THE USE OF ASBESTOS-FREE MATERIALS IN STATIC SEALING ON PUMPS

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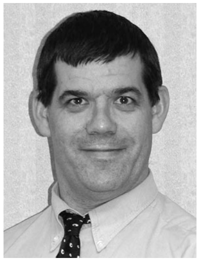

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Mr. Currie received a B.S. degree (Mechanical Engineering, 1981) from Sheffield Polytechnic. After graduation, he completed the selective management-training scheme of the United Kingdom coal industry. He joined Flexitallic in 1995 and took up his current position in 1998.

ABSTRACT

Asbestos-free gaskets have been used to seal flanged connections on various applications. This paper discusses the use of a different style of gasket and details the advantages and benefits resulting from such a change. The discussion includes an analysis, supported by laboratory testing and successful field experiences. The paper is sectioned into three case studies, each topic relating to a type of product.

- The development of high strength asbestos-free sheet materials for usage on split case pumps using modern manmade fibers, including a successful study using the material on a natural gas pumping station on activated methyldiethanolamine (MDEA). The MDEA removes carbon dioxide in natural gas process plants.
- The successful implementation in the usage of serrated metal core technology with various facing materials, in pump case gaskets, used on hydrocarbon service in oil refineries within the United Kingdom.
- The development and usage of structurally modified polytetrafluoroethylene (PTFE) filled products in pumping aggressive chemicals on sealless pumps.

The paper details the materials, the application areas, and the problems resolved. Also included are design considerations and an introduction to installation guidance, with discussions on previous failures.

INTRODUCTION

The problem is moving away from established materials based on asbestos products onto asbestos-free products. The substitute materials available, along with new styles of gaskets, have resulted in many new challenges and opportunities.

The transition from an asbestos-based sheet material onto other nonasbestos products has resulted in a variety of high performance products. The technology employed to manufacture the calendered sheet product is utilized using asbestos-free combinations and new developments and manufacturing techniques.

There is not one ideal product to replace asbestos and have the same degree of flexibility. High performance sealing materials such as exfoliated graphite, exfoliated vermiculite, along with polytetrafluoroethylene (PTFE) products have entered the marketplace and provided the level of sealing. The material used for the high performance split case pump involved the usage of high strength aramid with rubber binders.

The introduction of material combinations of metal and nonmetallic components in new combinations has seen growth in new areas.

The development and increased usage of modified materials based on PTFE provide effective solutions.

CASE STUDY 1

When the first generation of asbestos-free sealing materials was developed, the reinforcing fibers were either aramid or glass. The usage of alternative materials, cellulose, carbon, and mineral wool, has provided a wider range of products.

The high performance requirement in the split case pump has progressed with the aramid and glass combination. The main disadvantage of aramid is its relatively high cost compared to that of asbestos, and the embrittlement of the fibers at elevated temperatures of 200° to 250°C (392° to 482°F). The usage of the monofilament glass provides secondary reinforcement at elevated temperatures.

The glass used is manufactured using careful tolerance to provide fiber diameters of 6 to 10 micron. This provides the most benefit when combined with aramid. The glass also has a surface dressing applied to promote compatibility to the matrix. Included in the mix are coupling agents to promote chemical cross links with the rubber binder.

When the blend of aramid and glass fibers entangle, the monofilament glass is trapped within the matrix and reduces the tensile strength ratio to around three. This is required with the high performance product.

The split case pump gasket has traditionally involved a thin sheet product that has to maintain high seating stress due to the pressure containment envelope. Surfaces would be traditionally smooth, usually without any machine marks, for the gasket to flow and grip onto. Figure 1 and Figure 2 show a typical pump arrangement.

Asbestos-based products contained a high percentage of fibrillating fiber that provides strength. The replacement of the fiber by aramid provides a material with superior strength at lower fiber levels (Table 1).

The case to consider is a lean amine circulation pump in a gas distribution plant in the northwest of England. Flange rating for connectors were 900 lb pressure class with typical operating pressure of 8 MPa at a temperature of 50°C (122°F). The approximate area of sealing face was 525,000 mm^2 (813.75 in^2). Bolting on the pump is 52 off, 1.3/4 grade B7 bolting. The use of the pumps was in the removal of CO_2 in natural gas.

Two pumps were showing leakage on the casing joint. The leaks had occurred after a short period of service time. Several failures had occurred following change of material from an asbestos-based product to a nonasbestos aramid-glass mixture. Previous to the change from asbestos, a run time greater than 12 months was expected. Two different suppliers had been used, and on each occasion failure had occurred after a short period of time.

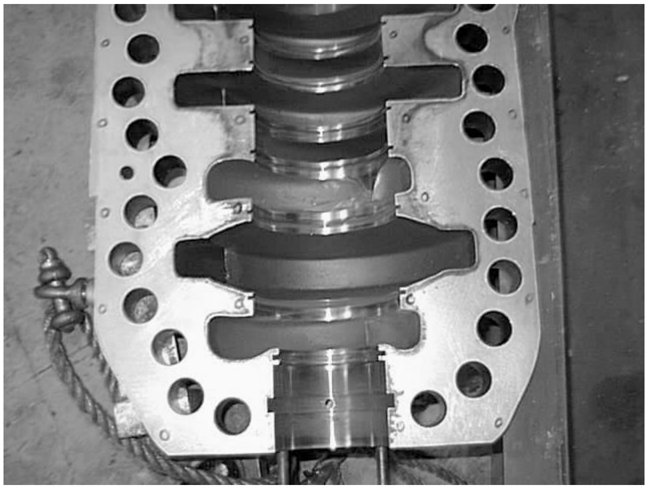


Figure 1. Typical Pump Sealing Face.

