Assembly Instruction
for
Lamination

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Contents

1. Safety

The following personal protection gear must be used when cutting, drilling, sanding and grinding Glassfiber Reinforced Epoxy, Vinyl ester, and unsaturated polyester (=GRE, GRVE, and GRUP) materials:

- Safety shoes or boots;
- Safety goggles;
- Work gloves (GRP/FRP material can be very sharp and may cause cuts or splinters);
- Closely fitting and buttoned-up protective clothing (coverall) must be worn when operating the shaver;
- A safety helmet and earplugs are to be used if required by the situation;
- A hair net must be worn, if applicable, when, cutting, drilling, grinding, etc.;
- An appropriate dust mask is to be used when cutting, drilling, grinding and sanding.

1.1. Safety precautions

- Avoid skin contact with resin and hardener. In case of contact, wash skin thoroughly with soap and water or clean with black box wipes.
- DO NOT wash hands with acetone.
- Avoid eye contact with resin and hardener. In case of contact, the open eye should be immediately rinsed with running water or eye wash bottle and the emergency doctor shall be called.

1. Resin, hardener, and solvents are flammable. Therefore, smoking and the use of open fire are prohibited! A fire extinguisher is recommended. Note: At Fincantieri a fire brigade is present.

- Epoxy resin and hardener must not be stored together.
- Store Vinyl ester hardener and accelerator separately and always measure or weigh in separate containers. Do not mix directly with each other.
- The danger of explosion: Further important information on the handling of resin, hardener, and accelerator can be found in leaflet M023 "Polyester and Epoxy Resins" of the Professional Association of Chemical Industry. All data-sheets issued by the Berufsgenossenschaft of the Chemical Industry can be obtained from the Jedermann-Verlag, P.O.B. 103140, 69115 Heidelberg, Germany. Jointers are trained regarding this topic.
- Eating and drinking in the workplace are prohibited.
- The personal protective equipment such as safety glasses, dust mask, ear plugs, safety shoes, work gloves, coverall, apron, face shield must be worn.
- Prior to commencing work read the applicable safety data sheets for the processing materials.
- Eyewash bottle.
- First aid kit.

1.2. Order & Safety

Housekeeping can eliminate some workplace hazards and help get a job done safely and properly. Poor housekeeping can easily contribute to accidents by hiding hazards from sight that may cause injuries. Therefore, be sure to keep work areas, including tooling, clean, neat and orderly.

2. Reference documents

a. Basic installation guide Fiberdur

3. Check and inspection of materials

Thorough preparation before starting bonding operations will ensure that the work can proceed smoothly. Make sure that all pipes and fittings required, together with a sufficient quantity of adhesive, are at hand before starting work. Check pipe/fittings and adhesive containers for damage and correct type. Check availability (required amount) of the correct type of cobalt accelerator, resin and hardener, when using vinyl ester or hardener/curing agent when using epoxy resin, incl. approved manufacturer. Make sure that products are correctly stored e.g. glass fabric is dry.
Make sure, when applicable, that drawings are available for correct spooling.
Check pipe and fittings for visual defects.

The main visually detectable defects are:

- Deformations and dimensional deviations.
- Surface cracks and microcracks.
- Near-surface delaminations.
- Inclusions and air entrapments.
- Impact damage.
- Blisters.
- Internal excess of adhesive (internal inspection).
- Corrosion and erosion (internal inspection).

Storage:
Storage recommendations for the adhesives, resin, hardener, accelerators, and glass are as follows:

- Keep the materials in their original packaging.
- Do not expose these materials to direct sunlight.
- The materials must be stored in a dry area with temperatures between 0°C and 40°C.
- Check the expiration dates; observe the principle of ‘first in, first out’.
- Adhesive kits must be stored upright.

See also paragraph 1.1. Safety precautions as well as MSDS materials.

4. Check availability of tooling

Before bonding, all tooling and available consumables must be checked.

Tooling

- Heating blanket.
- Measuring tape or carpenter's ruler.
- Pi-tape or Vernier caliper.
- Pipefitters' wrap-around.
- Spirit level and a marker pen.
- Stable support (brackets) with rubber coated clamping device.
- Ratchet straps.
- Disc grinder with grinding wheel or with diamond fitted cut-off wheel.
- IR temperature gauge for surface temperature measurement.
- Dewpoint, Temperature, Relative humidity meter.
- Weather protection shelter (depending on weather conditions).

Consumables

- Cutting discs.
- Emery disks, emery cups, emery cloth, flapper wheels (all grade P35 to P40).
- Spatula (rubber scraper plate, filling knife).
- Rubber gloves, work gloves, dust masks, safety goggles.
- Brush.
- Air relief roller.
- Lamb's wool roller.

5. Heating blankets

When the adhesive bonded joint is made up the adhesive needs additionally to be hot cured. It is important to select the right type of heating blankets.

Requirements for proper handling of the heating blanket:

- Do not leave the heating blanket on the floor. Do not step on the heating blanket.
- Do not sharply fold the heating blanket.
- Do not use the electric cable as a grip, e.g. removing the heating blanket from the joint.
- After use: store the blanket in a dry and designated place.

The following heating blankets are available in 230 Volt and 110 Volt Fiberdur:

- DN25-80.
- DN100-DN200.
- DN 250-DN350.
- Heating blanket 3000*300mm.

6. Cutting Pipes

Pipes can be cut into lengths by hand using a metal-cutting saw. Make the cut is at right-angles to the pipe axis. When cutting manually it is useful to mark the pipe with a pipefitters wraparound before cutting.

In case a pipe with the correct length and (factory) shaved spigot end is available, then continue with the next section. This section is relevant in cases where the pipe length has to be adjusted or a cylindrical spigot end is to be shaved.

Cutting of pipe:

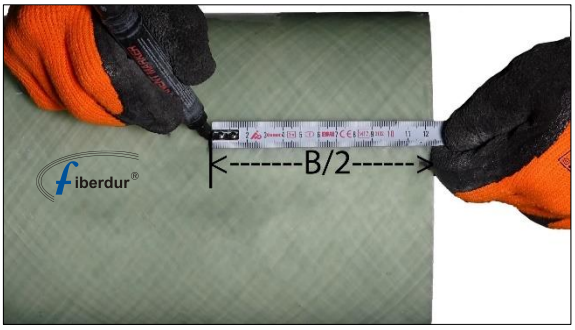
- Clean the pipe surfaces inside and outside (where areas are not machined or abraded) when contaminated prior to any operation on the pipe.
- Take care that the pipe is adequately supported or clamped on a pipe vice.
- Use always rubber padding or equivalent between the pipe and the steel of the support. The padding shall have a minimum thickness of 3 mm in order to protect the pipe from damage.
- Calculate the required length from the product drawing or by measurement
- Scribe the pipe at the required length, using a pipefitters' wrap-around and take notice of the minimum cutting length (see Addendum B for some examples of calculating the cutting lengths).
- Cut the pipe square using a hacksaw or an abrasive wheel.
- Check the squareness of the cut end. See Addendum B for the allowable tolerances.
- Cut pipes all the way through. Support the free ends sufficiently. This avoids the pipe breaking off before cutting is completed.

