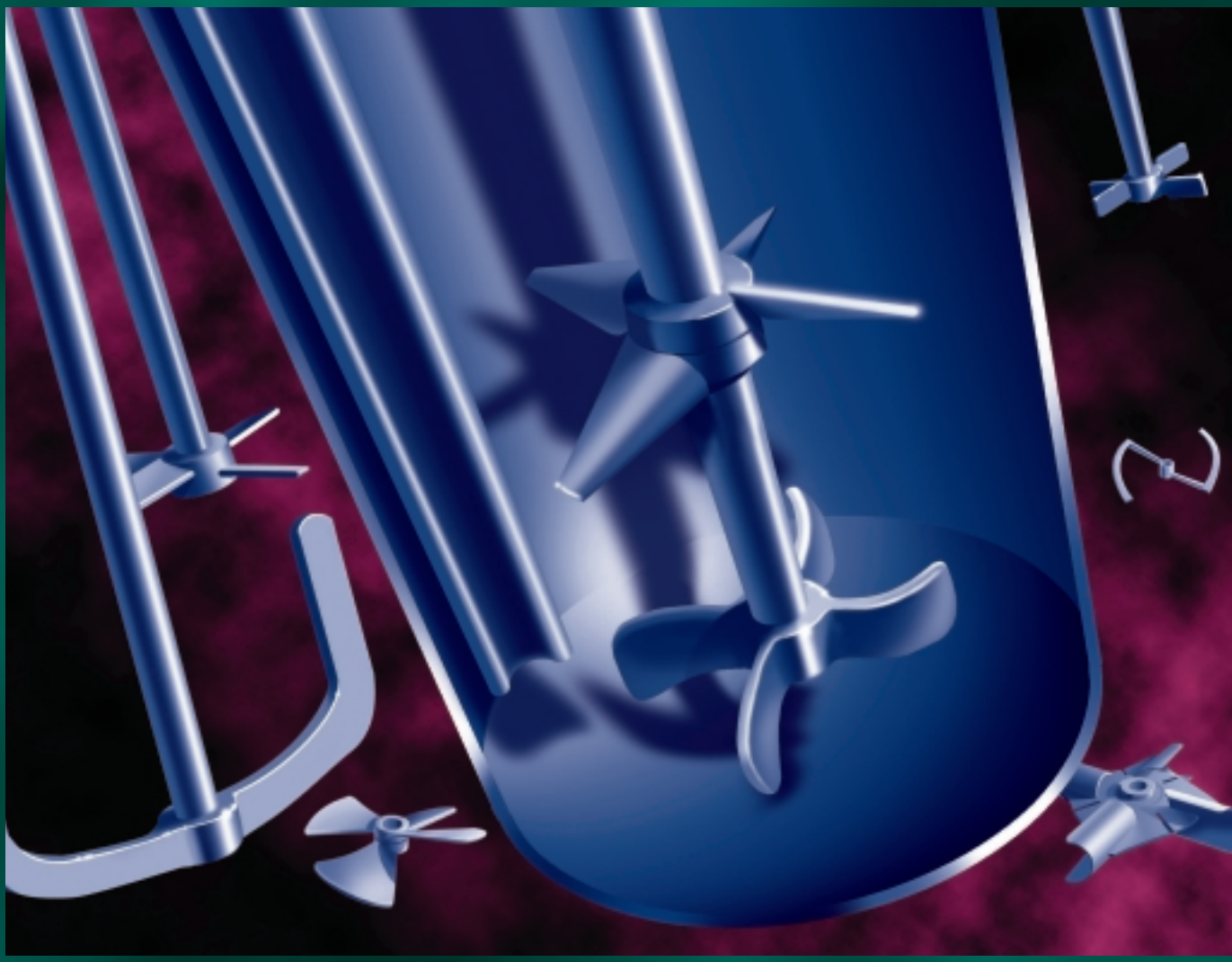
Pfaudler Mixing Systems



PFAUDLER
REACTOR SYSTEMS

Pfaudler Engineered Mixing Systems for Glass-Lined Vessels

Pfaudler has been supplying mixing systems and mixing applications assistance for glass-lined reactors since the 1930s. These systems have always been combinations of glass-lined agitators and baffles, from the days of the Retreat Curve Impeller (RCI) and finger baffles used in the "Pfaudler Agitative System" to the world-renowned Cryo-Lock® family of impellers, ProSol, and state-of-the-art baffle systems like the concave baffle. The one constant through the years has been Pfaudler's commitment to meeting customer process objectives with well-manufactured, reliable glass-lined mixing systems.

