Section TECH-J
Miscellaneous Pump Information

TECH-J-1 Safe Operation of Magnetic Drive Pumps

Recommendations for Planning and Installation of Monitoring Systems for Magnetic Drive Pumps

Monitoring Systems for Magnetic Drive Pumps

In the case of sealless pumps (magnetic drive centrifugal pumps and canned motor pumps) in particular, unallowed operating conditions will quickly cause major damage, with substantial expense as consequence. The following operating conditions must be avoided under all circumstances:

Dry-running of the bearings

It must be ensured that the pump is always filled with liquid when in operation. Tests have demonstrated that plain bearings are irreparably damaged even when running dry for only a very short time.

Protection methods:
Filling level indicator or flow-meter

Excessively small delivery flows or closed valves in delivery line

In this case, the liquid in the pump will gradually heat up. Depending on the specific medium, this may cause evaporation of the liquid between the bearings, and dry-running of these bearings, or thermal destruction of the plastic lining. Consequently, overheating will occur immediately if the pressure-line valve is completely closed.

Protection methods:
Motor load monitor, flow-meter, by-pass from pressure line (upstream the pressure valve).

Excessively high delivery flows

If the maximum delivery flow stated in the pump's performance characteristic curve is substantially exceeded, adequate bearing lubrication is no longer assured, due to the lack of circulation of medium in the bearings. Also axial forces increase to such an extent that the bearings can be irreparably damaged. For this reason, our pumps should never be operated at greater delivery flows than those published in our performance characteristic curve.

Protection methods:
Motor Load Monitor, Flow-meter, Orifice in the Pressure Line

The following contains a description and assessment of the PumpSmart® load monitoring systems. These systems are available as accessories for our pumps.

PS10/PS20 Pump Load Monitors

The PS10 and PS20 Pump Load Monitors measure the motor input power in combination with a proprietary algorithm to accurately determine the pump's load.

During dry-run conditions, pump power is reduced and recognized by the PumpSmart® Pump Load Monitor. During run-out conditions, power increases, which is also a recognizable condition. Power increase is also experienced when internal wear results from upset conditions. Customers may configure the devices to automatically shut down the pump or warn the operator via integrated relay output(s).

PS10 Pump Load Monitor

The PS10 offers single underload or overload condition protection for pumps up to 40 HP (50 Amps MAX). Alarm setpoints can either be entered manually or automatically set using the Auto-Set functionality during normal operation.

PS20 Pump Load Monitor

The PS20 offers two underload and two overload condition protection functions (four total) as well as the ability to output pump load through an integrated 4-20 mA output. A six button keypad and LCD readout enables greater configuration and operation options. The PS20 can be applied on motors up to 999 F.L. Amps.

Refer to the PumpSmart® Section for additional details.

TECH-J-2 Dry Run Bearings

One of the primary causes of damage to magnetic drive pumps is lack of lubrication, or dry run. The frictional heat produced in the bearings when there is no lubrication results in significant heat generation. In lined magnetic drive pumps this can result in damage to the lining. In both lined and metallic magnetic drive pumps, the bearings may also be damaged.

There has been a lot of industry research to find methods to reduce the coefficient of friction. Some examples include silicon carbide bearings embedded with carbon particles and porous silicon carbide bearings. None of these results were so successful to allow safe operation under dry run conditions.

SAFEGLIDE Bearings

SAFEGLIDE is a diamond-like carbon coating which significantly reduces the coefficient of friction enabling periods of safe operation under dry run conditions. The coating is only a few microns thick resulting in no impact to the internal clearances. SAFEGLIDE is up to 1.5X harder than silicon carbide ensuring its protection lasts throughout the life of the pump. SAFEGLIDE has universal resistance to chemicals making it an excellent bearing choice for magnetic drive pumps.

Fig. 1 below shows test results forom Goulds Model 3298. The pump was operated without liquid ever being introduced to pump internals. Pump operation was stopped when the pump internal temperature reached 300°F. SAFEGLIDE bearings showed no damage after 20 minutes of bone dry operation.

