GRP Large Diameter Tanks:
a new Challenge for GRP Producers in Europe

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1.Introduction

This review deals with GRP large diameter tanks, i.e. tanks with large dimensions which require a production at the place of their further use.

Normally it is not possible to transport large diameter tanks with diameter > 5 m on the road. In this case it is necessary to manufacture the tank partly, or even completely at site.

The customer of GRP tanks should be aware of the fact that almost in every case GRP-large diameter tanks are economically interesting with regard to traditionnel material (such as rubber lined steel for example) taking into account the long lifetime of GRP-tanks. Furthermore, GRP material is provided with high mechanical characteristics. Thus it is possible to barrel large loads or big stirrer loads of 50kN and more.

GRP material is light, it is provided with 1/5 of the density of steel. This is the reason why conduits of high mechanical load can be produced at less weight than steel. Another important characteristic of GRP material is its low thermal conductivity . Unlike to steel it is often not necessary to insulate the material (contact-voltage proof, heat insulation).

2. Chemical Corrosion Resistance of GRP-Tanks

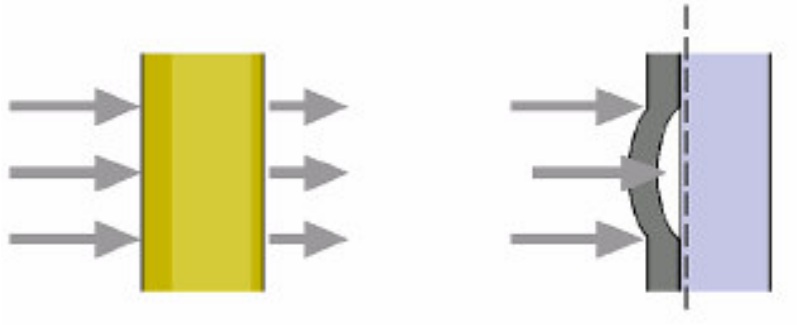
GRP is chemically high corosion resistant, this is the reason why they are used for the storage of water contaminating liquids.

The resins used guarantee chemical corrosion resistance of GRP laminating with regard to the liquid to be stored. The layer which is near to the liquid contains a high percentage of resin whereas the supporting laminate is provided with more glass content in order to guarantee stability under load.

Using vinylester resins in connection with high corrosion resistant glasses, such as C-glass veils or ECR-glasses it is possible to produce high corrosion resistant laminates without any additional chemical protection layer. 2,5 km of pipes equipped with this material had been produced for the transport of pure fluegases and steam for the power plants of Jänschwalde and Schwarze Pumpe.

If an engineering company decides in favour of GRP instead of rubber lined or coated steel they can rely on the advantage of a material which is resistant against chemicals.

The following picture explains the difference: (picture 1)

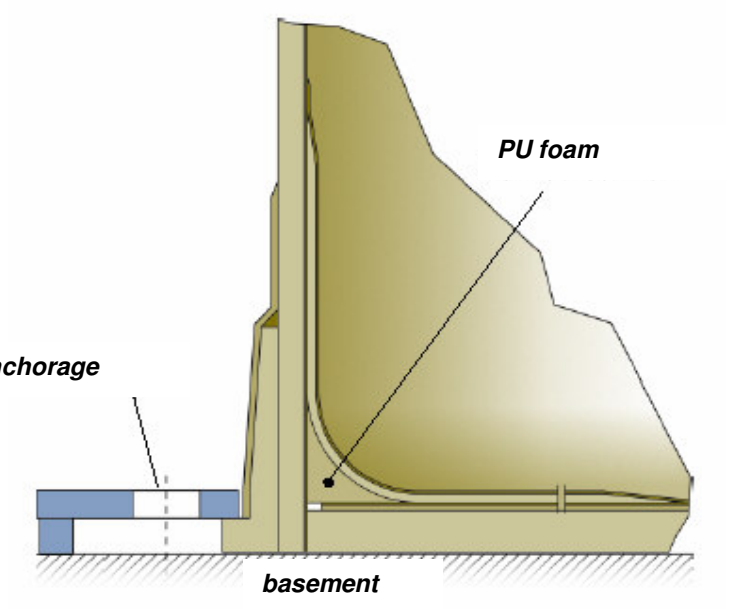


GRP wall structure
almost steadily diffusion
all over resistant

steel + coating/rubber lining
coating/rubber lining is more permeable than material of support (steel for instance)

3. Constructional Peculiarities of GRP Large Diameter Tanks

Normally GRP large diameter tanks are manufactured with flat bottom. In most of the applications it is reasonable to construct a flat upper bottom as well so that stirrers can be situated in the middle of the bottom. The loads of these stirrers can be radially conducted to the cylindric wall by means of steel equalizers.



