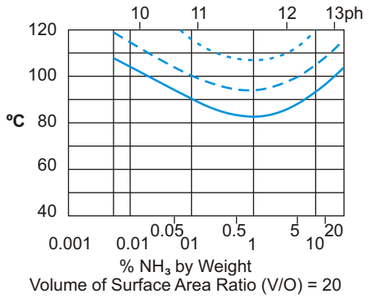
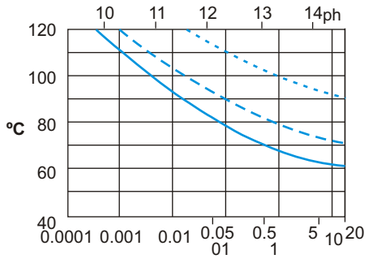
Ammonia



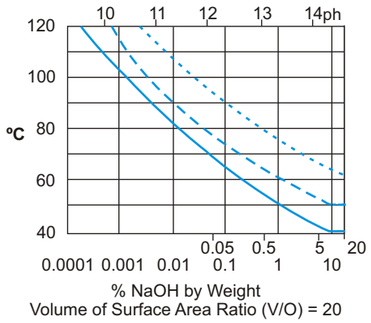
Volume of Surface Area Ratio (V/O) = 20

Potassium Hydroxide



Volume to Surface Area Ratio (V/O) = 20

Sodium Hydroxide



Volume of Surface Area Ratio (V/O) = 20

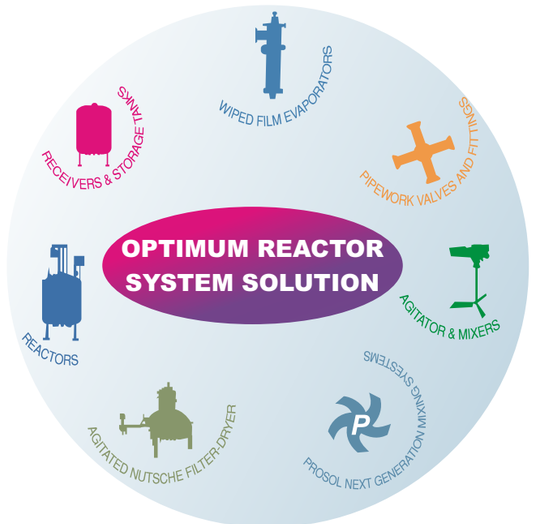
0.5mm/year 0.2mm/year
0.1 mm/year Fully Resistant

Right from the beginning ...

Getting us involved in your planning at an early stage could mean benefiting from the practical experience of Pfaudler companies worldwide. The use of glass may add significantly to the efficiency of your production - we will be pleased to provide you with supporting documentation for your decision-making process.