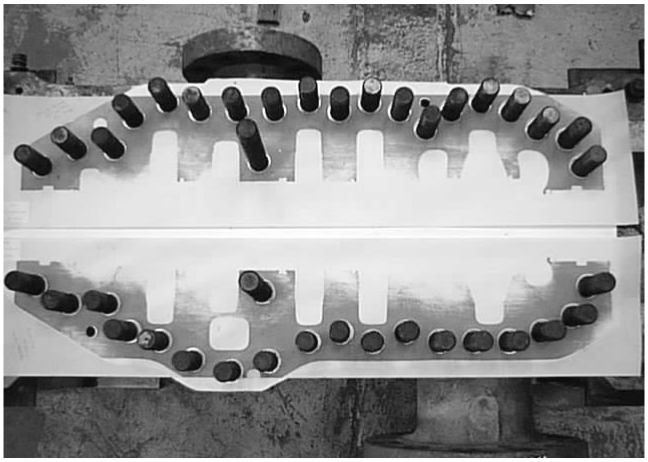


Figure 2. Typical Compression Pattern on Stress Sensitive Film.

Table 1. Typical Mechanical Properties of Sheet Material Used.

Thickness (mm)	0.4
Density (gcm-3	1.6
ASTM Compressibility (%)	11
ASTM Recovery (%)	62
ASTM Tensile Strength (MPa)	20
DIN Gas Permeability (mL/min)	0.01
ASTM Oil 3 Thickness Increase (%)	4
ASTM Fuel B Thickness Increase (%)	8
Specification	BS7531 Grade X

The examination of the material after removal indicated stress cracks across the sealing face indicating high surface stress. The stress cracks were tangential to the length of the pump. Insufficient material was available to determine if the failure was in line with rotation of calendar or normal to it. Some alignment of fiber can occur when using calendered technology.

On the material body, there was also indication of media attack from the product. To alleviate any concern of attack to the nitrile rubber binder by the media, free immersion tests and clamped tests were carried out using activated methyldiethanolamine (MDEA), using the company test rig. Placed in an oven, the material was heated to 50°C (122°F) to replicate usage. After three weeks testing, the thickness increase was below 2.3 percent and the weight increase below 16.8 percent. Leakage from the rig was not reported. Figure 3 shows the rig used.

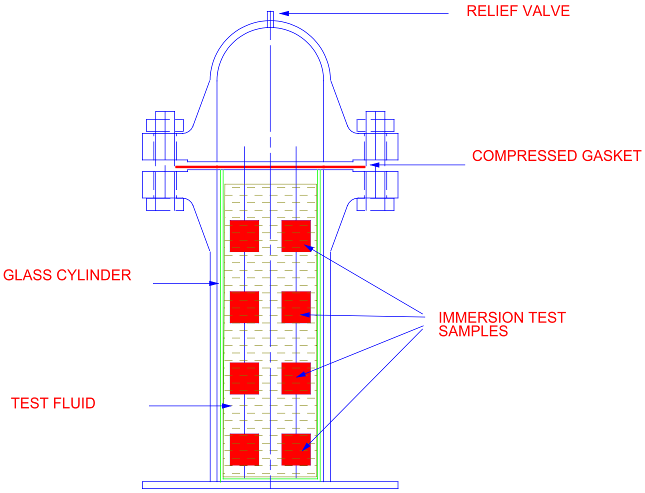


Figure 3. Immersion Test Rig.

Release agents and nonstick compounds may work against the operation of the gasket. Those, combined with a smooth finish, are not recommended in the usage of high performance products. For machined smooth applications, a nonstick coating is not recommended.

CASE STUDY 2

The usage of semimetallic products in circular applications has long been established, particularly where high assembly stress precludes the usage of sheet products. The semimetallic gaskets are used with limited sealing face width and without limitation on compression.

A typical style jacketed gasket is laid out in Figure 4. There is a metallic envelope, which is cold worked into a variety of shapes around a soft nonmetallic core. Depending on diameter and thickness, this could be in several forms. On high stress applications such as pumps, this is usually totally enclosed.

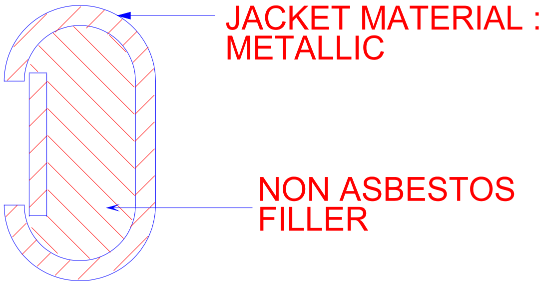


Figure 4. Jacketed Gasket Styles.

The materials of construction may be brass, aluminum, soft iron, copper, Monel®, or stainless steel for the outer jacket with millboard, graphite, PTFE, or vermiculite materials for the filler. The arrangement with the metal outer and nonmetallic filler requires a high seating stress to deform the metallic jacket onto the flange to effect a seal. To generate a high stress on the gasket, often a stress raising nubbin is machined onto the sealing face (Figure 5). This is unusual in a pump application with sealing areas limited and high-pressure containment.