Picture 2: Upper bottom forming of GRP large diameter tanks

It is especially important to draw the attention to a well performed construction of the flat bottom. Often it is required that the flat bottom is provided with an obtused knuckle at the cylinder side. This kind of construction entails a big wallthickness in the knuckle area of the bottom.

The laminated so called diaphragme bottom however, is a better and cost-effective variation: the tank or cylinder will be prefabricated without bottom, then installed on the subbase prepared before. Then the bottom of the tank is laminated into the subbase. The GRP cylinder in the lower area of the tank will be thus construced that moments of flexion can be taken from the lower part of the cylinder. Thus the bottom function only as a sealing component with regard to the chemical. Picture no. 2 shows this variant of the lower bottom construction.

This kind of production guarantees the entire bottom to lie even on a level with the basement; thus it is not necessary to equalize the bottom with the basement.

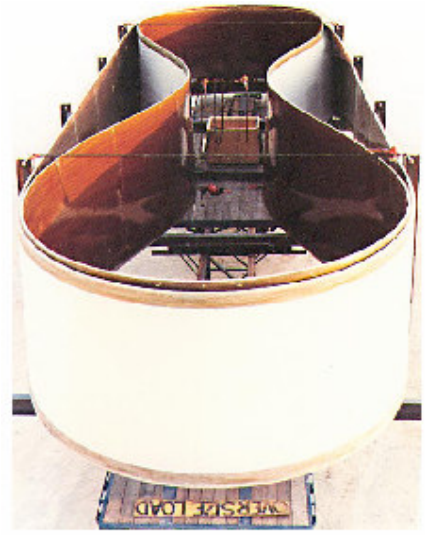
4. Manufacturing, Handling, Transport, Installation and Quality Control

There are various kinds of procedures how to manufacture GRP large diameter tanks with different advantages and disadvantages which will be described as follows:

Production by the vertical filament winding method at site:
The advantage to manufacture large diameter cylinders at site (2 x 4 m = 8 m) is obvious. It is also possible to connect the upper bottom with the cylinder by the filament winding method.

Delivery of ovalized cylinders and their completion at site
Provided the cylinders are not bigger than 2 m they can be produced at manufacturer's premises. This kind of production is an alternative to the above mentioned method. After their completion these tanks will be ovalized so that they can be transported to their place of destination. Picture no. 3 shows how ovalized cylinders can be transported on the road by means of a truck.

In picture no. 3 even 2 cylinders of the same diameter are presented. Both tanks can be transported at the same time by ovalization and contraction.



Picture 3:
Ovalization of GRP tanks for transport on the road

Advantage of this procedure: Lower costs at site, because no filament winding plant must be installed at site.

Production of mitred rings and their completion at side:
Tanks which are not very high can be cut in longitudinal segments and then be put together for transport. At site these segments can be completed to a tank by laminating the longitudinal seams. Because of the big ring tensile forces of larger tanks this kind of manufacturing can only be realised if tanks are small.

4.1 Production of GRP Cylinders at Site by Vertical Filament Winding

During the vertical filament winding procedure layers of resin impregnated glass are being applied onto a rotating mandrel . The combination of the layers are designated as so called „Rapports“ or „Moduln“. Depending on the manufacturer they can quite differ . Different mechanical characteristics and costs for laminating are resulting from the structure of laminates and their „Rapports“.

GRP large diameter tanks are manufactured at site by the vertical filament winding method .
Picture no. 4 shows a vertical filament winding installation equipped with filament winding pole and two mobile lifting platforms from where the resin impregnated glass is being applied. An electronic control system of lifting platform and mandrel guarantees an exact mounting of the rovings and matted layers.

