

High Performance Sealing Solutions

for the
Oil & Gas industry

ENDURA[®]
Oilfield Elastomers



Precision Polymer Engineering Ltd



ABERDEEN
O-RINGS & SEALS

Precision Polymer Engineering Limited



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Introduction

Precision Polymer Engineering Ltd (PPE) has been supplying high performance seals into the oilfield industry for over 30 years. During this time PPE has earned an enviable reputation for being a highly responsive and reliable partner of choice with some of the fastest manufacturing lead-times in the sealing industry.

Combining innovative design, uncompromising quality and the latest elastomer technology with specialist in-house material formulation, tool-making and state-of-the-art manufacturing facilities, PPE delivers high performance components quickly and effectively.

With sales operations located in UK, Europe, USA and Asia, PPE provides customers with world-class sealing solutions around the globe.

Aberdeen O-rings & Seals Ltd (AOS), part of the PPE Group of Companies, is conveniently located in Aberdeen to provide a first-class service to the oil and gas industry. AOS stocks and distributes one of the widest range of sealing components in Scotland. Well known for rapid response times, AOS has many years expertise and industry 'know-how' to help solve the most demanding sealing challenges.

All the products and support services detailed in this brochure are available through both Aberdeen O-rings & Seals Ltd and Precision Polymer Engineering Ltd.

Three core competencies set PPE and AOS apart from the competition:

- unique, market leading, high performance materials
- advanced design and manufacturing capabilities
- excellent technical support and customer service.

Through these core competencies PPE and AOS provide customers with a competitive advantage which is demonstrated by the benefits listed below.

Benefits of PPE/AOS sealing solutions:

- Increased productivity through reduced maintenance and downtime
- Extended seal life expectancy and integrity
- Performance enabling materials to maximise equipment capabilities
- Reliable, rapid, industry-leading production lead times to support fast-paced oilfield operations especially in emergency situations
- Machined elastomer prototyping for speed, moulded elastomer production for cost effectiveness and repeatability
- World-class local customer service and technical support
- Professional development with PPE training courses and education



Precision Polymer Engineering Ltd



Oil exploration and extraction presents the most challenging conditions for elastomer seals; a combination of extreme temperatures, aggressive chemicals and gases, abrasive media, high pressure and destructive forces, subject seals to the harshest environments in the world.

In addition, the techniques employed to exploit reserves are becoming more complex, with operations moving to more remote locations and deeper well depths, extending the operating demands on the seals even further.

Product Innovation and Materials Technology

Recognising the increasing challenges that face the oil and gas exploration and extraction industry, PPE operates at the forefront of elastomer technology and is constantly pushing the boundaries to develop the **most technically advanced elastomer materials available**. Innovation is a way-of-life at PPE with in-house material formulation and a continuous development programme that provides elastomers that not only keep pace with the current needs of the oilfield industry, but look to future requirements.

The **EnDura®** range of elite materials has been specifically developed for use in downhole, surface and subsea oilfield equipment and offers excellent explosive decompression (ED) resistance. The range includes unique material grades that provide the ultimate in chemical resistance, mechanical properties and low temperature performance.



Superior sealing solutions for borehole seismic equipment

A leading international seismic equipment manufacturer carried out comparative tests on **EnDura® V91J, V91A** and various competitor O-rings. The O-rings were subjected to typical operating conditions of temperatures between -40°C (-40°F) and +230°C (+446°F) and pressures up to 207 MPa (30,000 psi). The EnDura® V91J and V91A O-rings outperformed all other materials tested with a significant increase in service life achieved. The manufacturer commented that superior materials, excellent quality and short manufacturing lead-times made PPE their seal manufacturer of choice.

PPE seals provide performance advantage for hydraulic R.E.D.

A principal designer, manufacturer and supplier of downhole remote equalisation devices (R.E.D) was experiencing difficulties meeting ISO 14310 Grade V1 of the NORSOK Standard D-010 due to seal failure. The V1 validation involves the hydraulic R.E.D being tested to 52 MPa (7,500 psi) differential pressure within a temperature interval of 75°C (167°F) and 4°C (39°F), over four cycles. **V95X** was the first material to pass the test, going on to complete seven cycles without showing any signs of leakage. The superior compression set performance, high strength and extrusion resistant properties of V95X provided the OEM with a unique competitive advantage.

Manufacturing capabilities

Operating from a purpose-built 6,000 sq.m. (64,500 sq.ft.) manufacturing facility equipped with some of the most modern production apparatus in the world, PPE manufactures seals to the highest quality standards to ensure repeatable performance in the field. Investment in one of the world's largest moulding presses available enables PPE to offer fully moulded O-rings and formed seals up to 2.5 metres (8ft) diameter, manufactured on a single tool in one pressing action. This provides the most accurate part dimensions and highest quality components that are far superior to jointed or cord seals. Accredited to ISO9001:2000, full traceability on elastomer materials is available during every manufacturing process through to finished components.



Rapid redesign of compressor seals for North Sea platform

When a compressor used in transporting gas from a North Sea gas platform to onshore storage facilities failed unexpectedly, PPE were contacted and tasked with replacing the failed scarf-jointed, cord seal with a more reliable seal. Within 48 hours PPE's rapid response service designed and manufactured a 1.2m diameter O-ring made from explosive decompression resistant FKM elastomer. As a result, the new higher quality seal has provided longer production up-times and eliminated the unpredictability of using the previous jointed cord seals.

Rapid manufacturing lead-times

PPE and AOS understand that the oilfield industry demands the highest level of service and responsiveness. Our in-house tool-making department and production facilities contain the latest and most efficient equipment in the world which results in rapid manufacturing capabilities. If the required component is not available from our extensive stock, it can be manufactured within the shortest lead-times in the industry.

For time critical and emergency breakdown situations PPE and AOS offer a 48-hour rapid manufacturing service. This premium service aims to manufacture and despatch parts from our production facility in Blackburn within 48 hours of receipt of order (based on a Monday-Friday timeframe). Size and material restrictions apply, please contact your local sales office for further details.



Critical seals manufactured, tested and delivered to offshore platform in just 4 hours

Aberdeen O-rings and Seals (AOS) recently came to the rescue of a blue-chip oil and gas service company with their fast response time and extensive stocks. The customer had a twelve-hour window to source, pressure test and deliver to an offshore platform ED resistant O-rings for valves operating in high temperature conditions.

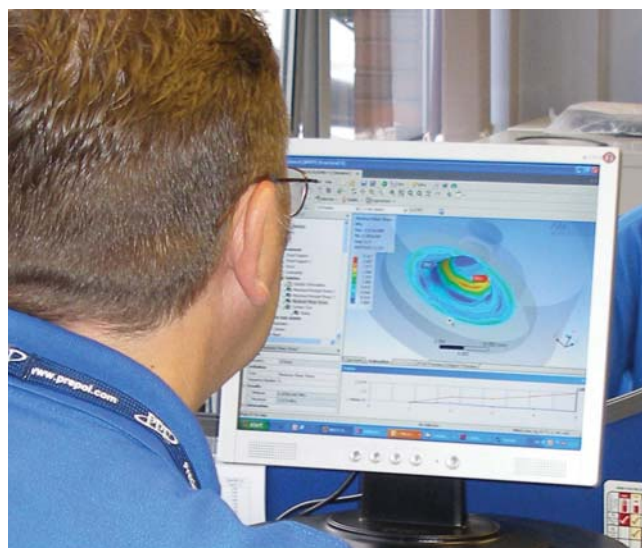
After a swift visit to the customer's premises to evaluate the valve and application, AOS engineers were able to recommend the correct **EnDura® Z95X** O-rings – supplied from stock in Aberdeen. In addition, new PTFE ball seats and PEEK wear seats were manufactured using the rapid production service. The time taken to solve the problem from initial contact was just 4 hours, saving the customer thousands of pounds in production downtime.

Component design

Problem solving is central to PPE's culture, providing customers with optimal design solutions which exceed expectations. PPE engineers can offer a range of services for the design of custom engineered components. From expert advice on existing designs, to a complete design project working to customer specifications, with many years experience, PPE engineers can design custom shapes and profiles to meet any requirements.

CAD drawings are accepted from customers in almost any software format, combined with in-house 3D modeling and analytical behavioural-predictive tools such as FEA (finite element analysis), allow PPE to explore a broad range of "what-if" scenarios, ensuring the seal functionality is right first time, every time.

See page 46 for more details.



New design of rotary wiper seal provides improved consistency and reliability

A leading well intervention service company was experiencing inconsistent performance from their rotary wiper seal. The tolerances of the existing design were found to be causing the problem. Working closely with PPE design teams, the critical performance criteria was identified and finite element analysis (FEA) facilitated design optimisation. This analysis allowed realistic tolerances to be applied, switching the production process from machined parts to moulded seals which resulted in increased consistency and reliability in application.

Technical support

Support and expert technical advice are always available from PPE and AOS. Our engineers and material technologists provide support on component design, material selection and compatibility, testing and analysis. Our consultancy service and field support includes on-site assistance with problem solving and troubleshooting.

Online tools and Engineers resource

MyPPE is an exclusive online portal available on the PPE website (www.prepol.com) which provides useful information on every aspect of elastomer sealing. An invaluable technical resource for Engineers, MyPPE includes chemical compatibility data and material selector, a hardware wizard which identifies the best fit standard sized O-ring for given groove dimensions and PPELive.

PPELive allows registered users to automatically generate and download standard seal components online and import 3D CAD models and 2D drawings directly into any software package. Alternatively drawings and models can be emailed directly to users.

Material testing and analysis

PPE offers an extensive range of independent testing and consultancy services for companies and organisations which are looking for assistance in investigating polymers materials of any sort. In partnership with the Materials Characterisation Centre (MCC) which is equipped with the latest state-of-the-art test apparatus, PPE's Material Technology Department provides a range of services including; material analysis, product development, characterisation, testing, evaluation and detailed analysis of polymeric materials.

Typical examples of the type of work undertaken are:

- Failure analysis
- Chemical compatibility testing
- Thermal analysis
- Mechanical evaluation
- High pressure leak testing
- Explosive decompression testing (see page 13 for more details)



Training and learning

PPE and AOS offer customised training courses which are tailored to sealing applications experienced within the oil and gas industry. Our experts will provide delegates with a wealth of knowledge relating to polymer and sealing technology, from a basic level up to advanced and specialist subjects.

Courses are held at PPE's purpose-built training centre in Blackburn, convention centres located in Aberdeen or at delegates' own business premises (subject to a minimum group size).



PPE and AOS offer a wide range of high performance elastomer materials for various sealing applications in the oil and gas industry. Many of these unique materials have been developed to offer specific characteristics including; the ultimate in chemical resistance, mechanical properties, high pressure capability, explosive decompression (ED) resistance and industry-leading low and high temperature performance.

Effect of low temperature on elastomer sealing

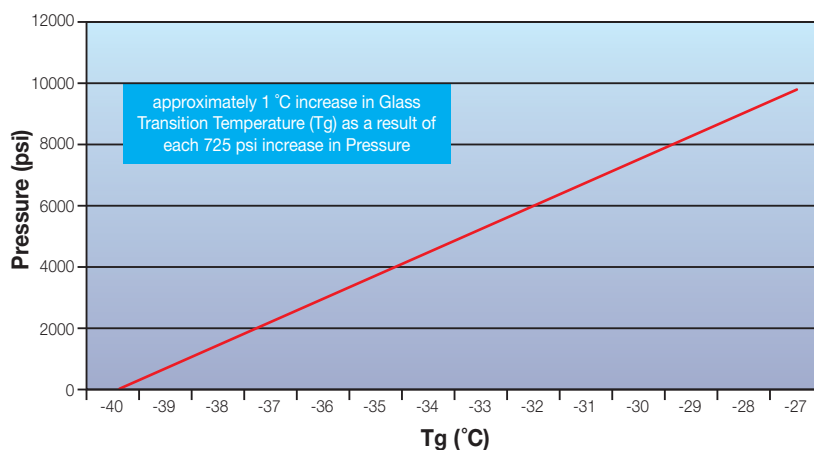
Low temperature performance of elastomer seals is becoming more important with the commercialisation of oilfields in cold locations, such as in Alaska, the North Sea and Russia. Traditionally, FKM seals have not been recommended for low temperature dynamic applications below -30°C (-22°F). This is due to the Glass Transition Temperature (T_g) of most low temperature ED resistant FKM elastomer formulations. The T_g is the temperature at which an elastomer changes its physical properties from elastic and pliable to rigid and brittle and, as a result, loses its sealing ability. Any movement of either the seals or the mating surfaces of the equipment at this temperature could result in damage to the seal surface in the form of cracking or splitting.