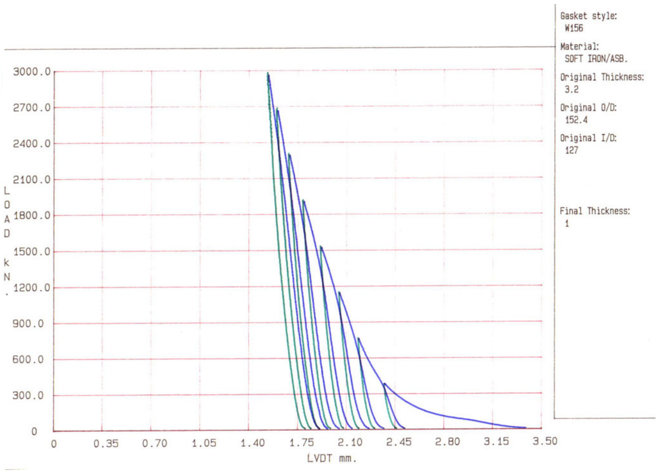


Figure 5. Load Deflection Curve for Jacketed Gasket.

When load is applied to the gasket, deformation occurs of the soft core and reduction in thickness. The metal jacket will deform into the flange face. In areas of overlap of metal, higher stress is generated. When the load is removed, deformation of the gasket remains with little recovery. A typical stress strain relationship is given in Figure 6. This is raw data from the rig and, when corrected for jig yield, the recovery line is near vertical indicating low levels of recovery. The minimum seating stress for the jacketed style range from 5500 psi to 9000 psi. The compression test was taken up to 70,000 psi in stages of 10,000 psi increments.

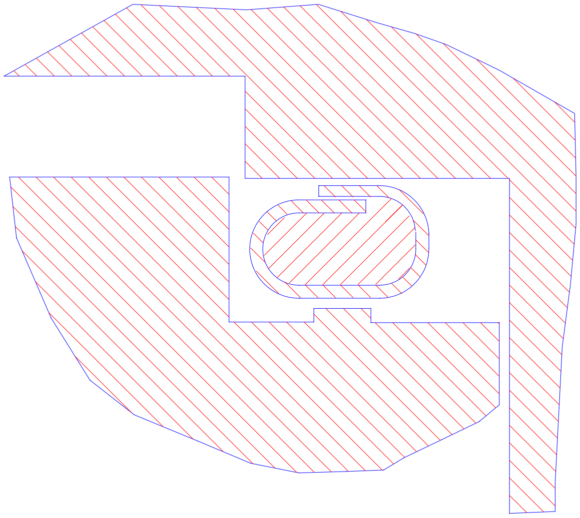


Figure 6. Jacketed Gasket in Flange with Stress Raising Nubbin.

The serrated metallic core is a reverse of the jacketed product. The reverse being a soft outside of conformable facing material and a strong metallic core. The solid metal core is machined to a given profile, and both faces of the gasket are covered with a soft deformable material (Figure 7).

The core is machined to a predetermined profile, and covered with a known thickness and density of facing material. It is essential the combinations are maintained to obtain optimum performance. Too little facing will allow penetration of sealing faces and flattening of metallic core, while too great a facing reduces gasket blowout. DIN (German Institute for Standardization) standards detail some combination of dimensions, but many gasket companies have developed internal standards, with parallel, convex, and shallow forms.

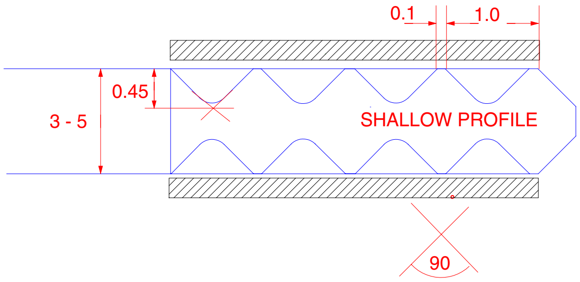


Figure 7. Serrated Metallic Core Profile.

The serrated metal core gasket requires a lower seating stress to maintain a pressure envelope than the jacketed style product, in some cases 25 percent lower. The soft facing deforms under the loading and flows into the surface irregularities on the flange and compacts into the serrations on the gasket. Some facing materials, graphite and vermiculite, also increase in density in the process and provide high levels of stress retention and sealing. A typical seating stress range for a serrated core of 316 stainless with graphite facing would be 20 MPa up to 500 MPa.

Typical facing materials include graphite, PTFE, nonasbestos sheeting, soft metals, and, recently, high temperature vermiculite products. Serrated cores are available in many metallic grades.

The load deflection curves for graphite faced and PTFE faced with stainless 316 core are given in Figure 8 and Figure 9. The serrated metal core with a facing of PTFE and graphite has been used to replace the jacketed gasket.

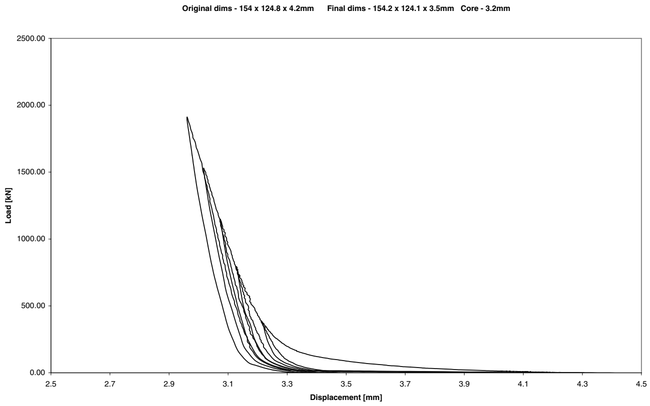


Figure 8. Load Deflection for Graphite Faced Serrated Core.

