fig. 7.2.a).
To operate the shaver, carefully follow the applicable shaver instructions (see section 2).

Fig. 7.2.a

b The pipe end to be shaved shall be clean (see relevant requirements in section 6) and must be adequately supported (see section 7.1.b and fig. 7.2.b).

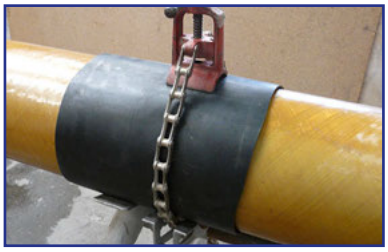


Fig. 7.2.b

c Start the shaving procedure (see fig. 7.2.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.

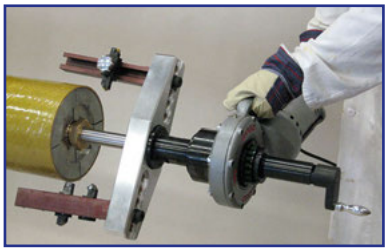


Fig.7.2.c

d Repeat the shaving action until the required spigot dimensions (see Annex C, table C) are achieved.
Indications of the spigot dimensions are obtained by measuring the dimensions while the shaver is mounted.

The spigot diameter (S1) is determined at about half of the spigot length (SA) (see fig. 7.2.d1).
The wall thickness of the spigot (T) is measured at the end of the spigot at a number (>= 6) of positions qually spaced in the circumference (see fig. 7.2.d2).

Fig. 7.2.d1

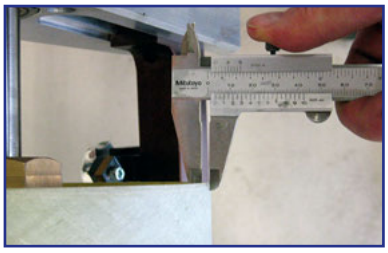


Fig. 7.2.d2

The actual spigot dimensions shall be determined after dismantling of the shaver from the pipe end. The spigot dimensions shall comply with the requirements of Annex C, table C.

- In case of non-compliance with dimensional requirements, following corrective actions shall be taken:

  - Cut the shaved spigot end and put the left pipe section aside; this section can be used for a shorter assembly length.
  - Continue the dimensioning process starting from the description of section 7.1.

8 Preparing for bonding

Before any actual bonding activity can start, the spigot- and bell end to be jointed shall be prepared as described below. Especially in the small diameter range (ID <= 200 mm), 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).

8.1 Sanding and conditioning of both bonding surfaces

Make sure to comply with the relevant requirements stated in section 6.

Note 1
The maximum number of sanding operations for each of the bonding surfaces, either the spigot- or the bell end, is two.
In case the spigot is re-sanded the relevant spigot dimensions shall be checked by measuring.
For dimensional requirements see Annex C, table C.

Determine the spigot diameter S1.
The wall thickness of the spigot (T) is measured at the end of the spigot at a number (>= 6) of positions equally spaced in the circumference.

In case the number of sanding operations of the bonding surfaces is more than two, or the spigot dimensions are not in compliance with the requirements, the product shall not be used or the spigot end shall be cut.

8.2 Dry fit and marking

In order to be able to check the required final position of the spigot relative to the bell, the joint of a pipe and a fitting is marked with an alignment mark.

Scribe a line on the outer surface of the bell, parallel to the axis of the product, and continuing on the outer surface of the pipe containing the shaved spigot end (see fig. 8.2).

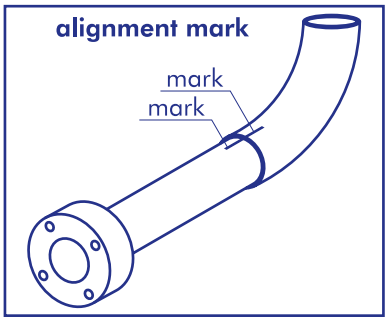


Fig. 8.2

8.3 Mounting of pulling equipment

a If possible, the conical-cylindrical adhesive bonded joint is assembled without the use of mechanical pulling equipment. However, starting from ID 200 mm it is allowed to mount the spigot in the bell using pulling equipment.

b The pulling equipment is installed on both sides of the joint; normally two winches will suffice.
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.

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

9 Bonding

The actual bonding starts with the preparation of the adhesive and finishes after completion of the curing, when the adhesive between the jointed parts is cooled down to ambient temperature.
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 pushed into the bell shall fall within the pot-life/working time.

