Elastomers for the oil & gas industry
The science of elastomer compounding is regarded by many as a ‘black art’ - one in which our technologists have become recognised experts.

Elastomers in significant use in the oil and gas industry are selected for fluid seal applications according to their physical and chemical characteristics, such as temperature capability and media resistance.

It is important however to recognise that a crude polymer can only be made into an engineering elastomer through the addition of a multitude of compounding chemicals. It is the nature and combination of these chemicals that ultimately defines the characteristics of an elastomer.

Compounding

The science of compounding is regarded by many as a ‘black art’ with technologists worldwide striving to perpetuate this mysticism. Although many manufacturers base their compounds and seals on the same polymer, they may perform in significantly different ways - in some cases as disparate as short-term failure against long-term capability.

In excess of 20 classes of compounding ingredients exist. These range from reinforcing fillers, curatives, accelerators, protectants, coupling agents and fire retardants, through to extenders and process aids - enabling almost an infinite variety of grades to be compounded.

End users must satisfy themselves that their seal suppliers operate a no-compromise policy with regard to compounding, using only the highest quality raw ingredients, purchased from reputable suppliers to rigorous specifications, and then judiciously compounded to give optimum properties.

It is easy to dilute expensive specialised materials with cheaper ingredients to lower the cost of a final elastomer compound, or to add large quantities of process aids that ease production. These policies often lead to impaired performance.

In-house compounding

Behind the brand

Through its Materials Technology Centre in the UK, James Walker develops and compounds its own range of elastomer materials, holding over 300 unique formulations including many bespoke developments for specific customer applications.
Material selection

Low temperature performance

Establishing the operational low temperature performance of elastomers is a highly complex task and ultimately dependent on other application conditions such as pressure, seal configuration, storage, assembly and media.

For this reason it is essential that customers discuss specific application conditions with the James Walker Technical Support Team.

In order to provide transparency when comparing the performance of different compounds we have used two common laboratory test methodologies: Temperature retraction and Gehman torsional modulus.

Whilst these tests do not provide absolute figures for performance in application, they do offer a basis for the accurate comparison of low temperature capability between different materials.

**TR10 temperature retraction**

(ISO 2921)

Material sample is stretched and cooled then allowed to retract freely as the temperature is raised.

The temperature at which the sample has recovered by 10% is referred to as TR10.

**T70 Gehman torsional modulus**

(ISO 1432)

The temperature at which an elastomer sample stiffens and the limit of technically useful flexibility is reached. This is commonly defined by a torsional modulus value of 70 MPa.

Sealing capability testing

In an effort to provide greater clarity on materials capability James Walker uses a product configured test in an effort to determine the lowest possible temperature at which each material will effect a seal. We make this assessment using an O-ring in a constrained housing to replicate conditions of designed groove fill, squeeze and surface finish.

The results only relate to the product in the format and conditions tested and offer no accurate guidance to performance in application where the media, pressure, product design, housing design and housing surface finish will all have a bearing on performance.

It is our belief that, when selecting and specifying materials, relying solely on published low temperature claims utilizing undisclosed test methodologies is unwise and potentially dangerous. The only true method to determine whether the low temperature sealing capability of a material will be suitable is to undertake product configured tests under conditions as close as possible to those found in application.
A variety of industry standards and test methods exist for evaluating rapid gas decompression resistance in a way that allows compound performance to be compared.

Regardless of the test used, James Walker maintains a position that only materials capable of sustaining no damage under industry standard RGD testing will provide optimum operational safety in critical applications.

**NORSOK M-710 Annex B Rev. 2/3**
- Media: 90% CH₄, 10% CO₂
- Temperature: 100°C (212°F)
- Pressure: 150 bar / 15 MPa (2176 psi)
- Decompression rate: 40 bar/min
- Number of cycles: 10/8

**ISO 23936-2**
- Media: 85% CH₄, 15% CO₂
- Temperature: 100°C (212°F)
- Pressure: 150 bar / 15 MPa (2176 psi)
- Decompression rate: 40 bar/min
- Number of cycles: 8

**Total GS EP PVV 154 and PVV 156**
- Media: 80% CH₄, 20% CO₂
- Temperature: 75°C (167°F)
- Pressure: 190 bar / 19 MPa (2756 psi)
- Decompression rate: 127 bar/min
- Number of cycles: 5

Both media and temperature have a major influence on RGD performance and because of this, testing beyond standard industry approvals is required to assess full capability for resistance to RGD in operational conditions.