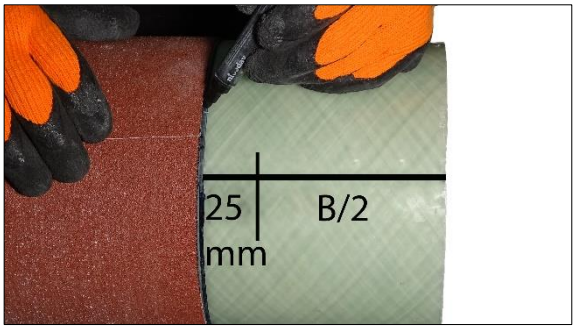
7. Preparation

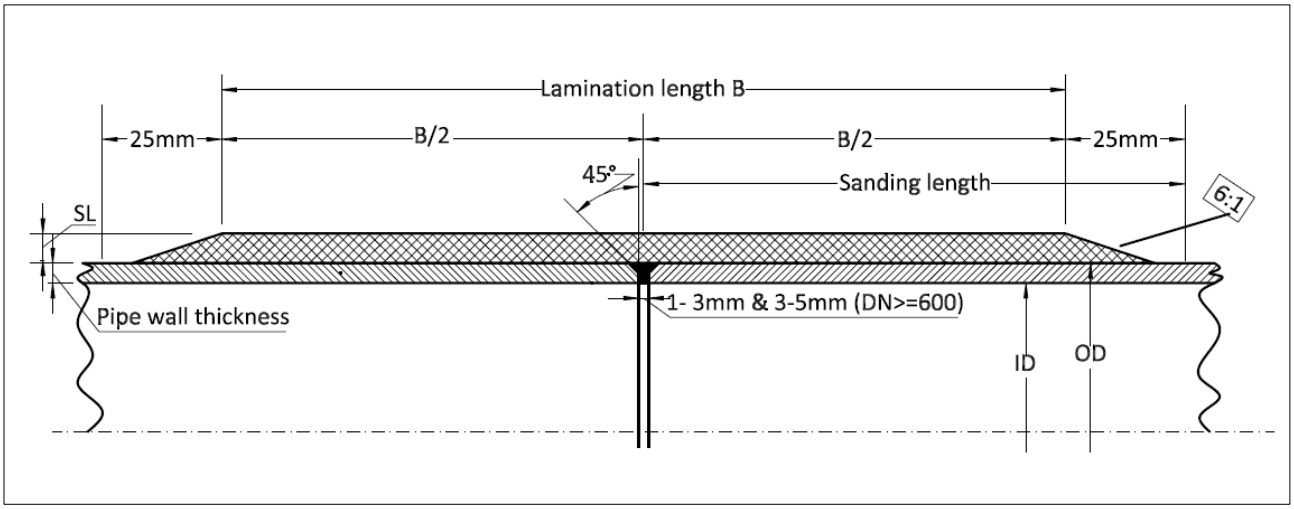
Careful preparation before starting the lamination operation will ensure that the work can proceed smoothly. This includes cutting the glass mats and glass fabric required and making sure that sufficient quantities of resin and hardener are at hand.

8. Surface Preparation

- The surface of pipes and other glass fiber reinforced components which are to be laminated over each other or together must be prepared by abrasive sanding before the laminate material is applied.

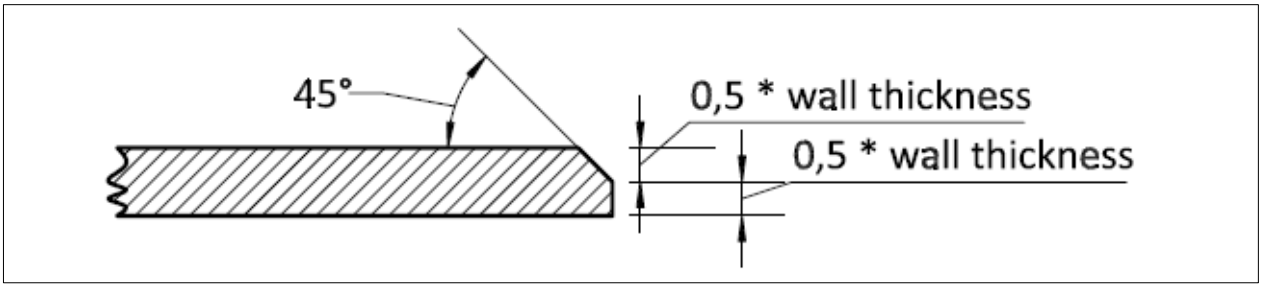






- Mark the laminate length B/2 at the required distance of the pipe end. The distance can be read in the table given in Addendum A
- The length of pipe surface to be sanded should be 25mm longer than the length of the laminate, set the second mark.

- About 0.3 to 0.6mm of the initial wall thickness should be sanded away. With respect to the minimum required wall
- The nose ends have to be sanded as well. As shown in the figure the angle shall be 45° and about 0.5 of the pipe thickness has to be sanded away.
- On completion of sanding, the bonding surface should be free of resin rich, shiny areas. The appearance should be grey and dull. Excess emery powder is removed using a clean and dry brush. The grid size of the sanding paper or grinding disc should be P35-P40. Break the edges of the sandpapered pipe ends.

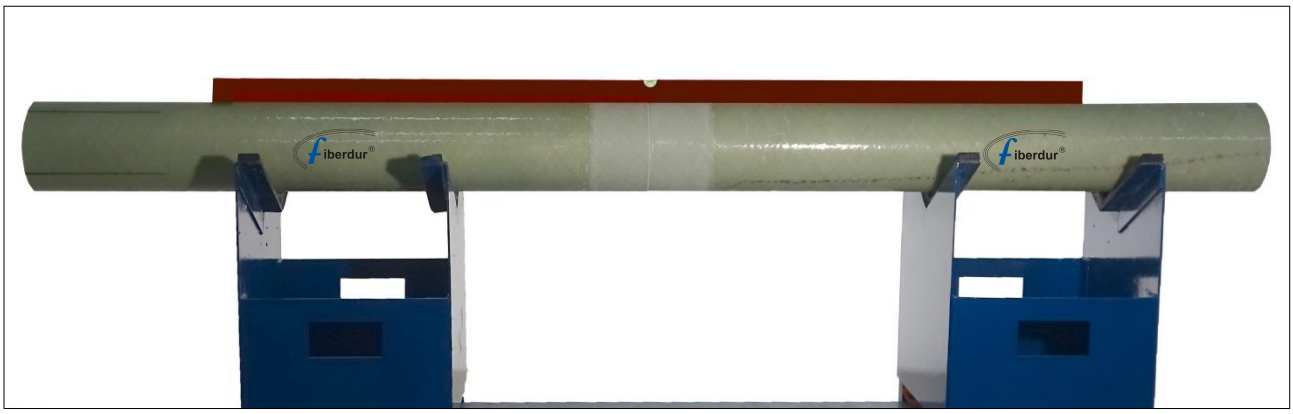


- If interior laminates are to be carried out diameter >=600mm and accessible, the inside surfaces must be treated correspondingly on the inside.
- The pipe parts must be dry. If not, then the pipe ends should be dried with a heating blanket for at least 15 minutes.
- Protect prepared surfaces from dirt, humidity, etc. Grease, oil, or surface contamination act as release agents and prevent adhesion of the laminate.
- Do not use solvents to clean surfaces to be laminated as this may spread contamination.

9. Environmental check

Execute the environmental check, temperature surface, ambient temperature, relative humidity, dewpoint; only when OK continue.

10. Alignment

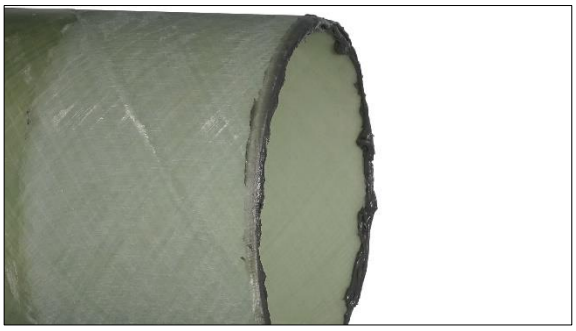


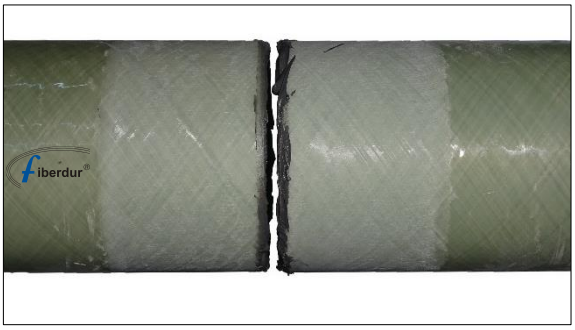
- Pipe components to be connected must be secured in a fixture or jig to remain correctly aligned during lamination and the curing period.
- The gap between two ends must be between 1-3 mm & 3-5 mm if DN>=600 mm. Keep it as close as possible to 1 mm & 3 mm if DN>=600.

11. Mixing adhesive

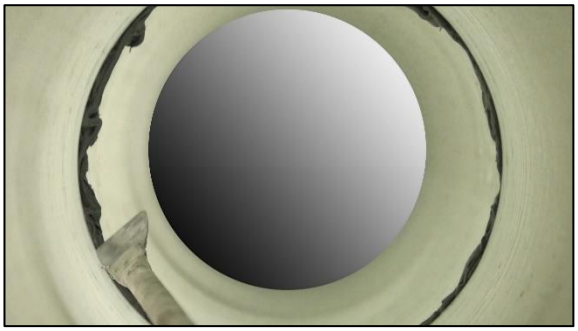
- Mix the adhesive EP220 (Epoxy type) at a temperature of [15°< temp < 30°] for 2 minutes. The mixed adhesive should have a homogeneous consistency and uniform color.