9.1 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 on the prepared bonding surfaces, immediately after finishing the mix procedure of the adhesive components.

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

9.2 Application of adhesive

a Use a fresh spatula or adhesive scraper for the application of adhesive on the freshly prepared bonding surfaces.
In case this 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 spigot- and bell end with some force with a thin, uniform coating of adhesive (hardly any thickness).

c Apply a thin (0.5 – 0.8 mm) and uniform layer of adhesive on the adhesive coated bonding surface of the bell end.
Apply a somewhat thicker (0.8 – 1.0 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 and on the pipe stop shoulder in the bell end (see fig. 9.2.c1 and fig. 9.2.c2).

d Avoid any contact with the adhesive coatings on the bonding surfaces and prevent any contamination.

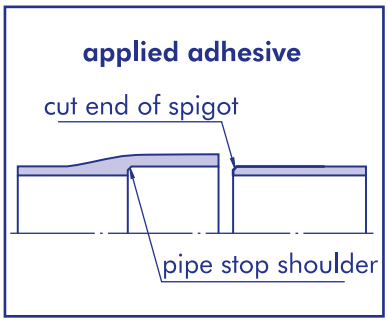


Fig. 9.2.c1

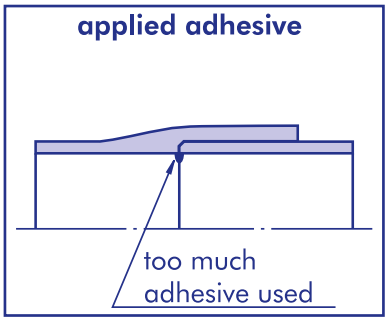


Fig. 9.2.c2

9.3 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 push it home while rotating slowly one quarter of a rotation, if possible.
Pay attention to the alignment mark on the outer surface with regard to the orientation of the parts to be jointed.

c When using pulling equipment for joints ID > 200 mm, the winches are hooked, each winch is equally loaded and the sections to be bonded are pulled together with a smooth movement.

d Make sure that the spigot is inserted centrically into the bell until the entrance of the spigot is stopped by the shoulder in the bell.

Note 2
Continuation of activities on the pipeline system may never result in displacement of the position of the spigot relative to the bell in whatever direction or orientation.

e Remove the excessive adhesive from the outer surface (see fig. 9.3.d1) and if possible from the inside of the joint.
The fillet on the head of the bell should be smoothly rounded; the fillet on the inside of the joint may be smoothened using a plug (see fig. 9.3.d2).

Fig. 9.3.d1

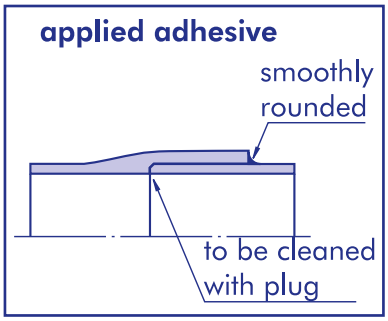


Fig. 9.3.d2

9.4 Curing of adhesive

a Until completion of the cure of the adhesive the joint shall not be moved, vibrated or otherwise disturbed.

b Wrap the 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. 9.4.b).

Fig. 9.4.b

c Overlapping ends of oversized blankets risk to be over-heated.
Insulate overlapping ends of the blanket 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 reach up to at least 100 mm over both sides of the heating blanket and should fit around the pipe (see fig. 9.4.d).

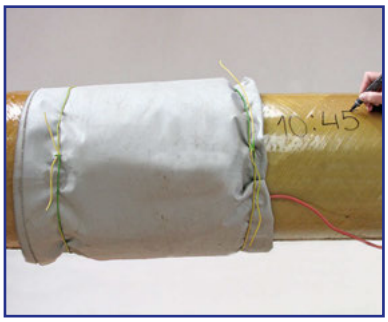


Fig. 9.4.d

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. 9.4.d).
For the required curing process 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. 9.4.g).

Fig. 9.4.g

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

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.