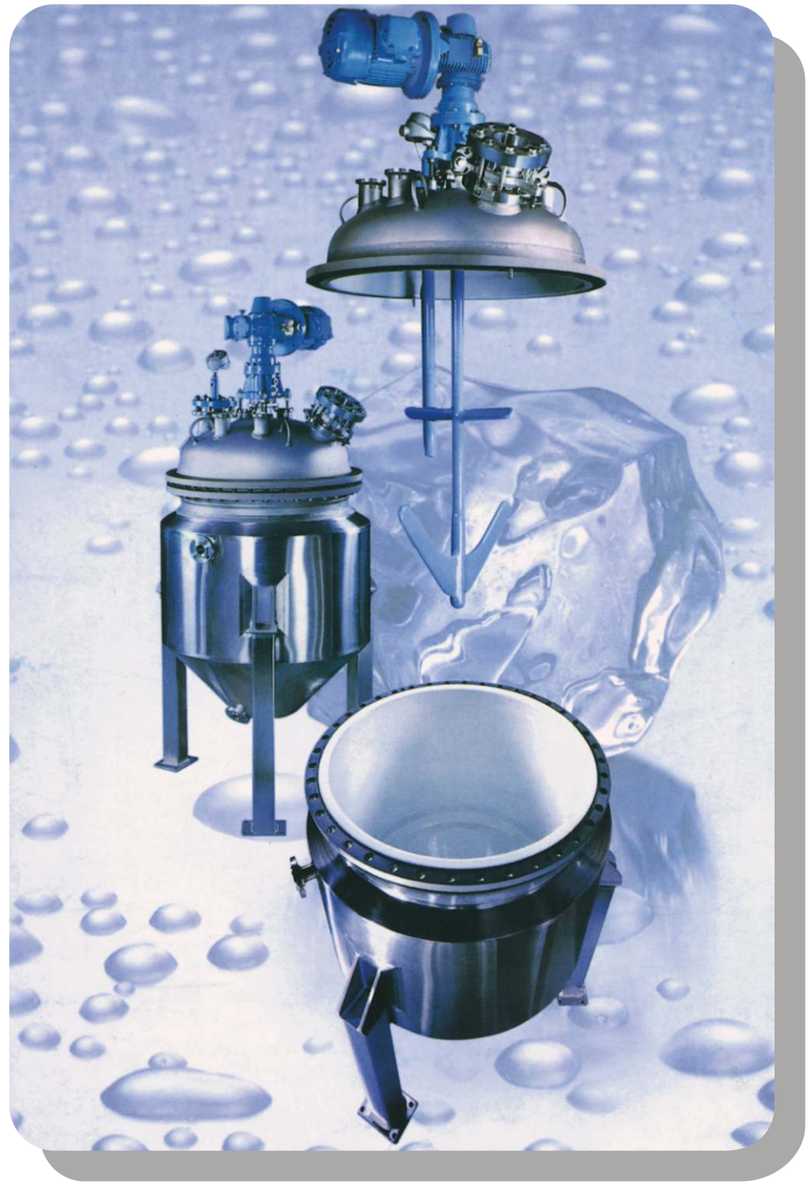
... up the operative system

Implementation, operation and maintenance are our issues. Our specialists and their know-how ensure the safe, efficient and continuous operation of apparati and entire systems.



PE/03-GMM-01/05

STAINLESS STEEL GLASTEEL® 4000



PFAUDLER REACTOR SYSTEMS

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PFAUDLER REACTOR SYSTEMS

www.gmmpfaudler.com

Stainless steel base of Pfaudier Rx Series pharmaceutical reactor is lined with Pfaudler Glasteel 4000, the first high-voltage test glass ever developed for reliable bonding to stainless. It opens new possibilities for pharmaceutical, ultra-clean, cryogenic and other applications.

Glassing Breakthrough

Score another first for Pfaudier research, which has pioneered most of the major developments in glassed-steel equipment. For the 70-some years that stainless steel has been available as a material of construction, it has rejected all efforts to bond glass reliably to it - until now. After decades of effort, Pfaudler researchers have developed a new glass formulation, along with special application and firing techniques. It's called Glasteel 4000 and it is the first high-voltage test glass that can be applied and tested to guarantee a reliable glass lining of uniform thickness and quality on stainless steel. No thin spots, no bare metal, no exposed base coat - all of which can occur with other glasses on stainless steel.

Glasteel 4000 glass made possible the invention of the revolutionary Pfaudier Rx Series Pharmaceutical Glasteel Reactors. This series fulfilled a long-felt need for pharmaceutical manufacturers concerned with meeting FDA Good Manufacturing Practices.

The highly polished exteriors of conventional all-stainless reactors are easy to clean and sanitize, which largely acdounts for their widespread use. But the bare stainless interiors can interact with powerful corrosives in the process solutions, and this can both contaminate the product and shorten equipment life.

The Rx series Glasteel reactor provides the same smoothly polished, easy-to-maintain exterior, but the interior has a lining of virtually inert glass that resists corrosion, abrasion, thermal shock, and product adherence. The inert glass will not contaminate the product and functions to protect the product purity, color, and quality. In addition, the stainless steel substrates and Glasteel 4000 linings of the Rx series reactors also make them valuable for other applications, such as cryogenic processes and pure products for electronics.