12. Apply the adhesive



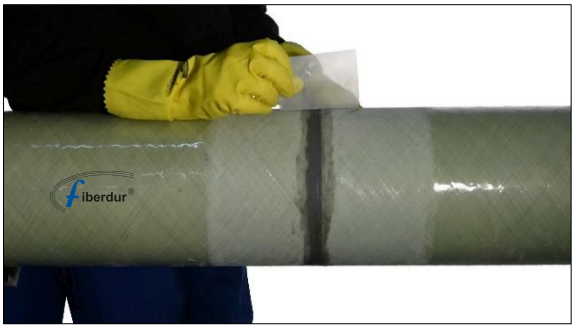


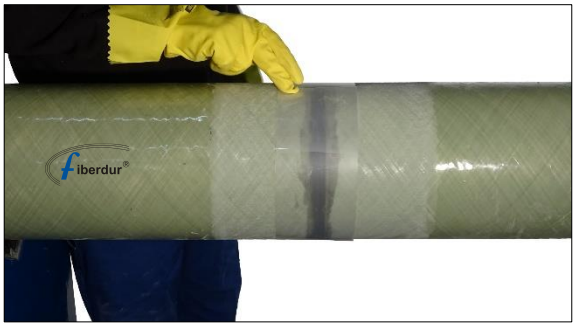
- Surface preparation by sanding must be less than 1 hour before assembly.
- Apply the adhesive immediately after mixing on the pipe ends first.
- Before being connected, a thin layer adhesive EP220-1 (epoxy) is applied to the cut edges of the pipes and/or fittings.
- Then move the pipes firmly together. The remaining gap must be filled with adhesive. **Take care that no adhesive is pressed through the gap.**

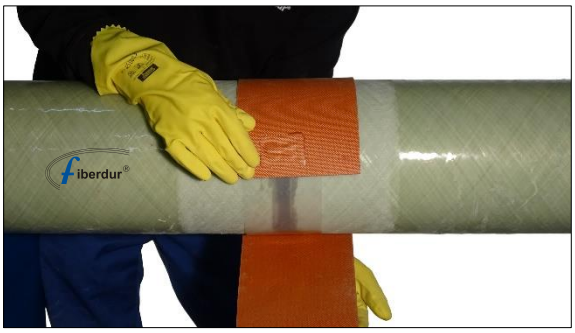


- Remove excess adhesive from the outside and inside of the pipe when accessible.

13. Curing of the adhesive







- Apply heating blanket after at least 15 minutes and till adhesive is not tacky.
- The adhesive needs to be cured for 15 minutes using a heating blanket. Between the heating blanket and the adhesive, a plastic film must first be wrapped to protect the heating blanket from contamination by the adhesive.

- It is recommended to monitor the temperature of the heating blanket during the curing phase by means of a digital thermometer. Make sure that the entire surface is covered with the heating blanket during the curing.
- Switch on the electricity and check that the heating blanket heats up. Measure the temperature of heating blanket outside (overlap) after 15 minutes and the temperature of the heating blanket outside (overlap) before switching off. The temperature must be higher than 100°C.
- The pipe/fitting parts must not be moved before and during the curing phase. After curing and cool down, the parts can be moved carefully.

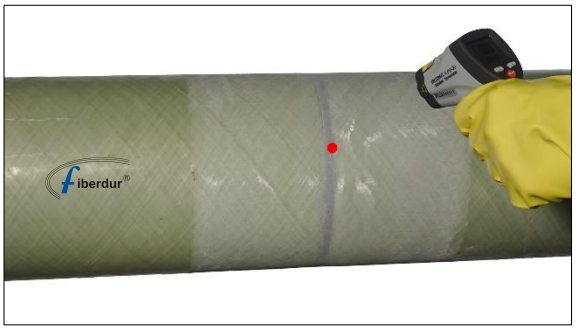
14. Reinforcing laminate

- See preparation: Determine the amount of chopped strand mat, woven roving and breather/ bleeder cloth (de-airing band as per Addendum A). Cut the required amount from the chopped strand mat and woven roving rolls to size and overlap as illustrated.

- The glass mats and glass fabrics are cut to size and laid out.

- After curing with the heating blanket it is mandatory that the surface is sanded again. Sand the surface over a width of B mm (see literature) + an extra width of 25 mm. Use sandpaper P35-P60 grid or similar abrasive disc.
- Remove all excess emery powder using a dry brush. Protect prepared surfaces from dirt, humidity, etc. Grease, oil, or surface contamination act as release agents and prevent adequate adhesion of the laminate.
- The pipe parts should be clean and dry. If not, then the pipe ends should be dried with a heating blanket for at least 15 minutes.
- Do not use solvents to clean surfaces to be laminated
- Laminating the pipe/fitting parts must commence within 1 hour after sanding the surface.

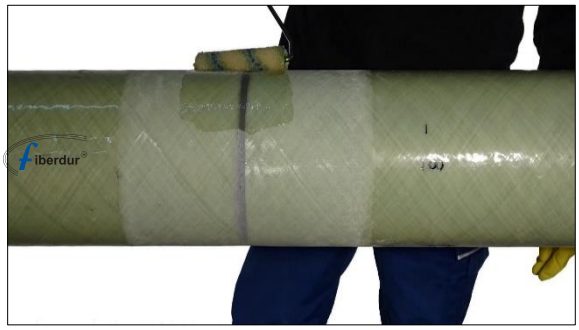
15. Environmental check prior to laminating

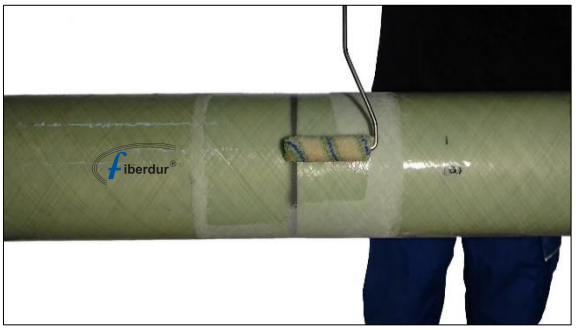


Relative humidity measurement

- Complete the environmental check, the temperature of both surfaces, ambient temperature, relative humidity, dewpoint; only when OK continue with the reinforcing layer.
- Measure the temperature of the mixed resin; the value should be between 15°C and 40°C.
- Details about the resin mixture are described in chapter 26.

16. Applying a reinforcing laminate first layer





- Wet the pipe surface with the resin/hardener/accelerator mixture using a brush or lamb's wool roller.

- Next, the first glass chopped strand mat is laid up, soaked in laminating resin and rolled with e.g. lamb's wool roller. No white (dry) spots shall be visible.
- Where the glass segments, chopped strand mat, overlap: the starting point of the layer must be well impregnated before the overlap can be finished. The overlap shall be around 50 mm.

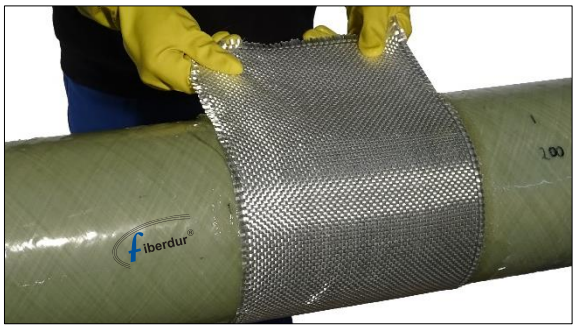
- To squeeze out air bubbles, use a de-airing roller, e.g. a steel fluted roller. De-airing is recommended after each layer of chopped strand mat (M) and before woven roving (G).

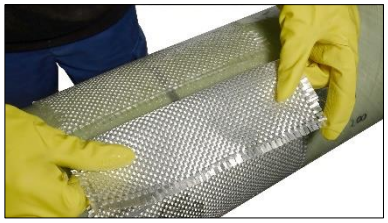
- The process continues similarly for the second layer woven roving. Again, for applying the next layer no white spots shall be visible. Look also at any blind spots (check the underside of pipe) to ensure impregnation is OK.
- Where the glass layers, woven roving, overlap: the starting point of the layer must be well impregnated before the overlap can be finished. The overlap shall be around 50 mm.
- The laminate is additionally compressed by winding over a hand controlled tensioned layer of breather/bleeder cloth (de-airing mesh tape). The external cloth must be applied evenly with an overlap of approx. 50% and must be well soaked in resin.

17. Applying a reinforcing laminate second layer

The first layer chopped strand mat

- It is recommended not to stack the overlaps at one spot but distribute them over the circumference.





The first layer is woven roving

18. Finishing Layer

- The finishing layer is chopped strand mat, as can be seen in the picture.
- The width of the mat is 2 cm more than the joint layer, meaning B + 2 cm.
- The mat provides a good finish at the edges.
- Again, good wetting is required using a lamb's wool roller.
- Finally, de-air the finish layer and/ or use breather/ bleeder tape.