10 Materials, tools and consumables

10.1 Materials

- Adhesive *

10.2 Tools

- Shaver *
- Heating blanket (plus temperature controller, if applicable) *

- Measuring tape and/or folding rule
- Vernier calliper
- Pi-tape
- Pipe fitters' wrap-around
- Level and marker
- Protractor
- Pipe vice or stable supports (brackets) with rubber coated clamping device
- Hacksaw, disc grinder or power jigsaw
- Small electrical or air driven straight grinder with adjustable rotation speed
- Pairs of winches or come-alongs (if applicable)
- Pairs of band clamps with puller rings (if applicable)
- 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)

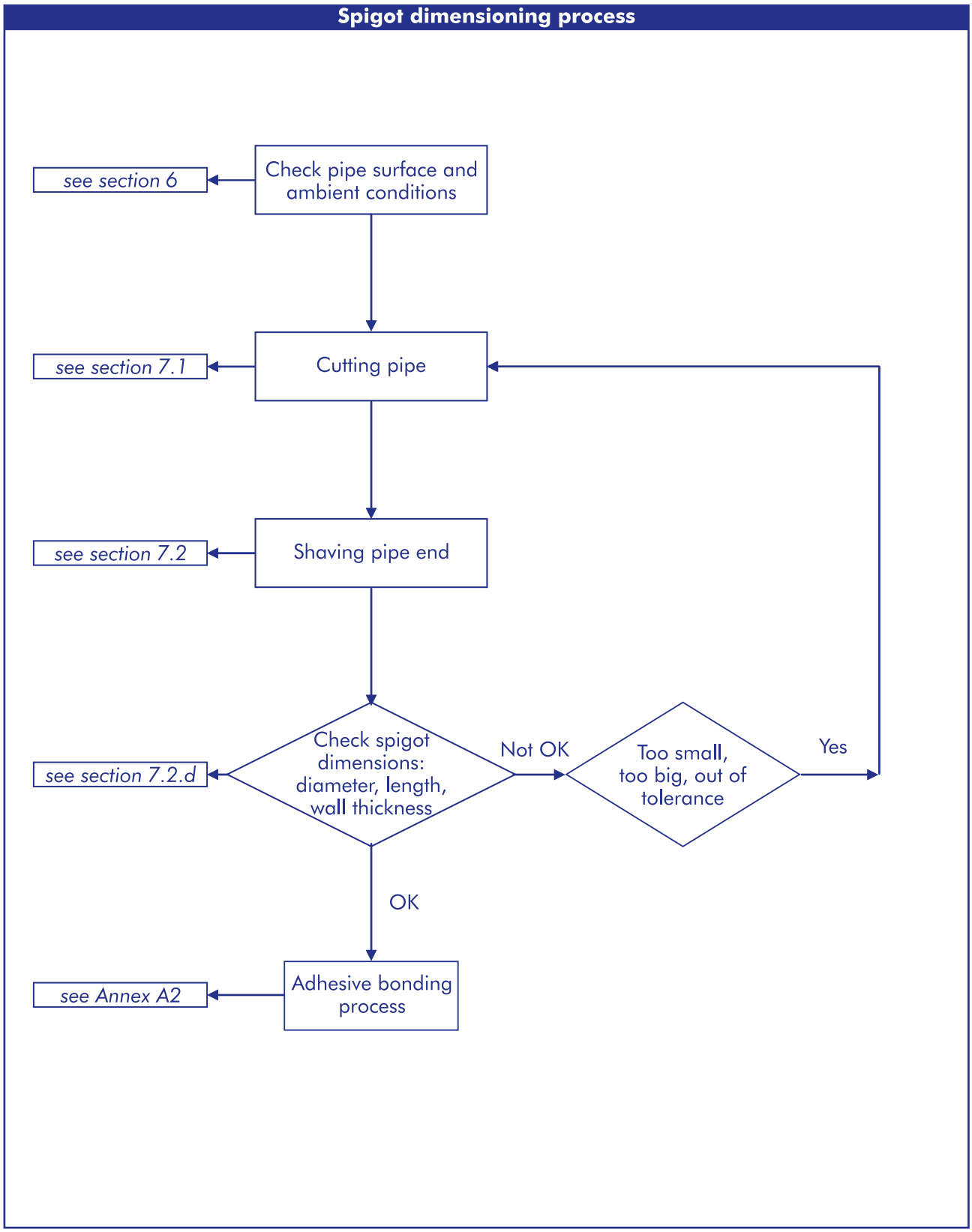
** To be supplied by the pipe manufacturer.*