James Walker operates one of the most comprehensive facilities for RGD testing and regularly undertakes testing for customers to validate seal performance in application specific conditions.

**Behind the brand**

**Vermilion®** Three fluoroelastomer material formulated by James Walker is the first elastomer Shell TAT approved to Shell MESC SPE 85/301.
Many chemical species cause degradation to elastomeric compounds, either by attacking the polymer or some of its compounding ingredients.

Such degradation is often highly dependent on exposure temperature, in terms of both the reaction initiating in the first place, and then the rate at which the reaction proceeds.

**Sour (H₂S)**

Hydrogen sulphide, H₂S, is present in oilfield media in quantities from a few ppm to high percentages but its effects on elastomeric materials are highly temperature dependent.

The resistance of our materials to sour media is assessed through undergoing the industry-recognised Norsok M-710 / ISO 23936-2 test regime. This provides a solid indication of a material’s response to exposure to H₂S and through measuring the effects over differing time periods across a range of concentrations it is possible to generate a predicted life expectancy using the Arrhenius model.

Whilst such figures are not necessarily representative of an operational life, they do allow meaningful comparison of ‘sour’ resistance across different materials.

Although some materials are shown to have excellent resistance to H₂S this is always dependent on other application parameters and often at the expense of performance in other areas. For this reason it is always advisable to consult our Technical Support Team.

**Carbon Dioxide (CO₂)**

CO₂ is a small polar molecule and will readily diffuse into elastomers and at high pressures will be in the form of a supercritical fluid. During depressurisation the supercritical CO₂ can revert to a gas with a significant increase in volume.

It is for this reason that CO₂ is so aggressive towards elastomeric seals and because of this James Walker has invested in an extensive test programme to evaluate performance and develop materials suitable for this media.

**Methanol**

The use of methanol is important and extensive in the Oil & Gas industry in applications such as hydrate inhibitors, drying pipelines or as a chemical solvent.

Methanol can cause excessive volume swell in elastomeric seals but to combat this James Walker has specifically formulated materials in the Vermilion® range that have excellent methanol compatibility – greatly extending their use within oil and gas applications.

Behind the brand

James Walker offers a range of materials testing options including chemical compatibility and rapid gas decompression plus testing under extremes of temperature and pressure through its Materials Technology Centre in the UK.
Fluoroelastomers (FKM)

Fluoroelastomers offer excellent resistance to oils, fuels, mineral and synthetic lubricants, aliphatic and aromatic hydrocarbons, plus H₂S and sour conditions.

Advantages:
- All FKM materials featured in this publication have been compounded for excellent rapid gas decompression (RGD) resistance.

Limitations:
- Limited resistance to steam, hot water, and other polar fluids. Special grades are available, resistant to low alcohols such as methanol.

Typical temperature range:
- -32°C to +200°C (-26°F to +392°F). In product configured testing under laboratory conditions, special ultra-low temperature grades have been shown to work down to -60°C (-76°F).

Notes:
- Properties vary significantly with type.

Formulated specifically for critical oil and gas applications, our range of fluoroelastomers includes:

- Vermilion® One
- Vermilion® Two
- Vermilion® Three
- FR® 25/90
- Vermilion® Four
- FR® 58/90

Behind the brand

James Walker introduced the first fluoroelastomer compounds with rapid gas decompression resistant properties in the 1980s to meet the demands of deepsea drilling applications in the North Sea oilfields.
A fluoroelastomer (FKM) with ultra-low temperature capability and excellent methanol resistance. Providing excellent H₂S resistance and typical FKM tolerance of aromatics and hot water, this material also offers good resistance to rapid gas decompression (RGD).

Sealing capability confirmed down to -60°C (-76°F) in product configured testing.

(See material data sheet for test details)
**Vermilion® Two**

**Methanol resistance**

A fluoroelastomer (FKM) with excellent resistance to methanol, H₂S and rapid gas decompression (RGD), providing good low temperature performance and the typical FKM tolerance of aromatics and hot water plus inherent extrusion resistance.

Sealing capability confirmed down to -46°C (-51°F) in product configured testing.

(See material data sheet for test details)
Vermilion® Three is a next generation enhanced performance development of James Walker’s industry leading FR® 25/90 material.

A fluoroelastomer (FKM) offering excellent temperature performance, resistance to H₂S and rapid gas decompression (RGD) plus the typical FKM tolerance of aromatics and hot water.