Picture 4: Vertical filament winding installation with filament winding pole two mobile lifting platforms

The mandrel of the installation is a rigid circular encasing made of wood or sheet steel, which can be moved inside in order to remove the component from the mould. After the first installation of the mandrel roundness is examinated and documented.

The production of a cylinder includes the following main steps:

- Preparation of the mandrel (cleaning of the surface, mounting of the mandrel, winding-up of the separating foil)
- production of the chemical protection layer
- production of the supporing laminate
- production of stiffening ribs or bandings
- production of the paraffined layer outside

Picture 5: The pure resin layer is being applied

Picture no 5 shows the first step how to manufacture the chemical protection layer. First a layer of pure resin is being applied onto the skin of the mandrel by using a fiber spraying equipment.

After completion of the chemical protection layer follows an intermediate curing. Lateron the filament winding equipment is prepared in order to complete the supporting layers of laminate. In our example the laminate consists of winding rovings and UD-tissues (UD = unidirectional).

Picture 6: shows how the resin impregnated rovings are applied onto the rotating mandrel.

As far as there is no hall available for the installation of the tank a big tent roof is necessary to house an entire vertical winding installation.

4.2 Handling, Transport and Installation

The production of a large diameter GRP tank requires many crane activities. Sometimes cylinders need to be transported to the installation site of the tank.
Often, space of construction sites is cramped and there are obstacles such as pipe bridges to get over.
The coordination of each step in connection with lifting works and the simultaneous activities of other companies requires a lot of attention of those who are responsible for the execution of the order and those who are working at site.

Picture 7: Transport of a GRP tank with upper bottom (Ø 8 m)

Picture no. 7 shows the transport of such a tank. Upper bottom and the upper cylinder had been connected by the filament winding method.

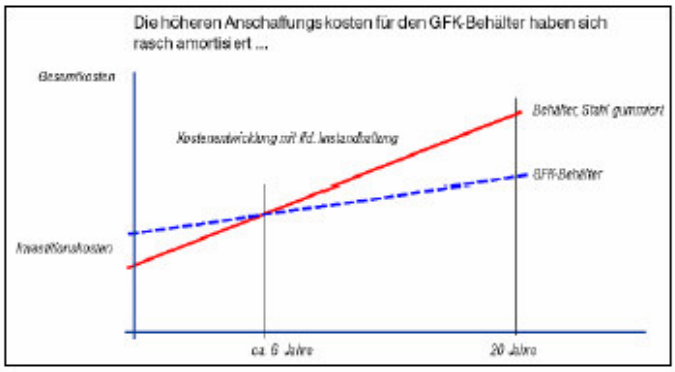
4.3 Quality Control at Site

Quality controlling measures must be planned and realised at site in order to satisfy the client's requirements concerning quality and delivery time of the final product.
Every day the supervisor at site should inform the parent company about progress at site. That is the only way how to take steps against delays in time.

It is a big advantage if the above indicated methods and instructions had already been documented and obviously introduced by the company. This applies if the company has got the DIN ISO 9001 certificate.

5. Costs of Rubber Lined Steel compared with GRP Large Diameter Tanks

Often, GRP large diameter tanks compete with rubber lined steel tanks. Investment costs for tanks made of steel equipped with a simple rubber layer are normally lower than those made of GRP. We have to take into consideration, however, that GRP is being designed for high safety factors and for an operating time of about 25 years without claiming considerable redevelopment measures during this time. Comparing the lifetime of both material a point of intersection can be found which demonstrates that GRP-tanks are the more reasonable alternative.



Above illustration compares investment costs/service costs of a rubber lined large diameter tank and GRP large diameter tank.

Savings of operating expenses as shown in above drawing can be obtained because lifetime of rubber lining is limited to about 6 – 7 years. After this time rubber lining of tanks made of steel must be renewed, fact which entails considerable costs.

6. Summary

The significance of GRP material for engineering companies and power plants will become more important if both is taken into consideration: excellent characteristics and longterm economic advantages.

Enclosed reference list, table 11, indicates large diameter tanks manufactured by FIBERDUR-VANK. Our good experiences for many years are the reason for us to see our chances in the future of European application fields.