High pressure has the apparent effect of increasing the T_g of an elastomer; as a general rule, for every 5 MPa (725 psi) bar increase in pressure, the T_g increases by 1°C . This has significant implications for engineers involved in the selection of elastomer seals. For example, an elastomer having a T_g of -30°C (-22°F) at atmospheric pressure, would in effect have a T_g of only -20°C (-4°F) when the pressure acting on the seal is increased to 50 MPa (7250 psi).

EnDura® V91A is the first low-temperature, explosive decompression resistant, FKM of its kind that is capable of retaining its elastomeric properties at temperatures as low as -46°C (-51°F). This revolutionary material allows engineers to extend the effective limit of their equipment in low temperature applications.

Seal integrity tests conducted by a prominent European ball valve manufacturer concluded that **EnDura® V91A** outperformed other competitor seals as well as PTFE and spring energised PTFE lip seals. The sealing performance of 2.62mm (0.103") cross section EnDura® V91A O-rings was shown to be excellent with leak-free results. Using a nitrogen/helium mix the O-rings maintained sealing integrity when subjected to temperatures of -40°C (-40°F) and pressures up to 28 MPa (4061 psi).

The Apparent Effect of Pressure on Glass Transition Temperature

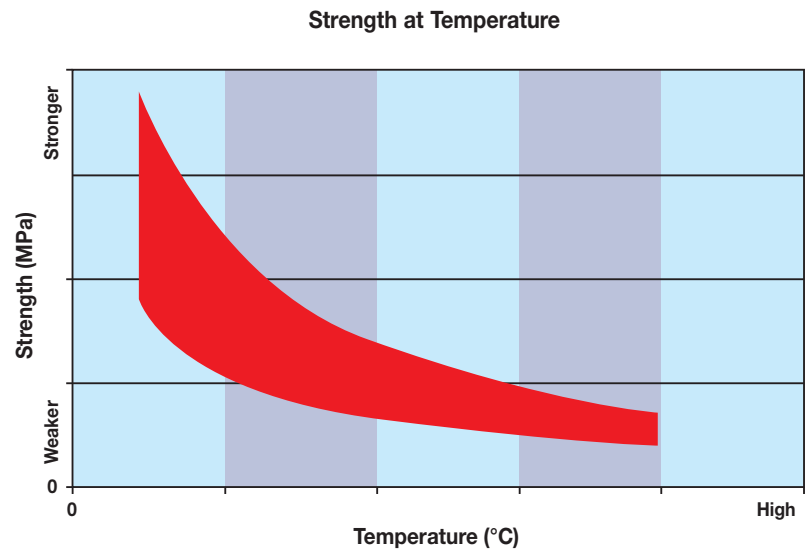


Effect of high temperature on elastomer strength

The strength of an elastomer measured at room temperature can be very different compared with its strength when measured at high temperatures which can be typical of operating conditions. As a general rule, when elastomers get hotter their strength is reduced. By using advanced measuring techniques, the strength of elastomer materials at different temperatures can be measured. This information can then be used in finite element analysis (FEA) to determine whether a sealing material is suitable for use in high temperature conditions.

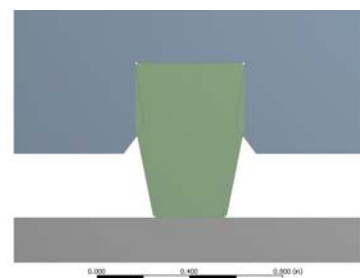
The graph opposite shows diagrammatically how the strength of an elastomer is reduced with increasing temperature.

By understanding these effects of temperature, PPE's design engineers can confidently predict the performance of seals in the most demanding applications.

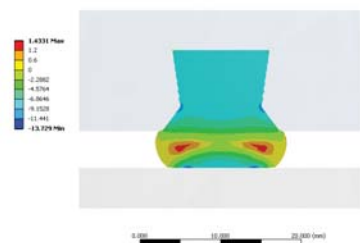
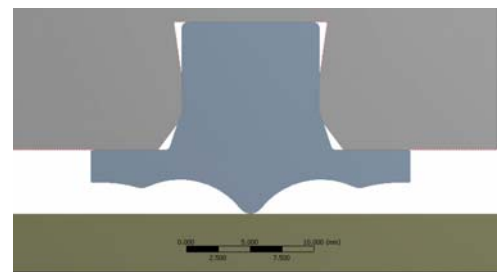


A highly loaded face seal, operating at 140°C (284°F) was experiencing cracking, resulting in leakage. Finite element analysis of the existing design combined with failure analysis identified high stresses within the seal.

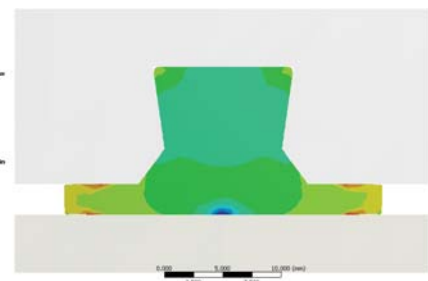
The seal was re-designed to reduce the stresses and the sealing material changed to a compound which retains its high strength at temperature, PPE's **V76F** FKM material resolved the problem.



Before



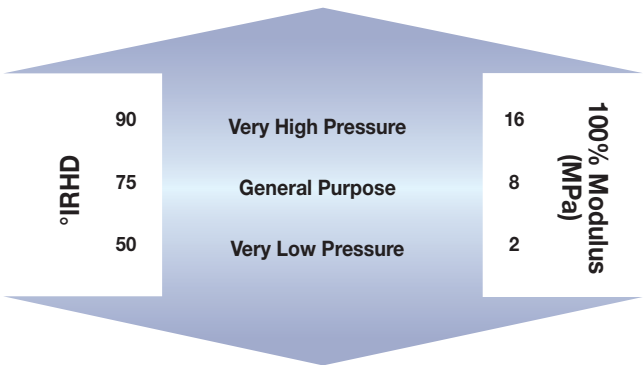
After



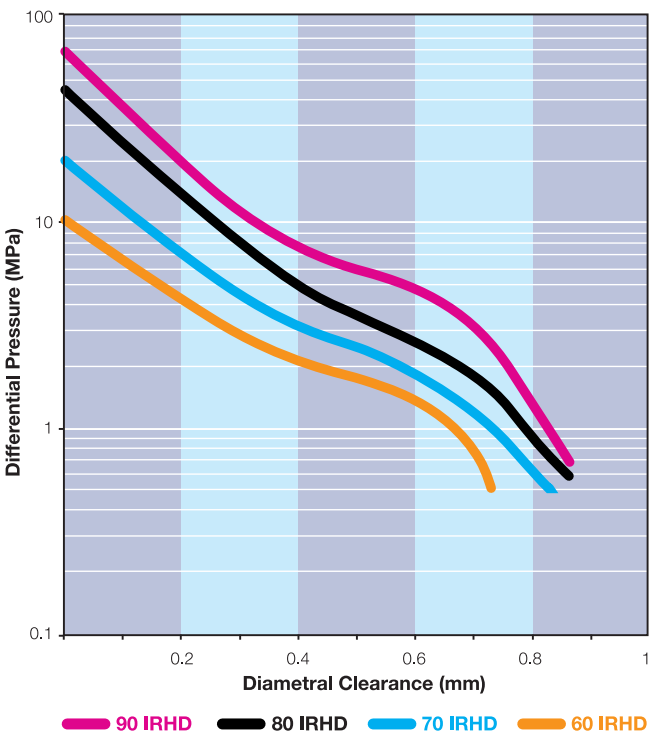
Pressure Guidelines

High pressure sealing applications typically require robust high modulus, high hardness materials. Conversely, softer, lower modulus elastomers are more compliant and better suited to low pressure sealing applications. Frequently elastomers are specified using hardness. However this is a localised surface measure and does not directly relate to modulus which is a measure of a seal's overall stiffness. Materials with higher modulus are more resilient to high pressure extrusion.

General Rules Governing Material Selection



Approximate Extrusion Pressure for a Given Diametral Clearance



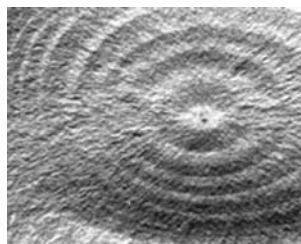
Combinations of pressure and clearance that lie to the right of the pertinent line will result in extrusion of an O-ring and the inclusion of a back-up ring, or use of a T-Seal or L-Seal is advised.

The chart opposite is a simplified representation of nitrile rubbers under continuous use at 70°C (158°F). Elevated operating temperatures considerably weaken elastomers; therefore the above chart is not applicable to ambient burst tests, or operation at extremes of temperature. The graph on page 10 shows the loss of strength with increasing temperature of elastomer materials.

Contact PPE for assistance in selecting the correct solution for your high pressure application.

Explosive Decompression

Explosive Decompression (ED), also referred to as Rapid Gas Decompression (RGD), is a failure mechanism of elastomer seals that is due to the rapid decompression of a gaseous media. When elastomer seals are exposed to high-pressure gas for a prolonged period the gas permeates into the seal material. When the external pressure is reduced, the gas which is dissolved within the seal material comes out of solution to form micro bubbles. As the gas expands, it may permeate out of the seal material. However, if the rate of decompression (and hence expansion) is high, gas which is trapped within the seal can cause fissuring and result in seal failure.



Elastomer seals affected by explosive decompression.

Explosive Decompression Standards

There are a number of international standards for testing elastomer materials in ED conditions, they include:

- NORSOK Specification M-710 Rev.2 Section 7.3/Annex B: "Qualification of non-metallic Sealing Materials and Manufacturers - Resistance to rapid gas decompression (RGD)"
- TOTAL General Specification GS PVV 142 Appendix 8 "Elastomer O-ring Seals Explosion Decompression Type Testing Procedure"
- NACE TM0297 "Effects of High-Temperature, High-Pressure Carbon Dioxide Decompression on Elastomeric Materials"

A SUMMARY OF ED STANDARD TEST CONDITIONS

	NORSOK M710	TOTAL GS PVV 142	NACE TM0297	MCC RGD-01
Specimen	BS325 O-ring	BS425 O-ring	AS325 O-ring	BS325
Constraint	20% compression	15% compression	Optional	18% compression
Replication	Three	Four	Nine	Four
Fluid	90/10 CH ₄ /CO ₂	80/20 CH ₄ /CO ₂	100% CO ₂	90/10 CH ₄ /CO ₂
Temperature	100, 150 or 200°C	75°C ± 2°C	50, 100, 120, 150, 175, or 230°C ± 3°C	100°C
Pressure	15, 20 or 30 MPa	19 ± 2 MPa	7, 17, 28, or 38 MPa	38 Mpa
Initial exposure period	72hrs	72hrs	--	--
Soak period	24hrs	48hrs	24hrs	72hrs ± 4 hrs
Decompression Rate	2-4 MPa/min	19 to 0 MPa in 90 secs	7 ± 0.7 MPa/min	2 MPa/min
Dwell at ambient pressure	1hr	1hr	--	--
Cycles	10	5	1	1

SUMMARY OF PPE/AOS MATERIALS TESTED TO THE REQUIREMENTS OF VARIOUS STANDARDS

	NORSOK M710 7.3 RGD	TOTAL PVV 142 03/01 Rev. 00	NACE		MCC RGD-01
			ED TM0297	H ₂ S TM0187	
EnDura® V91J	✓	✓	✓	✓	✓
EnDura® V91A	✓	✓	✓	✓	✓
EnDura® G92E			✓		✓
EnDura® A90H			✓		✓
EnDura® Z95X	✓	✓		✓	✓
Z85L					✓

Explosive Decompression Testing

In partnership with PPE and AOS, the Materials Characterisation Centre (MCC) contains state-of-the-art ED test equipment which can pressurise seals of various geometries up to 70 MPa (10,000 psi) and can decompress over any desired cycle or time, whilst at temperatures of up to 300°C. Using this equipment, compounds can be developed and tested to overcome explosive decompression, with pressure, temperature, gas mixtures and pressure release cycles simulating actual field operation. The performance of seal types and grades can be confirmed before installation.