10.3 Consumables

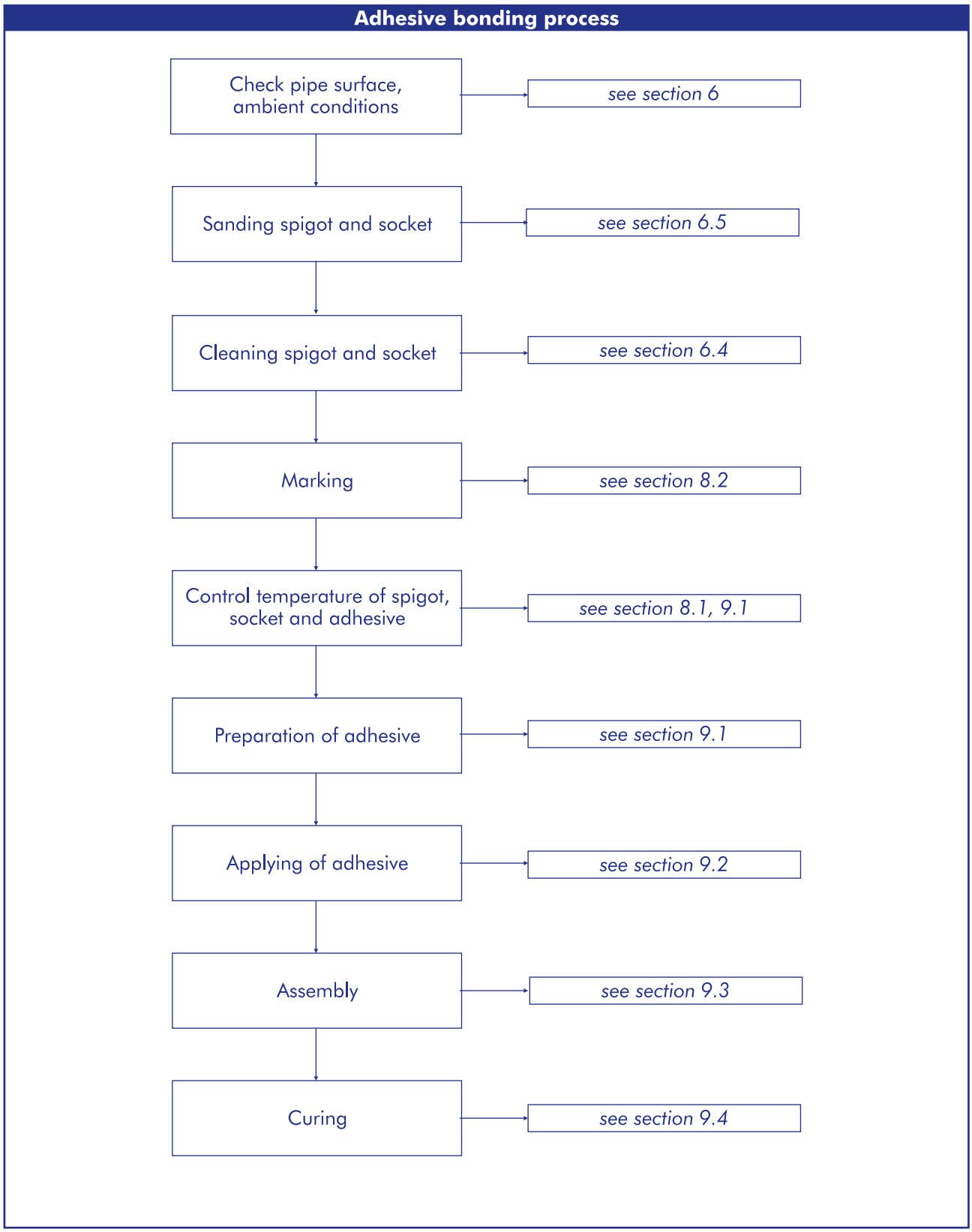
- Cutting disks
- Emery cups grade P40 to P60
- Spatula (rubber scraper plate, filling knife), marker pen, dust (paint) brush
- Rubber gloves, working gloves, dust masks, safety goggles
- Cleaning plug
- Overalls, safety shoes, safety helmet
- Cleaning rags, cleaning fluid such as acetone, Methyl Ethyl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