Pfaudler Mixers

The different impeller configurations in the Cryo-Lock family were designed by Pfaudler to meet the needs of different process conditions and requirements, mixing operations, viscosity ranges, etc.

This inherent flexibility can be broadened considerably by changing other factors of the mixing system, such as the drive speed and baffle arrangement. Thus, most of the glassed Cryo-Lock impellers may be used in more than one of the five basic unit operations:

- *Blending/Heat Transfer*
- *Emulsification*
- *Suspension*
- *Gas Dispersion*
- *High Viscosity Blending*

ProSol™ – Process Solutions

ProSol involves Pfaudler combining advanced computer modeling techniques with new mixing technology to custom-design the optimum solution for each reactor processing requirement. ProSol mixing systems mean you can retain the benefits of glass-lined equipment while matching the state-of-the-art effectiveness of alloy mixing systems in any application range. With ProSol, Pfaudler is offering a more effective baffle for all applications, and expanded application range where a glass-lined solution may not always have been considered the first option. Now glass-lined is suitable for more uses in:

- gas dispersion
- transistion regime blending
- high viscosity blending

In addition to increasing the range of applications, Pfaudler ProSol can deliver core benefits to your processing needs.

- improve the effectiveness of general purpose mixing systems
- improve the performance of existing solutions through retrofitting
- reduce process/mixing times
- optimize product quality, yield and throughput
- maximize energy efficiencies

Using computational techniques and new agitation components, Pfaudler can develop the optimum solution whatever the complexity or degree of difficulty of your reactor processing requirement. Problem solving is supported by research and development and resources at our pilot plant and through Pfaudler's established team of experts. This ensures we can meet exacting quality control limits including providing process guarantees and your FDA requirements.

Pfaudler's Glasteel® reactors equipped with Cryo-Lock now provide the exact combination of attributes you need for broad-range mixing flexibility.

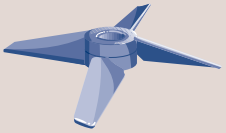
- Impeller/baffle combinations to serve all basic mixing operations
- Quick changeover reconfigures your glass-lined reactor for maximum flexibility
- Unlimited impeller options – custom designs can interchange with standards
- Much less downtime and lower maintenance costs than conventional one-piece glassed agitators

This means you can respond to changing market conditions by reconfiguring your Glasteel reactor, modifying or completely changing your mixing operation whenever necessary, and you can do it *quickly*, with minimum downtime.

Cryo-Lock Family of Agitators

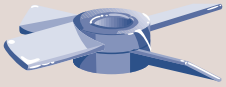
Curved Blade Turbine (CBT)

The first Cryo-Lock agitator introduced was a 4-blade turbine, only two-thirds the diameter of the traditional one-piece Retreat Curve Impeller (RCI). However, the CBT is characterized by a higher power number. The net effect is that the CBT delivers the same level of power investment and bulk fluid motion as the RCI, with the same low-level mixing capability. Like the RCI, the CBT is a very effective general-purpose impeller.



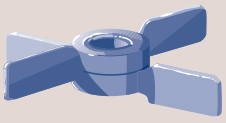
Turbofoil (TBF)

The TBF is the only glass-lined, high-efficiency impeller readily available in the marketplace. Its high flow, low-torque characteristics make it an economical choice for many blending and heat transfer applications in the turbulent flow regime. It handles most liquid/solid applications effectively by providing a fluid velocity high enough to keep even heavy solids in suspension.



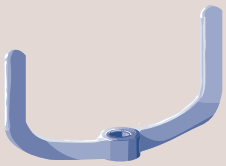
Pitched Blade Turbine (PBT)

This design is often considered to be a general-purpose impeller system for conventional alloy mixers. The glass-lined version of the PBT is also quite flexible, but it cannot deal effectively with small mixing volumes. Because of its high pumping capacity and moderate power requirements, it is often used in flow-oriented processes such as blending, solids suspension, heat transfer and light-duty emulsification.



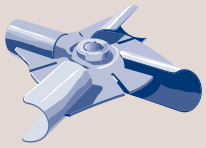
Vertical Blade Turbine (VBT)

The VBT is the classic radial-flow impeller, with a high degree of energy dissipation in the impeller zone and modest pumping capacity. With the appropriate baffle(s), it is best suited for multi-phase mixing applications which require high levels of power investment (i.e. gas dispersions, demanding emulsifications). With a PTFE disk sandwiched between the two hubs, it becomes the only glass-lined disk turbine readily available in the marketplace.