With 3L accumulators, the ED test rigs have been designed to meet TOTAL, NACE and NORSOK test requirements with all temperatures, pressures, gas mixtures and depressurisation rates detailed therein. The O-ring carrier inserts are interchangeable to allow O-rings to be tested at various squeeze levels in face and piston geometries. This equipment also tests high-pressure sealing capability versus diametral clearance and back-up ring performance and can test leak rates for fugitive emission testing.

ED TEST RIG CAPABILITIES

	FROM	TO
Pressure	0	70 MPa (10,000 psi)
Temperature	Ambient	300°C (572°F)
Gases	Non-sour gas	
Geometries	Face and piston	
Squeeze	As required	
O-ring size: 70 MPa	Not applicable	47mm outer diameter
35 MPa	40mm outer diameter	129mm outer diameter
O-ring cross section	1mm	15mm
Depressurisation rate	As required	
No. of test O-rings	1	3



Chemical Resistance Tests

In addition to the ED test standards detailed earlier, a number of EnDura® elastomer grades have been tested in sour gas (H₂S) and methanol for chemical resistance.

Sour Gas (Hydrogen Sulphide H₂S)

Hydrogen sulphide (H₂S) is an aggressive species towards some elastomer compounds. Its main mode of action is to incorporate sulphur by way of additional cross-links between polymer chains. This in effect is a continuation of the cure cycle which many elastomers undergo in order to prevent irreversible chain slippage when strained. Therefore, by increasing the amount of cross-linking, the elastomer becomes stiffer. In extreme cases the resulting brittleness causes loss of sealing function.

EnDura® grades V91K (FKM), V91A (FKM) and Z95X (HNBR) have been independently tested by MERL (Materials Engineering Research Laboratory) and qualified according to NACE standard TM0187 (Chemical Ageing of Elastomeric Materials in sour liquid (H₂S) environments).

Test conditions

10% H₂S, 15% CO₂ in methane gas, over a hydrocarbon/water liquid phase, as the exposure medium, 10 MPa (1,450 psi) pressure, temperature of 100°C (212°F) for the duration of 100 hours.

The compression set of the three sample specimens was tested (using ASTM D395 method B) within two hours of removal from the test chamber and again after 24hrs recovery at room temperature. Compression set is the measure of the inability of an elastomer to recover fully from a deformed state to its original state when the strain is removed. Compression set is a property which reflects the ability of a seal to function and which is adversely affected by temperature.

Results

V91A, V91J and Z95X performed satisfactorily after exposure to a fluid mixture containing 10% H₂S and hydrocarbon solvent. Compression set was low throughout with further reductions occurring after 24 hours recovery at room temperature.

AVERAGE COMPRESSION SET CHANGE AFTER EXPOSURE TO 10% H₂S (measured within two hours)

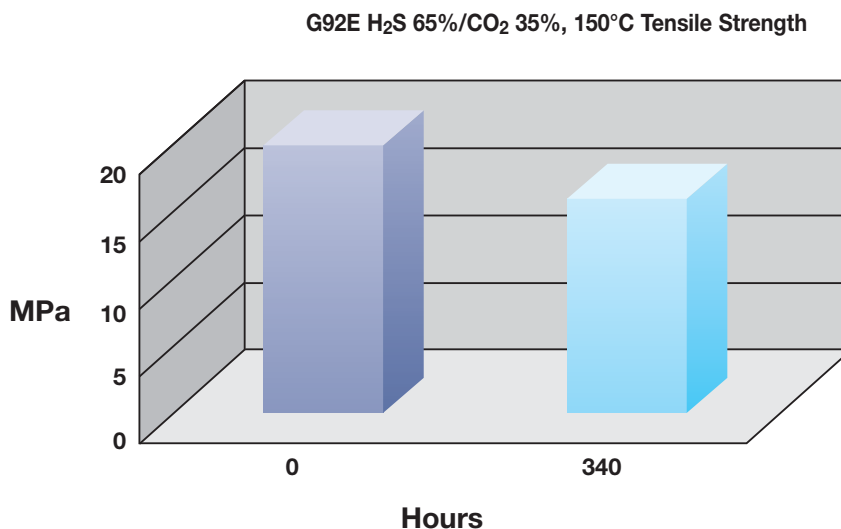
Material Grade	Compression Set change (%)
V91J (FKM)	+10.0
V91A (FKM)	+7.1
Z95X (HNBR)	+15.9

AVERAGE COMPRESSION SET CHANGE AFTER EXPOSURE TO 10% H₂S (measured after 24hrs recovery at room temperature)

Material Grade	Compression Set change (%)
V91J (FKM)	+2.6
V91A (FKM)	+5.1
Z95X (HNBR)	+7.3

Additional tests carried out on EnDura® grade **Perlast® G92E** showed that the tensile strength of the perfluoroelastomer (FFKM) material was only minimally reduced (from 20 MPa to 16 MPa) after being immersed in a 65% H₂S / 35% CO₂ gas mixture for 340 hours at 150°C (302°F).

This demonstrates this material's ability to maintain its mechanical properties whilst providing excellent long-term chemical resistance.



Results from an independent study conducted in H₂S concentrations up to 64%, at elevated temperatures up to 220°C (428°F), suggest that peroxide-cured FKM elastomers (such as EnDura® V91J, V91K & V91A FKM grades) provide superior resistance to stiffening which causes a loss of sealability. It is important to note that the effect of sour gas may be combined with the effect of other chemicals the seal may be in contact with (i.e. aromatic hydrocarbons). This, combined with elevated temperatures and pressure, will significantly influence the rate at which the seal is affected.

Methanol Immersion Tests

EnDura® grades V91J, V91K, V91A, Perlast® G92E and a leading competitor FKM grade were immersion tested in 100% methanol. The test used BS1806-214 size O-rings under room temperature conditions over a period of 580 hours.

Three specimens of each material were immersed in methanol liquid and measured for volume change (swell) at regular intervals. The amount of volume change was measured using ASTM D297 Test method.

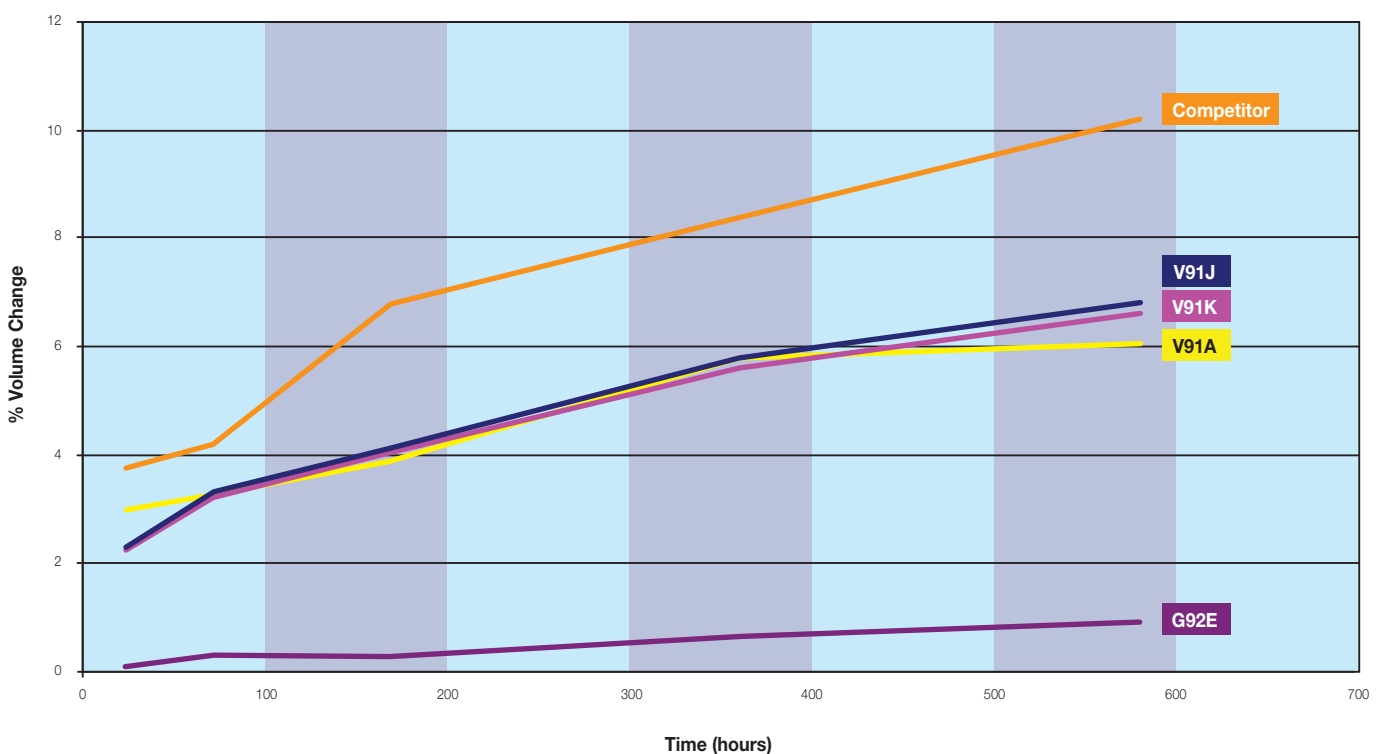
Results

Perlast® G92E experienced the least swell as is expected for a perfluoroelastomer (FFKM). The EnDura FKM grades also performed very well compared to the leading competitor FKM which swelled by a further 4%.

TABLE OF RESULTS

No. of Hours	Volume Change (%)				
	EnDura® V91J FKM	EnDura® V91K FKM	EnDura® V91A FKM	Competitor FKM	Perlast® G92E FFKM
24	2.3	2.2	3	3.8	0.1
72	3.3	3.2	3.3	4.2	0.3
168	4.1	4	3.9	6.8	0.3
360	5.8	5.6	5.8	8.4	0.6
580	6.8	6.6	6.1	10.2	0.9

Methanol Immersion at Room Temperature



Elastomer Types

EPDM

EPDM polymers exhibit outstanding resistance to weathering, ozone, water and steam. These rubbers have good chemical resistance and are particularly recommended for use with phosphate ester based hydraulic systems. They are not suitable for use with mineral oils or petroleum based fluids and are typically used in carbon storage applications.

Nitrile NBR

Nitrile is widely used throughout the oilfield industry due to it being less expensive than some other high performance materials. The properties of this copolymer are governed by the ratios of the two monomers acrylonitrile (ACN) and butadiene. The higher the ACN content, the higher will be the resistance to aromatic hydrocarbons. Lower ACN content provides better low temperature flexibility. The most commonly specified, and the best overall balance for most applications is, therefore, 'medium nitrile'. General characteristics of NBRs include excellent resistance to aliphatic hydrocarbon oils, fuels and greases, very low gas permeability, good heat ageing properties and ozone resistance, improved tensile and abrasion strength, hardness, density and low compression set.

Hydrogenated Nitrile HNBR

HNBR elastomers are a saturated version of NBR, showing superior heat resistance. General properties include excellent wear resistance, high tensile strength, high hot-tear resistance, low compression set and very good ozone and weathering resistance. They also exhibit good resistance to many oil additives, hydrogen sulphide and amines present in crude oil. HNBRs fill the gap between NBRs and FKMs in many areas of application where resistance to heat and aggressive media are required simultaneously, and may therefore provide a lower cost alternative to FKM elastomers.