Bone dry operation is not the typical field conditions. Typically the pump will operate for a period of time before becoming starved. The test results below are from a Goulds Model 3298. Water was introduced to the pump and then drained before start-up.

Proven Performance

ITT has been using SAFEGLIDE technology since 1990. An analysis of parts in service for over 40,000 hours in a service in which product crystallized out revealed that SAFEGLIDE was still intact despite bearing contamination with crystalline solids. Goulds has been using SAFEGLIDE bearings since 1997.

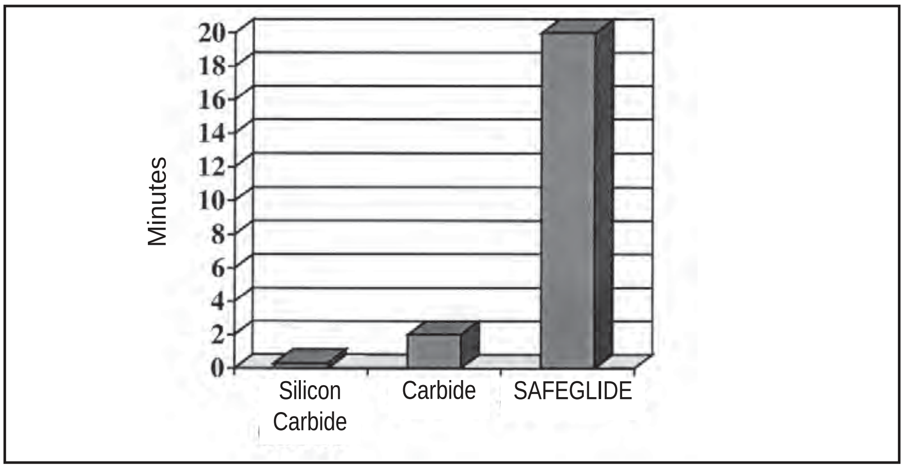


Fig. 1 Comparison of Bone Dry Protection

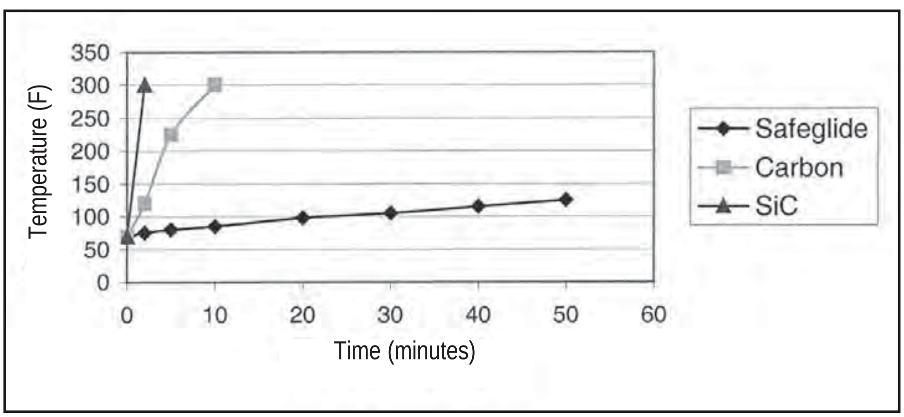


Fig. 2 Comparison of Temperature Rise

TECH-J-3 Centrifugal Pump Operation without NPSH Problems

Centrifugal Value with Centrifugal Pumps

General

There are many detailed publications on the subject of the NPSH value. In practice, however, mistakes are made repeatedly, with pump damage or even complete system failure as a result.

This guideline is therefore intended to indicate where and how the system NPSH value can be rendered more favorable using various parameters, and the criteria which are important for pump selection.

NPSH means "Net Positive Suction Head." A system from which, for instance, cold water flows to a pump from a height of 1 m without a pressure drop has an NPSH value of aprox 11 m (not 1m).

NPSH = 11 m
A = available

Here, only one pump with an NPSHR value of 10.5 m or less can normally be used, in order that a safety margin of at least 0.5 m is available.