Sealing capability confirmed down to -46°C (-51°F) in product configured testing (See material data sheet for test details)
**RGD performance**

An excellent cost-effective general purpose fluoroelastomer (FKM) providing outstanding resistance to rapid gas decompression in addition to the resistance to H₂S, aromatics and hot water typical of an FKM.

This low temperature material has now been superseded by Vermilion® Three which provides enhanced RGD resistance at elevated temperatures.

Sealing capability confirmed down to -46°C (-51°F) in product configured testing.

(See material data sheet for test details)

This is a graphical overview of material performance characteristics.

Details of all approvals are available on our material data sheets. Full third party test reports are also available.
Vermilion® Four

RGD and sour

Vermilion® Four is a next generation development of James Walker’s industry leading FR® 58/90 material with significant performance enhancement.

An excellent cost-effective general purpose fluoroelastomer (FKM) providing outstanding resistance to rapid gas decompression (RGD) at larger cross sections and higher temperatures, this material also provides excellent resistance to H$_2$S plus the tolerance to aromatics and hot water typical of a peroxide cured FKM.

Sealing capability confirmed down to -33°C (-27°F) in product configured testing.

(See material data sheet for test details)
Low temperature performance
TR10 -14°C (+7°F)
T70 -12°C (+10°F)

High temperature performance
Continuous +210°C (+410°F)

Sour qualification
Qualified to Norsok M-710 ISO 23936-2
‘sour’

Norsok M-710 / ISO 23936-2
Testing for RGD resistance
‘0000’ rating at 100°C
5.33 mm / 150 bar / 90% CH₄, 10% CO₂ / 8 cycles

RGD performance
FR®
58/90

A good cost-effective general purpose fluoroelastomer (FKM) providing excellent resistance to rapid gas decompression (RGD) at larger cross sections and higher temperatures, this material also provides the resistance to H₂S and aromatics typical of an FKM.

The benchmark FKM for over 30 years, this material has now been superseded by the outstanding performance of our next generation Vermilion® Four material.

Sealing capability confirmed down to -33°C (-27°F) in product configured testing

(See material data sheet for test details)
The complete package for exceptional performance and value across the widest range of applications.

Hydrogenated nitrile is derived from conventional nitrile. It is produced by a process that hydrogenates the unsaturation (carbon double bonds) in the butadiene unit of the polymer.

These materials have the excellent oil/fuel resistance of nitrile (NBR) elastomers combined with superior mechanical properties, improved chemical resistance, better weatherability, better thermal capability and outstanding abrasion resistance.

Advantages:
- Good oil/fuel and chemical resistance;
- Good weathering resistance, excellent mechanical properties inc. tensile strength, tear, modulus, elongation at break and abrasion; wide temperature range; can be compounded for excellent rapid gas decompression (RGD) resistance.

Limitations:
- Limited resistance to aromatics.

Typical temperature range:
- –36°C to +160°C, or +180°C in oil
- (–33°F to +320°F, or +356°F in oil).

Lower minimum temperatures can be achieved.

Notes:
- Special grades can be sulphur cured for dynamic applications but the higher temperature capability is reduced.

Formulated specifically for critical oil and gas applications, our range of HNBR elastomers includes:

- Vermilion® Five
- Elast-O-Lion® 985
- Vermilion® Seven
- Elast-O-Lion® 101

Behind the brand
If all the O-rings produced by James Walker in a year were stacked on top of each other, the column would reach the outer edge of the stratosphere.
Vermilion® Five is a next generation enhanced performance development of James Walker’s industry leading Elast-O-Lion® 985 material.

This hydrogenated nitrile (HNBR) material offers excellent low temperature performance combined with good resistance to rapid gas decompression (RGD) and sour conditions.

Sealing capability confirmed down to -55°C (-67°F) in product configured testing

(See material data sheet for test details)
Elast-O-Lion® 985 is a general purpose hydrogenated nitrile (HNBR) with superior mechanical properties, excellent low temperature capability and outstanding abrasion resistance.

This grade has now been superseded by our Vermilion® Five material which offers the same market leading low temperature capability combined with enhanced resistance to RGD.

Sealing capability confirmed down to -55°C (-67°F) in product configured testing
(See material data sheet for test details)
Vermilion® Seven is a next generation enhanced performance development of James Walker’s industry leading Elast-O-Lion® 101 material. An hydrogenated nitrile (HNBR) material offering excellent rapid gas decompression (RGD) resistance at elevated temperature and good resistance to sour conditions combined with outstanding physical robustness and improved extrusion resistance. Sealing capability confirmed down to -33°C (-27°F) in product configured testing. (See material data sheet for test details)

This is a graphical overview of material performance characteristics. Those characteristics highlighted in blue underlined text represent the areas of enhanced performance over existing technology.