Glasteel 4000 is not only used in the Rx series reactor, it has already seen use in other series and, in fact, could be used in any standard Pfaudler glass-lined reactor capable of being fabricated from stainless steel. In addition, it has been used to cover special agitators and other accessories made of stainless steel.

Temperature Limits

Although Glasteel 4000 has a high degree of helpful compressive stress in the glass layer, there are definite limits to the level of thermal stress that the glass can withstand without incurring damage. Only two conditions must be considered when determining the temperature limits :

1. Introducing media into a vessel. The limits are determined from Chart A
2. Introducing media into a jacket. The limits are determined from Chart B

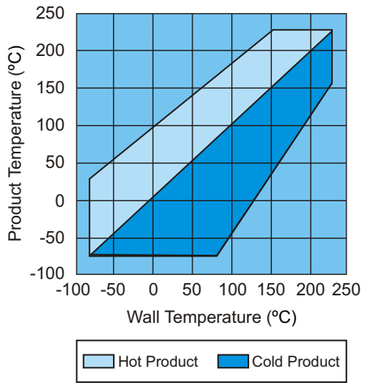
In both cases, the safe operating range lies within the polygons as outlined on the charts. The left and right sides of the polygons represent, respectively, the minimum and maximum wall temperatures allowed. The bottom and top of the polygons represent, respectively, the minimum and maximum reactant temperatures allowed (Chart A), and the minimum and maximum jacket temperatures allowed (Chart B).

With Chart B, it is also necessary to know the heat transfer film coefficient of the jacket medium. Three curves are shown: one for heating steam and cooling water (8500 W/m^2K) and two for typical heating/cooling oils (1500 and 1000 W/m^2K).

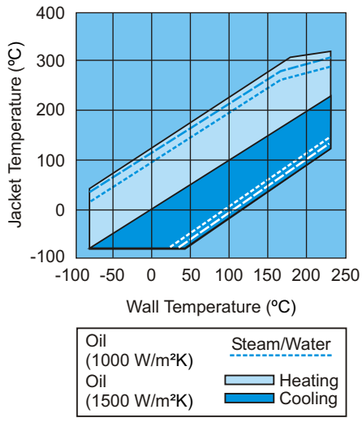
CAUTION:

"Safe" operating temperatures vary with conditions. Because so many variables are involved, temperature ranges are given only as a guide. When practical, operation below the maximum and above the minimum is recommended. Contact GMM Pfaudler for details.

Vessel Side (Chart A)



Jacket Side (Chart B)



Operating Temperature Examples

Exercise No. 1

Determine the maximum and minimum allowable wall temperatures of a vessel when introducing a product at 100°C into the vessel.

Procedure: Since the medium is being introduced into the vessel, Chart A applies. Find the product temperature of 100°C on the product temperature axis (ordinate). Follow this constant temperature horizontally, parallel to the wall temperature axis (abscissa). It intesects the polygon at wall temperatures of 2°C at the lower temperature end and at 187°C at the upper temperature end.

Answer: Product at 100°C can sagely be introduced into a vessel having a wall temperature between 2° and 187°C.

Exercise No. 2

A vessel with a wall temperature of 100°C is to be heated using hot oil with a heat transfer film coefficient of 1000 W/m^2K. What is the maximum oil temperature that can be used?

Procedure: Since the medium is being introduced into the jacket, Chart B applies. Find the wall temperature of 100°C along the wall temperature axis (abscissa). Follow this wall temperature vertically, parallel to the jacket temperature axis (ordinate). It intersects the upper temperature side of the 1000 W/m^2K oil polygon at a jacket temperature of 222°C.

Answer: A temperature of 222°C is the maximum allowable for a 1000 W/m^2K oil introduced into the jacket of a vessel with a wall temperature of 100°C.

