Glass fibre reinforcement type significantly impacts FRP corrosion performance

As metal prices rise, engineers and end-users are increasing their use of glass-fibre-reinforced polymer (FRP) solutions in corrosive environments. In many cases, FRP is lower in cost, has outstanding performance and provides equal, if not superior, quality over high-cost alloys.

By

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Recent articles in the USA focused on several coal-burning power plants using alloy steel components in their flue gas desulphurization (FGD) units. The FGD units remove pollutants but the owners are being forced to spend millions of dollars on short-term corrosion repairs of the alloy steel. Power plant owners using FRP are experiencing good results and the use of FRP applications in corrosive environments is growing in the power & energy, mining, chemical processing and other demanding markets.

Using the proper glass type

The type of glass fibre reinforcement plays a significant role in how the FRP application will perform in corrosive environments. It is imperative that the proper FRP materials are selected to ensure their corrosion performance properties meet the needs of their specific environments. As there are many glass fibre reinforcement types (Table 1) available on the market today, using the correct type of glass fibre will improve the lifetime performance of the FRP application and reduce the risk of failure.

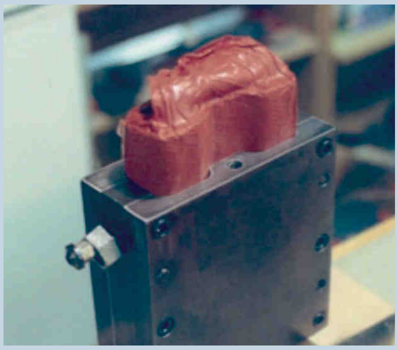
Tab. 1: Glass type evolution

Glass type	Year invented	Inventor
A-glass	1938	Owens Corning
E-glass	1939	Owens Corning
C-glass	1943	Owens Corning
R-glass	1965	Saint Gobain[1]
S-glass	1965	Owens Corning
AR-glass	1974	Owens Corning
E-CR Glass	1980	Owens Corning
Advantex®	1996	Owens Corning
H-glass	2004	Saint Gobain[1]
HPG	2004	Owens Corning
Direct melt-S	2008	Owens Corning

1- Owens Corning acquired the glass fibre business of Saint-Gobain in November 2007.

Corrosive environments

Glass fibre reinforcements play an important role in FRP applications facing corrosive environments. They provide the mechanical structure (strength and stiffness) required of the FRP part and optimize corrosion performance. If an incorrect glass



fibre type is selected and a corrosive chemical comes into contact with the fibre, it can degrade the fibre and destroy the resin bond, resulting in a significant reduction in structural properties.

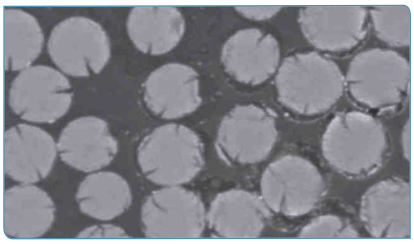


Fig.1 : E-glass starts to break down, with leaching, and cracking causing de-bonding from the resin which could lead to the potential failure of the application.

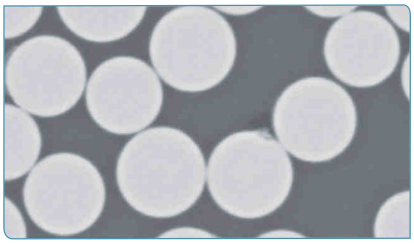


Fig.2 : Advantex® glass continues to perform after three months with no leaching, cracking or weakening. It maintains its strength in a corrosive environment.

The scanning electron microscopy pictures above show how glass fibre types in a composite respond to 10% sulphuric acid after three months of exposure. In a corrosive environment, gaseous or liquid chemicals can reach glass fibres in the structural portion of a finished FRP part causing premature failure due to multiple factors including: poor curing, diffusion, osmosis, applied stress, embrittlement, micro-cracking, impact, thermal gradients, pressure gradients and time according to the book titled *Aging of Composites*.