Fluoroelastomer FKM

This class of rubber is available as a copolymer, terpolymer or tetrapolymer; the type determines the fluorine content (between 65% and 70%) and thus chemical resistance. General properties include excellent resistance to heat, aliphatic and aromatic hydrocarbons, chlorinated solvents, mineral and synthetic lubricants and petroleum fluids. FKMs have a clear superiority in O-ring sealing force retention over most other oil-heat resistant rubbers with the exception of perfluoroelastomers such as Perlast®. FKMs do show poor resistance to ethers, ketones, esters, amines and hydraulic fluids based on phosphate esters. Special compounds are required to provide suitable resistance to hot water, steam and wet chlorine.



Fluoroelastomer FKM (continued)

Copolymer, Terpolymer or Tetrapolymer

Fluoroelastomer or fluorocarbon (FKM/FPM) materials are available in three general types depending on their fluorine content and the number of monomers contained within the polymer.

FLUOROELASTOMER TYPES		
Type	Fluorine Content	Advantages / Disadvantages
Copolymer (A/E)	65% - 65.5%	Contains two monomers (simple molecules from which polymers are built). General purpose, most common, most widely used for sealing. Best compression set and very good fluid resistance. Often referred to as 'A' and 'E' type grades. These are normally the least expensive types of compound.
Terpolymer (B or F)	67%	Contains three monomers. Better fluid and oil/solvent resistance than copolymers but at the expense of poorer compression set resistance. Often referred to as 'B' or 'F' type grades. 'F' grades offer superior fluid resistance over 'B' grades.
Tetrapolymer (G)	67% - 69%	Contains four monomers. Improved fluid, acid, solvent resistance over other types. Compression set better than terpolymers. These are sometimes known as 'G' grades. In addition, certain tetrapolymers have good low-temperature flexibility. Tetrapolymers are the most expensive of the three types listed here. Tetrapolymer materials can also be referred to as GF, GLT and GFLT grades which correspond to Viton[®], the registered trade name of DuPont's FKM material. GF – Good high temperature performance and chemical resistance but reduced mechanical properties and low temperature performance. GLT – Improved low temperature performance but reduced chemical resistance. GFLT – Good all-round low/high temperature performance and chemical resistance.

Aflas FEPM or TFE/P

FEPM exhibits similar thermal stability to FKM elastomers, but better electrical resistance and a different chemical resistance profile. FEPM compounds have the ability to resist a wide range of chemical combinations such as sour gas and oil, acids and strong alkalis, ozone and weather, steam and water, all hydraulic fluids, alcohols, amine corrosion inhibitors, water-based drilling and completion fluids and high pH completion fluids. However, they are not compatible with aromatic hydrocarbons, chlorinated hydrocarbons, organic acetates and organic refrigerants.

Perfluoroelastomer FFKM

FFKMs exhibit outstanding high temperature properties and are the most chemically resistant elastomer available; effectively a rubber form of PTFE. They are superior to FKM elastomers, showing continuous dry-heat resistance to 260°C (500°F), with extended performance to 330°C (626°F) for high temperature grades. They are extremely inert chemically and show excellent resistance to the majority of chemicals that attack other elastomers. Other notable properties include excellent resistance to oil-well sour gases, high temperature steam, low out-gassing under vacuum and good long-term high temperature compression set resistance.

Chemical Resistance Guide

Key: 1 - Excellent 2 - Good 3 - Doubtful 4 - Do not use

PPE grade		V91J	V91K	V91A	V95X	A90H	Z95X	Z85L	N70M	G75B	G92E
Material type		FKM	FKM	FKM	FKM	FEPM	HNBR	HNBR	NBR	FFKM	FFKM
Acid		1	1	1	1	1	2	2	2	1	1
Alkanes		1	1	1	1	1	1	1	1	1	1
Amines		3	3	4	4	2	4	4	4	1	1
Base oil		1	1	1	1	1	1	1	1	1	1
Biocides		3	3	3	1	2	2	2	2	1	1
Biodiesel		1	1	1	1	1	2	2	3	1	1
Bioethanol		1	1	1	1	1	1	1	1	1	1
Brine	Chloride	1	1	1	1	1	1	1	1	1	1
	Bromide	1	1	1	2	1	2	2	3	1	1
	Formate	2	2	2	3	1	3	3	3	1	1
Carbon Dioxide (CO ₂)		2	2	2	2	2	3	1	1	1	1
Cement		1	1	1	3	1	1	1	2	1	1
Corrosion Inhibitors		2	2	3	2	1	1	2	3	1	1
De-emulsifier (mud)		1	1	1	1	1	1	1	2	1	1
Defoamers		1	1	2	1	1	1	1	1	1	1
Dielectric fluid		1	1	1	1	1	1	1	1	1	1
Emulsifiers		1	1	2	1	1	2	1	2	1	1
Emulsion (oil and water)		1	1	2	2	1	1	2	1	1	1
Foaming agents		1	1	2	2	1	1	2	2	1	1
Formation water	Acid	1	1	1	1	1	2	2	2	1	1
	Chloride	1	1	1	1	1	1	1	2	1	1
Gravel packer fluid		1	1	1	1	1	1	1	1	1	1
Hydraulic control fluid	Oceanic HW 443	2	2	2	2	1	2	2	2	1	1
	Oceanic HW 500	1	1	2	2	1	2	2	2	1	1
	Oceanic HW 525	1	1	2	1	1	2	2	2	1	1
	Oceanic HW 540	1	1	2	1	1	2	2	2	1	1
Hydrogen Sulphide (H ₂ S)	<1%	1	1	1	2	1	1	1	3	1	1
	<10%	2	2	2	2	1	2	2	3	1	1
	<30%	2	2	2	3	1	3	3	4	1	1
Lost circulation fluids		1	1	1	1	1	1	1	1	2	2
Lubricants		1	1	1	1	1	1	1	1	1	1
Methane		1	1	1	1	1	1	2	1	1	1
Methanol		1	1	2	2	1	1	1	1	1	1
Mineral based oil		1	1	1	1	1	1	1	1	1	1
Mud	Water	1	1	1	1	1	1	1	1	1	1
	Oil	1	1	1	1	1	1	1	1	1	1
	Synthetic oil	2	2	3	3	2	2	1	3	1	1
Polyalkylene glycol		1	1	1	1	1	1	1	2	1	1
Poly-α-olefin		1	1	1	1	1	1	1	2	1	1
Poly-ol fire resistant ester		2	2	3	2	3	3	3	3	1	1
Sea water		1	1	1	1	1	1	1	1	1	1
Slurries		1	1	1	1	1	1	1	1	1	1
Synthetic biodegradeable ester		2	2	2	3	2	3	3	3	1	1
Thinners/dissolvers		1	1	1	2	1	2	2	2	1	1
Viscosifiers		1	1	1	1	1	1	1	1	1	1
Well cleaning fluids		2	2	2	1	1	1	2	2	1	1

Polyurethane (AU)

Polyurethanes are thermoplastic resins (sometimes classed as elastomers) which exhibit excellent mechanical and physical properties whilst providing outstanding resistance to petroleum oils and hydrocarbon fuels. Polyurethane rubbers are used where high abrasion resistance and oil/solvent resistance are required simultaneously. In all applications, consideration should be given to hydrolysis and limited heat resistance.

PEEK

PEEK (polyetheretherketone) is a resilient, semicrystalline thermoplastic with extraordinary mechanical properties. The material is highly resistant to wear, hydrolysis, thermal degradation and experiences less creep compared to PTFE. PEEK also exhibits good chemical resistance in both organic and aqueous environments. PEEK material grades are available as 'virgin' (non-filled) or various filled grades, which provide enhanced physical characteristics.

T55B Virgin (non-filled)

Thermoplastic polymer with excellent mechanical properties at high temperatures. PEEK offers excellent chemical resistance, very low moisture absorption and excellent mechanical strength and stiffness. In dynamic applications, PEEK offers inherently good wear and abrasion resistance. PEEK is unaffected by continuous exposure to hot water and steam.

T57B Glass filled

The addition of a glass filler increases the flexural modulus, compressive strength and reduces the expansion rate. The strength at higher temperatures is increased and it offers better resistance to creep.

T58B Carbon filled

Carbon fibre fillers enhance the compressive and tensile strength over glass filled grade. The stiffness is also increased, whilst offering improved wear resistance and load bearing capabilities at elevated temperatures.

T56B Bearing grade

Enhanced compressive strength, wear rate, PV limit and reduced friction over standard PEEK.



PTFE

PTFE (polytetrafluoroethylene) is generally considered a thermoplastic polymer; it has the lowest coefficient of friction of any solid engineering material. PTFE material grades are available as 'virgin' (non-filled) or various filled grades, which provide enhanced physical characteristics.

T99W Virgin (non-filled)

Thermally stable up to 260°C while still possessing a certain compressive plasticity at temperatures near to absolute zero. Virgin PTFE is practically inert against all known elements and compounds, attacked only by alkaline metals in the elementary state, halogenides, CF_3 and by elementary fluorine at high temperatures and pressures. PTFE is quite flexible and resistant to breaking when subject to tensile or compression stresses.

However, below the yield point, part of the resulting deformations remains after the discontinuance of the stresses, with the result that certain strains are induced in the piece. Virgin PTFE has a low coefficient of friction, but is weakened in dynamic applications by its wear rate, (which can be improved with fillers). Hardness varies between 50 and 60 Shore D.

T99G 25% Glass-filled

Wear properties and deformation strength under load are improved. The electrical and chemical characteristics remain substantially unchanged, but glass itself has a rather poor resistance against alkalis and is easily attacked by hydrofluoric acid. The coefficient of friction is slightly increased.

T99GM 15% Glass / 5% Molybdenum-filled

Wear properties and deformation strength under load are improved. The electrical and chemical characteristics remain substantially unchanged, but glass itself has a rather poor resistance against alkalis and is easily attacked by hydrofluoric acid and increases the coefficient of friction, molybdenum disulphide (MoS_2) is added to compensate this effect.

T99C 25% Carbon-filled

The carbon improves the wear and deformation strength to a considerable degree, but substantially changes the electrical properties. It has better thermal conductivity than glass filler and offers a lower wear rate of the opposing surfaces due to being less abrasive. Carbon fibre offers good properties in water whilst remaining chemically inert and resistant to hydrofluoric acid.

T99X 15% Graphite-filled

Graphite lowers the coefficient of friction. It improves the deformation under load, strength and, to a minor degree, the wear properties when compared to virgin PTFE.

T99B 40% Bronze-filled

Bronze-filled PTFE has the best wear properties, remarkable deformation strengths and good thermal conductivity, but poor electrical characteristics and chemical resistance. Not recommended in applications involving aluminium or soft metal rods/bores, heavy side-loading or in the presence of water.

T99E 10% Ekonol®-filled

Ekonol® is a polyester which, combined with PTFE, produces a material that is extremely wear resistant.

T99E offers the ultimate in wear resistance for seals operating in the toughest conditions without being abrasive to mating surfaces.

