fiberdur®

The Expert in Fibre Reinforced Pipe Systems

9

VERARBEITUNGSANLEITUNG

INSTRUCTION FOR HANDLING AND INSTALLATION

CONSEILS POUR MANUTENTION ASSEMBLAGE ET MISE EN OEUVRE

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Subject to alterations because of engineering progress!

9.1 BONDING TECHNOLOGY

9.1.1 WORKING PROCEDURE

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.

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

IMPORTANT
Cut pipes all the way through, supporting the free ends as required. This avoids the pipe breaking off before cutting is completed.

SURFACE PREPARATION
Good bonding depends on good adhesion between the adhesive and the materials being bonded. The bonding surfaces of the pipe and bonded socket ends must therefore be prepared for the adhesive in the correct manner.

CYLINDRICAL BONDING
Part of the Fiberdur pipes and fittings are bonded using cylindrical socket ends. This kind of bonding is easy and no special tools are required. Pipe ends are uniformly and thoroughly emerized under dry conditions (over bonding length +10mm). This procedure is also applied to the inside and leading edge of the bonded socket end of the fitting.
After emerizing bonding surfaces should be free of shiny areas. The surfaces are evenly worked and should be free of large pits. It should be possible to slide fittings onto pipe ends easily without them becoming jammed. Symmetrically round components can be emerized on a dolly. This ensures a uniformly emerized surface. The procedure is easier and faster.

CONCIAL BONDING

Filament wound pipes and fittings from Diameter DN 200 PN 16 and Diameter DN 350 PN 10 are fabricated at works including a concial bell end and conically shaved spigot end.

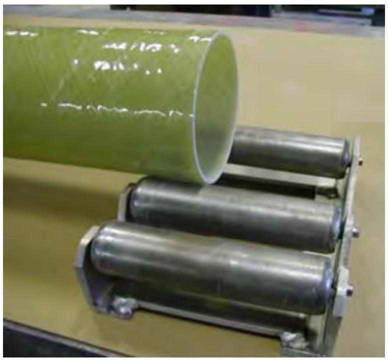
Bonding on site requires the following preparation:

- Manually emerize all bonding surfaces to ensure that any dirt is removed.
- Inspect and prepare the bonding surfaces as required and as described above. Grinding on conical surfaces of the pipes prefabricated at works must be carried out by hand.

It is recommended to use grinding- or peeling machines if pipes must be cut into lengths and prepared to be bonded with fittings.

IMPORTANT

Remove all excess emery powder using a brush. Protect prepared surfaces from dirt, humidity, etc. Grease, oil, or human perspiration act as parting agents and prevent adhesion. Do not use solvents to clean bonding surfaces. Bonding surfaces should be prepared immediately before bonding is carried out.



9.1.2 HANDLING ADHESIVE

ADHESIVE EP 220-1 (Epoxy resin)

Quantity per charge: 561 g
Resin (Component A): 374 g
Hardener (Component B): 187 g

Take note of shelf-life indicated, max. 2 years.

For adhesive EP 220-1, always mix the total quantities for each charge. Alternative mixing proportions are not permitted. The hardener is added to the resin and both components thoroughly mixed in the container. The adhesive is ready for use when mixture is of a uniform consistency. No streaks should be visible. At low ambient temperatures (less than 15°C) the resin (component A) should be gently heated since it is otherwise too viscous. At ambient temperatures under 10°C bonding requires heating (e.g. using electric heating elements for dryers).

IMPORTANT

Make sure to obtain a good mix also at the bottom and in the corners of the container. Store adhesive in a dry place.

When mixing and using adhesives, observe the safety instructions (see adhesive container or DIN safety information sheet).

ADHESIVE VE 200 (Polyvinyl ester resin)

Quantity per charge: 282,4 g
Resin (Component A): 275,0 g
Hardener (Component B): 7,4 g

The shelf-life of the adhesive depends on the storage temperature. At 10°C the shelf-life is 3 months minimum (see details included on container).

The quantity of hardener is measured for the total quantity of adhesive. Normally, the total quantities for each charge are mixed in the container. At higher ambient temperatures the quantity of hardener added can be reduced. This extends the pot-life of the adhesive.

Recommended hardener quantities:

- up to 30°C 100 %
- over 30°C 50 %

After adding the hardener, the adhesive is mixed thoroughly. The mixture must show a uniform colour before the adhesive is ready for use. No streaks should be visible. At low ambient temperatures (less than 15°C) the resin (component A) should be gently heated since it is otherwise too viscous. At ambient temperatures under 10°C bonding requires heating (e.g. using electric heating elements or blowers).

IMPORTANT

Make sure to obtain a good mix also at the bottom and in the corners of the container. Store adhesive in a dry place. When mixing and using adhesives, observe the safety instructions (see adhesive container or DIN safety information sheet).

NUMBER OF CONNECTIONS USING ADHESIVE EP 220-1 AND VE 200

The following table shows the number of bondings which can be carried out for the various nominal diameters using one charge of adhesive:

- EP 220-1 (561 g)
- VE 200 (282,4 g)

The calculation of the quantity of adhesive used assumes that the total quantity of adhesive is used within the specified pot-life. This requires preparation of a corresponding number of bonding locations. Since the number of possible bonded connections is very large in the case of small nominal diameters, it is recommended to make provision for various nominal diameters at the planning stage.

NUMBER OF BONDED CONNECTIONS

Nominal Diameter		EP 220-1	VE 200
DN 25	1“	25	22
DN 40	1 ½“	19-20	13-15
DN 50	2“	12-13	9-10
DN 65	2 ½“	10-11	7-8
DN 80	3“	8-9	6-7
DN 100	4“	5-6	3-4
DN 150	6“	4-5	2-3
DN 200	8“	3-4	1-2
DN 250	10“	1-2	1
DN 300	12“	1	0,5

UTILIZATION LIMITS (POT-LIFE)

The period in which adhesive can be used (pot-life) and the curing period of mixed adhesive depends on temperature according to the following table.