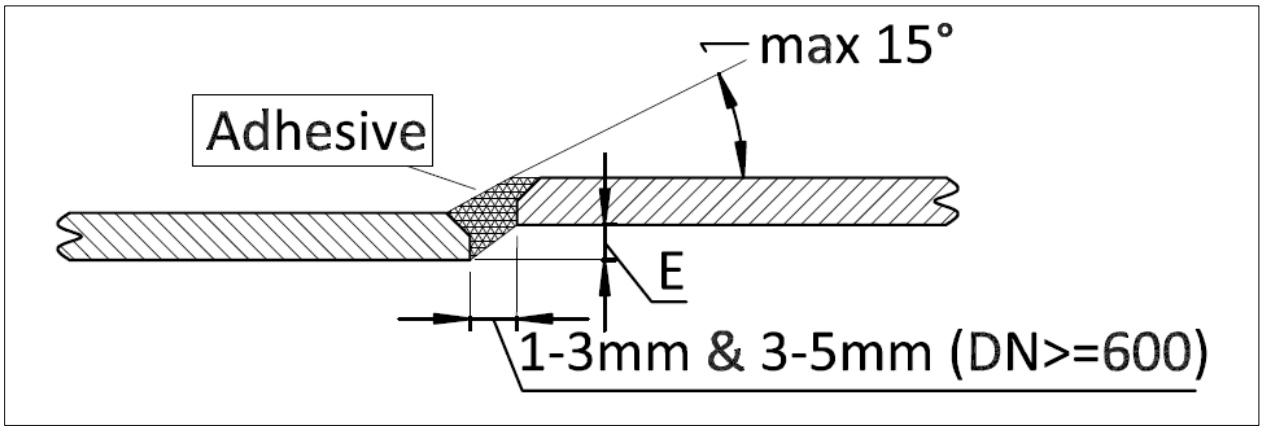
19. Curing with a heating blanket

Cure

- Wait at least 30 minutes and until the surface is not sticky anymore.
- Apply one or more heating blankets.
- Check that the complete surface is covered by the heating blanket during the curing.
- Cure at ambient temperature ≈20°C for 2 hours until the laminate is cold and solid and then with the switched on heating blanket for 60 minutes.
- Check: After switch on the electricity, check that the heating blanket heats up. Measure the temperature of heating blanket outside (overlap) after 15 minutes and the temperature of the heating blanket outside (overlap) before switching off. The temperature must be higher than 100°C.
- The curing should be performed after 5 modules of (MGB)≈10mm and after completion of lamination (see example).
- **Important:**
  When the curing period for a phase of the lamination part is ready, the cured laminate (or adhesive) is again sanded prior to the next phase of lamination.

20. Overlap with Butt Joints, mismatch

If pipes of large nominal diameter are highly mismatched, i.e. out-of-round, it must be ensured that, in relation to a nominal diameter and wall thickness, the tolerance mismatch “E” is kept smaller than the values shown in the following table. This is achieved using a clamping device.



Permissible pipe mismatch								
Nominal Diameter	25-125	150	200	250	300	350	400	450
Mismatch “E” (mm)	2	2,5	3	3,5	4	4,5	5	5,5
Nominal Diameter	500	600	700	800	900	1000	1200	
Mismatch “E” (mm)	6	6,5	7	8	9	10,5	11,5	

Adhesive or equivalent should be used to provide continuity at the section around the joint. The angle can be max. 15°.

In the case of pipe nominal diameters that allow interior work to be carried out, corrosion performance can be further improved by applying internal lamination layers.

21. Mixing Resin

21.1. Standard resin mix

Under standard conditions, for lamination processes with Vinyl ester resin we recommend the following resin mixture (parts are in weight):

Recipe
Vinyl ester
1000 parts Vinyl ester
30 parts hardener MEKP-M 60
15 Accelerator Cobalt accelerator, 1%ig

Components not yet mixed, such as resin, hardener, and accelerator, require appropriate storage. Inappropriate storage reduces storage life and results in a chemical modification of the basic materials that make it not suitable to use. Storage times are:

Storage temperature		
Storage Temperature		**Vinyl ester Resin**
below 10°C		up to 3 months
10° C – 30° C		up to 1 month

Important

Hardener and accelerator must be stored **separately** and always measured or weighed in separate containers. They must **NOT** be mixed together directly.

Risk of Explosion

Important information about handling resin, hardener, and the accelerator is contained in Information Sheet MO23 “Polyester and Epoxy Resins” published by the Employer’s Association of the German Chemical Industry.

21.2. Reaction times during processing under standard conditions

At ambient temperatures of approx. 20° C and a laminate thickness of 8-10 mm, the following processing times can be expected for a standard resin mixture:

Curing phases		
Operation		**Vinyl ester Resin**
Resin and hardener are mixed		0 min
Resin begins to thicken		20-30 min
Gelled components begin to warm up		30-40 min
Exothermic temperature peak		50-70 min
Cold and solid		70-120 min
Curing up to full mechanical strength level	see section “Curing”	

21.3. Ambient temperatures and large laminate thicknesses

With a standard resin mixture, the cross-linking reaction happens faster at higher ambient temperatures. This means that laminate connections need to be completed in less time. Also, since the exothermic cross-linking reaction releases heat the possibility of overheating may occur, depending on the ambient **temperature** and the **thickness** of the laminate. This must be avoided. When working at temperatures over 25°C or with larger laminate thickness, steps must be taken to extend the lamination period and to slow down the curing period.

21.4. Vinyl ester resin laminates

The speed of reaction is governed by the ratio of resin/hardener/accelerator and can be modified according to ambient temperature or laminate thickness. The following table provides approximate values for possible mixture ratios (by weight) at various temperatures and laminate thickness.

Mixture rations for laminates up to appr. 12mm			
Working Temperature	**Proportion Of Resin**	**Proportion Of Hardener**	**Proportion Of Accelerator**
10° C – 15° C	1000	30	15
15° C – 20° C	1000	30	15
20° C – 25° C	1000	30	10
25° C – 30° C	1000	30	5

Mixture rations for laminates up to appr. 12-20 mm			
Working Temperature	**Proportion of Resin**	**Proportion of Hardener**	**Proportion of Accelerator**
10° C – 15° C	1000	30	15
15° C – 20° C	1000	30	10
20° C – 25° C	1000	30	5
25° C – 30° C	1000	30	3

These approximate values can be adapted to suit the lamination experience of the operators. The proportion of hardener or accelerator should always be within the limit values shown above. Thicker laminates can be completed using intermediate curing.

The minimum mixing time of the components is 2 minutes.

22. Curing Process

22.1. Standard curing

The curing period for a laminated joint depends on the ambient temperature or on the temperature that occurs in the laminate during the curing process. The following curing periods are to be expected for a laminate of approximately 10 mm thickness with a standard resin mix:

Table 8. Standard curing time as a function of temperature

Standard curing time as a function of temperature		
Ambient curing temperature		**Vinyl ester Resin**
approx. 20°C		approx. 24 hours
approx. 50°C		approx. 5 hours
approx. 80°C		approx. 1.5 hours

At an external temperature <15° C work must be carried out in a heated shelter.

22.2. Post curing

The mechanical strength and chemical resistance to corrosion of a laminate depends on the degree of cure obtained. The more complete the cure is, the higher the resistance. If curing takes place at room temperature, appropriate completion of cure (i.e. post-curing) is required in order to ensure a connection of high quality. It is therefore appropriate that connections are cured constantly and in a controlled way through high temperatures. FIBERDUR heating elements provide these conditions and are adjusted to curing temperatures.
If too much heat is applied before or during the gelling phase, the viscosity of the resin is reduced. The resin will flow out of the joint and the reinforcing fibers will no longer be wetted.
Heat must be applied at a constant rate and be continuously monitored. Overheating of the laminate must also be prevented since overheated laminates have reduced strength and inferior chemical stability.

Under normal conditions, post-curing should take place for:

Resin type	Time
Vinyl ester resin: 80° C – 95° C	Duration 60 min

Maximal temperatures in the case of thermal post-cure:
Vinyl ester resin: 120° C

22.3. Curing with large laminate thicknesses

Heat is produced during the curing period. The thicker the laminate, the more heat is released. In the case of too thick a laminate, this can result in overheating the laminate. For the above-mentioned reasons, this must be avoided.

In such a case it may be necessary to work with intermediate curing, where half of the wall thickness required is first laid up and cured. The surface is then treated with emery cloth and the remaining laminate laid up according to requirements.

23. Environmental Factors

23.1. Humidity effects

Care must be taken that the components to be bonded/laminated are protected from moisture/ humidity (rain, mist, dew, snow etc.) during both preparation and assembly. This can be achieved by using an assembly tent and/or heating device. The formation of condensation due to a temperature difference between the workpiece and ambient temperature must always be avoided. In case of direct sunlight, e.g. in Middle East conditions, keep the spigot and bell in the shade several hours before bonding.