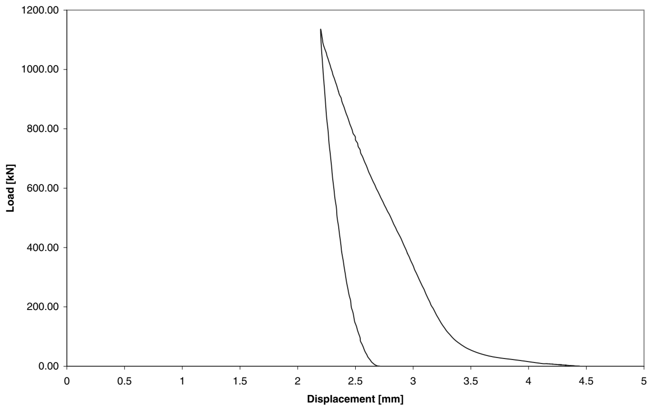


Figure 9. Load Deflection for PTFE Faced Serrated Core.

The graphite-faced core has been loaded up to a surface stress of 62 MPa and reduced to zero, and then loaded to 124 MPa and unloaded. This has been repeated in 4 off 62 MPa increments until reaching a final surface stress. The PTFE-faced core has been loaded up to a surface stress of 500 MPa.

The images of the metallic core without facing are shown in Figure 10, and with PTFE facing after loading to 500 MPa is shown in Figure 11. The PTFE facing was removed from the metallic and total core penetration of material was not observed (Figure 12).

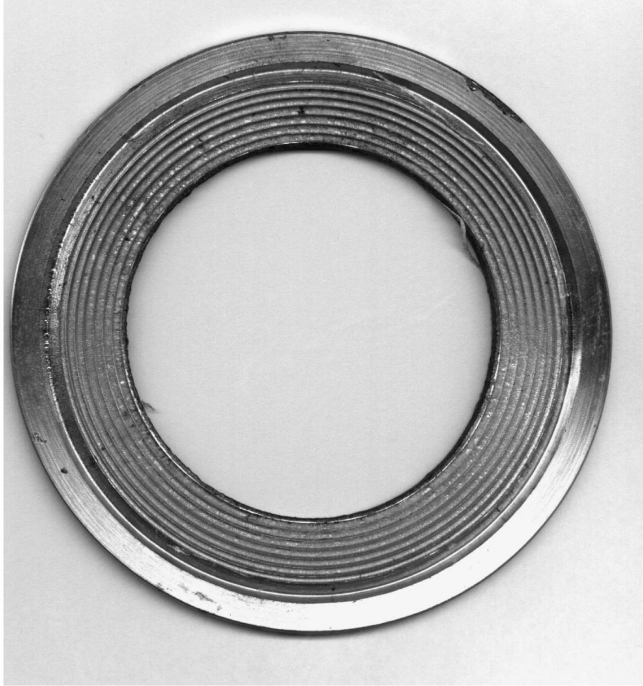


Figure 10. Serrated Metallic Core with Facing Removed.

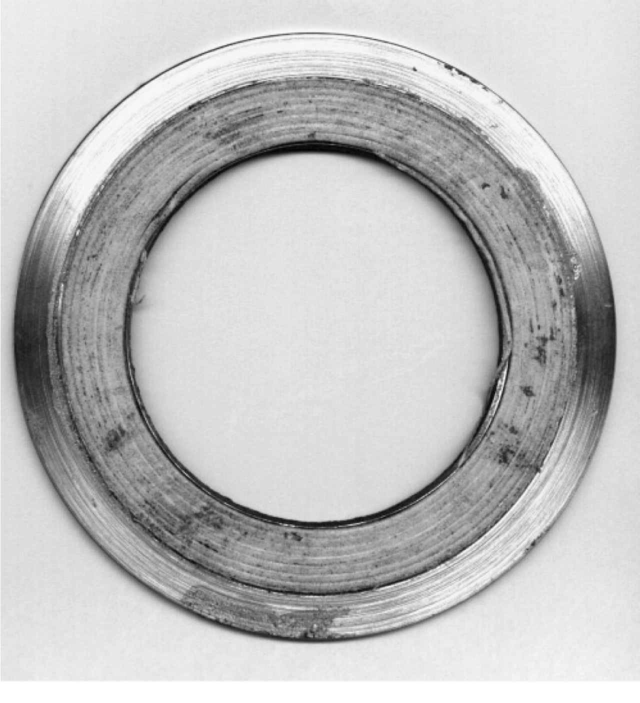


Figure 11. Serrated Metallic Core Faced with PTFE after Compression to 500 MPa.