IMPORTANT

If the shelf life (pot-life) is exceeded, the adhesive becomes very viscous and lumpy. Adhesion of bonded components is then no longer ensure. Therefore, make sure that the pot-life of adhesives has not been exceeded. Bonded components may only be aligned within the pot-life.

Temperature (°C)	Pot-Life (Minutes)		Curing period (Hours)	
	EP 220-1	VE 200	EP 220-1	VE 200
5	60	60	60 [1)]	60 [1)]
10	50	45	45 [1)]	45 [1)]
20	25	25	20[1)]	2
30	20	15	10[1)]	1
40	10	10	5[1)]	2/3
60	5	5	3	½
80	--	--	2	--
100	--	--	1	--
120	--	--	1	--

[1)]= At these ambient temperatures complete curing is no longer possible. Optimum properties of strength and anti-corrosion do not apply. Hot curing or hot after curing is necessary (see above)

9.1.2 HANDLING ADHESIVE

ADHESIVE APPLICATION

The adhesive mixture is applied to the sections of pipe and fitting which have been emerized.

First, rub in a thin coat of adhesive using pressure. This is followed by a thicker coat. The thickness of adhesive on the pipe end should fill the bonding gap between pipe and fitting. Depending on nominal diameter, a thickness of 2-4 mm should be sufficient.

The cut edges of the pipe should be sized with a thin coat of adhesive. A thin coating of adhesive is also rubbed in at the socket end of the fitting using pressure. This is followed by the application of a coating of adhesive approx.
1 mm thick.

IMPORTANT

All emerized sections of pipe and fittings must be sized with adhesive. The quantity of adhesive on fittings is sufficient when pushing the pipe forward produces a bead of adhesive.

Excess adhesive in the socket end of the fitting is forced inwards and reduces the cross-section area. Therefore, the bead should be kept to a minimum. Excess adhesive must be removed.

9.1.3 JOINING PIPES AND FITTINGS

CYLINDRICAL BONDING

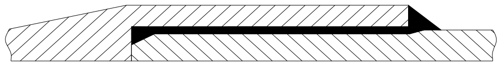
The fitting is inserted onto the pipe (previously coated with adhesive) and pushed fully home. Next, the excess adhesive at the out edge between socket end and pipe is so removed that a fillet-type filling remains. This bead serves as corner reinforcement.

Any excess adhesive on the inside of the fitting must be removed. If accessible, a spatula or similar tool is used. At locations impossible to access, excess and not yet hardened adhesive must be distributed over or removed from the pipe using a pig drawn through the pipe. The pig can be made of foam rubber or rubber, preferably wrapped around with a felt or fabric rag. When using the pig, care must be taken not to disturb the bonded connection by movement or pulling apart.

9.1.3 JOINING PIPES AND FITTINGS

CYLINDRICAL BONDING

On completion of fitting alignment, care must be taken to prevent any movement of components during the curing process.



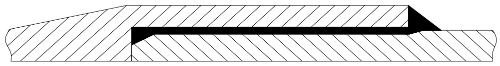
CONICAL BONDING

Conical bonds are additionally secured using a clamping device. Thus, the bonding gap is kept to a minimum. This also ensures that the bond remains secure when work is carried out at the other end of the pipe. This allows fast and reliable completion of conical bonding. Care must be taken that the clamping device secures the connection until curing has been completed.

IMPORTANT

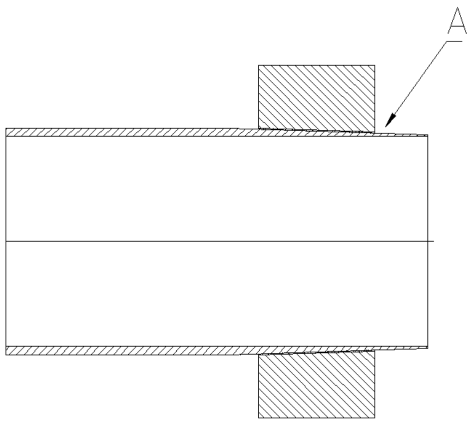
It should be possible to push the fitting onto the pipe without stress. Insertion should take place with components fully square to each other. If not, the adhesive will be forced to one side.

Alignment of bonded components can only be carried out within the utilisation limits (pot-life). Bonded components should not be moved again after this period. The conical spigot ends of a pipe must not be bonded into a fitting having a cylindrical bonding socket end.



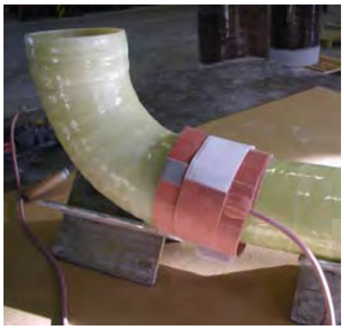
CONICAL BONDING OF COLLARS

Collars with factory-provided conical socket have – due to their design – a shorter bonding surface. Therefore the pipe must be shortened at point A before bonding (see sketch).



9.1.4 HOT CURING/AFTERCURING

The mechanical strength and chemical resistance to corrosion of an adhesive depends on the degree of cure obtained. The more complete the cure, the higher the values. If curing takes place at room temperature tempering for aftercure is required, in particular for the epoxy resin adhesive EP 220-1, in order to ensure a bonded connection of high quality. It is therefore appropriate that bonded connections are cured at high temperatures.
FIBERDUR heating elements meet these requirements and are adjusted to curing temperatures.
The following table shows recommended temperature and curing periods for hot or aftercures when using FIBERDUR heating elements.