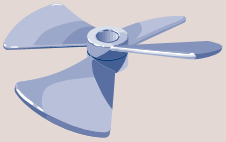
Anchor (ANC)

Available in both single-hub and two-hub designs, the anchor is sometimes used with higher viscosity fluids for crystallization, heat transfer and non-Newtonian products. It is normally operated with narrow wall clearance to produce a tangential flow. The blade height of the one-hub anchor is limited by the need to maneuver the shape through the man-way. Since the two-hub anchor does not have this restriction, its blades extend higher and, within the limits of available torque, it can handle larger batches in a given size reactor.



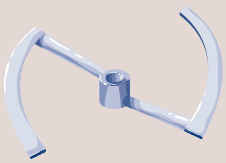
Gas Dispersion Turbine (GST)

The patent pending GST is a radial flow impeller designed for gas dispersion applications. It provides superior uniformity and increased mass transfer rate compared to a traditional flat-blade or disc-type turbine. The GST has significantly better gassed to ungassed power characteristics than any other glass-lined impeller on the market. Also, it can handle gas rates more than twice as high as the VBT with Disc, CBT or PBT.



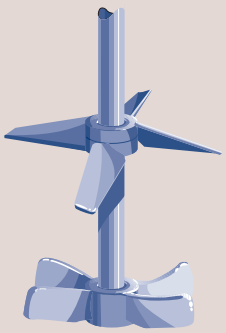
MaxFlo Turbine (MXT)

The patent pending MXT is an axial flow, high-efficiency impeller designed to mix high viscosity slurries (10,000 - 15,000 cP) or solutions which cannot be handled by traditional high-efficiency impellers (e.g. TBF). The MXT gets its high flow to power ratio through high flow coefficient. It is also effective at suspending solids.



Helical Ribbon (HLX)

The HLX is a glass-lined version of the traditional helical ribbon mixer, designed to handle high viscosity (>100,000 cP) blending.

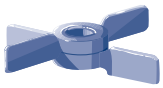
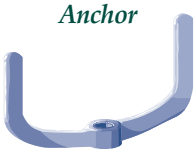
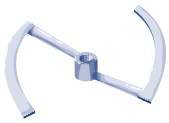
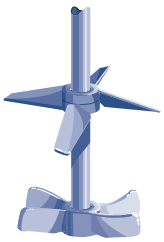


Multi-Flight Configurations

A single impeller is often inadequate to deal with high-viscosity mixing, homogeneous solids suspension, the incorporation of floating solids, and some multi-phase applications requiring a high level of power investment. This inadequacy is most pronounced in vessels with height to diameter ratios that exceed 1.2. For these more demanding applications, a multi-flight system is strongly recommended. To maintain low-level mixing capability, a CBT is most often used as the lower impeller. The upper flight is typically an axial flow impeller, a PBT when additional power investment is required; a TBF when an increase in fluid motion is desired. Multiple VBTs are sometimes used for difficult gas dispersion applications. Triple-flight systems are sometimes required for the most demanding applications.

When it comes to implementing and easily maintaining such a custom configuration, the advantages of the Cryo-Lock system are obvious.

Cryo-Lock Family of Agitators

	Blending and Heat Transfer	Emulsification	Suspension	Gas Dispersion	High Viscosity	Low-Level Mixing
Curved Blade Turbine 	Excellent	Good	Good	Adequate	Adequate	Excellent
Turbofoil 	Excellent	Adequate	Good	Adequate	Poor	Adequate
Pitched Blade Turbine 	Excellent	Good	Excellent	Adequate	Good	Adequate
Vertical Blade Turbine 	Good	Excellent	Adequate	Adequate	Adequate	Adequate
Anchor 	Adequate	Poor	Adequate	Poor	Good	Good
Gas Dispersion Turbine 	Good	Excellent	Adequate	Excellent	Adequate	Adequate
MaxFlo 	Excellent	Adequate	Excellent	Adequate	Good	Adequate
Helical Ribbon 	Adequate	Poor	Poor	Poor	Good	Poor
Multi-Flight Impeller 	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent

The Basics Behind Baffling

When a center-mounted impeller is used in an unbaffled vessel, the impeller imparts a high velocity swirl and vortexing motion to the fluid, but very little mixing takes place. Baffles are used to convert this swirling motion to a more 3-dimensional flow accompanied by turbulent dissipation, thereby promoting top-to-bottom turnover and mixing. Placing a baffle in an agitated vessel increases the transfer of power from the impeller to the fluid. A visual indication of this transfer of power is a reduction in size of the free surface vortex, the magnitude of which is a function of the following:

1. Shape - The less streamlined the baffle, the more effective it will be (i.e., a flat plate is a more effective baffle than a round pipe of equal cross section).