Repairs to a pipeline containing liquid must be preceded by a thorough drying of the pipeline. No liquid may be allowed to seep on to the locations under repair. Even the smallest quantities are damaging.

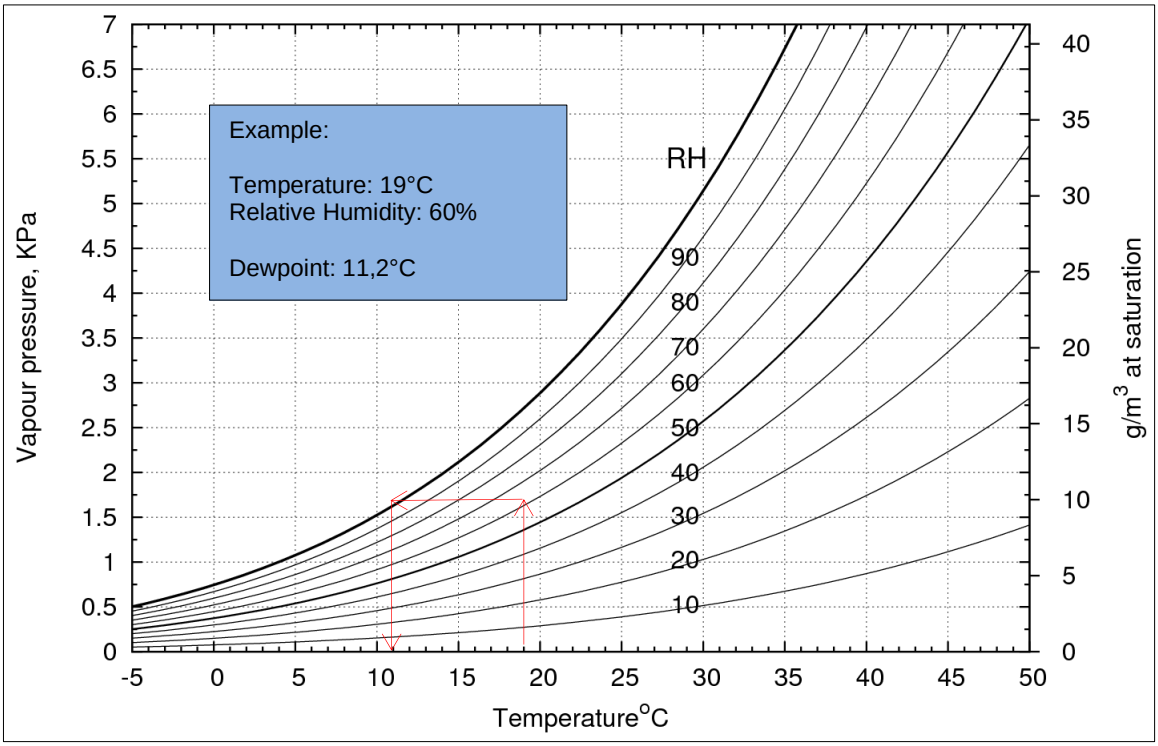
Take care that all parts needed for the lamination are well conditioned (e.g. all have an equal temperature). This is necessary to avoid moisture on the parts concerned.

The dewpoint must be ≤ (object temperature-3°C).

The effects on working time and curing periods have already been detailed. It is also necessary to remember that the viscosity of the laminate resin is dependent on ambient temperature.

The following diagram can be used to determine whether, at given local climatic conditions, undershooting the dew-point is possible or not. Ambient conditions are measured.

When processing the components, care must generally be taken to maintain a safety margin in relation to the dew-point temperature. If a workpiece is heated, care must be taken that, on cooling while in use, its temperature does not fall below dew-point.



The basic values are:

Environmental check			
			Measured value
•	Ambient temperature,	$T_{ambient}$	°C
•	Relative humidity, preferably measured as close as possible to the GRP pieces	RH	%
•	Dewpoint	Dp	°C
•	Requirement $T_{ambient}$—Dp >= 3 °C		

When processing the components, care must generally be taken to maintain a safety margin in relation to the dew-point temperature. If a workpiece is heated, care must be taken that, on cooling while in use, its temperature does not fall below dewpoint.

23.2. Effects of ambient temperature

The effects of ambient temperature of adhesives on viscosity in relation to temperature are described below.

EP 220-1

At temperatures under 15°C, it is advisable to heat the resin slightly before use. Otherwise, as viscosity is very high, the resin will be very viscous and difficult to use. It will also not be possible to obtain a thorough mix or to penetrate the adhesive into the surface sufficiently well. It must also be remembered that the temperature of the pipe affects the viscosity of the adhesive. If, for example, the pre-heated adhesive is applied at temperatures under approx. 10°C, the adhesive coating will cool very rapidly, resulting in high viscosity. Pre-heating the pipe ends offers a solution, but it must be remembered that the higher pipe temperature affects the pot-life of the applied adhesive. At an ambient temperature below 10°C, we recommend carrying out the work in a heated tent or workshop. Heating pipe ends, the bell ends of fittings and adhesive is an option, but not always the recommended one.

24. Defect types

For defects the reference document is Annex A.1 ISO 14692 (2017). which gives a summary of visible defects, along with acceptance criteria and corrective actions.

Disclaimer

This literature is intended for use by personnel having specialized training in accordance with currently accepted industry practice. We recommend that your engineers verify the suitability of this guideline for your intended application. Since we have no control over the conditions of service, we expressly disclaim responsibility for the results obtained or for any consequential or incidental damages of any kind incurred.

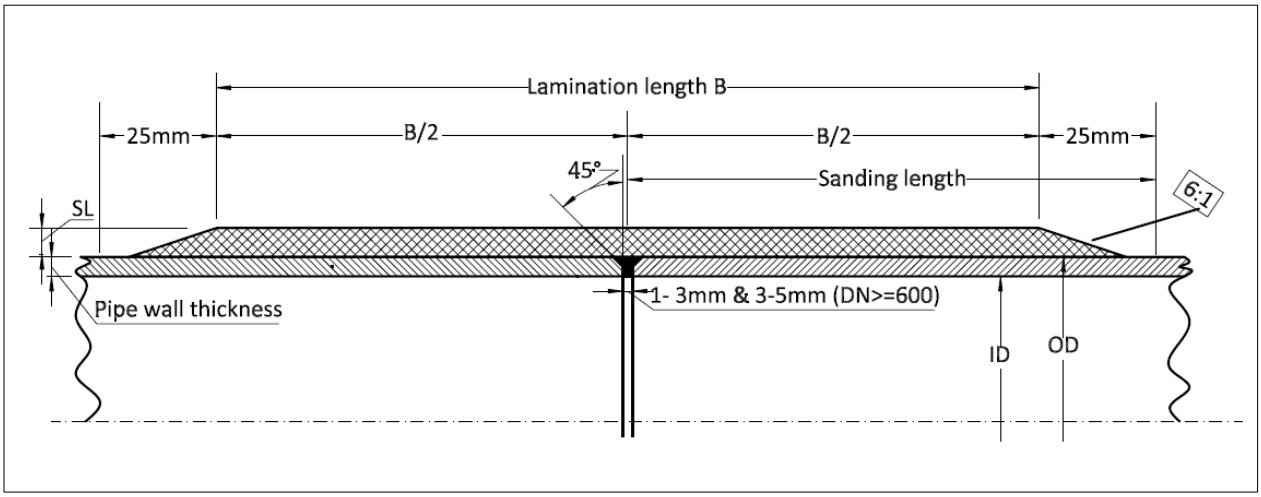
Addendum A. Butt and Wrap laminate

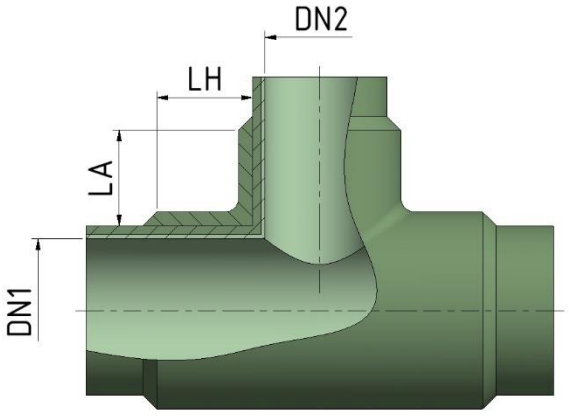
Butt and wrap laminate PN 16					
According to DIN 16966, PART 8				σ = 150/mm²	Glass resin ratio (45±10)m-%
DN	**SL (mm)**	**Dimensions of cut pieces**			**Laminate build-up**
		B (mm)	**L (mm)**	**Tape-*Width (mm)**	
25	3,5	50	120	100	MGB + 1(MB) +M'
40	3,5	50	180	100	MGB + 1(MB) +M'
50	3,5	75	200	100	MGB + 1(MB) +M'
65	3,5	75	250	100	MGB + 1(MB) +M'
80	3,5	110	310	100	MGB + 1(MB) +M'
100	5,0	140	380	100	2(MGB) + M'
125	5,0	175	470	100	2(MGB) + M'
150	5,0	210	550	100	2(MGB) + M'
200	7,1	250	750	100	3(MGB) + M'
250	7,1	300	900	100	3(MGB) + M'
300	9,2	375	1100	100	4(MGB) + M'
350	11,3	425	1250	100	5(MGB) + M'
400	13,4	500	1450	100	6(MGB) + M'
450	13,4	550	1600	100	6(MGB) + M'
500	15,5	600	1750	100	7(MGB) + M'
600	19,7	745	2100	100	9(MGB) + M'
700	21,8	880	2450	100	10(MGB) + M'
800	23,9	990	2800	100	11(MGB) + M'
900	28,1	1115	3150	100	13(MGB) + M'
1000	30,2	1235	3450	100	14(MGB) + M'