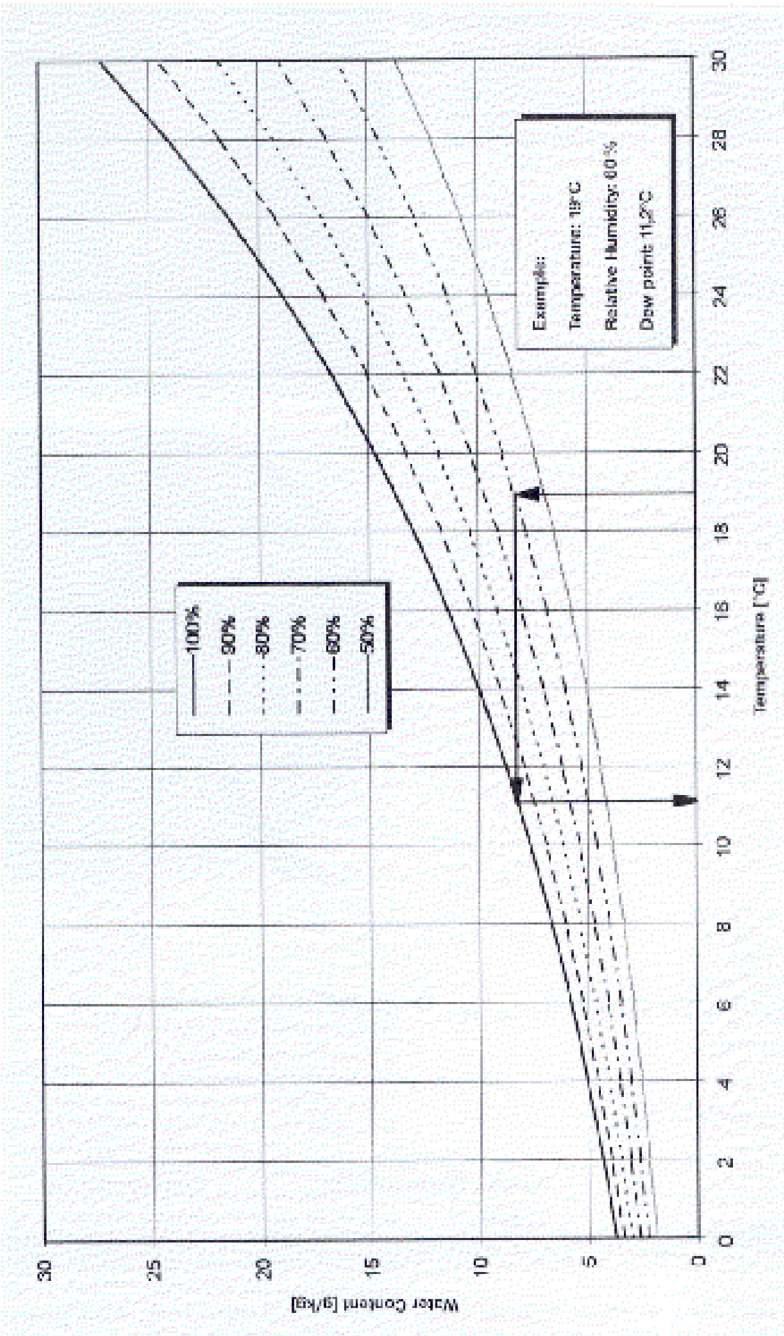
ADHESIVE	CURING TEMPERATURE	CURING PERIOD
EP 220-1	70-80° C	60 min
VE 200	70-80° C	30 min

FOR HIGHER TG-VALUES THE FOLLOWING CURING TEMPERATURES AND CURING TIMES ARE NECESSARY:

ADHESIVE	CURING TEMPERATURE	CURING PERIOD (soak and curing)
EP 220-1 Tg ≥100° C	100° C	60 min + 60 min
VE 200 Tg ≥ 80° C	80° C	30 min + 30 min

Heat can also be provided using electric radiating heaters or hot air blowers. Depending on their output, these items should be installed at approx. 300 mm from the bonded pipe components. This avoids excessive heating.

WATER CONTENT OF AIR IN RELATION TO RELATIVE HUMIDITY



9.1.5 SPECIAL NOTES ABOUT ENVIRONMENTAL EFFECTS

EFFECTS OF HUMIDITY

Care must be taken that the components to be bonded are protected from humidity (rain, mist, dew, snow, etc.) during both preparation and assembly. This can be achieved by using an assembly tent or a tarpaulin.
Even when direct humidity, such as rain or mist, is not observable, local climatic conditions may be such that a film of humidity forms on the components to be bonded trough condensation. This occurs when the temperature remains under dew-point.
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.
The basic values are:

Ambient temperature	T_1
Relative humidity	PHI
Component temperature	T_2
Temperature of dew point	T_t

On the basis of the input data T_1 and PHI, the dew-point temperature T_t is calculated using the diagram. The calculated values allow the following situation analysis:

$T_2 > T_t$:	Condensation is not possible
$T_2 \leq T_t$:	Condensation may form. Workpieces must be warmed to approx. 5° C above T_t.

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.

EFFECTS OF AMBIENT TEMPERATURE

The effects of ambient temperature on the pot-life and curing period of adhesives has already been described above. Attention is drawn at this point to the dependency of adhesive viscosity on temperature.