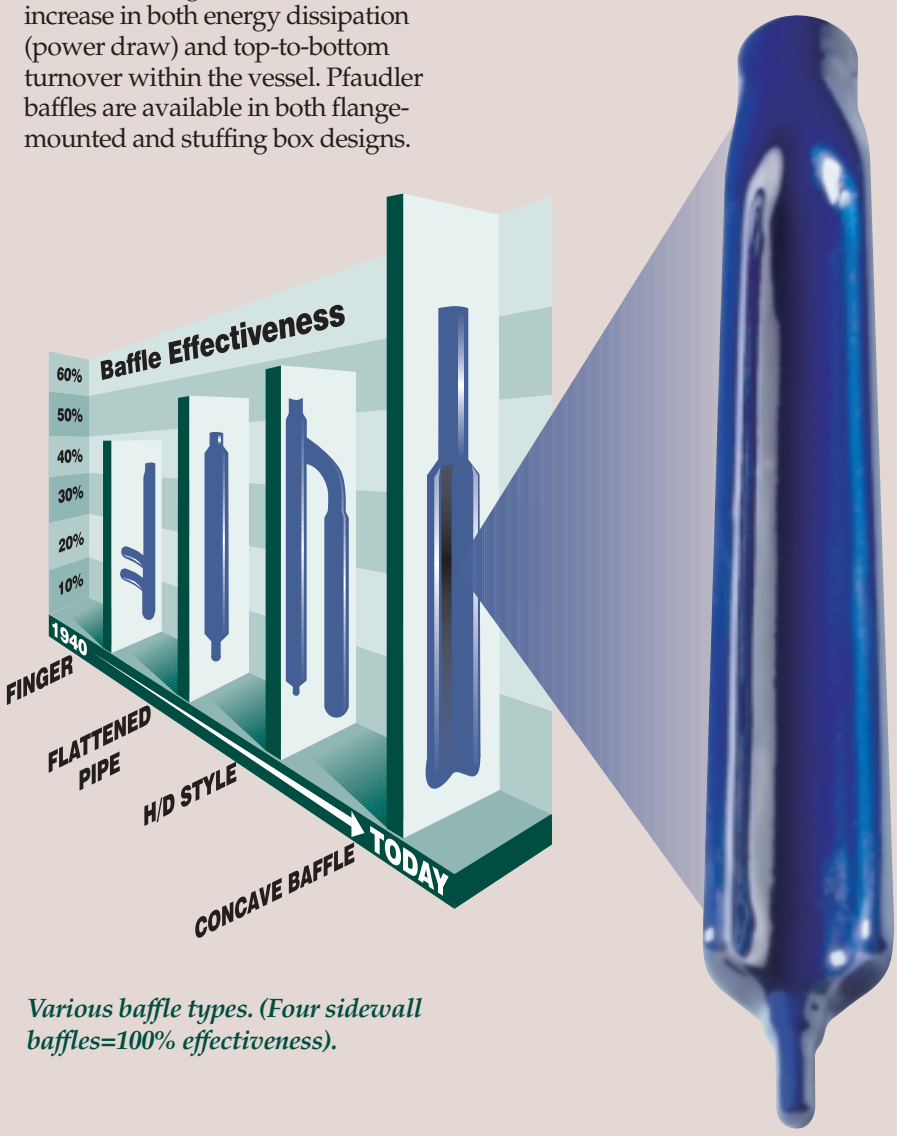
2. Placement - The closer the baffle is to the sidewall of the vessel, the more effective it will be in converting swirl to top-to-bottom turnover.

3. Size - The larger the projected area of the baffle, the greater the baffle effect.

A fully baffled condition (complete vortex elimination, defined as 100% baffle effectiveness) is produced by four flat plates (***shape***) located at the sidewall of the vessel (***placement***), of width equal to 1/12 of the vessel's diameter (***size***). They typically extend the length of the vessel's straight side and are spaced at 90 degree intervals. While four sidewall baffles are generally used in alloy vessel construction, they are not practical in glass-lined reactors. Consequently, glass-lined vessels typically have one baffle which is supported from a top head nozzle. Over the years several different styles of glass-lined baffles have evolved, each one providing improved baffle effectiveness (i.e. vortex reduction) over its predecessor.