Elastomers

PPE grade	Material Type	Hardness (°RHD)	Compression Set		Tensile Strength (MPa)	100% Modulus (MPa)	Elongation at Break (%)	Operating Temperature	Chemical Resistance				ED/RGD Resistant
			Conditions	(%)					Steam	Oil	Gas	H ₂ S* (%)	
A70H	FEPM	75	24hrs @ 200°C	35	18.6	3.5	250	-5 to +250°C	✓	✓	✓	<30	
A90H		93	70hrs @ 200°C	35	19	17.5	130	0°C to +250°C	✓	✓	✓	<30	✓
G75B	FFKM	78	72hrs @ 200°C	18	19.2	12	160	-15°C to +325°C	✓	✓	✓	>30	
G92E		90	24hrs @ 200°C	24	26	25	110	-15°C to +260°C	✓	✓	✓	>30	✓
N70M	NBR	70	24hrs @ 100°C	25	14	5	350	-40°C to +120°C		✓	✓		
N73B		71	24hrs @ 70°C	6	17.2	5	350	-35°C to +120°C		✓	✓		
N75L		70	24hrs @ 100°C	15	12	4	275	-60°C to +135°C		✓	✓		
N90M		90	24hrs @ 70°C	25	12.5	12.5	100	-30°C to +120°C		✓	✓		
N93B		88	24hrs @ 70°C	6.5	19	11	275	-35°C to +120°C		✓	✓		
V71C	FKM	72	24hrs @ 200°C	18	13	4	180	-51°C to +225°C	✓	✓	✓	<1	
V74C		75	72hrs @ 200°C	9.5	12.5	6	220	-18°C to +225°C		✓	✓	<1	
V75B		70	24hrs @ 200°C	14	12.1	6	215	-20°C to +200°C		✓	✓	<1	
V75J		75	24hrs @ 200°C	11.6	17.4	6	300	-15°C to +200°C	✓	✓	✓	<5	
V76E		75	24hrs @ 200°C	20	18.4	6.1	180	-20°C to +206°C	✓	✓	✓	<10	
V76F		71	72hrs @ 200 °C	12	27.4	19	210	-15°C to +250°C	✓	✓	✓	<10	
V91A		90	24hrs @ 200°C	12	14	6.5	130	-46°C to +225°C	✓	✓	✓	<5	✓
V91J		90	24hrs @ 200°C	24	24	11	210	-17°C to +225°C	✓	✓	✓	<5	✓
V91K		90	24hrs @ 200°C	24	16	7	220	-35°C to +225°C	✓	✓	✓	<5	✓
V95F		90	24hrs @ 200°C	50	10	10	100	-10°C to +200°C		✓	✓	<1	
V95X		92	24hrs @ 200°C	15	16	10	120	-20°C to +200°C		✓	✓	<1	✓
Z70B	HNBR	70	24hrs @ 150°C	15	16.3	10	250	-30°C to +180°C	✓	✓	✓	<5	
Z73B		70	24hrs @ 135°C	12	16.3	8.5	250	-30°C to +180°C	✓	✓	✓	<5	
Z75L		78	22hrs @ 150°C	30	15	8	205	-40°C to +180°C	✓	✓	✓	<10	
Z85B		80	24hrs @ 135°C	21	20.5	12.3	275	-30°C to +180°C	✓	✓	✓	<5	
Z85L		85	24hrs @ 150°C	21	18.3	16	195	-40°C to +160°C	✓	✓	✓	<10	✓
Z95X		89	24hrs @ 150°C	20	32	18	264	-25°C to +180°C	✓	✓	✓	<5	✓

*H₂S data is for general guidance only, please contact the PPE Technical Department for further advice.

CNC-machined Elastomer Compounds

PPE Grade	Material Type	Description	Hardness (Shore A)	Compression Set		Tensile Strength (MPa)	100% Modulus (MPa)	Elongation at Break (%)	Operating Temperature
				Conditions	(%)				
Q48TC	AU	Polyurethane	96	24hrs @ 100°C	35	50	12	450	-37°C to +110°C
Q90B		Polyurethane, black	92	70hrs @ 100°C	25	10	10	100	-30°C to +100°C
Z85TM	HNBR	Hydrogenated nitrile, black	88	24hrs @ 100°C	15	20	15	200	-20°C to +150°C
V85TM	FKM	Fluoroelastomer, brown	85	24hrs @ 100°C	10	10	8	200	-20°C to +220°C

CNC-machined Plastics

PPE Grade	Material Type	Description	Hardness (Shore D)	Tensile Strength (MPa)	μ (@ 50% Lpv)	PV Limit (Lpv) MPa.m.min ⁻¹	Wear Rate μ m.min ⁻¹ (@ 50% Lpv)	Compressive modulus (GPa)	Operating Temperature
T55B	PEEK	Virgin (non-filled), white	88	105	0.58	145	7.5	3.6	-200°C to +250°C
T56B		Bearing grade	87	125	0.17	794	3.2	6.89	-200°C to +240°C
T57B		30% Glass filled	90	155	0.24	-	-	3.6	-200°C to +240°C
T58B		30% Carbon filled	92	225	0.28	376	3.8	3.79	-200°C to +240°C
T99W	PTFE	Virgin (non-filled), white	55	27	0.08	-	-	0.48	-200°C to +260°C
T99G		25% Glass filled, grey	60	15	0.33	-	-	0.67	-200°C to +260°C
T99GM		15% Glass, 5% MoS filled	58	16	0.20	-	-	0.49	-200°C to +260°C
T99C		25% Carbon filled, black	67	18	0.25	447	4.2	0.60	-200°C to +260°C
T99X		15% Graphite filled, grey	65	15	0.24	-	-	0.34	-200°C to +260°C
T99B		40% Bronze filled, brown	60	22	0.23	-	-	0.46	-200°C to +260°C
T99E		10% Ekonol filled	63	13	0.20	-	-	0.60	-200°C to +260°C



Products



O-rings

The most common type of static seal is the flexible elastomer O-ring. O-rings provide an affordable seal that, in most cases, is simple to install and subject to correct material selection, gives acceptable life between maintenance checks. Available in a variety of materials to suit every sealing application, fully moulded O-rings are manufactured to several international sizes standards, including BS1806, BS4518, AS568 and ISO3601. Alternatively non-standard custom sizes, up to 2.5m (8ft) diameter, can be produced to suit specific requirements.

STANDARD MATERIALS

Material Code	ASTM Designation	Temperature Range	Features
N70M	NBR	-40°C to +120°C	General purpose
N75L		-60°C to +120°C	Low temperature
N73B		-35°C to +120°C	Low compression set
N90M		-30°C to +120°C	High pressure
Z73B	HNBR	-30°C to +180°C	General purpose
Z85B		-20°C to +180°C	Abrasion resistant
Z85L		-40°C to +160°C	Low temperature
Z95X		-25°C to +180°C	ED resistant
A70H	FEPM	-5°C to +250°C	General purpose
A90H		-5°C to +250°C	ED resistant
V75B	FKM	-20°C to +200°C	General purpose
V75J		-15°C to +200°C	Steam and methanol resistant
V71C		-51°C to +225°C	Low temperature
V91A		-46°C to +225°C	ED, steam and methanol resistant EnDura® grade
V91K		-35°C to +225°C	ED, steam and methanol resistant EnDura® grade
V91J		-17°C to +225°C	ED, steam and methanol resistant EnDura® grade
G75B	FFKM	-15°C to 325°C	High temperature
G92E		-15°C to 260°C	ED resistant

Part numbering and ordering information

O-rings may be ordered against standard sizes such as ISO3601, BS1806, BS4518, AS568 or as an internal diameter and cross section.

Part Number format:

V 9 1 J - 2 3 0 . 0 0 - 5 . 3 0

4-6 digit material code

Inner diameter (mm) with two decimal places

Cross section (mm) with two decimal places

X-rings (4-lobe seals)

X-rings can be used in both reciprocating and rotary locations. They are typically specified at lower pressures (up to 5 MPa or 725 psi) and temperatures. Often installed into a narrower groove than an O-ring, the square envelope prevents rolling and spiral failure in reciprocating applications. X-rings offer low friction as they trap media between the lobe to form a lubricant reservoir. High sealing efficiency is achieved as the mould part line is not coincident with the primary sealing faces.



STANDARD MATERIALS

Material Code	ASTM Designation	Temperature Range	Features
N70M	NBR	-40°C to +120°C	General purpose
N75L		-60°C to +120°C	Low temperature
N73B		-35°C to +120°C	Low compression set
Z73B	HNBR	-30°C to +180°C	General purpose
Z85B		-20°C to +180°C	Abrasion resistant
A70H	FEPM	-5°C to +250°C	General purpose
V75B	FKM	-20°C to +200°C	General purpose
V75J		-15°C to +200°C	Steam and methanol resistant
V71C		-51°C to +225°C	Low temperature

In low pressure applications friction can be further minimized by selection of low modulus materials and specification of a cross section which is as low as possible. In high pressure applications friction can be minimised by selecting a harder grade of material with low coefficient of friction.

Part numbering and ordering information

X-rings may be ordered as an internal diameter and cross section.

Part Number format:

V 7 5 J - 4 L - 1 0 9 . 0 0 - 5 . 3 0

4-6 digit material code

Profile 4L

Inner diameter (mm) with two decimal places

Cross section (mm) with two decimal places

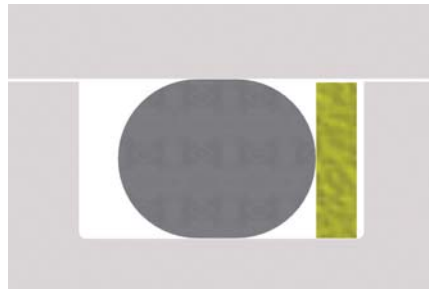
Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.

Back-up Rings

Under extreme pressures elastomers may extrude out of the clearance gap on the low pressure side of a groove. This visco-elastic failure mode is dependent upon differential pressure, size of gap, material and operating temperature. High modulus elastomer materials can offer increased extrusion resistance. However, above 10 MPa (1,500 psi), it is common practice to widen the groove and add either one or two back-up rings adjacent to the O-ring. Back-up rings are typically made of plastic materials that do not suffer the same visco-elastic extrusion mechanism as elastomers.



O-ring extrusion



Non-energized O-ring with back-up



Energized O-ring with back-up

For intermediate pressure low modulus plastics, such as PTFE are used. At extremely high pressures higher modulus plastics such as PEEK are used together with higher modulus elastomers.

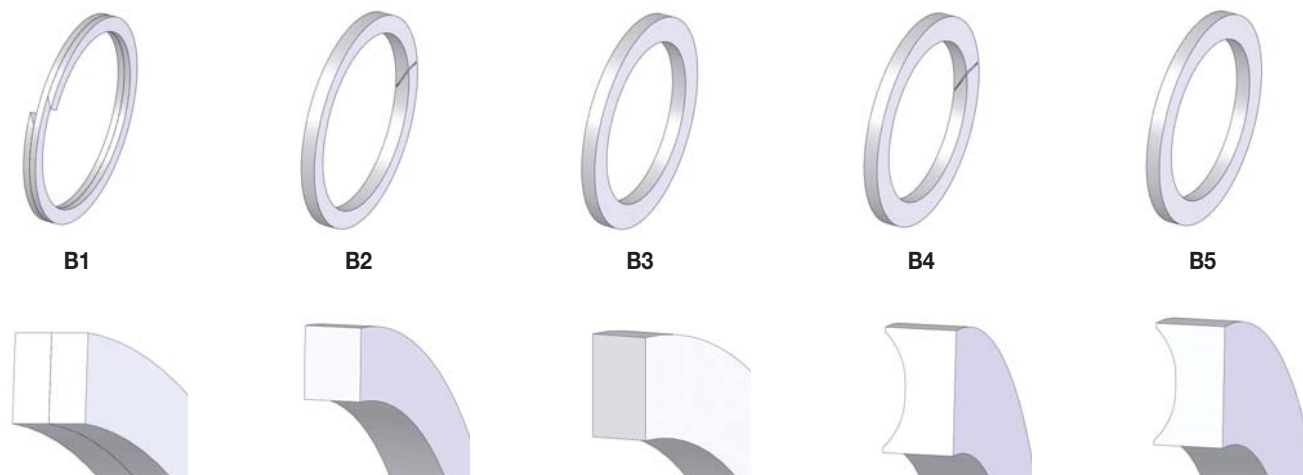
Applications with unidirectional pressure require just one back-up; however it is recommended that two back-ups are used to help ensure correct assembly.

Back-ups may be used in both static and dynamic applications.

STANDARD MATERIALS

Material Code	Temperature Range	ASTM Designation	Description
T99W	-200°C to +260°C	PTFE	Virgin
T99C	-200°C to +260°C		25% Carbon
T99GM	-200°C to +260°C		15% Glass 5% MoS ₂
T99B	-200°C to +260°C		40% Bronze
T99E	-200°C to +260°C		10% Ekonol®
T55B	-200°C to +250°C	PEEK	Virgin
T56B	-200°C to +240°C		Bearing grade
T57B	-200°C to +240°C		Glass filled
T58B	-200°C to +240°C		Carbon filled

Back-up Ring Profiles



Part numbering and ordering information

Part Number format:

T 9 9 G M B 2 S P M 2 0 9 3 5 7

4-6 digit material code

Profile B1, B2, B3, B4, B5

Static (S), Hydraulic (H), Pneumatic (P)
(H & P only applicable to ISO3601 & BS4518 grooves)

Rod Groove (R), Piston Groove (P)

Groove standard
ISO3601(I), AS4716(A)†, MIL-G-5514 (S)†, BS1806(B), BS4518 (M)

Dash Size Reference (3 digits / 4-2 digits for BS4518)

Example

A virgin PTFE scarf cut back-up to be used with a static AS568-214 O-ring in an AS4716 rod groove would be referenced as:

T99W B2SR A214

Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.