EP 220-1

At temperatures under 15° C it is a good idea to heat the resin slightly before using it. Otherwise, viscosity is very high, the resin is very viscous and difficult to use. It will not be possible to obtain a thorough mix. Also, it is not possible to rub 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, preheated adhesive is applied at temperatures under approx. 10° C, the coating of adhesive will cool very rapidly, resulting in high viscosity. Pre-heating the pipe ends provides a solution, but it must be remembered that the increased pipe temperature effects the pot-life of the applied adhesive. At ambient temperature below 10° C, we recommend carrying out the work in a heated tent or workshop. Heating pipe ends, the socket ends of fittings and adhesive is an option, but not always the recommended one.

VE 200

At temperatures under 15° C it is a good idea to heat the resin slightly before using it (to 20° C max.). This is because viscosity changes in relation to temperature as outlined above. At temperatures under 10° C, it is inappropriate to bond without additional heating. We recommend carrying out operations in heated rooms. If ambient temperature increases to over 30° C, it may occur with adhesive VE 200 that a reduction of the quantity of hardener results in an extension of pot-life. Our recommendations for quantities were outlined above.
Strength of bonding is determined by the adhesive and the condition of the bonding surface only. The pipe material (epoxy resin, vinyl ester resin or metal) has no effect on bonding strength.
These instructions have been produced on the basis of a wide range of practical experience. Depending on the conditions on site and the range of experience of personnel, questions may arise which have not been dealt with in this document. If so, please consult our applications technology dept.

9.2 LAMINATION TECHNOLOGY

9.2.1 WORKING PROCEDURE

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.

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

IMPORTANT
Cut pipes all the way through and support the free ends. This avoids the pipe breaking off before completion of cutting.

SURFACE PREPARATION
The surface of pipes and other glass fiber reinforced components which are to be laminated over each other or together must be emerized before the laminate material is applied. The length of pipe surface to be emerized should be 2-5 cm longer than the length of laminate. On completion of emerizing, the bonding surface should be free of shiny areas. Excess emery powder is removed using a clean brush. If interior laminates are to be carried out, the inside surfaces must be treated correspondingly.

IMPORTANT
Remove all excess emery powder using a dry brush. Protect prepared surfaces from dirt, humidity, etc.. Grease, oil, or human perspiration act as parting agents and prevent adhesion of the laminate.
Do not use solvents to clean surfaces to be laminated.

ALIGNING COMPONENTS
Pipe components to be connected must be secured so as to remain correctly aligned during lamination and the curing period. Before being connected, the cut edges of pipes and fittings are sized by coating them with adhesive EP 220-1 (epoxy resin) or VE 200 (polyvinyl ester resin). After joining, the remaining gap is filled with adhesive. After this, a bonded laminate consisting of mat and resin can be applied. When the curing period for the joint is over, the fixing laminate (or adhesive) is again emerized prior to lamination.

9.2.1 WORKING PROCEDURE

LAMINATION

The glass mats and glass fabrics are cut to size and the resin mixture prepared for the lamination process. The resin is applied to the prepared surface using a lamb's wool roller.

Next, the first glass mat is laid up, soaked in laminating resin and rollered. The process continues similarly for the second layer. Rolling is carried out using a deaerating roller, e.g. a steel fluted roller. The laminate is additionally compressed by binding over a layer of glass silk tape. The glass silk tape must be applied evenly with an overlap of approx. 50% and well soaked in resin.

Laminate build-up occurs by laying up successive layers in a modular way. The lamb's wool roller is again used to apply resin to the existing laminate, a layer of glass fabric is laid up, soaked with resin, and rolled flat to remove the air. The newly laid up laminate layers are compressed using glass silk tape. Care must also be taken here to wind the glass silk with a 50 % overlap and soak well.

IMPORTANT

Soak glass reinforcement completely with laminate resin. Roll down laminate layers using a roller to remove all air. Wind glass silk tape onto laminate layers evenly and tightly.

Before starting the epoxy resin must be warmed up to approx. 40° C.

9.2.1 WORKING PROCEDURE

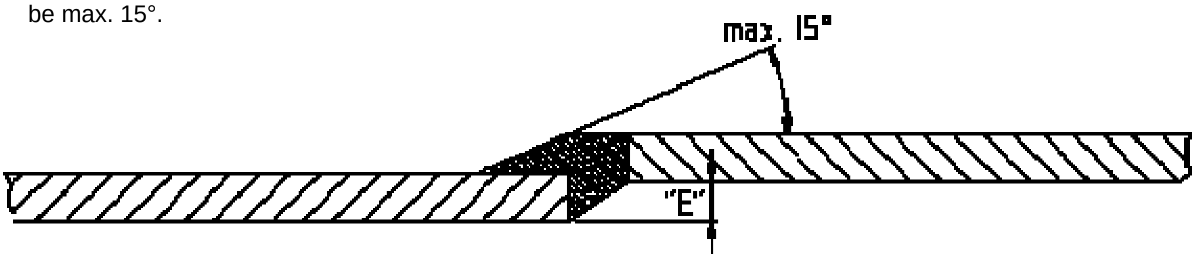
OVERLAP WITH BUTT JOINTS

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

NOMINAL DIAMETER	350	400	500	600	700	750	800	1000
Mismatch (mm)	4,5	5,0	5,5	6,5	7,5	8,0	8,5	6,0

Table 1: permissible pipe mismatch

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



9.2.2 MIXIN THE RESIN

STANDARD RESIN MIX

Under standard conditions, for lamination processes with epoxy resin or vinyl ester resin, we recommend the following resin mixtures:

EPOXY RESIN	VINYL ESTER RESIN
1000 parts resin EPIKOTE 827	1000 parts vinyl ester resin
250 parts hardener HYSL 6040	30 parts hardener MEKP-M 60 15 parts accelerator 1% cobalt

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 so that use is no longer possible. Storage times are:

STORAGE TEMPERATURE	EPOXY RESIN	VINYLESTER RESIN
below 10°C	up to 2 years	up to 3 months
10° C – 30° C	up to 1 year	up to 1 month

IMPORTANT

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

RISK OF EXPLOSION

More important information about handling resin, hardener, and accelerator is contained in Information Sheet MO23 "Polyester and Epoxy Resins" published by the Employer's Association of the German Chemical Industry.