The Concave Baffle is the latest design in glass-lined baffle technology. The revolutionary, patent-pending design is characterized by a dramatic improvement in baffle effectiveness. The premise behind the Concave Baffle is to maximize the drag coefficient of the baffle. For the Concave Baffle, the drag coefficient is 2.3. For the flattened-pipe, it is 1.3. This results in increased power investment and improved uniformity of suspended particles. The "reaction" which is related to this increase in drag force results in an increase in both energy dissipation (power draw) and top-to-bottom turnover within the vessel. Pfaudler baffles are available in both flange-mounted and stuffing box designs.

Pfaudler baffles can also serve as a thermowell and can be provided with a variety of temperature-sensing options including the traditional tantalum encased RTD and our new TMI temperature sensor. The TMI is a spring-loaded, dual element DIN RTD. By using the TMI, the gasketed joint, which is present with the traditional threaded RTD, is eliminated. The Concave Baffle shown here is suitable for a TMI temperature sensor.



Various baffle types. (Four sidewall baffles=100% effectiveness).

Minimum Mixing Volumes for Standard Cryo-Lock/Fin Baffle Configurations

Reactor Series	Reactor Size	Standard Cryo-Lock Impeller	Capacity (gallons) to Bottom of Impeller	Capacity (gallons) to Top of Impeller	Capacity (gallons) to Bottom of Baffle
RA48 &RS48	300/500	23″ CBT	17	59	96
RA60 & RS60	750/1000	29″ CBT	35	100	181
RA78 & RS78	1500/2000	33″ CBT	61	161	316
RA96 & RS96	3000/4000	41″CBT	96	336	619

The superiority of the ProSol Pfaudler mixing system – CBT with concave baffle – over competitive standard offerings has been dramatically shown in demonstration tests. Ask your Pfaudler representative for more information.

System Innovation and Integration

When it comes to engineered mixing systems, Pfaudler innovation is not limited to Cryo-Lock impeller systems. The Quatro Pipe was developed in response to a demand for more effective use of limited top head nozzles. By combining the functions of baffle, dip pipe, sampling tube, and thermowell, the Quatro Pipe can potentially free at least two nozzles for process piping or instrumentation.

Glass-lined or Teflon-lined dip pipes often play an integral role in the overall performance of a reactor system. By combining basic chemical processing knowledge with information about proposed or existing mixing systems, Pfaudler can assist in specifying the details of dip pipes, sparger assemblies, or in-tank filter elements, and provide an added degree of assurance when it comes to the mechanical integrity of these devices.

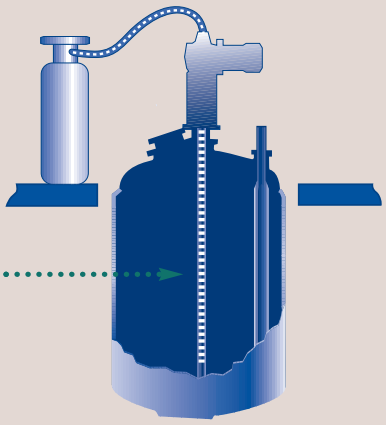
It is also worth noting that Pfaudler mixing systems are not limited to glass-lined construction. Pfaudler has supplied alloy mixing systems for years. The same glass-lined impeller systems which provide effective agitation at both low and nominal batch volumes are also available in stainless steels and a number of nickel-based alloys. The same skilled fabrication techniques used to manufacture the Pfaudler family of glass-lined agitation systems can be utilized to supply the same devices in polished stainless steel.

Named Cryo-Lock because it is based on an application of cryogenics, this breakthrough development not only solved the problems related to one-piece agitator design and maintenance, but opened new realms of operational flexibility for glass-lined agitated reactors.

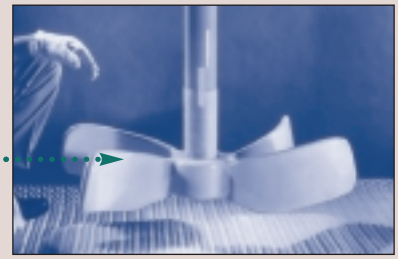
Glass-metal and ceramic-metal composites are frequent materials of choice for process vessels and other equipment handling products that are highly corrosive, sticky or metal sensitive.