Non-standard back-up rings may also be ordered against ISO3601-4 dimensions, or by providing the groove size into which the back-up is to be installed.

† AS4716 piston and rod grooves
correspond to the AS568 O-ring standard

† MIL-G-5514 piston and rod groove should be
selected for MS28774 & MS27595 back-ups.

T-seals

T-seals comprise of an elastomer T-shaped component and two plastic back-up rings. Used in reciprocating piston and rod applications, the T-seal's design prevents rolling and offers improved high pressure performance as the back-up rings are energized by elastomer. The elastomer contact provides improved low pressure sealing over PTFE contact seals.

All PPE T-seals are moulded with an offset tool part line to provide optimal sealing efficiency. T-seals may be installed into standard O-ring grooves designed for 0, 1 or 2 back-ups.



STANDARD MATERIALS

	Material Code	ASTM Designation	Temperature Range	Description
ELASTOMER	N73B	NBR	-35°C to +120°C	Low compression set
	V91J	FKM	-17°C to +225°C	ED, steam and methanol resistant
	V76F		-15°C to +250°C	High strength, high chemical resistance
	Z73B	HNBR	-30°C to +180°C	Low compression set
	Z85B		-20°C to +180°C	Abrasion resistant
	Z95X		-25°C to +180°C	ED resistant
	G75B	FFKM	-15°C to 325°C	High temperature
	G92E		-15°C to 260°C	ED resistant
PLASTIC	T99W	PTFE	-200°C to +260°C	Virgin
	T99C		-200°C to +260°C	25% Carbon
	T99GM		-200°C to +260°C	15% Glass 5% MoS ₂
	T99E		-200°C to +260°C	10% Ekonol®
	T55B	PEEK	-200°C to +250°C	Virgin
	T56B		-200°C to +240°C	Bearing grade
	T57B		-200°C to +240°C	Glass filled
	T58B		-200°C to +240°C	Carbon filled

PPE offers two standard T-seal designs. T1 is a traditional square sided T-seal with small corner radii that ensures that the supplied back-ups cannot be installed the incorrect way around. The PPE T2 profile increases the corner radii and angles the side walls, making it more suitable for use in slower reciprocating rod applications where low tensile strength materials are to be used.

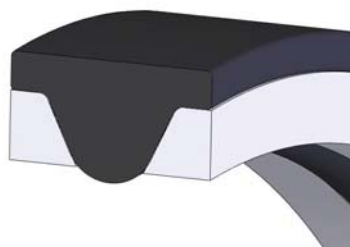
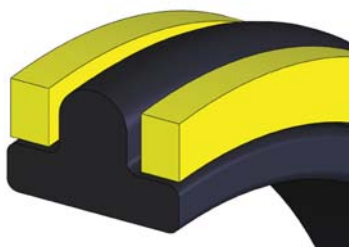
T-seals Profiles



T1



T2



Part numbering and ordering information

Part Number format:

Z 7 3 B - T 9 9 C - T 1 - R S I 1 - 3 1 4

Elastomer 4-6 digit material code

Plastic 4-6 digit material code

Profile T1, T2

Rod Groove (R), Piston Groove (P)

Scarf cut back-up rings (C), Solid back-up rings (S)

Groove standard

ISO3601(I), AS4716(A), MIL-G-5514 (S), BS1806(B), BS4518 (M)

Groove width

No back-up width (0), one back-up width (1), two back-up width (2)

(Narrow-base) (Inter-base) (Wide-base)

Dash Size Reference (3 digits / 4-2 digits for BS4518)

Example

An EnDura® V91J T-seal with virgin PEEK scarf cut back-ups, to be used in an AS4716-325 inter-base piston groove would be referenced as: **V91J-T55B-T1-PCA1-325**

Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.

Products

L-seals

L-seals comprise of an elastomer L-shaped component and a plastic back-up ring. L-seals are used statically with unidirectional pressure and offer improved high pressure performance as the back-up rings are energized by elastomer. The elastomer contact provides improved low pressure sealing over PTFE contact seals. L-seals are may be installed into standard O-ring grooves designed for 0, 1 or 2 back-ups.



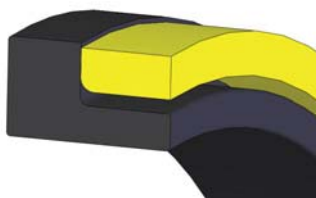
STANDARD MATERIALS

	Material Code	ASTM Designation	Temperature Range	Description
ELASTOMER	N75L	NBR	-60°C to +135°C	Low temperature
	N73B		-35°C to +120°C	Low compression set
	V91J	FKM	-17°C to +225°C	ED, steam and methanol resistant
	V91A		-46°C to +225°C	Low temperature, ED, steam and methanol resistant
	V75J		-15°C to +200°C	Steam and methanol resistant
	V74C		-18°C to +225°C	Low compression set
	V71C		-51°C to +225°C	Low temperature
	Z73B	HNBR	-30°C to +180°C	Low compression set
	Z85B		-20°C to +180°C	Abrasion resistant
	Z95X		-25°C to +180°C	ED resistant
	A70H	FEPM	-5°C to +250°C	General purpose
	G75B	FFKM	-15°C to 325°C	High temperature
	G92E		-15°C to 260°C	ED resistant
PLASTIC	T99W	PTFE	-200°C to +260°C	Virgin
	T55B	PEEK	-200°C to +240°C	Virgin

L-seals Profile



L1



Part numbering and ordering information

Part Number format:

A 7 0 H - T 9 9 W - L 1 - P C A 1 - 4 5 8

Elastomer 4-6 digit material code

Plastic 4-6 digit material code

Profile L1

Rod Groove (R), Piston Groove (P)

Scarf cut back-up rings (C), Solid back-up rings (S)

Groove standard

ISO3601(I), AS4716(A), MIL-G-5514 (S), BS1806(B), BS4518 (M)

Groove width

No back-up width (0), one back-up width (1), two back-up width (2)

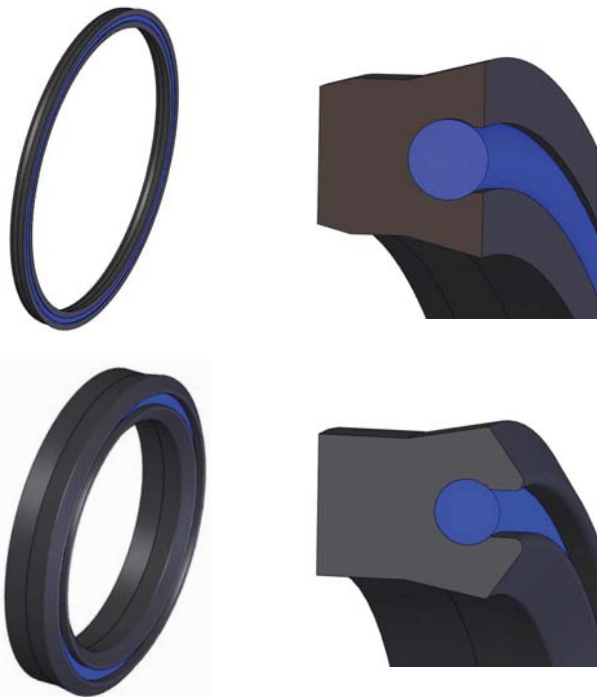
(Narrow-base) (Inter-base) (Wide-base)

Dash Size Reference (3 digits / 4-2 digits for BS4518)

Example

An EnDura® Z95X L-seal with virgin PTFE scarf cut back-ups, to be used in a BS1806-222 narrow-base piston groove would be referenced as: **Z95X-T99W-L1-PCB0-222**

Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.



Energised Lip Seals

Energised lip seals comprise a high modulus, U-shaped, symmetrical, elastomer jacket and a low modulus O-ring energizer, available from PPE in two profiles; U1 and U2. Used in reciprocating dynamic applications with unidirectional pressure, such as rod seals, they provide a versatile, multi-purpose sealing solution for use in high and low pressure applications.

The U1 profile includes scraper lips, to stop the ingress of debris in rotary, rod and piston geometries.

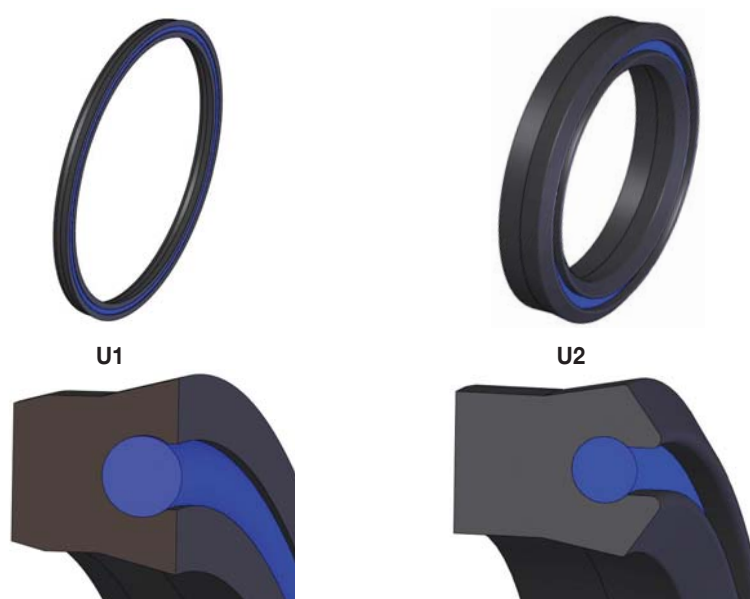
The U2 profile positions the seal contact point above the principle axis of the energizing O-ring to maximize seal contact force and sealing efficiency.

The U2 profile may also be utilized in highly abrasive rotary applications where PTFE contact seals are not suitable, such as mud motors. This profile forms a positive contact seal, rather than a hydro-dynamic seal, often used in this type of application, leading to longer oil reservoir retention and increased life.

STANDARD MATERIALS

	Material Code	ASTM Designation	Temperature Range	Description
JACKET	Q48TC	AU	-37°C to +110°C	Hydrolysis resistant
	Z95X	HNBR	-25°C to +180°C	ED resistant
	Z85TM		-20°C to +150°C	Machined grade
	Z85B		-20°C to +180°C	Abrasion resistant
	V91J	FKM	-17°C to +225°C	ED resistant
	V85TM		-20°C to +220°C	Machined grade
ENERGISER	N75L	NBR	-60°C to +135°C	Low temperature
	N70M		-40°C to +120°C	General purpose
	N73B		-35°C to +120°C	Low compression set
	Z70B	HNBR	-30°C to +180°C	General purpose
	Z85L		-40°C to +160°C	Low temperature
	A70H	FEPM	-5°C to +250°C	General purpose
	V75B	FKM	-20°C to +200°C	General purpose
	V75J		-15°C to +200°C	Steam and methanol resistant
	V71C		-51°C to +250°C	Low temperature

Lip Seals Profiles



Part numbering and ordering information

Part Number format:

V 8 5 T M - V 7 5 B - U 1 - 1 8 7 - 2 0 6 - 1 0 0 0

Jacket 4-6 digit material code

Energiser 4-6 digit material code

Profile U1, U2

Groove depth (Nominal radial cross section in inches x 1000)

Groove width (Nominal groove width in inches x 1000)

Nominal inner diameter of seal groove in inches x 1000

STANDARD CROSS SECTIONS

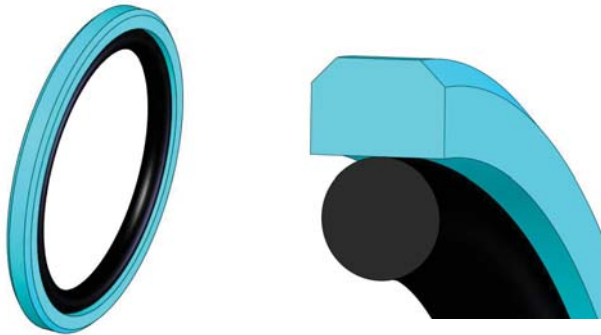
Nominal Gland Depth	Nominal Groove Depth (Inches)	U1 Groove width	U2 Groove width
1/8	0.125	0.138	0.275
3/16	0.187	0.206	0.343
1/4	0.250	0.275	0.413
5/16	0.312	0.343	0.550
3/8	0.375	0.413	0.688

Example

An U2 profile seal with a Z85TM jacket and N70A energiser, to be used in a 1/4" depth, 0.413" wide and 1" inner diameter groove would be referenced as: **Z85TM-N70M-U2-250-413-1000**

Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.