REACTION TIMES DURING PROCESSING

PROCESSING TIMES 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:

OPERATION	EPOXY RESIN	VINYLESTER RESIN
Resin and hardener are mixed	0 min	0 min
Resin begins to thicken	20-30 min	20-30 min
Gelled components begin to warm up	30-40 min	30-40 min
Exothermic temperature peak	2-3 hours	50-70 min
Cold and solid	3-6 hours	70-120 min
Curing up to full mechanical strength level	see section "Curing"	

WORKING AT VARIOUS AMBIENT TEMPERATURES AND LARGE LAMINATE THICKNESSES
With a standard resin mixture the cross-linking reaction takes place faster at higher ambient temperatures. This means that laminate connections must be completed in less time. Also, since the exothermic cross-linking reaction sets heat free, overheating may occur, depending on the ambient temperature and the thickness of 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.

Vinyl ester resin laminates
The speed of reaction is governed by the ration 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 APPROX. 12 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	15
20° C – 25 ° C	1000	30	10
25° C – 30 ° C	1000	30	5

MIXTURE RATIONS FOR LAMINATES UP TO APPROX. 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 special boundary conditions or the lamination experience of operatives. The proportion of hardener or accelerator should be within the limit values shown above. Thicker laminates can be completed using intermediate curing.

Epoxy resin laminates
In the case of epoxy resin, a modification of the mixture ratio is not permissible. A defined mixture ratio is a pre-condition for optimum curing. The speed of reaction cannot be shortened or extended at higher temperatures by modification of the mixture ratio.
At higher ambient temperatures, or with thicker laminates, intermediate curing must take place.

9.2.3 CURING PROCESS

STANDARD CURING

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

AMBIENT CURING TEMPERATURE	EPOXY RESIN	VINYLESTER RESIN
approx. 20° C	approx. 18 hours	approx. 24 hours
approx. 50° C	approx. 2 hours	approx. 5 hours
approx. 80° C	approx. 1 hour	approx. 1,5 hours

At external temperatures <15° C
Thermal aftercuring required.

At external temperatures <10° C
Work must be carried out in rooms or a heated assembly tent.

AFTERCURING

The mechanical strength and chemical resistance to corrosion of a laminate depends on the degree of cure obtained. The more perfect the cure, the higher the values. If curing takes place at room temperature, tempering for aftercure 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 introduced 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 soaked.
Heat must be introduced at a constant rate and be continuously monitored. Overheating of the laminate must be prevented since overheated laminates have reduced strength and inferior chemical stability.

Under normal conditions, aftercuring should take place for:

- Epoxy resin: 80° C – 100° C duration 60 min
- Vinyl ester resin: 80° C – 95° C duration 90 min

Maximal temperatures in the case of thermal aftercure:

- Epoxy resin: 150° C
- Vinyl ester resin: 95° C

CURING WITH LARGE LAMINATE THICKNESSES

Heat is produced during the curing period. The thicker the laminate, the more heat is set free. In the case of too thick a laminate, this can result in overheating of 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.

9.2.4 ENVIRONMENTAL FACTORS

HUMIDITY EFFECTS

Care must be taken that the components to be laminated are protected from humidity (rain, mist, dew, snow etc.) during both preparation and assembly. This can be achieved by using an assembly tent or heating devices. The formation of condensation due to the temperature difference between workpiece and ambient temperature must be avoided (see chapter 9.1).
Repairs to a pipeline containing liquid must be preceded by complete drying of the pipeline. No liquid may be allowed to seep on to the locations under repair. Even the smallest quantities are damaging.

AMBIENT TEMPERATURE EFFECTS

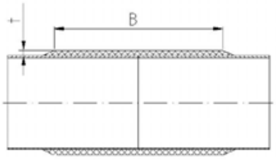
The effects on working time and curing periods have already been detailed. It is also necessary to remember that the viscosity of the laminate resin is dependent on ambient temperature.
Especially in the case of epoxy resin, the soaking properties of the glass fabric and glass matting is dependent on the temperature of the resin. Therefore, at ambient temperatures under 15° C it is appropriate to heat resin and hardener to approx. 22° C prior to mixing. Care must be taken that preheating is not excessive, since processing time is otherwise considerably reduced.

9.2.5 SAFETY MEASURES

- Avoid all contact with the hardener. In the case of accidental contact, thoroughly wash the skin using soap and water !
- Resin, hardener and solvents are inflammable. Therefore, smoking and the presence of naked lights are prohibited !
- Hardener and accelerator must not be brought into contact with each other ! Risk of explosion !
- Further safety rules are contained in the Information Sheet “Polyester and Epoxy Resins”.

Strength of a laminate connection is determined by the laminate applied and the condition of the bonding surface only. The pipe material (epoxy resin, vinyl ester resin or metal) has no effect on bonding strength.
These instructions have been produced on the basis of a wide range or practical experience. According tot he conditions on site and the range of experience of personnel, questions may arise which have not been dealt with in this document. If so, please consult our applications technology dept.