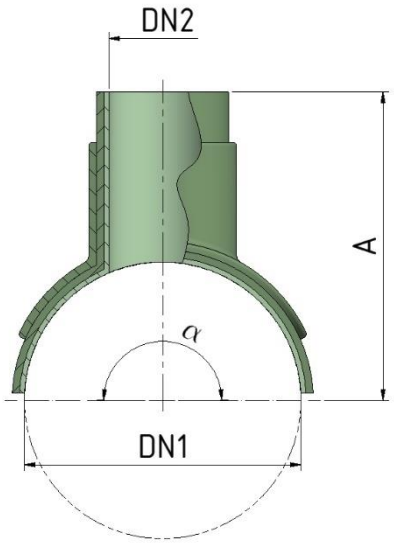
Butt and Wrap laminate PN 10					
According to DIN 16966, PART 8				σ = 150/mm²	Glass resin ratio (45±10)m-%
DN	**SL (mm)**	**Dimensions of cut pieces**			**Laminate build-up**
		L (mm)	**L (mm)**	**Tape*Width (mm)**	
25-125	see PN 16 DN 25-125				
150	3,5	130	540	100	MGB + 1 (MB) + M'
200	5,0	165	720	100	2(MGB) + M'
250	5,0	205	870	100	2(MGB) + M'
300	7,1	250	1080	100	3(MGB) + M'
350	7,1	290	1220	100	3(MGB) + M'
400	9,2	300	1400	100	4(MGB) + M'
450	11,3	350	1560	100	5(MGB) + M'
500	11,3	410	1720	100	5(MGB) + M'
600	13,4	460	2060	100	6(MGB) + M'
700	13,4	525	2400	100	6(MGB) + M'
800	15,5	625	2750	100	7(MGB) + M'
900	17,6	700	3080	100	8(MGB) + M'
1000	19,7	750	3400	100	9(MGB) + M'
1100	21,8	850	3900	100	10(MGB) + M'

Note: Additional information on laminated reducing Tees can be found in Fiberdur Fincantieri documents.

Butt and Wrap laminate PN 6					
According to DIN 16966, PART 8				σ = 150/mm²	Glass resin ratio (45±10)m-%
DN	**SL (mm)**	**Dimensions of cut pieces**			**Laminate build-up**
		B (mm)	**L (mm)**	**Tape*Width (mm)**	
150-300	see PN 10 DN 150-300				
350	5,0	170	1200	100	2(MGB) + M'
400	5,0	200	1360	100	2(MGB) + M'
450	7,1	220	1530	100	3(MGB) + M'
500	7,1	240	1700	100	3(MGB) + M'
600	7,1	290	2030	100	3(MGB) + M'
700	9,2	335	2370	100	4(MGB) + M'
800	9,2	370	2700	100	4(MGB) + M'
900	11,3	430	3030	100	5(MGB) + M'
1000	11,3	460	3350	100	5(MGB) + M'
1100	13,4	510	3690	100	6(MGB) + M'







Laminated reducing Tee, pipe shape laminate

Laminated reducing Tee, saddle shape laminate

Laminated Reducing Tee 16

DN	Branch																
Pipe run	**25**	**40**	**50**	**65**	**80**	**100**	**125**	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**	**600**	**700**
40	R																
50	R	R															
65	R	R	R														
80	R	R	R	R													
100	K	R	R	R	R												
125	K	R	R	R	R	R											
150	K	R	R	R	R	R	R										
200	K	K	K	R	R	R	R	R									
250	K	K	K	R	R	R	R	R	R								
300	K	K	K	K	R	R	R	R	R	R							
350	K	K	K	K	K	R	R	R	R	R	R						
400	K	K	K	K	K	K	R	R	R	R	R	R					
450	K	K	K	K	K	K	K	R	R	R	R	R	R				
500	K	K	K	K	K	K	K	R	R	R	R	R	R	R			
600	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R		
700	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R	R	R
800	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R	R
900	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R	R
1000	K	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R

R is pipe shape laminate and K is saddle shape laminate

Pipe-shaped: d>0,25 D

Saddle-shaped d<=0,25 D

Laminated Reducing Tee 10

DN	Branch																		
Pipe run	25	40	50	65	80	100	125	150	200	250	300	350	400	450	500	600	700	800	900	1000
40	R	R																		
50	R	R	R																	
65	K	R	R	R																
80	K	K	R	R	R															
100	K	K	R	R	R	R														
125	K	K	K	R	R	R	R													
150	K	K	K	R	R	R	R	R												
200	K	K	K	K	K	R	R	R	R											
250	K	K	K	K	K	K	R	R	R	R										
300	K	K	K	K	K	K	R	R	R	R	R									
350	K	K	K	K	K	K	K	R	R	R	R	R								
400	K	K	K	K	K	K	K	K	R	R	R	R	R							
450	K	K	K	K	K	K	K	K	R	R	R	R	R	R						
500	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R					
600	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R				
700	K	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R			
800	K	K	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R		
900	K	K	K	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R	
1000	K	K	K	K	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R
1100	K	K	K	K	K	K	K	K	K	K	K	K	K	R	R	R	R	R	R	R

R is pipe shape laminate and K is saddle shape laminate

Pipe-shaped: d>0,4 D

Saddle-shaped d<=0,4 D

Laminate dimensions, connecting piece laminate, PN 16

Pipe run DN	DN	Branch									
		25	40	50	65	80	100	125	150	200	250
40	Laminate type	A									
	LH (mm)	50									
	LA (mm)	50									
50	Laminate type	A	A								
	LH (mm)	50	50								
	LA (mm)	50	50								
65	Laminate type	A	A	A							
	LH (mm)	50	50	50							
	LA (mm)	50	50	50							
80	Laminate type	A	A	A	A						
	LH (mm)	50	50	50	50						
	LA (mm)	50	50	50	50						
100	Laminate type	A	A	A	A	A					
	LH (mm)	50	50	50	50	75					
	LA (mm)	50	50	50	50	75					
125	Laminate type	A	A	A	A	A	A				
	LH (mm)	50	50	50	50	75	75				
	LA (mm)	50	50	50	50	75	75				
150	Laminate type	A	A	A	A	A	A	B			
	LH (mm)	50	50	50	50	75	75	100			
	LA (mm)	50	50	50	50	75	75	75			
200	Laminate type	A	A	A	A	A	B	B	B		
	LH (mm)	50	50	50	50	75	75	100	120		
	LA (mm)	50	50	50	50	75	75	75	75		
250	Laminate type	A	A	A	A	B	B	L	M	N	
	LH (mm)	50	50	50	50	75	75	100	120	140	
	LA (mm)	50	50	50	50	75	75	75	75	100	
300	Laminate type	A	A	B	B	C	L	M	M	N	O
	LH (mm)	50	50	50	50	75	75	100	120	140	180
	LA (mm)	50	50	50	50	75	75	75	75	100	120

Stub laminating <DN 100: 1 h curing after 2*MG (=mat/glass fabric) and start grinding surface prior to continuation of lamination
Details regarding stub end laminations DN >300 mm are available on request