Non standard dimensions are available upon request.



Cap Seals (heavy duty)

Suitable for use on piston and rod bi-directional sealing applications, heavy duty cap seals consist of an elastomer O-ring and a PTFE cap. The elastomer is used to transmit system pressure to energise the cap which provides improved wear resistance, less friction and anti-extrusion properties.

The heavy duty (CH) profile cap seal offers long life, low wear, high surface speed (up to 4m/s), high pressure resistance (up to 40MPa or 5800psi) and maintains the differential pressure needed for operation. However cap seals are regarded as a wet seal as they typically allow an acceptable level of fluid transfer across the cap.

The CH cap seal is designed to allow retro-fitting into non-PPE grooves for seals of similar design.

STANDARD MATERIALS

	Material Code	ASTM Designation	Temperature Range	Description
ELASTOMER	N75L	NBR	-60°C to +135°C	Low temperature
	N70M		-40°C to +120°C	General purpose
	N73B		-35°C to +120°C	Low compression set
	Z70B	HNBR	-30°C to +180°C	General purpose
	Z75L		-40°C to +160°C	Low temperature
	A70H	FEPM	-5°C to +250°C	General purpose
	V75B	FKM	-20°C to +200°C	General purpose
	V75J		-15°C to +200°C	Steam and methanol resistant
	V71C		-51°C to +250°C	Low temperature
CAP	T99W	PTFE	-200°C to +260°C	Virgin
	T99C		-200°C to +260°C	25% Carbon
	T99X		-200°C to +260°C	15% Graphite
	T99B		-200°C to +260°C	40% Bronze
	T99GM		-200°C to +260°C	PTFE - 15% Glass 5% MoS ₂
	T99E		-200°C to +260°C	PTFE - 10% Ekonol

Part numbering and ordering information

Part Number format:

V 7 5 J - T 9 9 C - C H - P C U - 5 0 . 8 0

Elastomer 4-6 digit material code

Cap 4-6 digit material code

Profile CH

Rod Groove (R), Piston Groove (P)

Series (A-F)

Un-notched (U)

Inner diameter (mm) with two decimal places

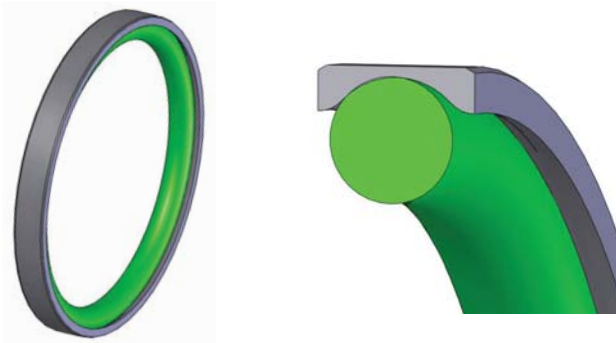
STANDARD CROSS SECTIONS

Series	Nominal delta in groove diameter (mm) - Rod	Nominal delta in groove diameter (mm) - Piston	Groove width (mm)	O-ring cross section (mm)	Maximum diametral clearance
A	4.9	4.9	2.2	1.78	0.3
B	7.3	7.5	3.2	2.62	0.3
C	10.7	11	4.2	3.53	0.4
D	15.1	15.5	6.3	5.33	0.4
E	20.5	21	8.1	6.99	0.5
F	24	24.5	8.1	6.99	0.5

Example

A CH profile cap seal with a V75J energizing O-ring and a T99C PTFE cap to be used in a piston groove in a nominal bore diameter of 50.80mm and groove depth of 5.5mm would be referenced as: **V75J-T99C-CH-PCU-50.80**

Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.



Cap Seals (low profile)

Low profile cap seals comprise a standard elastomer O-ring energiser and a shaped PTFE cap which conforms to the O-ring. This profile prevents spiralling and offers improved wear resistance in light to medium duty applications. The elastomer is used to transmit system pressure to energise the cap which provides, less friction and anti-extrusion properties.

The low profile (CL) seal is designed to allow retro-fitting into BS1806, MIL-G-5514 and AS4716 grooves.

STANDARD MATERIALS

	Material Code	ASTM Designation	Temperature Range	Description
ELASTOMER	N75L	NBR	-60°C to +135°C	Low temperature
	N70M		-40°C to +120°C	General purpose
	N73B		-35°C to +120°C	Low compression set
	Z70B	HNBR	-30°C to +180°C	General purpose
	Z75L		-40°C to +160°C	Low temperature
	A70H	FEPM	-5°C to +250°C	General purpose
	V75B	FKM	-20°C to +200°C	General purpose
	V75J		-15°C to +200°C	Steam and methanol resistant
	V71C		-51°C to +250°C	Low temperature
CAP	T99W	PTFE	-200°C to +260°C	Virgin
	T99C		-200°C to +260°C	25% Carbon
	T99X		-200°C to +260°C	15% Graphite
	T99B		-200°C to +260°C	40% Bronze
	T99GM		-200°C to +260°C	15% Glass 5% MoS ₂
	T99E		-200°C to +260°C	10% Ekonol

Part numbering and ordering information

Part Number format:

N 7 5 L - T 9 9 E - C L - R B U - 2 5 . 4 0

Elastomer 4-6 digit material code

Cap 4-6 digit material code

Profile CL

Rod Groove (R), Piston Groove (P)

Series A-F

Un-notched U

Inner diameter (mm) with two decimal places

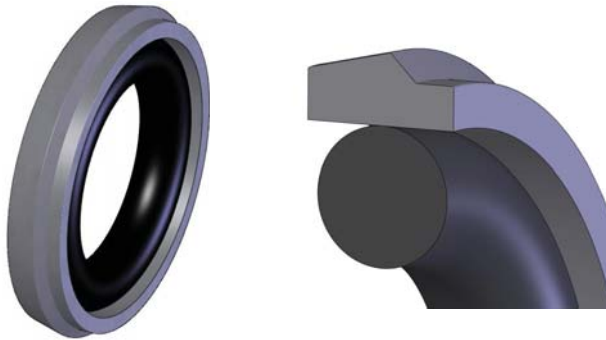
STANDARD CROSS SECTIONS

Series	Nominal delta in groove diameter (mm)	Groove width (mm)	O-ring cross section (mm)	Maximum diametral clearance
A	2.9	2.4	1.78	0.1
B	4.5	3.6	2.62	0.14
C	6.2	4.8	3.53	0.16
D	9.4	7.1	5.33	0.2
E	12.2	9.5	6.99	0.3
F	15	10	8.4	0.4

Example

A CL profile cap seal with a N75L energizing O-ring and a T99E PTFE cap to be used in a rod groove with nominal rod diameter of 25.40mm and nominal groove depth of 2.25mm would be referenced as: **N75L-T99E-CL-RBU-25.40**

Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.



Cap Seals (Venting)

Suitable for use on piston and rod dynamic sealing applications with uni-directional pressure venting, cap seals consist of an elastomer O-ring which energises a 'P' shaped profile PTFE stepped seal. The elastomer is used to transmit system pressure to energise the cap which provides improved wear resistance, low friction and anti-extrusion properties. The venting feature prevents the build up of trapped pressure in tandem sealing systems, which could otherwise result in high wear and system locking.

The venting (CV) profile cap seal offers long life, low wear, high surface speed (up to 15m/s) and high pressure resistance (up to 80 MPa or 11,600 psi).

CV cap seals are designed to allow retro-fitting into ISO7425-2 grooves typically used for seals of similar design.

STANDARD MATERIALS

	Material Code	ASTM Designation	Temperature Range	Description
ELASTOMER	N75L	NBR	-60°C to +135°C	Low temperature
	N70M		-40°C to +120°C	General purpose
	N73B		-35°C to +120°C	Low compression set
	Z70B	HNBR	-30°C to +180°C	General purpose
	Z75L		-40°C to +160°C	Low temperature
	A70H	FEPM	-5°C to +250°C	General purpose
	V75B	FKM	-20°C to +200°C	General purpose
	V75J		-15°C to +200°C	Steam and methanol resistant
	V71C		-51°C to +250°C	Low temperature
CAP	T99W	PTFE	-200°C to +260°C	Virgin
	T99C		-200°C to +260°C	25% Carbon
	T99X		-200°C to +260°C	15% Graphite
	T99B		-200°C to +260°C	40% Bronze
	T99GM		-200°C to +260°C	15% Glass 5% MoS ₂
	T99E		-200°C to +260°C	10% Ekonol

Part numbering and ordering information

Part Number format:

V 7 5 B - T 9 9 B - C V - R D U - 8 8 . 9 0

Elastomer 4-6 digit material code

Cap 4-6 digit material code

Profile CV

Rod Groove (R), Piston Groove (P)

Series A-F

Un-notched U

Inner diameter (mm) with two decimal places

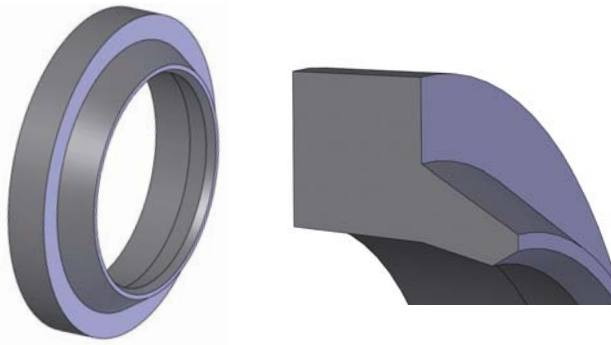
STANDARD CROSS SECTIONS

Series	Nominal delta in groove diameter (mm)	Nominal groove depth (mm)	Groove width (mm)	O-ring cross section (mm)	Maximum diametral clearance
A	4.9	2.45	2.2	1.78	0.3
B	7.3	3.65	3.2	2.62	0.3
C	10.7	5.35	4.2	3.53	0.4
D	15.1	7.55	6.3	5.33	0.4
E	20.5	10.25	8.1	6.99	0.5
F	24	12	8.1	6.99	0.5

Example

A CV profile cap seal with a V75B energizing O-ring and a T99B PTFE cap to be used in a rod groove with nominal rod diameter of 88.90mm and groove depth of 7.55mm would be referenced as: **V75B-T99B-CV-RDU-88.90**

Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.



Wiper Seals

An important element of any fluid power sealing system are wiper seals which prevent contaminants such as moisture, dust and debris entering the system and causing damage to metalwork and other sealing components. The snap-in configuration allows the W1 wiper seal to be fitted in many existing rod seal wiper grooves.

STANDARD MATERIALS

Material Code	ASTM Designation	Temperature Range	Description
N90M	NBR	-30°C to +120°C	General purpose
Z85B	HNBR	-20°C to +180°C	Abrasion resistant
Z85TM		-20°C to +150°C	Machined grade
V85TM	FKM	-20°C to +220°C	Machined grade

STANDARD CROSS SECTIONS

Series	Nominal groove depth (mm)	Groove width (mm)
A	3.3	2.4
B	4.4	3.6
C	6.3	4.8

Part numbering and ordering information

Part Number format:

Z 8 5 B - W 1 - A - 5 2 . 5 0

Elastomer 4-6 digit material code

Profile W1

Series A-C

Inner diameter (mm) with two decimal places

Example

A Z85TM, W1 wiper to be used in a rod groove with nominal rod diameter of 60.00mm and nominal groove depth of 4.4mm would be referenced as: **Z85TM-W1-B-60.00**

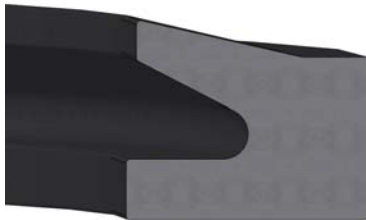
Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.