BUTT LAMINATE



9.2.6 LAMINATE STRUCTURE

BUTT LAMINATE PN 16

According to DIN 16966, PART 8 σ = 150/mm² Glass contents (45±10)m-%

DN	S (mm)	DIMENSIONS OF CUT PIECES			LAMINATE STRUCTURE
		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 LAMINATE PN 10

According to DIN 16966, PART 8 σ = 150/mm² Glass contents (45±10)m-%

DN	S (mm)	DIMENSIONS OF CUT PIECES			LAMINATE STRUCTURE
		B (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'

BUTT LAMINATE PN 6

According to DIN 16966, PART 8 σ = 150/mm^2 Glass contents (45±10)m-%

DN	S (mm)	DIMENSIONS OF CUT PIECES			LAMINATE STRUCTURE
		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'

M:	Mat (450 g/m^2)/Article-No. 40450127/40460127	Pipes from DN 600 must receive an internally laminate. (2xmats 100 mm width)
G:	fabric (720 g/ m^2)/Article-No. 40320127	
B:	Ventration veil (20 g/m^2)/Article-No. 40350010	
*:	4 rounds	
M':	Mat teared (450 g/m^2)/Article-No. 40450127/40460127	

CONNECTION PIECE LAMINATE

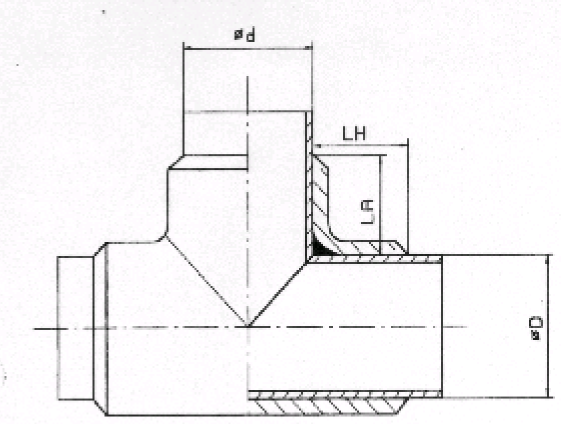


Bild 1: Stutzenlaminat rohrförmig (R)

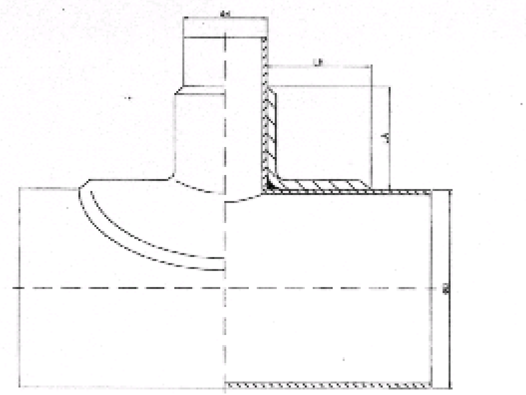


Bild 2: Stutzenlaminat kreisförmig (K)

CONNECTION PIECE LAMINATE

SELECTION OF LAMINATE SHAPE:

NOM. PRESSURE	**16**
PIPE-SHAPED	d > 0,25 D
CIRCULAR	d ≤ 0,25 D

NOM. DIA.	**BRANCH PIPE**																
MAIN PIPE	**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

Table 1: Selection of circular (K) or pipe-shaped (R) reinforcement nom. pressure PN 16

NOM. PRESSURE	**10**
PIPE-SHAPED	d > 0,4 D
CIRCULAR	d ≤ 0,4 D

NOM. DIA.	**BRANCH PIPE**																			
MAIN PIPE	**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

Table 2: Selection of circular (K) or pipe-shaped (R) reinforcement nom. pressure PN 10

MAIN PIPE DN	DN	BRANCH PIPE									
		25	**40**	**50**	**65**	**80**	**100**	**125**	**150**	**200**	**250**
40	**Type of Laminate**	A									
	LH (mm)	50									
	LA (mm)	50									
50	**Type of Laminate**	A	A								
	LH (mm)	50	50								
	LA (mm)	50	50								
65	**Type of Laminate**	A	A	A							
	LH (mm)	50	50	50							
	LA (mm)	50	50	50							
80	**Type of Laminate**	A	A	A	A						
	LH (mm)	50	50	50	50						
	LA (mm)	50	50	50	50						
100	**Type of Laminate**	A	A	A	A	A					
	LH (mm)	50	50	50	50	75					
	LA (mm)	50	50	50	50	75					
125	**Type of Laminate**	A	A	A	A	A	A				
	LH (mm)	50	50	50	50	75	75				
	LA (mm)	50	50	50	50	75	75				
150	**Type of Laminate**	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	**Type of Laminate**	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	**Type of Laminate**	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	**Type of Laminate**	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

Table 3: Laminate dimensions, connecting piece laminate, nom. pressure 16

Stub-laminating < DN 100: Intermediate hardening 1 h after 2xmat/glas fabric (mat/tissue), grinding

Details regarding the stub-end-laminations (design of lamination and dimensions) > DN 300 are available upon request.

MAIN PIPE DN	DN	BRANCH PIPE																	
		25	40	50	65	80	100	125	150	200	250	300	350	400	500	600	700	800	900
40	Type of Laminate	A																	
	LH (mm)	50																	
	LA (mm)	50																	
50	Type of Laminate	A	A																
	LH (mm)	50	50																
	LA (mm)	50	50																
65	Type of Laminate	A	A	A															
	LH (mm)	50	50	50															
	LA (mm)	50	50	50															
80	Type of Laminate	A	A	A	A														
	LH (mm)	50	50	50	50														
	LA (mm)	50	50	50	50														
100	Type of Laminate	A	A	A	A	A													
	LH (mm)	50	50	50	50	75													
	LA (mm)	50	50	50	50	75													
125	Type of Laminate	A	A	A	B	B	C												
	LH (mm)	50	50	50	50	75	75												
	LA (mm)	50	50	50	50	75	75												
150	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	M	N	N	O	O	P	P	P	Q	Q	R	R	S	S	U	U	V	
	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	Type of Laminate	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