Laminate dimensions, connecting piece laminate, PN 10

Pipe run DN	DN	Branch																	
		25	40	50	65	80	100	125	150	200	250	300	350	400	500	600	700	800	900
40	Laminate type	A																	
	LH (mm)	50																	
	LA (mm)	50																	
50	Laminate type	A	A																
	LH (mm)	50	50																
	LA (mm)	50	50																
65	Laminate type	A	A	A															
	LH (mm)	50	50	50															
	LA (mm)	50	50	50															
80	Laminate type	A	A	A	A														
	LH (mm)	50	50	50	50														
	LA (mm)	50	50	50	50														
100	Laminate type	A	A	A	A	A													
	LH (mm)	50	50	50	50	75													
	LA (mm)	50	50	50	50	75													
125	Laminate type	A	A	A	B	B	C												
	LH (mm)	50	50	50	50	75	75												
	LA (mm)	50	50	50	50	75	75												
150	Laminate type	A	A	A	A	A	A	B											
	LH (mm)	50	50	50	50	75	75	100											
	LA (mm)	50	50	50	50	75	75	75											
200	Laminate type	A	A	A	A	A	B	B	B										
	LH (mm)	50	50	50	50	75	75	100	120										
	LA (mm)	50	50	50	50	75	75	75	75										
250	Laminate type	A	A	A	A	B	B	L	M	N									
	LH (mm)	50	50	50	50	75	75	100	120	140									
	LA (mm)	50	50	50	50	75	75	75	75	100									
300	Laminate type	A	A	B	B	C	L	M	M	N	O								
	LH (mm)	50	50	50	50	75	75	100	120	140	180								
	LA (mm)	50	50	50	50	75	75	75	75	100	120								
350	Laminate type	A	B	B	C	L	M	M	M	N	O	O							
	LH (mm)	50	50	50	50	75	75	100	100	125	150	175							
	LA (mm)	50	50	50	50	50	50	50	50	75	100	100							
400	Laminate type	B	B	C	L	M	M	M	N	O	O	O	P						
	LH (mm)	50	50	75	75	75	75	100	100	125	150	175	200						
	LA (mm)	50	50	50	50	50	50	50	50	75	100	100	125						
450	Laminate type	B	C	L	M	M	M	N	O	O	O	P	P	P					
	LH (mm)	75	75	75	75	75	75	100	100	125	150	175	200	225					
	LA (mm)	50	50	50	50	50	50	50	50	75	100	100	125	125					
500	Laminate type	C	C	M	M	M	N	N	O	O	P	P	P	Q					
	LH (mm)	75	75	75	75	75	75	100	100	125	150	175	200	225					
	LA (mm)	50	50	50	50	50	50	50	50	75	100	100	125	125					

600	Laminate type	C	M	M	M	N	N	O	O	P	P	P	Q	Q	R			
	LH (mm)	75	75	75	75	75	100	100	100	125	150	175	200	225	250			
	LA (mm)	50	50	50	50	50	50	75	75	75	100	100	125	125	150			
700	Laminate type	M	M	M	N	N	O	O	P	P	P	Q	Q	R	R	S		
	LH (mm)	100	100	100	100	100	100	100	100	125	150	175	200	225	250	300		
	LA (mm)	50	50	50	50	50	50	75	75	75	100	100	125	125	150	200		
800	Laminate type	M	M	N	N	O	O	P	P	P	Q	Q	R	R	S	S	U	
	LH (mm)	100	100	100	100	100	100	100	100	125	150	175	200	225	250	350	350	
	LA (mm)	50	50	50	50	50	50	75	75	75	100	100	125	125	150	200	200	
900	Laminate type	M	N	N	O	O	P	P	P	Q	Q	R	R	S	S	U	U	V
	typ																	
	LH (mm)	100	100	100	100	100	100	100	100	125	150	175	200	225	250	350	350	375
	LA (mm)	50	50	50	50	50	50	75	75	75	100	100	125	125	150	200	200	225
1000	Laminate type	N	N	O	O	P	P	P	Q	Q	R	R	S	S	U	U	V	V	W
	LH (mm)	100	100	100	100	100	100	100	100	125	150	175	200	225	250	350	350	375	375
	LA (mm)	50	50	50	50	50	50	75	75	75	100	100	125	125	150	200	225	250	250

Stub laminating <DN 100: 1 h curing after 2*MG (=mat/glass fabric) and start grinding surface prior to continuation of lamination

Laminate dimensions, connecting piece laminate, PN 6

Pipe run DN	DN	Branch																		
		25	40	50	65	80	100	125	150	200	250	300	350	400	500	600	700	800	900	1000
350	Laminate type	A	A	A	A	A	A	B	B	B	B	B								
	LH (mm)	50	50	50	50	75	75	100	100	100	125	150								
	LA (mm)	50	50	50	50	50	50	50	50	50	75	75								
400	Laminate type	A	A	A	A	B	B	B	B	C	C	C	C							
	LH (mm)	50	50	75	50	75	75	100	100	100	125	150	150							
	LA (mm)	50	50	50	50	50	50	50	50	75	75	75	100							
450	Laminate type	B	B	B	B	B	B	C	C	C	C	D	D	D						
	LH (mm)	75	75	75	75	75	75	100	100	100	125	150	150	175						
	LA (mm)	50	50	50	50	50	50	50	50	50	75	75	100	100						
500	Laminate type	B	B	B	B	C	C	C	C	D	D	D	D	D						
	LH (mm)	75	75	75	75	75	75	100	100	100	125	150	150	175						
	LA (mm)	50	50	50	50	50	50	50	50	50	75	75	100	100						
600	Laminate type	B	B	B	C	C	C	C	D	D	D	D	D	E	E					
	LH (mm)	75	75	75	75	75	100	100	100	100	125	150	150	175	175					
	LA (mm)	50	50	50	50	50	50	50	50	50	75	75	100	100	125					
700	Laminate type	B	B	C	C	C	C	D	D	D	D	D	E	E	E	G				
	LH (mm)	100	100	100	100	100	100	100	100	100	125	150	150	175	175	225				
	LA (mm)	50	50	50	50	50	50	50	50	50	75	75	100	100	125	150				
800	Laminate type	C	C	C	C	D	D	D	D	D	E	E	E	G	G	P	P	P		
	LH (mm)	100	100	100	100	100	100	100	100	100	125	150	150	175	175	250	250	250		
	LA (mm)	50	50	50	50	50	50	50	50	50	75	75	100	100	125	150	150	150		
900	Laminate type	C	C	D	D	D	D	D	E	E	E	G	G	P	P	Q	Q	Q		
	LH (mm)	100	100	100	100	100	100	100	100	100	125	150	150	175	175	250	250	250		
	LA (mm)	50	50	50	50	50	50	50	50	50	75	75	100	100	125	150	150	150		
1000	Laminate type	C	D	D	D	D	D	E	E	E	G	G	P	P	Q	Q	Q	Q	R	R
	LH (mm)	100	100	100	100	100	100	100	100	125	150	150	175	175	225	250	250	250	250	250
	LA (mm)	50	50	50	50	50	50	50	50	75	75	100	100	125	150	150	150	150	225	250

Stub laminating <DN 100: 1 h curing after 2*MG (=mat/glass fabric) and start grinding surface prior to continuation of lamination

Laminate build up		
Type	**Laminate build-up**	**Thickness (mm)**
A	M+2X{GM}	5,5
B	M+3X{GM}	7,5
C	M+4X{GM}	9,5
D	M+5X{GM}	11,5
E	M+6X{GM}	13,5
F	M+7X{GM}	15,5
G	M+8X{GM}	17,5