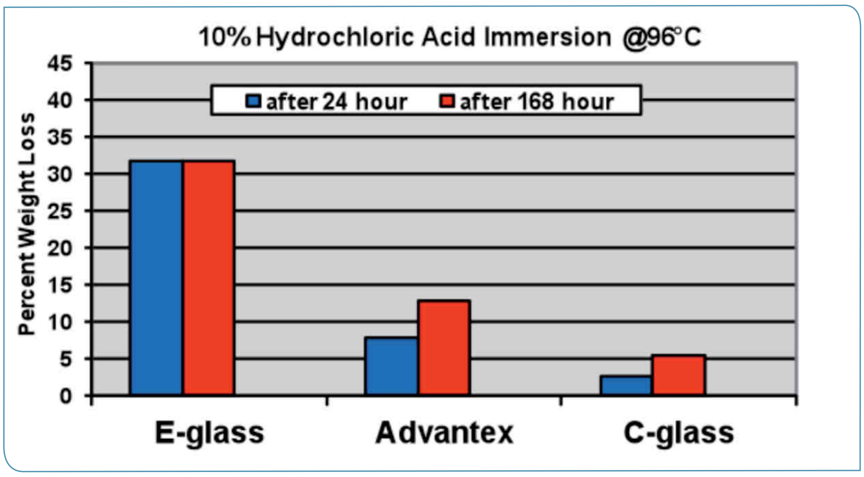


Fig.4 : Bare glass weight lost testing

Glass fibre selection

How to determine which glass type should be used? Similar to selecting the appropriate resin type for a certain chemical environment, a correct glass fibre must be selected for the corrosion barrier veil (if a glass veil is selected), the corrosion barrier chopped roving/mat section and the structural portion of the FRP part.

Owens Corning released the industry's first Glass Fibre Reinforcement Chemical Resistance Guide to help end-users, engineers and fabricators specify/select the proper glass type for some of the most common chemical environments. To download a copy, visit Owens Corning's Advantex® website: http://owenscorning.com/composites/aboutadvantex.asp Below are a few samples:

- Ferric chloride: the bare glass weight loss testing indicates Advantex® glass performs well in ferric chloride and should be considered for the mat portion of the corrosion barrier and the structural section. Standard E-glass is not a good choice for any part of the application since it loses over 37% of its weight as the ferric chloride attacks and destroys standard E-glass (see Figure 3).

- Hydrochloric acid: the bare glass weight loss testing, as shown in Figure 4, along with the stress-corrosion testing Owens Corning conducted, indicates that C-Glass should be used for the veil portion of the corrosion barrier (if glass veil is selected) and Advantex® glass should be used for the chop/mat portion of the corrosion barrier and the structural portion of the FRP part exposed to hydrochloric acid. Standard E-glass performs poorly and should not be used.

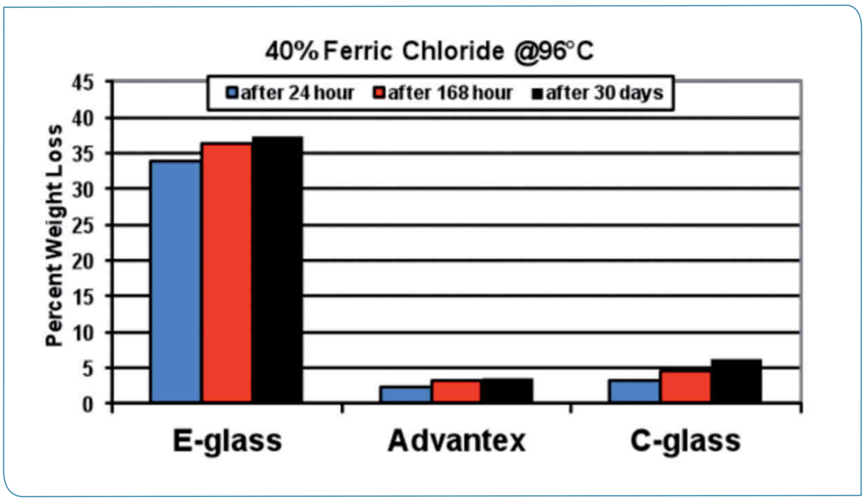


Fig.3 : Bare glass weight lost testing

More information

Owens Corning supports end-users, engineers and fabricators in specifying the proper type of glass fibre reinforcement for their use. Owens Corning offers a link on the Advantex® website to submit requests and also provides a faxable form in their glass fibre chemical resistance guide. Once Owens Corning receives the form, they will send a letter containing the recommended veil and chop/mat glass type for the corrosion barrier and the recommended glass type for the structural portion of the FRP part dependent upon the corrosive environment.