Table 4: Laminate dimensions, connecting piece laminate, nom. pressure 10

Stub-laminating < DN 100: Intermediate hardening 1 h after 2xmat/glas fabric (mat/tissue), grinding

MAIN PIPE DN	DN	BRANCH PIPE																		
		25	40	50	65	80	100	125	150	200	250	300	350	400	500	600	700	800	900	1000
350	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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	Type of Laminate	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

Table 5: Laminate dimensions, connecting piece laminate, nom. pressure 6

Stub-laminating < DN 100: Intermediate hardening 1 h after 2xmat/glas fabric (mat/tissue), grinding

TYPE	STRUCTURE	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

Table 6: Laminate structures (M:mat; 450 g/m²/Article-No. 40450127/40460127) (G:fabric; 720 g/m²/Article-No. 40320127)

TYPE	STRUCTURE	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

Table 7: Laminate structures (M:mat; 450 g/m²/Article-No. 40450127/40460127) (G:fabric; 720 g/m²/Article-No. 40320127)

9.3 TRANSPORT AND STORAGE

9.3.1 GENERAL INFORMATION

To ensure that FIBERDUR glassfiber reinforced plastic components are handled safely and appropriately, care must be taken to handle correctly when transporting, loading and unloading, and storing.
The instruction has been produced on the basis of practical experience and is meant to provide practice-related advice. Main guidelines, safety regulations and transport insurance regulations must be given priority.

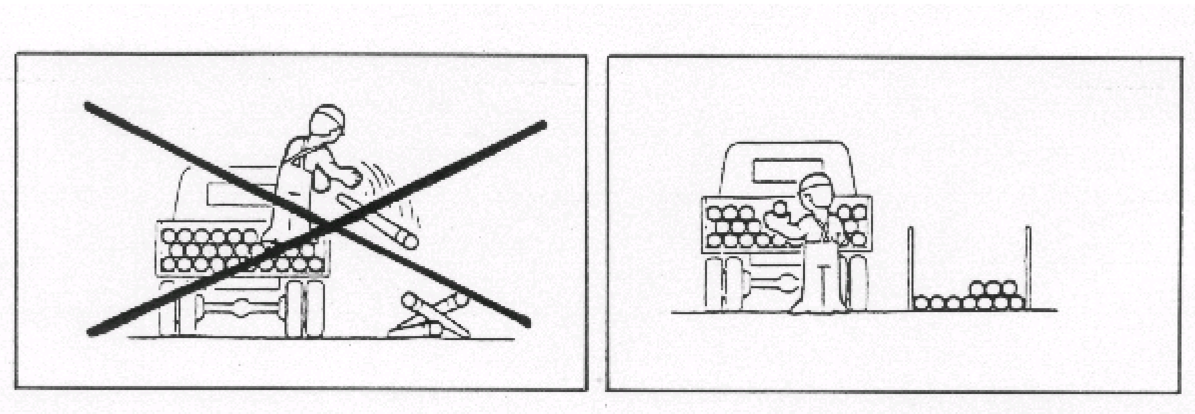
9.3.2 GOODS-IN INSPECTION ON DELIVERY
INTERMEDIATE CHECKS DURING FURTHER USE

Goods-in inspection
Components arriving at the factory or site are to be immediately inspected for damage during transport. Any damaged components should be stored separately. Inspection protocols and transport damage reports are to be made out in the presence of carriers and countersigned by them.

Intermediate checks
In their own interest, personnel responsible for working with FIBERDUR material are strongly advised to check all materials for defects arising from storage prior to commencing work with these materials. This applies particularly in the case of lengthy storage periods on site, following internal transport and during transfer from one department to another. Intermediate inspection takes the form of a visual check. This ensures that only defect-free material is used in operations.

9.3.3 TRANSPORT AND HANDLING
LOADING AND UNLOADING ON SITE

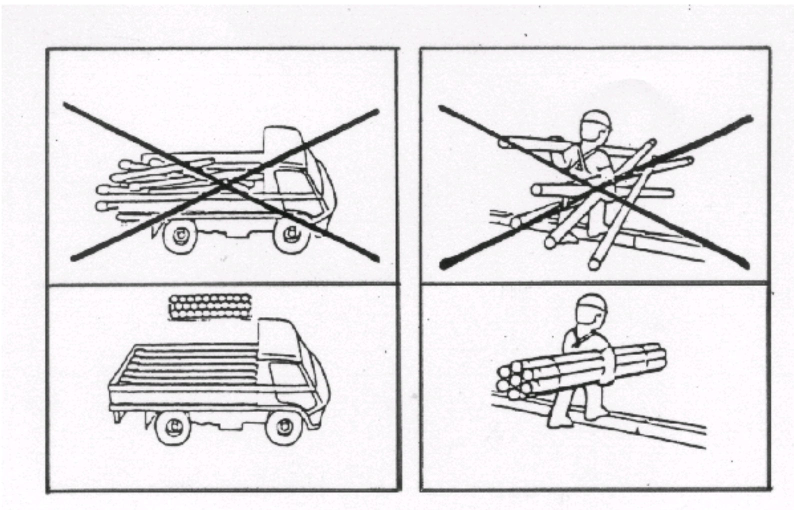
Plastic components and plastic-lined devices should under no circumstances be thrown or dragged across the floor. When loading and unloading, appropriate lifting equipment or an adequate number of personnel should be used. Because of their low specific weight, a wide range of FIBERDUR components can be unloaded manually. Lifting equipment should always be used with bulky or large volume components. Points of concentrated load should be avoided. For this reason, more flexible arresting devices such as plastic ropes or webbing should be used. Chains or steel ropes must not be used as arresting devices. When fitting arresting devices, care must be taken to obtain good weight distribution. If lifting lugs are attached to bulky goods, they must be used with cross arms. Under no circumstances should ropes be wound around connecting pieces. Work protection guidelines must be observed when lifting loads.
Sudden impact when dropping, moving, swinging or stacking is to be avoided.