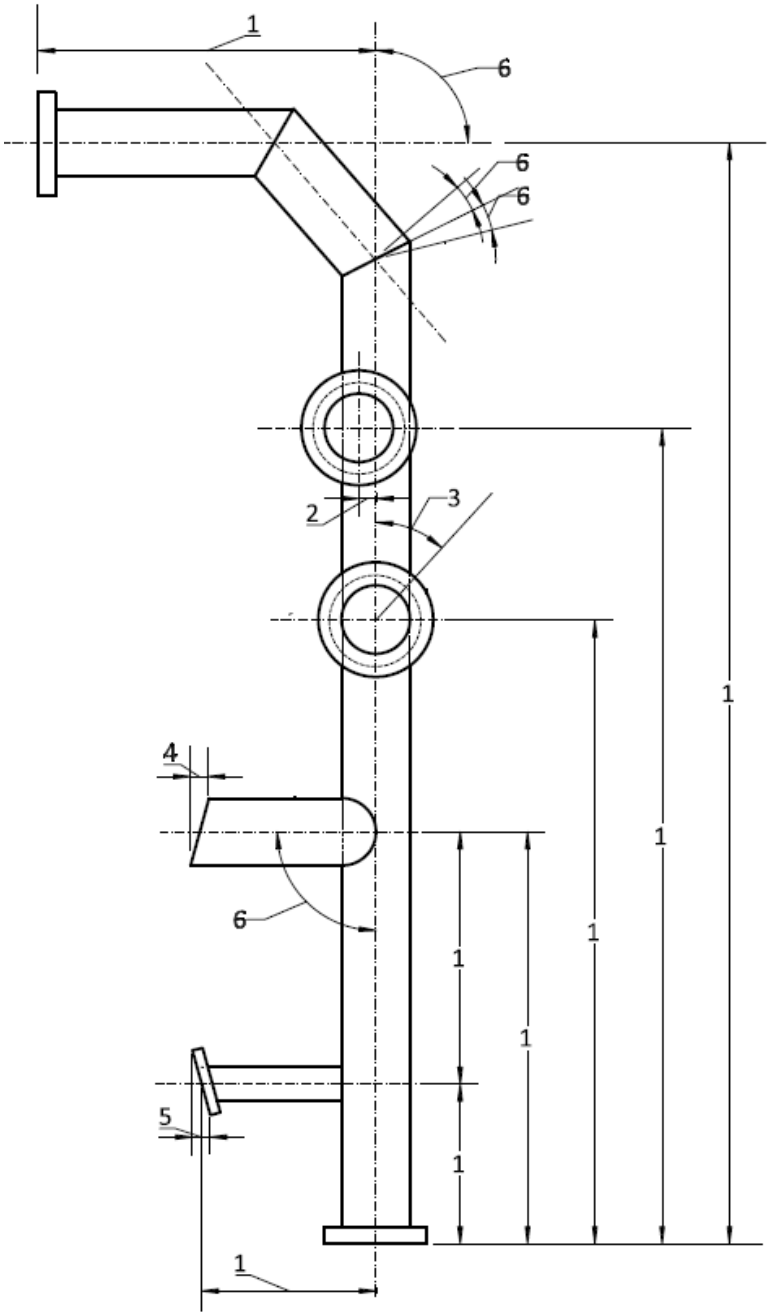
M:Mat; 450 g/m$^{2/}$Article-Nr. 40450127/40460127) (G:fabric; 720 g/m^2/Article-Nr. 40320127)

Laminate build up		
Type	**Laminate build-up**	**Thickness (mm)**
L	M+4X{GM}	9,5
M	M+5X{GM}	11,5
N	M+6X{GM}	13,5
O	M+7X{GM}	15,5
P	M+8X{GM}	17,5
Q	M+9X{GM}	19,5
R	M+10X{GM}	21,5
S	M+11X{GM}	23,5
T	M+12X{GM}	25,5
U	M+13X{GM}	27,5
V	M+14X{GM}	29,5
W	M+15X{GM}	31,5

M:Mat; 450 g/m$^{2/}$Article-Nr. 40450127/40460127) (G:fabric; 720 g/m^2/Article-Nr. 40320127

Addendum B. Reference tolerances acc. ISO 14692

Internal Diameter (mm)	1	2	3	4	5	6
25 – 200	± 5mm	± 3mm	± 0.5°	± 3mm	± 1mm	± 0.5°
200 – 300	± 5mm	± 3mm	± 0.3°	± 3mm	± 1mm	± 0.5°
350 – 400	± 5mm	± 3mm	± 0.3°	± 3mm	± 2mm	± 0.5°
450 – 600	± 10mm	± 5mm	± 0.3°	± 3mm	± 2mm	± 0.5°
700 – 900	± 10mm	± 5mm	± 0.2°	± 4mm	± 3mm	± 0.5°
1000 – 1200	± 10mm	± 5mm	± 0.15°	± 6mm	± 3mm	± 0.5°
The Maximum gap shall be limited to 6 mm.						



Dimension 1

- Face to Face dimensions
- Center to Face dimensions
- Location of attachments
- Center to Center dimensions

Dimension 2

- Lateral transition of branches or connections

Dimension 3

- Rotation of flanges, from the indicated position

Dimension 4

- End preparations

Dimension 5

- Cut off alignment of flanges from indicated position, measured across the full gasket face

Dimension 6

- Angular deflection

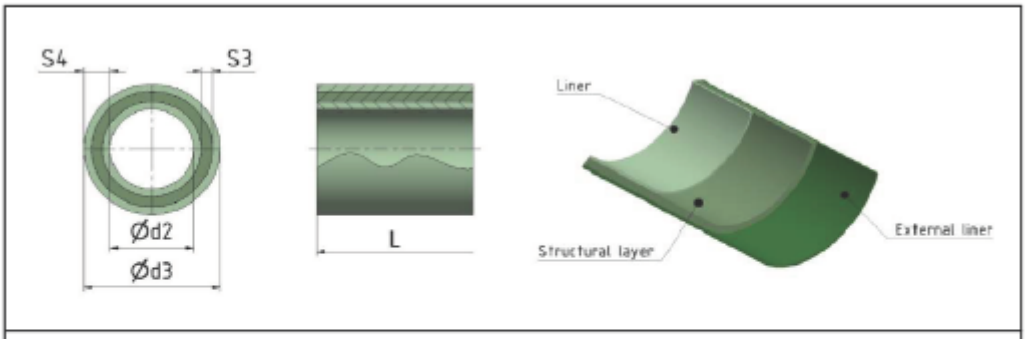
Addendum C. Quality Control Plan

Adhesive fit/Marking by Jointer	
Name responsible jointer or Pin number	
Date dd/mm/yyyy.	
Relative Humidity.	
ambient temperature.	
Dewpoint.	
Heating blanket number.	
Field joint number.	
Start time curing.	
End time curing.	
Surface temperature blanket 15’ after power on >100 °C	
Surface temperature blanket just before power off >100 °C	

Lamination structural layer/Marking by Jointer	
Name responsible jointer or Pin number	
Date dd/mm/yyyy.	
Relative Humidity.	
ambient temperature.	
Dewpoint.	
Heating blanket number.	
Field joint number.	
Start time curing.	
End time curing.	
Surface temperature blanket 15’ after power on >100 °C	
Surface temperature blanket just before power off >100 °C	

Addendum D. Dimensions pipe wall

The outside diameter of the spigot end must be: **d3-1,0 < OD spigot end < d3-0,5**
The outside diameters must be measured with a vernier caliper or pi tape at the spigot: front, middle and the back (3 measurements) and fulfill the condition.



Pipe with 0,5mm Chemical Resistance Liner

Fibermarine® Full Vacuum Resistance

Type GRVE /GRE

Pipes with plain end

Delivery length :

DN 25 – DN 80: 6 m

DN 100 – DN 1000: 9 m

Outside diameter tolerances

DN 25 – DN 100 + 1,7 / -0,6 mm

DN 125 – DN 300 + 2,4 / -1,0 mm

DN 350 – DN 450 + 3,3 / -1,5 mm

≥ DN 500 + 4,2 / -2,0 mm

DN / ød2 (mm)	L (mm)	S3 (mm)	S4 (mm)	ød3 (mm)	Content (L/m)	Weight ca. (kg/m)	Art. N° GRVE	Art. N° GRE
25	6.000	1,6	2,4	29,8	0,5	0,4	6114190025	6114290025
40	6.000	1,6	2,4	44,8	1,3	0,6	6114190040	6114290040
50	6.000	1,6	2,4	54,8	2,0	0,7	6114190050	6114290050
65	6.000	1,6	2,4	69,8	3,3	0,9	6114190065	6114290065
80	6.000	1,6	2,4	84,8	5,0	1,1	6114190080	6114290080
100	9.000	1,6	2,4	104,8	7,9	1,4	6114190100	6114290100
125	9.000	2,0	2,8	130,6	12,3	2,0	6114180125	6114280125
150	9.000	2,4	3,2	156,4	17,7	2,8	6114180150	6114280150
200	9.000	3,2	4,0	208,0	31,4	4,6	6114180200	6114280200
250	9.000	3,8	4,6	259,2	49,1	6,6	6114180250	6114280250
300	9.000	4,7	5,5	311,0	70,7	9,5	6114180300	6114280300
350	9.000	5,7	6,5	363,0	96,2	13,1	6114180350	6114280350
400	9.000	6,6	7,4	414,8	125,6	17,0	6114180400	6114280400
450	9.000	7,6	8,4	466,8	159,0	21,8	6114180450	6114280450
500	9.000	8,5	9,3	518,6	196,3	26,8	6114180500	6114280500
600	9.000	10,2	11,0	622,0	282,6	38,0	6114180600	6114280600
700	9.000	11,9	12,7	725,4	384,7	51,2	6114180700	6114280700
800	9.000	13,7	14,5	829,0	502,4	66,8	6114180800	6114280800
900	9.000	15,4	16,2	932,4	635,9	83,9	6114180900	6114280900
1000	9.000	17,2	18,0	1036,0	785,0	103,6	6114181000	6114281000