Exercise No. 3

A batch has just been completed, and the wall temperature of the vessel is 150°C. What are the allowable upper and lower temperature limits of the product to be introduced into the vessel for the next batch?

Procedure: Chart A applies. Find the temperature of 150°C on the wall temperature axis. This line intersects the polygon at product temperatures of 42°C and 230°C.

Answer: The maximum and minimum allowable temperatures of a product to be introduced into a vessel with a wall temperature of 150°C are 230°C and 420°C respectively.

Exercise No. 4

Steam is being used to heat a product in a vessel. The vessel contents are at 50°C. Can 250°C steam safely be introduced into the jacket?

Procedure: Chart B applies. The intersection of a wall temperature of 50°C and a jacket temperature of 250°C is outside the steam polygon on the chart.

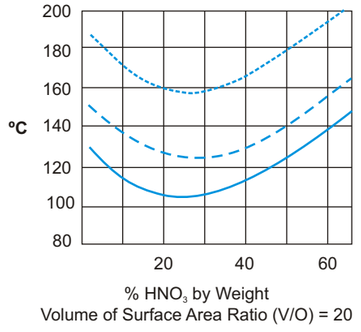
Answer: Steam at 250°C cannot safely be introduced into the jacket of a vessel with contents at 50°C.

Corrosion Resistance

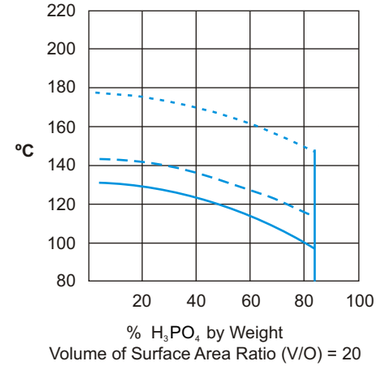
The graphs that follow present the isocorrosion curves for Glasteel 4000 glass. These curves are for pure acids and bases most commonly used in the chemical industry. They take into account,technically relevant parameters may include, for example the volume/surface area ratio, inhibition effects, concentration, and temperature.

In practical operation, these corrosives are nearly always encountered with liquid additives, dissolved substances, or gases, any of which may have positive or negative effects on resistance. Therefore GMM Pfaudler recommends performing corrosion tests or contacting a GMM Pfaudier specialist to assure material suitability for specific processes.

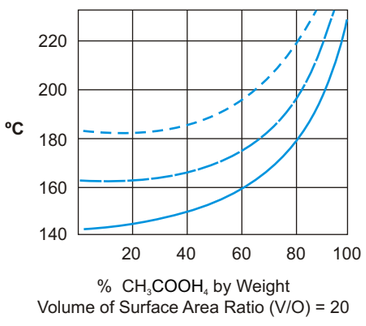
Nitric Acid



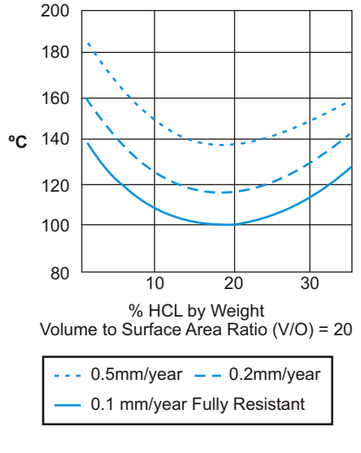
Phosphoric Acid



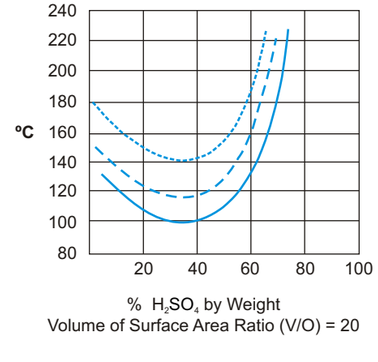
Acetic Acid



Hydrochloric Acid



Sulfuric Acid



Sodium Carbonate