High pressure closure lip seals

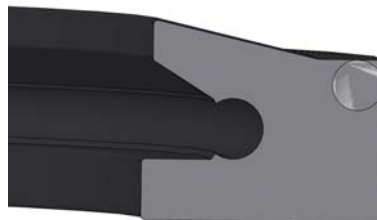
PPE has extensive expertise in the design of lip seals for high pressure enclosures and can offer custom designs and material selection to meet the specific requirements of your application. Seals can be designed to customer requirements to meet ASA ratings up to 2500 lbf with seal diameters up to 72 inches (1.8 metres) in a range of materials optimized for oil and gas applications.



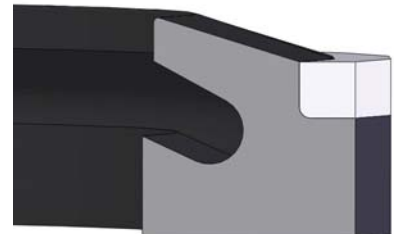
Typical Seal Designs



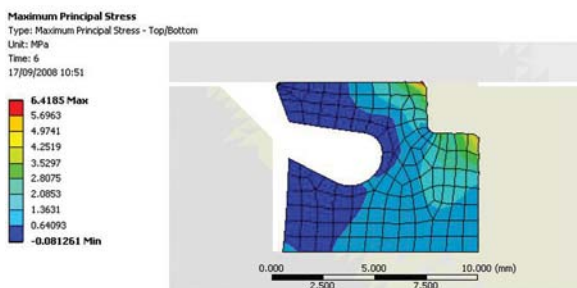
Low pressure seal



High pressure – integrated spring



High pressure – integrated back-up



ANSYS
v11



Finite element analysis of high pressure seal with back-up

Wear Rings / Bearings

Available in a variety of PTFE and PEEK blends, wear rings provide low friction bearings for use in rod and piston sealing applications. Designed to fit into ISO 10766 groove dimensions, the PPE range of PTFE and PEEK bearings is available with either a diagonal or square cut to meet the requirements of most oilfield applications.

It is common practice to increase the radial clearance when a bearing is introduced into the system. Contact PPE / AOS for seal / bearing system design assistance.

STANDARD MATERIALS			
Material Code	ASTM Designation	Temperature Range	Description
T99W	PTFE	-200°C to +260°C	Virgin
T99C		-200°C to +260°C	25% Carbon
T99X		-200°C to +260°C	15% Graphite
T99GM		-200°C to +260°C	15% Glass 5% MoS ₂
T99E		-200°C to +260°C	10% Ekonol
T99B		-200°C to +260°C	40% Bronze
T55B	PEEK	-200°C to +250°C	Virgin
T56B		-200°C to +240°C	Bearing grade
T57B		-200°C to +240°C	Glass filled
T58B		-200°C to +240°C	Carbon filled

See product datasheets for specific material properties.



J1 (Piston) / J3 (Rod)



J2 (Piston) / J4 (Rod)



Part numbering and ordering information

Part Number format:

T 5 5 B J 1 - 5 5 . 0 0 - 2 . 5 0 - 9 . 7 0 - 4 . 5

Bearing 4-6 digit material code

Profile J1, J2, J3, J4

Nominal diameter (mm) (Bore/Rod) with two decimal places

Nominal Cross Section (mm) with two decimal places

Groove width (mm) with one decimal place

Gap (mm) with one decimal place

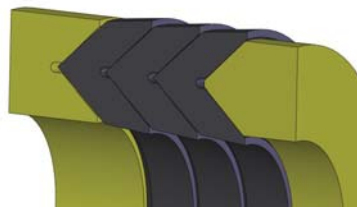
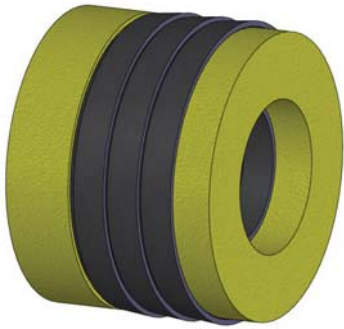
STANDARD CROSS SECTIONS

Nominal groove depth (mm)	Groove width (mm)
1.55	2.5
1.55	4
2.5	5.6
2.5	9.7
2.5	15
2.5	25
4	25

Example

A virgin PEEK, J1 wear ring to be used in a piston groove with nominal bore diameter of 55.00mm, nominal groove depth of 2.5mm, nominal groove width 9.7mm and gap 4.5mm would be referenced as: **T55BJ1-55.00-2.50-9.70-4.5**

Groove dimensions, inspection drawings and 3D CAD files may be downloaded using the PPELive on-line service, see page 7.



V-packing / Stack Sets

Stack sets comprise of one or more rings with a V-shaped profile that are positioned between male and female adapters, which are fitted top and bottom, to form a multi-lip packing suitable for mechanically challenging conditions in rod and piston locations.

Typical applications include mud pump packing where the seals encounter high pressure and an abrasive media containing various solids, oil and water.

PPE can provide V-Packing sets manufactured from moulded or machined elastomers, PTFE and PEEK.

Additional V-rings are added to the stack for high pressure applications, see table below.

RECOMMENDED NUMBER OF V-RINGS PER STACK

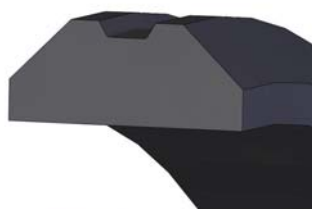
Pressure		Minimum number of V-rings
MPa	psi	
Up to 7	Up to 1000	3
7 - 14	1000 - 2000	4
14 - 27	2000 - 4000	5
27 - 41	4000 - 6000	6

Packer elements

High performance elastomer packer elements are a vital component of completion hardware. Used to provide a seal between the outside of the tubing and the inside of the casing, liner, or wellbore wall, the packer isolates and protects the annulus, preventing reservoir fluids from flowing up the full length of the casing and damaging it. PPE are experts in the manufacture of homogeneous, large cross section parts with low porosity to ensure excellent performance under high mechanical strain. PPE can post machine under-cuts into the inner diameter of a packer, or for ease of assembly, PPE can mould in-situ metallic components.



Dovetail Packing Element



Blow-out Preventer Ram Blocks

Ram blocks are used in pairs in blowout preventers, located at the wellhead. Their function is to clamp shut to seal off the wellbore, preventing the escape of pressure in the event of an unwanted blow-out of fluid or gas. Manufactured from high performance elastomer and steel and available in a range of sizes, ram blocks seal the hole without severing the drillstring allowing pressure control to be regained inside the well.



Pigs

Pipeline cleaning is an important component of any long-term integrity and maintenance program. Elastomer cleaning pigs are designed to remove internal debris from pipelines whilst they are propelled along by the pressure of the product. Pigs may incorporate a magnet to assist with location identification. Sealing pigs are also used to provide a seal between two products within the pipeline or sweep liquids from the line.



Wiper darts

Wiper darts are designed to displace well fluids and cement and act as a mechanical barrier to avoid the contamination of the cement with mud inside drill pipe and liner.



Bonded Port Seals

PPE supply bonded seal designs to allow port transitions at high pressure.



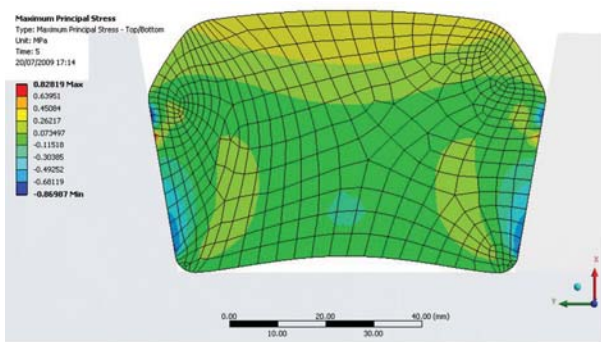
Products

Custom components

PPE and AOS offer a complete component design service with the ability to design and manufacture custom parts and bespoke engineered components to customer specifications.

Problem-solving is central to our culture, providing customers with optimal design solutions. Using the latest elastomer materials and manufacturing techniques, combined with many years experience, we can produce custom shapes and profiles to meet any requirements.

In developing custom parts we work closely with our customers to develop solutions that last longer, require less maintenance and deliver the lowest cost of ownership.



Finite element analysis of pipeline recovery tool seal.

PPE seals provide competitive advantage for innovative subsea pipeline tools

A leading, global supplier of pipeline recovery tools invited PPE to redesign the seal used during the dewatering operation. The existing seal and back-up rings used in the tools had to be returned to the surface to be replaced and reset after use. Using the latest seal design technology PPE provided a unique single unit seal, made from Z70B HNBR material, that allowed the seal to be reset after use subsea using an ROV (remote controlled vehicle). The new seal provides improved efficiency and enables the company to offer more operational flexibility during the laydown and recovery of subsea pipelines.

Product Selection Guide by Application

	APPLICATION	PRODUCTS / PROFILES															MATERIALS									
		O-rings	Back-up Rings	T-seals	L-seals	V-stack sets	X-rings (4-lobe seals)	Lip seals	Cap seal - HD	Cap seal - LP	Cap seal - stepped	Wiper seals	Spring seals	BOPs	Packers	Wear rings (bearings)	Custom components	EPDM	NBR	HNBR	FKM	FEPM	FFKM (Perlast®)	PEEK	PTFE	TPU
GENERAL	Filters	o																	o	o	o					
	Manifolds	o			o														o	o	o	o	o			
	Swivels	o		o			o	o									o		o	o	o	o	o			
	Actuators	o	o	o	o		o	o	o	o	o	o					o		o	o	o			o	o	o
EXPLORATION & DRILLING	MWDs	o	o	o													o			o	o				o	
	Cementing equipment					o														o						
	Mud pumps					o		o							o		o			o						
	Drill bits	o															o			o						
	Actuators	o	o	o		o		o	o	o	o	o					o			o	o	o		o		o
	Fishing Tools	o	o	o	o			o	o								o				o	o				o
TESTING & COMPLETION	Logging equipment	o	o	o		o											o			o	o	o	o	o	o	o
	Perforating equipment	o		o													o			o	o			o		
	Line packers & hangers					o											o		o			o	o		o	
	Christmas trees	o	o	o															o	o	o	o	o		o	o
	Sampling	o	o	o						o		o					o				o		o		o	
PRODUCTION / SUBSEA	Wellhead	o	o	o													o			o	o	o		o	o	
	Chokes & valves	o	o	o													o			o	o	o		o	o	
	Blow out preventors (BOPs)													o						o	o					
	Enhanced oil recovery	o	o	o	o	o								o	o		o			o	o	o	o	o	o	o
	Flow management			o		o											o			o	o	o		o		
	Pumps & compressors	o	o	o																o	o	o	o	o		o
	Power gen-sets	o						o									o	o			o					
	Pipelines	o																	o							
	Risers	o															o				o					
Carbon (CO ₂) capture / storage		o	o															o				o	o			



Precision Polymer Engineering Limited

Greenbank Road
Blackburn
BB1 3EA
England

Tel: +44 (0) 1254 295400
Fax: +44 (0) 1254 680182
Email: sales@prepol.com
www.prepol.com



Aberdeen O-rings & Seals Limited

Block 1, Unit 8 Souterhead Road Industrial Estate
Altens, Aberdeen
AB12 3LF
Scotland

Tel: +44 (0) 1224 877844
Fax: +44 (0) 1224 877866
Email: sales@aberdeenseals.co.uk
www.aberdeenseals.co.uk

PERLAST®

Perfluoroelastomer Parts

Perlast Limited

1754 Technology Drive, Suite 244
San Jose
CA 95110
USA

Tel: +1 408 441 2043
Fax: +1 408 441 1042
Email: sales-usa@perlast.com
www.perlast.com



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