NPSHR = 10.5 m
R = required

NPSHA Value of the System

Here, a customary formula which is fully adequate for practice is provided. The latest symbols in accordance with DIN 24 260 Part 1, September 1986 edition, are used here.

$$NPSHA = \frac{10\,(\rho_1 + \rho_{amb} - \rho_v)}{\varrho} + \frac{v_1^2}{10}$$

NPSHA in m
(previously NPSHavail.) Net positive suction head$_{avail.}$

ρ_1 (previously ρ_S) in bar
Gauge pressure in suction nozzle directly upstream the pump (in case of underpressure, this value is used with a negative "=" sign).
in bar

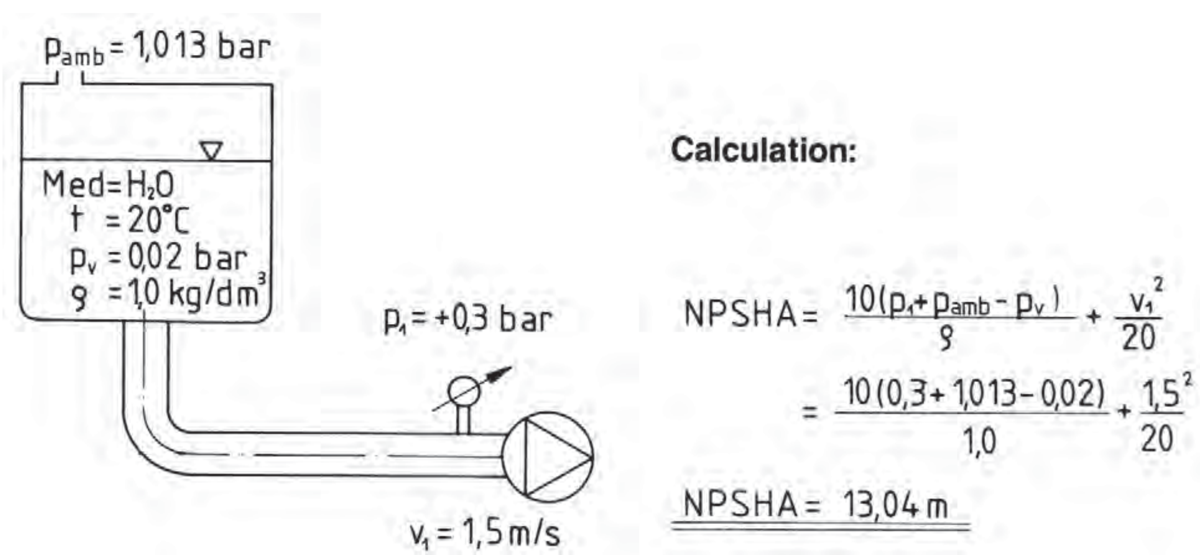
ρ_{amb} (previously ρ_B) in bar abs
Air pressure (normally 1.013 bar abs).

ρ_v (previously ρ_D) in bar abs
Vapor pressure of the fluid at working temperature.

ϱ in kg/dm^3
Density of the fluid at working temperature.

V_1 (previously V_S) in m/s
Velocity of fluid conveyed in the suction nozzle.

This data is referred directly to the center point of the suction nozzle. For the sake of simplicity, gravitational acceleration has been assumed not at 9.81 m/s^2 but instead at 10.0 m/s^2.



Example 1.

Suggestions for Remedies for NPSH Problems

NPSHR Value of the Pump

This value can be roughly calculated, but is generally determined on a test rig, at a specified speed, a defined impeller diameter and a defined delivery rate. The NPSHR value is determined by ascertaining the total delivery head of the pump at various suction heads. In order to obtain various suction heads, the pressure in the suction reservoir is lowered by means of a throttling device. Combinations of these methods are frequently used in order to achieve the required vacuum.

The greater the vacuum on the impeller inlet becomes, the more cavitation occurs. This impairs the pump's delivery head. The value at which the pump's total delivery head drops by 3% as a result of such cavitation is now stated as the NPSHR value.