Pfaudler developed the original glass-lined vessel construction a century ago, and for more than sixty years we have designed and built mixing systems of every type and variety, including glassed steel, for a broad spectrum of applications.

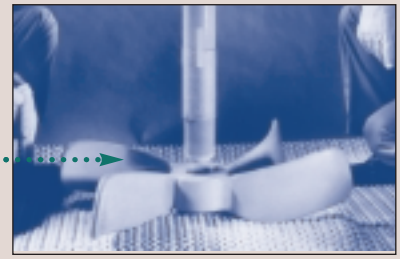
One result: our Glasteel agitated reactors have for decades been the work-horses of the specialty chemical and pharmaceutical industries worldwide.



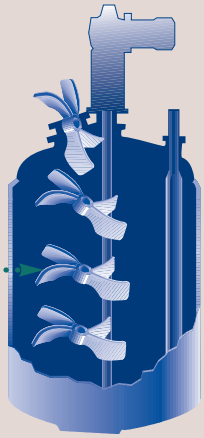
1 *Removal starts with liquid nitrogen fed into hollow agitator shaft.*



2 *Cryogenic cooling shrinks shaft and loosens glass-to-glass joint.*



3 *Turbine slides off shaft onto padded bottom head.*



4 *Separated turbine passes easily through manway.*

The two-piece agitator comprises a hollow, glassed shaft and a glassed impeller. The shaft and the bore of the impeller hub are precisely dimensioned to create an interference fit with sufficient strength to handle all mixing loads.

The impeller and shaft are joined or separated by piping liquid nitrogen into the shaft, causing a cooling effect that shrinks the shaft enough in a few minutes to release the interference fit and allow the hub to slide on or off. When the shaft is allowed to return to ambient temperature, it expands again to form a rigid glass-to-glass joint.

The precision dimensions that make this cryogenic technique feasible are accurately duplicated in the manufacturing process, so Cryo-Lock impellers and shafts are interchangeable off the shelf. This makes it unnecessary to replace a Cryo-Lock agitator shaft when only the impeller has suffered damage.

Since Cryo-Lock impellers are sized and shaped to fit through a reactor's manway, you can now change a damaged impeller *inside* the cleaned reactor, without having to remove the shaft, drive, motor and access cover. This significantly cuts the downtime required for changeover from days to hours in most cases.

SB25-100-2

The information contained in this bulletin is 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. Pfaudler, Inc. expressly disclaims any warranty, expressed or implied, of fitness for any specific purpose in connection with the information contained herein.

US Facilities

Pfaudler, Inc.
Rochester, New York
Tel: (1 716) 235-1000
Fax: (1 716) 423-9644

Glasteel® Parts and Services
Rochester, New York
Tel: (1 716) 235-1010
Fax: (1 716) 235-7923

Worldwide Facilities

Chemical Reactor Services Ltd.
Bolton, England
Tel: (44 1204) 862-777
Fax: (44 1204) 577-484

Bilston, England
Tel: (44 1902) 353-637
Fax: (44 1902) 495-696

GMM Pfaudler
Karamsad, India
Tel: (91 26) 9230367
Fax: (91 26) 9231935

Pfaudler-Balfour Ltd.
Leven, Fife, Scotland
Tel: (44 1333) 423-020
Fax: (44 1333) 427-432

Pfaudler Equipamentos
Industriais Ltda.
Taubate, SP, Brazil
Tel: (55 122) 326-244
Fax: (55 122) 326-301

Pfaudler S.A. de C.V.
Mexico City, Mexico
Tel: (52 5) 355-0100
Fax: (52 5) 355-0809

Pfaudler-Werke GmbH
Schwetzingen, Germany
Tel: (49 620) 2850
Fax: (49 620) 222412

Suzhou Pfaudler Glass-Lined Equipment Company Ltd.
Suzhou, China
Tel: (86 512) 7239104
Fax: (86 512) 7232903

pfaudler REACTOR SYSTEMS

1000 West Avenue
PO Box 23600
Rochester, NY 14692-3600
Tel: 716 235 1000
Fax: 716 235 6393
www.pfaudler.com

GPS
Glasteel® Parts and Services
A Unit of Pfaudler, Inc.

1999 Mt. Read Blvd.
PO Box 20857
Rochester, NY 14602
Tel: 716 235 1010
Fax: 716 235 7923

12/00 3M Mech No. 634