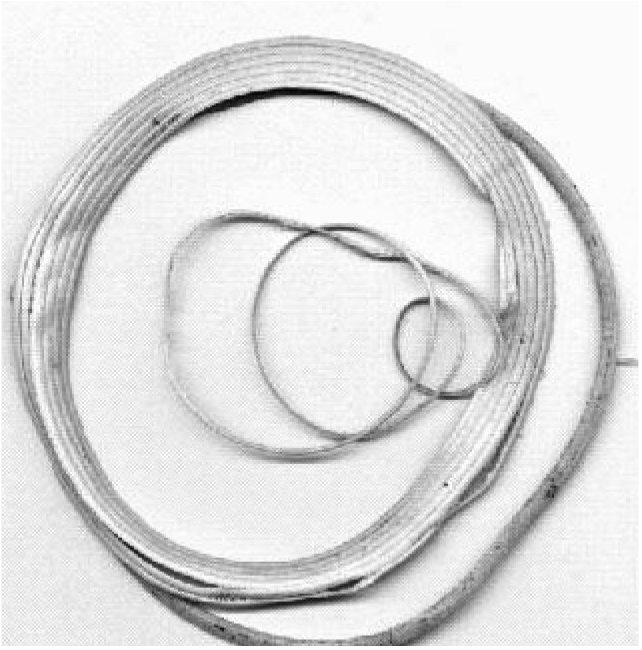


Figure 12. PTFE Facing Removed from Core.

The high loading range of the product allows the usage in many pump applications where arrangements have been designed for solid metallic and jacketed products. Metal-to-metal contact of outer faces is not required, giving ease in installation.

The lower seating stress requirement and higher strength core overcame uncontrolled bolt up technique and flange misalignment at bolt up.

CASE STUDY 3

Virgin PTFE may be problematic used without modification to the structure. Two methods have been employed to produce a product that has a reduced creep rate.

The expansion or blowing of the PTFE into a soft conformable material that, when used, deforms readily to a thin layer. Creep is thickness dependent, thicker PTFE creeps more than thinner. The reduction of the thickness therefore reduces the amount of creep. This method provides a universal solution giving excellent chemical resistance but suitable for lower pressure class.

An alternative method of approaching the problem is to introduce a structure into the PTFE through directionality and subsequent filler systems. The usage of microspheres, silica and barytes, are used to reduce the creep effects associated with this type of product.

The structural modification of the copolymers of fluorinated hydrocarbons provides interaction at a molecular level of reinforcement. The sheet is worked mechanically to provide directionality into the sheet, which is then biaxially fibrillated into a multilayer structure. This is similar to a plywood sheet, which has grain 90 degrees to each layer and could be used to represent the layered structure. The introduction of up to 50 percent filler into the closed structure has the effect of bulk reinforcement.

The usage of glass microspheres as filler provides a high compression material. The closed structure provides a material with good chemical resistance for low loading. The material with holes introduced by microspheres is soft and easily conformable (Table 2).

A guide to the selection of suitable sheet and facing materials is given in APPENDIX A (Figure A-1 and Figure A-2). Figure A-1 is a selector chart, general to all industries. This guideline is reinforced with the chemical/compatibility data for specific applications given in Figure A-2.

Table 2. Properties of Glass Microspheres as Filler.

Thickness (mm)	1.5	3.0
Density (gcm-3)	1.40	1.40
ASTM Compressibility (%)	41	30
ASTM Recovery (%)	37	43
ASTM Tensile Strength (MPa)	11	10
DIN Residual Stress @ 175′C (MPa)	33	26
DIN Gas Permeability (mL/min)	0.01	0.03
ASTM Liquid Leakage (mL/hr)	0.65	0.75
ASTM Creep Relaxation (%)	31	47
Conductivity of filled PTFE typical	0.25 to 0.4 W/mK	

The effect of gasket creep and thickness can be seen in Figure 13. ASTM F38B testing of different forms of PTFE showed that creep relaxation increases for gasket thickness and if pure, filled, or filled and structurally modified. The structurally modified PTFE outperforms all the other materials at all the thicknesses measured.

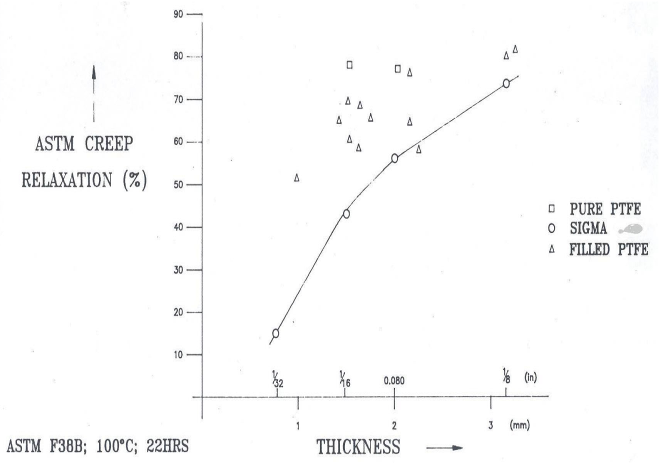


Figure 13. Creep Relaxation of PTFE Types.

A further requirement of Case Study 3 was to have a material that would also provide a heat shield against components on hot duty. The poor thermal conductivity of the glass microspheres variant material proved suitable.

FIELD REPORT

In Case Study 1, the gasket was cut and installed and has run successfully exceeding the previous time. Material was installed August 1998. Further pumps have been changed over to the style of product. Investigation into the condition will be made at the next scheduled stoppage.

The change from the jacketed style product to the serrated metal style product has been a total success where implemented. To date four pumps on the alkylation unit and 10 pumps on the site have been changed over. The product has performed without leakage and has been written into the site standard.

The modified PTFE has not shown the creep effects of virgin PTFE, and run on test and in usage for over 12 months with recommendations to change all virgin PTFE components.