Several tests at the same delivery rate and differing pressure in the suction nozzle are necessary, until by means of repeated measurement/calculation, etc., a total delivery head drip of 3% has been ascertained.

For determination of an NPSHR curve, these measurements are performed at various flows and at various impeller diameters. The compilation of such a series of curves requires high expenditures.

NPSHA<NPSHR - What can be done?

Referring to the system, the individual formula values can be adhered to.

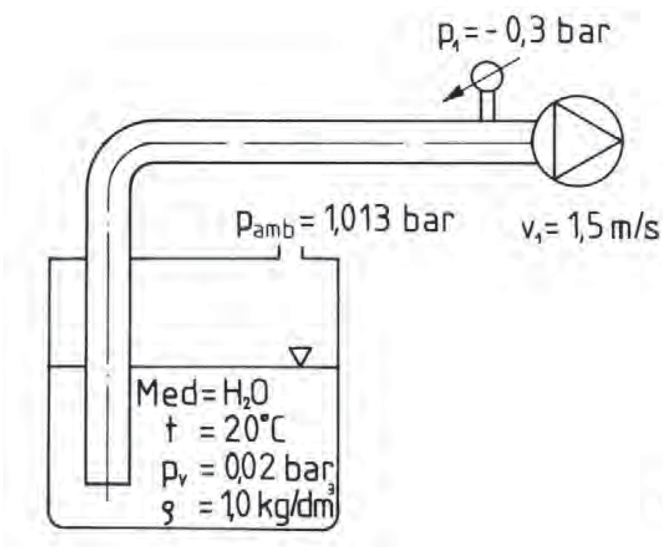
ρ_1 — Increase pressure at the suction nozzle, i.e. feed more fluid, which is to say, raise the fluid level in the feed reservoir, raise the intake reservoir to a higher level or lower the pump, e.g., one floor down.
On the other hand, the nominal diameter of the suction line should be adequately dimensioned, and it should be ensured that the valves/fittings in the suction line have the minimum possible friction loss coefficient in order that ρ_1 is as high as possible at the pump. Ball valves with a fully open cross-section, for instance, are particularly suitable.

ρ_{amb} — No opportunities for change.

ρ_v — In few cases, the fluid can be cooled before its entry to the pump, in order to reduce vapor pressure.

ℓ — No opportunities for change.

V_1 — Since this value accords with that of the pump's suction nozzle, it is of no significance for this observation. V_1 should, naturally, be as small as possible, as already mentioned with respect to $\rho_{v.}$



Calculation:

$$NPSHA = \frac{10(p_1 + p_{amb} - p_v)}{\varrho} + \frac{v_1^2}{20}$$

$$= \frac{10(-0{,}3 + 1{,}013 - 0{,}02)}{1{,}0} + \frac{1{,}5^2}{20}$$

$$\underline{\underline{NPSHA = 7{,}04\ m}}$$

Example 2.

The following remedies can be applied to the pump:

Reduce delivery rate	The NPSHR value will generally become smaller, and the NPSHA value greater. If necessary, split delivery to several pumps, e.g., operate standby pump as well.
Install larger impeller	In many cases, the NPSHR is better, but power consumption is, of course, also greater.
Reduce speed	Pumps running at lower speeds have better NPSHR values. In many cases, however, a larger pump also becomes necessary.
Install larger impeller and reduce speed	If a relatively small impeller is installed in the pump, this solution is ideal from a hydraulic viewpoint (smoother running, less wear).
Operate pump with cavitation	In individual cases, the pump supplier and the operator of the system can agree, that total delivery head drip should be not 3%, but more. This must be determined carefully, however, in order that delivery does not collapse completely.
Select pump with better NPSH value	Larger pumps in many cases have better NPSH values at the same delivery rate. If necessary, special impellers designed specifically for good suction can be installed.

Miscellaneous

Plastic pumps are, generally, relatively insensitive to cavitation. It is also difficult to hear this phenomenon, since plastic is a good sound insulator.

Magnetic pumps can be treated like pumps with single mechanical seals. The temperature of the fluid should be at least 20°C below its boiling point.