Annex A Schemes assembly process Conical-Cylindrical adhesive bonded joint

Annex A1 Scheme of spigot dimensioning process



Annex A2 Scheme of adhesive bonding process



Annex B Minimum cut length

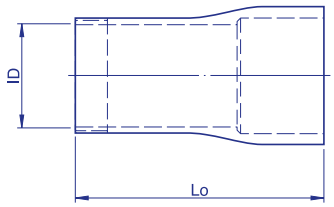


Fig. B Minimum cut length (Lo) for pipe Conical Bell – Cylindrical Spigot

Table B Minimum cut length (Lo) (mm)

ID (mm)	PN (bar)					
	8	12,5	16	20	25	32
25						280
40						280
50						280
65						290
80						540
100					540	550
125					550	565
150				550	560	575
200			550	565	580	600
250		560	565	580	600	625
300		560	575	595	620	650
350	570	570	590	610	640	
400	580	580	600	625	660	

Annex C Dimensions Cylindrical Spigot

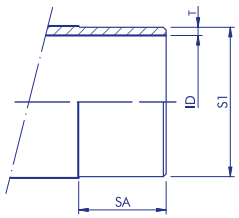


Fig. C Dimensions cylindrical spigot

Table C Dimensions Cylindrical Spigot

PN (bar)	ID (mm)	(T)* (mm)	Tmin* (mm)	Tmax* (mm)	S1* (±0.2) (mm)	SA* (0,+4) (mm)
8	350	3.5	2.8	4.2	357.0	74
	400	3.9	3.1	4.7	407.8	84
12.5	250	3.2	2.7	3.7	256.4	64
	300	3.7	3.1	4.3	307.4	64
	350	4.2	3.5	4.9	358.4	75
	400	4.7	3.9	5.5	409.4	85
16	200	3.2	2.8	3.6	206.4	54
	250	3.9	3.4	4.4	257.8	69
	300	4.5	3.9	5.1	309.0	80
	350	5.1	4.4	5.8	360.2	95
	400	5.8	5.0	6.6	411.6	105
20	150	3.1	2.8	3.4	156.2	54
	200	4.0	3.6	4.4	208.0	69
	250	4.8	4.3	5.3	259.6	85
	300	5.6	5.0	6.2	311.2	100
	350	6.4	5.7	7.1	362.8	116
	400	7.2	6.4	8.0	414.4	131

* (T) = Nominal wall thickness of the spigot (for reference only)
TolT = Tolerance on wall thickness of the spigot (T)
= ± (0.002 x ID, ≥ 0.3)
* T_{min} = Minimum wall thickness of spigot
= T – TolT
* T_{max} = Maximum wall thickness of spigot
= T + TolT
* S1 = Nominal Spigot Diameter
* SA = Nominal Spigot Length

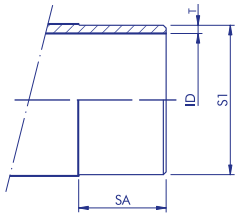


Fig. C Dimensions cylindrical spigot

Table C Dimensions Cylindrical Spigot

PN (bar)	ID (mm)	(T)* (mm)	Tmin* (mm)	Tmax* (mm)	S1* (±0.2) (mm)	SA* (0,+4) (mm)
25	100	3.1	2.8	3.4	106.2	44
	125	3.3	3.0	3.6	131.6	54
	150	3.8	3.5	4.1	157.6	64
	200	4.8	4.4	5.2	209.6	85
	250	5.8	5.3	6.3	261.6	105
	300	6.8	6.2	7.4	313.6	126
	350	7.8	7.1	8.5	365.6	146
	400	8.9	8.1	9.7	417.8	167
32	25	2.5	2.2	2.8	30.0	34
	40	2.5	2.2	2.8	45.0	34
	50	2.5	2.2	2.8	55.0	34
	65	3.1	2.8	3.4	71.2	44
	80	3.1	2.8	3.4	86.2	44
	100	3.3	3.0	3.6	106.6	54
	125	3.9	3.6	4.2	132.8	69
	150	4.5	4.2	4.8	159.0	80
	200	5.8	5.4	6.2	211.6	105
	250	7.1	6.6	7.6	264.2	131
	300	8.4	7.8	9.0	316.8	157

* (T) = Nominal wall thickness of the spigot (for reference only)
TolT = Tolerance on wall thickness of the spigot (T)
= ± (0.002 x ID, ≥ 0.3)
* T_{min} = Minimum wall thickness of spigot
= T – TolT
* T_{max} = Maximum wall thickness of spigot
= T + TolT
* S1 = Nominal Spigot Diameter
* SA = Nominal Spigot Length