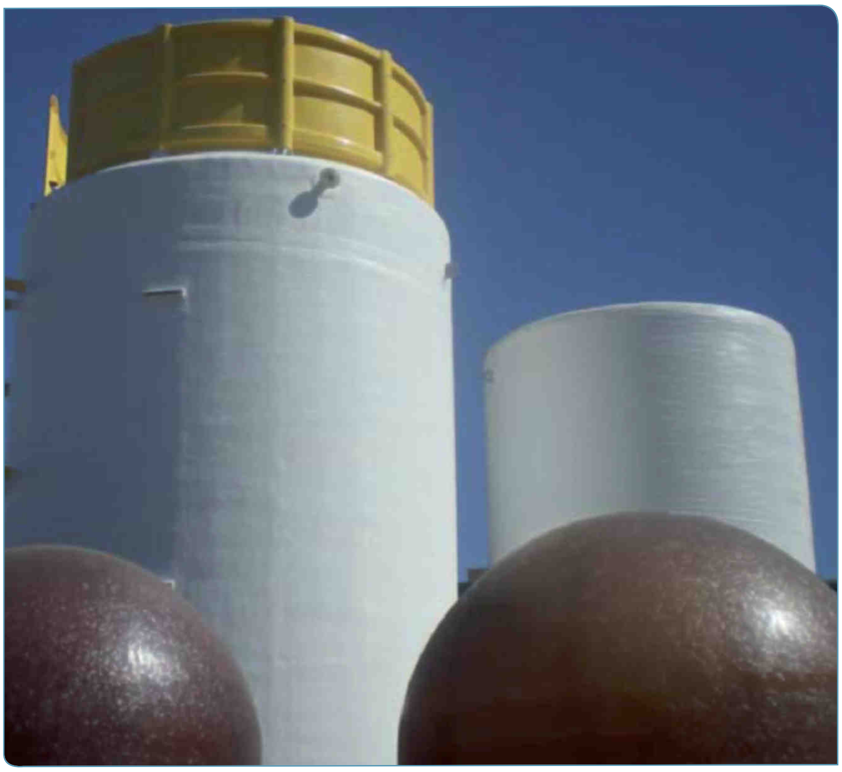


Fig.5 :An example of a sodium hydrochloride FRP tank

Boron-free glass

Advantex® glass is a patented boron-free glass formulation that is both a corrosion-resistant E-CR glass and an E-glass by definition. This glass material was developed with the following attributes: increased mechanical properties when compared to standard E-glass and E-CR glasses, and improved corrosion resistance when compared to standard E-glass, meeting both the ASTM D 578 4.2.4 and ISO 2078 standards.

Owens Corning invented Advantex® glass in 1996 and it has proven to be a best-in-class performing glass fibre type for FRP use in corrosive environments. Advantex® glass is produced in all regions of the world to provide customers the necessary product types from a local supply base. There are several industry standards recommending glass types for FRP use in corrosive environments. One of them is the ASTM D578 - Standard Specification for Glass Fibre Strands, section 4.2.4. This standard states "the nomenclature "E-CR glass" is used for boron-free modified E-glass compositions for improved resistance to corrosion by most acids." International Standard ISO 2078 - Designation of glass fibres, section 4.1.1, provides a chart with general indications of which glass types to use for certain environments (Table 2).

Tab. 2: ISO 2078 Glass designations

Glass type	General indication
E-glass	For general purpose: good electrical properties
D	Good dielectric
A	High alkali content
C	Chemical resistance
S	High mechanical strength
R	High mechanical strength
AR	Alkali resistant
E-CR	For use in acid environments

FRP specification standard

Many end-users and engineering firms are adjusting their FRP specification standards away from standard E-glass and inserting Advantex®/E-CR glass for FRP applications facing corrosive environments. Since FRP structures rely on glass reinforcements for their strength, using a glass fibre reinforcement which has better chemical resistance in many environments reduces risk and can improve the overall lifetime performance.

Advantex®/E-CR glass is being specified more frequently for use in mining, flue gas desulphurization, chemical processing, water and sewage, and many other industrial processes.

This glass material also offers advantages in areas with high voltage electrical currents. "*The main advantage of Advantex® glass with high-voltage applications is that it is boron free,*" said Byrd Hennessee, global product engineer for Owens Corning. "*There is a corona effect which occurs around high voltage lines, which attacks the boron in the glass, creating what the electrical industry refers to as a 'brittle fracture' failure, which means the boron-containing part is weakened and fails structurally. Since Advantex® does not contain boron it is less vulnerable to this type of brittle fracture failure.*" ■

More information:
www.owenscorning.com/composites/aboutAdvantex.asp