INTERMEDIATE TRANSPORTATIONG

In the case of long-haul transport routes or longer transit periods to factory or construction sites, the following must be observed:

Smaller components, such as fittings, are to be transported in stiff cardboard boxes, wooden crates or other similar containers. When transporting over uneven terrain, such as across country, the components can be protected against impact and scratches by loading them on a flexible supporting base, e.g. corrugated cardboard, wood shavings, etc. Long or bulky components, such as entire lengths of piping, pre-fabricated isometric components or larger fittings should be attached on vehicles so that no slippage, abrasion, bouncing or dropping is possible. Avoid hard and uneven supports. Insertion of a packing layer distributes the bearing force and increases friction. Transport of components is thus safer. Make sure that transported loads do not excessively overhang the tailboard of vehicles. Vibrations during transport can result in excessive bending stress. Care must generally be taken that containers, crates, boxes and loading surfaces are free of sharp edges and rigid, protruding nails, screws, metal strips and sections must be removed or papped.



HANDLING AT INSTALLATION SITE

When handling components on site, the following points in relation to quality awareness in use at the pre-installation and final installation phases require attention:

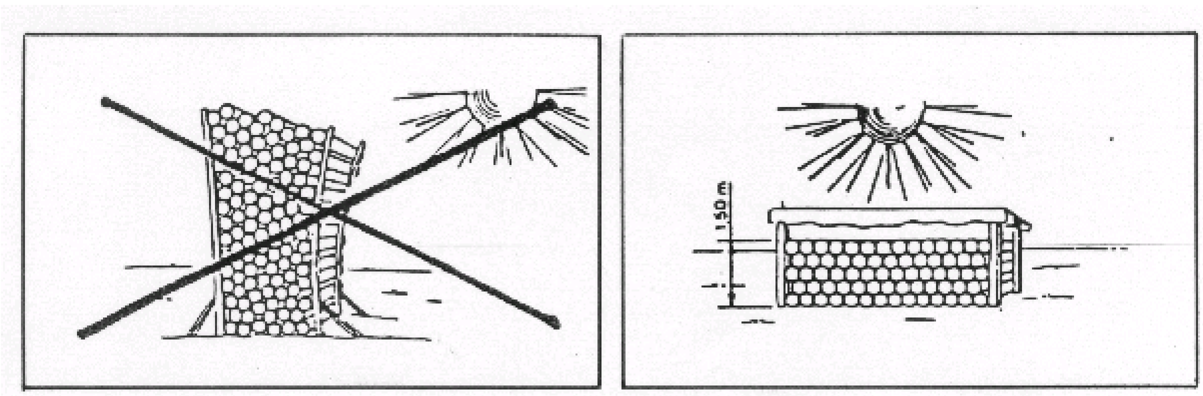
- When manually transporting entire lengths of piping (6 or 10 m) excessive bending or abrupt tilting is to be avoided. More than two persons should be deployed if necessary.
- Unload bulky half-products or pre-fabricated isometric components using several operatives, even if the material is lightweight.
- Do not drag plastic components over sharp edges or across floors.
- When transporting avoid knocking against steel supports, stairs and other equipment. Always lower gently to the floor.
- Symmetrically round components should only be rolled on stone-free surfaces. When storing, secure against rolling by using, for example, wedges.
- Do not set down larger items and pipes on their ends.
- Use appropriate lifting equipment and arresting devices for bulky components and containers including supports.

9.3.4 STORAGE

After delivery it is appropriate to forward material to a prepared component storage location or into the factory store. If longer storage periods on site are necessary, it is best to keep the components in their unbroken delivery packing.

Fittings and pipes in pipe palettes can be stored in the open. In case of extreme ambient conditions, appropriate protective measures must be taken. If components are not stored in their original packing, they are best stored on an even, smooth and stone-free support. Fittings can be stored on wooden shelves. A stacker can be used to store pipes. Beams can be used as supports. The span between supports must be appropriate to the nominal diameters of the pipe. Pipe stacks may be a maximum of 1.5 m, but lower heights are preferred for safety reasons. Pipe stacks must be secured at the side against movement. A large enough number of wooden slats must be inserted between each layer of pipes.

Adhesive used in connecting pipes and fittings must be protected against humidity, extreme heat and cold. The maximum storage life of each product must be observed. In the user's own interest, care should be taken when selecting a storage location that it is not exposed to vehicle movement on site and other similar undesirable effects.



9.3.5 DAMAGE ASSESSMENG

If defects are found on FIBERDUR components it is important to make a correct assessment of these to prevent wrong countermeasures being taken. It is appropriate to distinguish between two categories.

Surface damage

FIBERDUR pipes and fittings are provided with an external resin-rich surface coating. If there are visible signs of abrasion, scratches or scuffs here, these will not affect the service life of the component.

Laminate damage

At impact locations, circular or star-shaped cracks emanating from the centre of the point of impact are visible. This kind of damage is not limited to the outer surface, but penetrates deeper into the supporting laminate. Such damage is caused by the effects of impact. Plastics are generally prone to impact at low temperatures, especially at temperatures below zero. However, FIBERDUR glass-fiber reinforced components are, because of the different way they are materially structured, much less exposed than thermoplastics. Protective measures, however, can do no harm. Under these conditions, FIBERDUR recommends that special attention is give to observing the advice given above. Components having lamination defects must initially be excluded from use.