The Influence of Vapor Pressure

In this context, the significance of vapor pressure on the reliable operation of the pump should again be emphasized:

Vapor pressure is a function of temperature. Fluids which are pumped close to vapor pressure are a particular hazard, since even slight increases in temperature can cause evaporation. Not only the temperature fluctuations in general, but also obstructed cooling or an uncontrolled input of heat can trip this off. Inadequate heat dissipation can, for instance, be due to an excessively low delivery rate. Heat input may occur due to increased friction in a mechanical seal, increased bearing friction in magnetic pumps, and also particularly due to heat losses (eddy currents) in metal cans on sealless pumps.

Pumps with double mechanical seals are the least susceptible, since the contact surfaces are lubricated by a separate circuit.

Reference:

- Centrifugal pumps and centrifugal pump systems, DIN 24 260 Part 1

- NPSH in centrifugal pumps, Europump, 1981 edition

TECH-J-4 Fluoropolymers in Chemical Plant Construction

Comparison Between PTFE and PFA Processing

For a number of years fluoropolymers have played a significant role in the chemical and similar industries to protect plants and equipment against chemical attack by a broad range of aggressive media. This is because they offer substantially better chemical resistance and thermal stability than other plastics or elastomeric materials.

Following the development of PTFE, the introduction of melt-processable fluorinated ethylene-propylene (FEP) in 1960 opened up entirely new application areas. PFA, a perfluoroalkoxy polymer which has been in successful use for 20 years as a lining material, is now a thermoplastic successor to PTFE, with equivalent thermal and chemical resistance and superior properties with respect to processability, translucency, permeation resistance and mechanical strength.

In the chemical industry, both fluoropolymers - PTFE and PFA - are used mainly in the form of linings (Figs. 1, 2). For simple shapes, such as pipes, bends, T-pieces or reduction joints, PTFE is generally used; it is applied by means of paste extrusion, ram extrusion or tape winding (Fig. 3). In these processes a pre-form is made of the PTFE; this is then sintered and inserted into the metal workpiece. Using PTFE for lining of metal parts of complicated shape, such as valves and pumps, is more difficult. Isostatic molding is then the preferred method. In this PTFE powder is filled into the space created between the metal workpiece and a rubber bag which is specially made to fit into the shape of the area to be lined. The powder is pre-compressed, then cold-pressed into the desired shape. Finally, the rubber bag is removed and the lined part is sintered in an oven at over 360°C (680°F).

PFA, a thermoplastic material with a well-defined melting point, can be processed by means of transfer molding or injection molding. The granulate is melted in a melt pot or in the extruder and then forced into the hot tool by a hydraulic press.

This method enables very precise wall-thicknesses to be achieved, with tolerances of $\pm$ 0.5 mm, even at tight radii and in undercuts. Practically no mechanical finishing is needed, except to remove the sprue and to smooth the mating faces of flanges.

When using isostatic molding, however, a considerable amount of mechanical finishing is needed - depending on the degree of complication of the shape to be filled - to achieve the desired dimensions with precision.

The evenness of the wall-thickness may vary more, especially in the case of more complicated shapes such as valve housings.

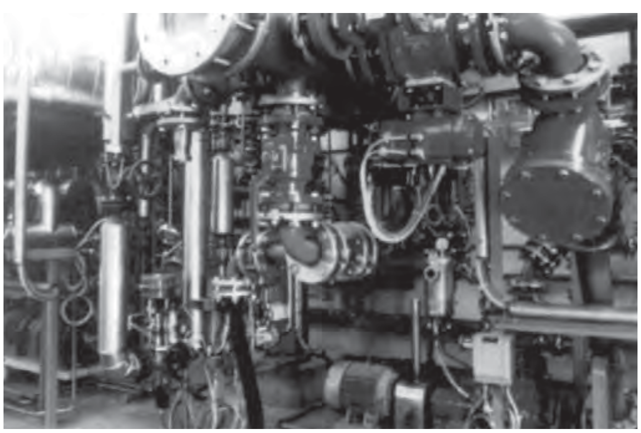


Fig. 1: Fluoropolymer lined valves in a chemical plant.