CONCLUSIONS

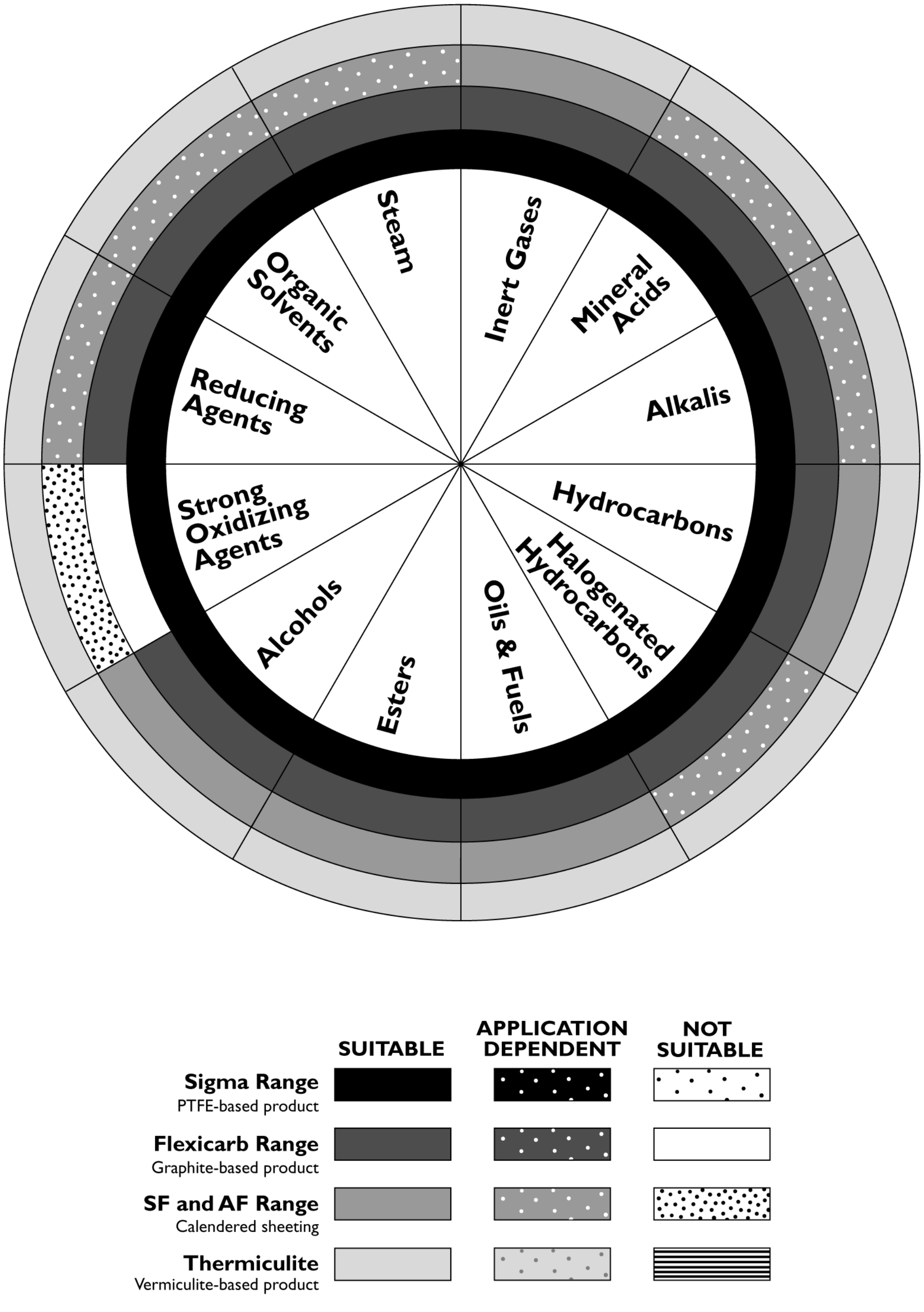
The usage of asbestos-free sheeting containing aramid and glass is a successful replacement for asbestos materials.

The usage of serrated metal core gaskets as a replacement for jacketed gaskets is well proven.

The creep failures of virgin unfilled PTFE can be eliminated using modified, filled PTFE.

APPENDIX A

Figure A-1. Chemical Selector Chart.



Guidelines only, refer to chemical application/compatibility data for specific application.

Key:

Sigma	PTFE-based product
Flexicarb	Graphite-based product
SF and AF	Calendered sheeting
Thermiculite	Vermiculite-based product

Figure A-2. Chemical Compatibility Guide for Different Materials.