GRP Large Diameter Tanks made by FIBERDUR-VANCK (Germany)

Location	Dimensions	Year	Function	Remarks
Buna Sow Leuna Schkopau	**Ø 7 m (3 pcs) high about 12 m**	**1998**	**Storage tank for brine and hydrochloric acid**	**Chemical plant production made at site by vertical filament winding**
Buna Sow Leuna Schkopau	**Ø 10 m high about 17 m**	**1998**	**storage tank for brine and hydrochloric acid**	**Chemical plant production made at site by vertical filament winding**
Buna Sow Leuna Schkopau	**Ø 8 m (2 pcs) high about 12 m**	**1999**	**storage tank for hydrochloric acid**	**Chemical plant production made at site by vertical filament winding**
PCK Schwedt	**Ø 9 m high about 9 m**	**1998**	**storage tank for water reagent**	**Refinery, Ovalizing for the transport on the road**
KW Schwarze Pumpe	**Ø 10 m high about 12 m**	**1997**	**storage tank for flue gas sewage water**	**Brown coal fired power plant at site production made by vertical filament winding**
KW Lippendorf	**Ø 11 m (2 pcs) high about 11 m**	**1999**	**storage tank for flue gas water**	**Brown coal fired power plant at site production made by vertical filament winding**
KW Lippendorf	**Ø 15 m high about 15 m**	**1999**	**Emptying tank in flue gas desulphurization with stirrer**	**Brown coal fired power plant at site production made by vertical filament winding**
Zinkfabrik Ruhrzink	**Ø 15 m (2 pcs) high 3,5 m**	**1998/99**	**storage tank for sulphuric acid**	**Mitred construction made of single parts**
Peres Reststoffverwertung	**Ø 8,2 m (3 pcs) high about 11 m**	**2000**	**storage tank for flue gas desul. plant sewage water**	**at site production made by vertical filament winding**

FIBERDUR-VANCK GmbH

CUBE GmbH - 4302/D - 10/97

GROSSBEHÄLTER
BSL - WERK SCHKOPAU

Großbehälter ab einem Durchmesser von ca. 7 Meter fertigt die Th. Vanck GmbH im vertikalen Wickelverfahren. Bauteile dieser Größenordnung werden in der Regel vor Ort gefertigt. So auch im vorliegenden Fall.
Die Großbehälter werden als Lagerbehälter eingesetzt.

Kunde	DOW Europe, Rotterdam
Betreiber	BSL Schkopau
Baujahr	1997
AB-Nr.	101468

Behälter	Nutz-volumen [ltr.]	Durch-messer [mm]	Zylinder-höhe [mm]	Gesamt-höhe [mm]	Leer gewicht [ca. kg]	Ausl.-Druck [bar]	Ausl.-Temp. [°C]	Medium	Werkstoff
V1050	310.000	7.000	8.100	9.800	9.500	+0,02 –0,01	50	Sole	GF-VE Derakane 411-45 mit 5 mm CSS
V1120	250.000	7.000	6.500	8.200	8.500	+0,02 –0,01	70	Sole	
V1220	1.180.000	10.000	15.000	16.940	30.000	+0,08 / –0,01	80	Sole	GF-VE Derakane 470-36 bzw. 470-30 mit 5 mm CSS
V3150	307.000	7.000	8.000	9.700	11.000	+0,01 / –0,01	60	HCl 20%ig	

Company history of CHRISTEN & LAUDON GmbH Staffelstein

1941
Foundation
Th. Vanck GmbH

1960
Staffelstein Tank
Building works
Staffelstein

1962
Deutsche Fibercast GmbH
Foundation
Deutsche
Fibercast GmbH

1963
LAUDON
Foundation
Laudon Gruppe

1978
Christen & Laudon
Christen&Laudon
GmbH
Gerolstein

1995
Theodor Vanck
Buying through
Ruhrkohle AG

1996
Fiberdur GmbH
Renaming
Fiberdur GmbH

1997
Fiberdur Vanck
Fusion to
Fiberdur-Vanck
GmbH

LAUDON
Laudon
GmbH & Co.KG
Weilerswist

Werk Staffelstein

2002
Christen & Laudon Staffelstein
Christen&Laudon
GmbH
Staffelstein

Shareholder
Günter Laudon