Certain chemical reactions require high temperatures. These reactions, as well as many others operating at lower temperatures, would benefit from faster heating and cooling rates for enhanced productivity and/or a high margin of thermal safety to minimize the danger of process upsets or operator error.

To meet these needs, Pfaudler has achieved another Pfaudler first, Ultra-Glas 6500, a glass specially developed to be rated to 343 degrees C (650 degrees F). This represents a large (200 degree F) improvement over Pfaudler’s internationally respected standard glass. Furthermore, this expanded heat tolerance is accomplished in Ultra-Glas 6500 without sacrificing abrasion, impact, or corrosion resistance, nor is there any increase in product adherence. The features of Pfaudler Ultra-Glas 6500 are the result of changes in glass composition and material preparation, altered applications and firing procedures, as well as changes in equipment design and materials of construction. These changes permit trouble-free application of the required high-stress coating (see Fig.1) and provide the highly corrosive-resistant glass lined surface for which Pfaudler has been respected for years. Technical details of corrosion rates in common chemicals and thermal operation limits follow herein.

**KEY FEATURES: PFAUDLER ULTRA-GLAS 6500**

1. Extends the range of Glasteel® applications.
2. Allows safe and easy handling of high temperature processes never before approved for Glasteel equipment.
3. Provides potential for reduced cycle time compared to conventional vessel glass.
4. Provides extended thermal shock protection for faster heating and cooling.
5. Provides increased operating safety margin through its enhanced thermal protection.
6. Is ideal for the higher temperatures required by today’s chemical process applications.

**Temperature Limits**

Although Ultra-Glas 6500 has a high degree of helpful compressive stress in the glass layer, there are definite limits to the level of thermal stress which the glass can withstand without incurring damage.

Only two thermal conditions must be considered when determining the temperature limits:

**A.** Introduction of media into a vessel. The limits are determined from Chart A (located on next page).

**B.** Introduction of media into a jacket. The limits are determined from Chart B (located on next page).

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

With Chart B, it is also necessary to know the heat transfer film coefficient of the jacket media. Three curves are shown: one for steam (8500 W/m²k) and two for typical heating oils (1500 and 1000 W/m²k).

**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 Pfaudler for details.
Operating Temperature – Example Exercises

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 media is being introduced into the vessel, Chart A applies. Find the product temperature of 100°C on the product temperature axis (ordinate). If you follow this constant temperature along the wall temperature axis (abscissa), you will see it intersects the polygon at wall temperatures of -30°C at the lower temperature end and at 232°C at the upper temperature end.

Answer: Product at 100°C can safely be introduced into a vessel whose wall temperature is between -30 and 232°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/m²K. What is the maximum temperature oil that can be used?

Procedure: Since the media is being introduced into the jacket, Chart B applies. Find the wall temperature of 100°C along the wall temperature axis (abscissa). If you follow this line along the jacket temperature axis (ordinate), it intersects the oil (1000 W/m²K) polygon at a jacket temperature of 343°C.

Answer: The maximum allowable temperature of a 1000 W/m²K oil introduced into the jacket of a 100°C vessel is 343°C.

Exercise No. 3
A batch has just been completed, and the wall temperature of the vessel is 150°C. What are the upper and lower temperature limits of the product that can be introduced in 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 -30 and 280°C.

Answer: A product’s maximum and minimum temperatures of that can be introduced into a vessel with a wall temperature of 150°C are 280°C and -30°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 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 a vessel whose contents are at 50°C.

Corrosion Resistance

In the charts that follow, we present the isocorrosion curves for Ultra-Glas 6500. The curves are for pure acids and bases most commonly used in the chemical industry and take into account technically relevant parameters influencing the rate of corrosion. For example, the volume/surface area ratio, inhibition effects, concentration and temperature. In practical operation these materials are always encountered with liquid additives, dissolved substances, or gases which may have positive or negative effects on resistance. Therefore we recommend performing corrosion tests or contacting a Pfaudler consultant to assure material suitability for individual processes.
The information contained in this bulletin are believed to be reliable general guidelines for consideration of the products and services described herein. The information is general in nature and should not be considered applicable to any specific process or application.

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