	SF3300	SF2400/2800	SF1670	SF2500	SIGMA	RGS	THERMICULITE 815
Acetic Acid Glacial	✓	✓	✗	✓	✓	✓	✓
Acetone	✓	✓	✗	✓	✓	✓	✓
Acetylene	✓	✓	✓	✓	✓	✓	✓
Acrylic Acid	✓	✓	✗	✓	✓	✓	✓
Acrylonitrile	✓	✓	✗	✓	✓	✓	✓
Air	✓	✓	✓	✓	✓	✓	✓
Alkaline Lye	✓	○	✗	✓	✓	✓	✓
Aluminium Chloride	✓	○	✗	✓	✓	✓	✓
Ammonia Gas	✓	✓	○	✓	✓	✓	✓
Ammonia	✓	✓	✗	✓	✓	✓	✓
Amyl Acetate	✓	✓	✓	✓	✓	✓	✓
Amyl Alcohol	✓	✓	✓	✓	✓	✓	✓
Aniline	✓	○	✗	✗	✓	✓	✓
Aqua-Regia	✗	✗	✗	○	✓	✗	✓
Aviation Fuel	✓	✓	✓	✓	✓	✓	✓
Beer	✓	✓	✓	✓	✓	✓	✓
Benzene	✓	✓	○	✓	✓	✓	✓
Benzoyl Chloride	✓	✓	✗	✓	✓	✓	✓
Biphenyl	✓	✓	✗	✓	✓	✓	✓
Blast Furnace Gas	✓	✓	✗	✓	✓	✓	✓
Bleach (Solution)	✓	✓	○	✓	✓	✓	✓
Boiler Feed Water	✓	✓	✓	✓	✓	✓	✓
Brine	✓	✓	✓	✓	✓	✓	✓
Bromine	✗	✗	✗	✗	✓	○	✗
n-Butyl Acetate	✓	✓	✓	✓	✓	✓	✓
Calcium Chlorate	✗	✗	✗	✓	✓	✓	✓
Caprolactam	✓	✓	○	✓	✓	✓	✓
Carbolic Acid	✗	✗	✗	✓	✓	✓	✓
Carbon Dioxide	✓	✓	✓	✓	✓	✓	✓
Carbon Disulphide	✗	✗	✗	✗	✓	✓	✓
Carbon Monoxide	✓	✓	✓	✓	✓	✓	✓
Carbon Tetrachloride	✓	✓	✗	✗	✓	✓	✓
Chile Saltpetre	✓	✓	✓	✓	✓	✓	✓
Chlorine Dry	✗	✗	✗	✓	✓	✓	✓
Chlorine Wet	✗	✗	✗	○	✓	✓	✓
Chlorinated Hydrocarbons	○	○	○	○	✓	✓	✓
Chloroacetic Acid	✓	○	✗	✓	✓	✓	✓
Chlorobenzene	✓	✓	✗	○	✓	✓	✓
Chromic Acid	✗	✗	✗	○	✓	○	○
Copper Sulphate	✓	✓	✓	✓	✓	✓	✓
Creosote	✓	✓	✗	✗	✓	✓	✓
Cresol	✗	✗	✓	○	✓	✓	✓
Crude Oil	✓	✓	○	✓	✓	✓	✓
Cyclohexanol	✓	✓	✓	✓	✓	✓	✓
1,4 Dichlorobenzene	○	○	✗	✗	✓	✓	✓
Diesel Oil	✓	✓	○	✓	✓	✓	✓
Dowtherm	✓	✓	✗	✓	✓	✓	✓
Dye Liquor	✓	○	○	✓	✓	✓	✓

	SF3300	SF2400/2800	SF1670	SF2500	SIGMA	RGS	THERMICULITE 815
Ethyl Acetate	✓	✓	✗	○	✓	✓	✓
Ethyl Alcohol	✓	✓	✓	✓	✓	✓	✓
Ethylene Glycol	✓	✓	✓	✓	✓	✓	✓
Ethylene Oxide	✓	✓	✗	✗	✓	✓	✓
Ethyl Ether	✓	✓	✓	✓	✓	✓	✓
Ethylene	✓	✓	✓	✓	✓	✓	✓
Ethylene Chloride	✗	✗	✗	✓	✓	✓	✓
Fatty Acids	✓	✓	✓	✓	✓	✓	✓
Ferric Chloride	✓	✓	○	✓	✓	○	✓
Fluorine	✗	✗	✗	✗	✗	✓	✗
Fluorosilicic Acid	✗	✗	✗	✓	✓	✓	✗
Formaldehyde	✓	✓	○	✓	✓	✓	✓
Formic Acid (85%)	○	○	✗	✓	✓	✓	✓
Formic Acid (10%)	✓	✓	○	✓	✓	✓	✓
Gas Oil	✓	✓	○	✓	✓	✓	✓
Gasoline	✓	✓	✓	✓	✓	✓	✓
Freons	○	○	✗	✗	✓	✓	✓
Heating Oil	✓	✓	✓	✓	✓	✓	✓
Hydraulic Oil (Glycol)	✓	✓	✓	✓	✓	✓	✓
Hydraulic Oil (Mineral)	✓	✓	✓	✓	✓	✓	✓
Hydraulic Oil (Ester)	✓	✓	○	○	✓	✓	✓
Hydrazine	✓	✓	✗	✓	✓	✓	✓
Hydrocarbons (Aromatic)	✓	✓	✗	✓	✓	✓	✓
Hydrocarbons (Aliphatic S)	✓	✓	○	✓	✓	✓	✓
Hydrocarbons (Aliphatic U)	✓	✓	○	✓	✓	✓	✓
Hydrochloric Acid (37%)	○	✗	✗	✓	✓	✓	✓
Hydrofluoric Acid	✗	✗	✗	○	○	✓	✗
Hydrogen	✓	✓	○	✓	✓	✓	✓
Hydrogen Chloride	✗	✗	✗	✓	✓	✓	✓
Hydrogen Fluoride	✗	✗	✗	○	○	✓	✗
Hydrogen Peroxide	✗	✗	✗	○	✓	○	✓
Hydrogen Sulphide	✓	✓	○	✓	✓	✓	✓
Isopropyl Acetate	✓	✓	✓	✓	✓	✓	✓
Isopropyl Alcohol	✓	✓	✓	✓	✓	✓	✓
Kerosene	✓	✓	✓	✓	✓	✓	✓
Lime (Quick)	✓	✓	✓	✓	✓	✓	✓
Lubricating Oil	✓	✓	○	✓	✓	✓	✓
Machine Oil	✓	✓	○	✓	✓	✓	✓
Magnesium Sulphate	✓	✓	✓	✓	✓	✓	✓
Malic Acid	✓	✓	○	✓	✓	✓	✓
Methane	✓	✓	✓	✓	✓	✓	✓
Methyl Acrylate	✓	✓	✗	○	✓	✓	✓
Methyl Alcohol	✓	✓	✓	✓	✓	✓	✓
Methyl Isobutyl Ketone	○	○	○	○	✓	✓	✓
Methyl Methacrylate	✓	✓	○	○	✓	✓	✓
Methylene Chloride	✗	✗	✗	○	✓	✓	✓
Mineral Oil	✓	✓	○	✓	✓	✓	✓
Mobiltherm	✓	✓	✗	✓	✓	✓	✓
Naphthalene	✓	✓	○	✓	✓	✓	✓
Natural Gas	✓	✓	✓	✓	✓	✓	✓
Nitric Acid (50%)	✗	✗	✗	✓	✓	○	✓
Nitric Acid (95%)	✗	✗	✗	✗	✓	✗	✓
Nitrogen	✓	✓	✓	✓	✓	✓	✓
Oleum	✗	✗	✗	✗	✓	✗	○