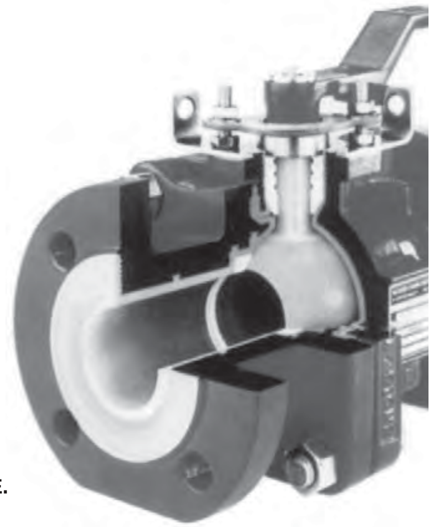


Fig. 2: Teflon PFA lined ball valve with stem packing rings made of Teflon PTFE.

Absorption and Permeation

Unlike metals, plastics and elastomers absorb varying amounts of the media with which they come in contact. This is often the case with organic compounds. Absorption may be followed by permeation through the wall lining. Though this is rarely observed with fluoropolymers, it can be counteracted by an increased wall-thickness or by installing devices to exhaust the space between the fluoropolymer lining and the metal wall. It has been clearly shown that in respect of permeation and absorption, melt-processed fluoropolymers such as PFA show better barrier properties than PTFE.

Vacuum Resistance

Vacuum resistance is needed because, in closed systems of the kind widely used in chemical processing, a drop in temperature creates a vacuum in the system, unless it is already operating below atmospheric pressure. When using PFA it is relatively simple to achieve adequate vacuum resistance for the lining. Usually the lining is "anchored" to the metal wall by means of "dove-tail" grooves or channels in the latter.

Fig. 3: Column section with paste-extruded lining of Teflon PTFE.

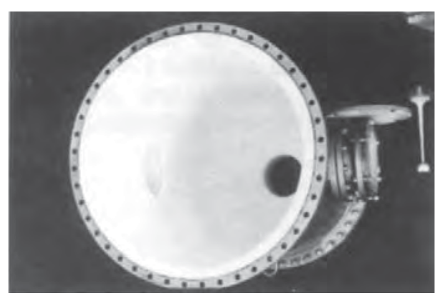
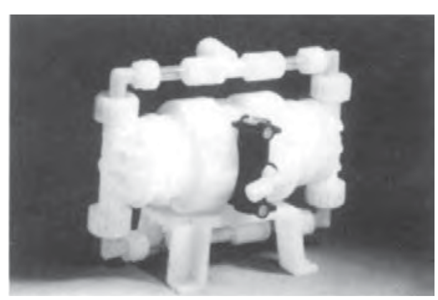


Fig. 4: Chemical pump built of Teflon PFA injection-molded components.



With PTFE granulate that has been cold-formed, it is more difficult to achieve a sound anchoring of the lining in the metal wall as relatively large channels would be needed in order to allow the PTFE powder to flow into the grooves. More typically, therefore, bonding agents are used between the PTFE lining and the metal housing. However, due to the anti-adhesive characteristics of fluoropolymers and the limited thermal resistance of the bonding agents, PTFE shows only limited vacuum resistance.

Quality Control Prevents Cracks and Voids

With PTFE and PFA linings, the dielectric strength is measured in order to identify faults. This method reliably pinpoints cracks and voids which go all the way through the material but, due to the well-known high resistivity of fluoropolymers, it does not indicate any faults which start 1.5 mm or more under the surface (fig. 5).

For this reason further tests using ultrasonic methods can also be applied. This test measures the distance from the surface of the lining to the metal housing. However, it is unreliable because it does not provide the true lining thickness when a void or porosity is present. In addition, this method is impractical to employ on small parts or small complicated shapes with undercuts and tight radii.

Another method to check for surface defects such as cracks and voids is with the so called “Met-L-Check” dye penetrant method. But this method is limited to detecting surface defects only.