Details of all approvals are available on our material data sheets. Full third party test reports are also available.
Elast-O-Lion® 101

RGD and sour resistance

An excellent cost-effective general purpose hydrogenated nitrile material (HNBR) providing excellent resistance to rapid gas decompression and abrasion.

Elast-O-Lion® 101 is a first generation material developed over 35 years ago and still regarded as a benchmark material for many critical oil and gas applications.

Sealing capability confirmed down to -33°C (-27°F) in product configured testing.

(See material data sheet for test details)
These are usually recognised by the trade name Aflas® and have base dipolymers that differ in viscosity and molecular weight.

FEPM compounds have resistance to oils, lubricants and some fuels approaching that of fluoroelastomer dipolymers. In addition, they exhibit excellent resistance to steam, amines, hydrogen sulphide, acids and bases. Fluorine content is around 56%, which may appear a retrograde step in fluoroelastomer development. However, synergy between the monomer units has resulted in a very useful, if specialised material.

The compounds can operate continuously at +170°C (+338°F) in steam and up to 200°C (392°F) in other media - however, they stiffen rapidly below 5°C (41°F).

Advantages:
- Excellent ozone/weathering resistance;
- good heat resistance;
- excellent resistance to steam and radiation;
- good overall chemical resistance.

Limitations:
- High Tg; low temperature is a limiting factor of this material type.
- Poor with aromatic hydrocarbons (BTEX).
- Poor extrusion resistance especially at high temperatures.

Typical temperature range: +170°C (+338°F) in steam with short excursions up to +260°C (+500°F);
other media +2°C to +200°C (+36°F to +392°F).

Formulated specifically for critical oil and gas applications, our range of FEPM elastomers includes;

Vermilion® Six
AF 69/90

Behind the brand
James Walker works at the cutting edge of material technology with third party test houses to understand the behaviour of elastomers under sour conditions.
Low temperature performance
TR10 +2°C (+36°F)
T70 +1°C (+34°F)

High temperature performance
Continuous
+200°C (+392°F)

Sour qualification
Qualified to Norsok M-710 ISO 23936-2 'sour'

Norsok M-710 / ISO 23936-2 Testing for RGD resistance
'0000' rating at 100°C
5.33 mm / 150 bar / 90% CH₄, 10% CO₂ / 8 cycles

Vermilion® Six is a next generation enhanced performance development of James Walker’s AF 69/90 material.

With typical characteristics of outstanding heat, amine, acid, H₂S and hot water resistance, this Aflas® material also provides good levels of resistance to rapid gas decompression (RGD).

Sealing capability confirmed down to -15°C (+5°F) in product configured testing

(See material data sheet for test details)
A robust Aflas® based synthetic rubber with excellent resistance to steam, amines, bases, methanol and hydrogen sulphide plus oils and lubricants.

AF 69/90 is a first generation material regarded as a benchmark material of its type for many critical oil and gas applications.

Sealing capability confirmed down to -15°C (+5°F) in product configured testing

(See material data sheet for test details)
Health warning: If fluoroelastomer (eg, FKM, FFKM, FEPM) products are heated to elevated temperatures, fumes will be produced which may give unpleasant effects, if inhaled. Whilst some fumes are emitted below 250°C from fluoroelastomers, the effect at these temperatures is negligible. Care should be taken to avoid contaminating tobacco with particles of fluoroelastomer, which may remain on hands or clothing. Safety Data Sheets (SDS) are available on request.

Information given in this publication is given in good faith and represents the results of specific individual tests carried out by James Walker or third parties in accordance with the methodologies described in this publication, performed in a laboratory. No representation or warranty is given in relation to such information. Values and/or operating limits given in this publication are not an indication that these values and/or operating limits can be applied simultaneously. While such results may comprise useful additional information and are industry standard tests, they are no substitute for conducting (or procuring from James Walker) your own tests and engineering analysis and satisfying yourself as to the suitability of the product you select. Please also note that a product tested in accordance with the published methodology may not perform to such values in application and/or under different test conditions or methodologies for a variety of reasons, including but not limited to the environment in which it is used/tested or which passes through it or otherwise affects the product, or due to the handling, storage or installation, or due to the effect of housing or other parts. Our personnel will be happy to discuss any historical examples we have of a product having been previously used in a particular application.

To ensure you are working with the very latest product specifications, please consult the relevant section of the James Walker website: www.jameswalker.biz.

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