	SF3300	SF2400/2800	SF1600	SF2500	SIGMA	RGS	THERMICULITE 815
Oxygen	✓	✓	✗	✓	✓	○	✓
Paraffin	✓	✓	✓	✓	✓	✓	✓
Pentachlorophenol	✗	✗	✗	✗	✓	✓	✓
Perchloric Acid	✗	✗	✗	✓	✓	✗	✗
Petrol	✓	✓	✓	✓	✓	✓	✓
Phenol	✗	✗	✓	○	✓	✓	✓
Phosgene	✗	✗	✗	✗	✓	✓	✗
Phosphoric Acid (Conc)	✗	✗	✗	✓	✓	✓	✓
Phosphoric Acid (Dil)	✓	✓	✗	✓	✓	✓	✓
Phosphorous	✗	✗	✗	✗	✓	○	✗
Phthalic Anhydride	✗	✗	✗	○	✓	✓	✓
Potassium Hydroxide	○	○	✗	✓	✓	✓	✓
Potassium Nitrate	✓	✓	✓	✓	✓	✓	✓
Potassium Permanganate	✓	✓	✓	✓	✓	✓	✓
Producer Gas	✓	✓	✓	✓	✓	✓	✓
Pyridine	✗	✗	✗	✗	✓	✓	✓
Sea Water	✓	✓	✓	✓	✓	✓	✓
Silicone Oil	✓	✓	✓	✓	✓	✓	✓
Soda Ash	✓	✓	✓	✓	✓	✓	✓
Sodium Bicarbonate	✓	✓	✓	✓	✓	✓	✓
Sodium Carbonate	✓	✓	✓	✓	✓	✓	✓
Sodium Cyanide	✓	✓	✓	✓	✓	✓	✓
Sodium Hydroxide (40%)	✗	✗	✗	✓	✓	✓	✓
Sodium Hydroxide (Dil)	✓	✓	✗	✓	✓	✓	✓
Sodium Hypochlorite	✓	✓	○	✓	✓	✓	✓
Sodium Nitrate	✓	✓	✓	✓	✓	✓	✓
Starch	✓	✓	✓	✓	✓	✓	✓
Steam	✓	✓	○	✓	✓	✓	✓
Steam Condensate	✓	✓	✓	✓	✓	✓	✓
Styrene	○	○	✗	✗	✓	✓	✓
Sulphur	✓	✓	○	✓	✓	✓	✓
Sulphur Dioxide	✓	✓	✓	✓	✓	✓	✓
Sulphur Trioxide	✗	✗	✗	✓	✓	✗	✓
Sulphuric Acid (Conc)	✗	✗	✗	✓	✓	✗	✓
Sulphuric Acid (Fuming)	✗	✗	✗	✗	✓	✗	○
Tar	✓	✓	✗	✓	✓	✓	✓
Turpentine	✓	✓	✓	✓	✓	✓	✓
Toluene	✓	✓	✗	✓	✓	✓	✓
Towns Gas	✓	✓	✓	✓	✓	✓	✓
Transformer Oil	✓	✓	○	✓	✓	✓	✓
Tributyl Phosphate	✓	✓	✓	✓	✓	✓	✓
Triethanolamine	✓	✓	✓	✓	✓	✓	✓
Urea	✓	✓	✓	✓	✓	✓	✓
Vegetable Oil	✓	✓	✓	✓	✓	✓	✓
Vinyl Acetate	✓	✓	○	✓	✓	✓	✓
Vinyl Chloride	✓	✓	○	✓	✓	✓	✓
Vinylidene Chloride	✓	✓	○	✓	✓	✓	✓
Water	✓	✓	✓	✓	✓	✓	✓
Water Condensate	✓	✓	✓	✓	✓	✓	✓
Water Distilled	✗	✗	✗	✗	✓	✓	✓
Whisky	✓	✓	✓	✓	✓	✓	✓
Wine	✓	✓	✓	✓	✓	✓	✓
White Spirit	✓	✓	○	✓	✓	✓	✓
Xylene	✓	✓	✗	✓	✓	✓	✓

✓ **Suitable** ○ **Application Dependent** ✗ **Not Suitable**

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