Chemical Structure

PTFE

$(–CF_2–CF_2–)_n$

PFA

$(–CF_2–CF_2–)_n – (CF_2–CF_2–)m$
I
O
I
CF_2
I
CF_2
I
CF_3

PFA, which is translucent, can reliably be checked optically. Cracks and voids under the surface can be made visible with suitable light sources. Hardly accessible locations in the lining can be examined using cold light lamps and flexible fibre light guides.

Cost Comparisons for Linings

In terms of raw material prices, PFA costs roughly three times as much as PTFE.

This disadvantage can, however, be compensated or greatly reduced, as a function of factors such as the shape to be lined, its size, the number of work pieces to be lined and the processing method adopted. This is possible because PFA neither requires manual process preparation nor finish machining with corresponding material losses.

The use of PFA for lining very large parts is not recommended because the high material cost would make the part too expensive. Another point to keep in mind is the cost of tools, which is not amortized when only small numbers of parts are to be lined. Furthermore, there are practical limits to the weight of injected material that molding machines are capable of handling.

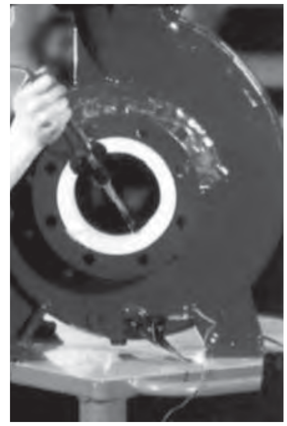


Fig. 5: Electric spark testing of an isostatically processed Teflon PTFE pump housing.

Conclusions

More than 20 years of experience with linings for various parts, e.g. valve and pump housings, have shown that PFA has numerous advantages when high thermal and chemical resistance are the main requirements.

The accurate and even wall-thickness that can be achieved with PFA is a major advantage, especially when working with media which have a strong tendency to diffuse.

Practical experience has also shown that PFA gives better barrier properties than PTFE.

Bromine manufacturers report, for example, that the penetration depth of bromine in PFA is about one third less than in PTFE, when operating conditions such as time, temperature and pressure are the same.

PTFE, on the other hand, is still widely used for components of chemical valves and other chemical processing equipment where flex fatigue resistance is required.

Typical examples of such applications are bellows, as well as diaphragms in valves and pumps.

For seat rings, plugs, seals and similar parts, PTFE is a suitable and economical material.

A recent trend for parts such as these is to use modified PTFE, as its dimensional stability and hardness are superior to those of standard PTFE.

Typical Physical and Mechanical properties of "Teflon®"				
Property	**Test Procedure**	**Units**	**"TEFLON" PTFE**	**"TEFLON" PFA**
Density	ASTM D792		2,16	2,15
Tensile strength	ASTM D638	MPa	24,5	31
Elongation at break	ASTM D638	%	350	300
Flexural modulus	ASTM D790	MPa	490	690
Flexural strength	MIT (0,2 mm) 180° flexion		750000	200000
Impact strength	ASTM D256 @ 23°C @ -54°C		No break 107	No break 155
Hardness	ASTM D2240	Shore D	55	60
Friction coefficient, dynamic			0,1	0,2
Melting point		°C	327	305
Service temperature (retention of 50% of elongation at break after 20000 h)		°C	260	260
Flame resistance	UL-94		94 V-0	94 V-0
Limiting O2 index	ASTM 2863	%	>95	>95
Heat of combustion	ASTM D240	MJ/kg	5,0	~5,0
Dielectric constant (@ 103-106Hz)	ASTM D510		2,1	2,1
Dissipation factor (@ 106Hz)	ASTM D150		0,002	0,002
Arc resistance	ASTM D495 (stainless steel electrodes)	s	>300	>180
Resistivity	ASTM D257	ž .cm	>1018	>1018
Surface resistivity	ASTM D257	ž	>1016	>1017
Weathering resistance	"Weather-O-Meter" (20000 h)		No break	No break
Solvent resistance	ASTM D543		Excellent	Excellent
Chemical resistance	ASTM D543		Excellent	Excellent