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Compatibility testing of elastomeric materials for rotary sealing use with Environmentally Acceptable Lubricants (EALs) in marine propulsion applications

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Compatibility testing of elastomeric materials for rotary sealing use with Environmentally Acceptable Lubricants (EALs) in marine propulsion applications

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With the introduction of regulations such as the US Environmental Protection Agency's Vessel General Permit (VGP) requiring vessels sailing in US coastal waters to use Environmentally Acceptable Lubricants (EALs) on all applications that have the potential for an "oil-to-sea" interface, it is now essential to develop a clear understanding of the effect on seals and components of switching to such lubricants.

At James Walker we have been carrying out static immersion testing on EALs for many years, and continue to do so; although during this time it has become apparent elastomeric compatibility can vary between static and dynamic applications.

Immersion testing remains an important part of our test regime for applications where there is little heat generated. It is particularly relevant when looking at static or semi-static applications such as steering positions in rudderstocks and azimuths, and controllable pitch propeller blade seals.

For our immersion testing, as part of our grading criteria for EAL applications (Fig 3), we have introduced limits to the changes in mechanical properties that are not listed in ISO/TR7620:2005 (Rubber Materials – Chemical Resistance). These are relatively stringent in order to provide the utmost confidence in the materials we offer for such applications. As a result of the introduction of our grading system, there may be some minor changes in suitability ratings to those previously reported in individual tests.

Our investigations have highlighted that seal materials used for dynamic applications such as propulsion shafts need to be validated as actual products rather than simple material samples. A number of factors can influence the performance of the seals that cannot necessarily be identified by immersion testing alone, most prominently the higher under-lip temperatures in the contact area, lubricity of the fluid and the mechanics of generating a fluid film.

It has been identified that the condition of the lubricant can influence rubber compatibility, in particular water content due to contamination. This not only reinforces the importance of testing seals on water/oil interfaces, but has directly affected our immersion testing regime. As a result we not only conduct immersion tests on pure lubricants, but also in lubricant and water mixes. It is recommended that tests last at least 1000 hours with changes monitored to ensure a swell equilibrium point is reached. There is evidence from immersion testing results that any volume swell or reaction in the fluid does not necessarily reach a 'plateau' or saturation point during short term tests, particularly where water contaminated lubricant is tested.

In order to fully comply with the VGP, EALs are chosen for their ability to biodegrade as per the definition in Appendix A of the 2013 VGP, whilst also being optimised for maximum performance under adverse conditions. Due to the very nature of these EALs, certain base oil types may be susceptible to chemical or physical influences in the presence of water at localised interfaces. Such interactions may affect seal performance through changes to lubricity, viscosity and heat build-up.

At James Walker we have been testing our elastomeric lip seals on dynamic shaft rigs simulating marine water interface applications since 2010. To undertake such a programme we have invested in a purpose-built multi-shaft rotary test rig, with each head capable of handling multiple fluids.



Fig 1: Fully computerised, multi-head test rig with continual data logging.

For applications subject to constant rotation, dynamic testing is required to determine EAL compatibility. Using our dynamic test rigs we have ‘screened’ a range of bio-oils with combinations of seal designs, seal materials, operating pressures and shaft materials in order to provide a rating on a scale from recommended to unsuitable.

Dynamic testing is also carried out over at least 1000 hours assessing water/oil interfaces, accurately representing marine propulsion sealing positions. Grading is determined by monitoring measures of torque and leakage, supplemented by an assessment of post-test seal condition.

Seal and lubricant combinations must perform well to meet James Walker’s high standards for long term sealing. Though both the ‘Recommended’ and ‘Fair’ classifications shown in our results completed the required test durations, some evidence suggesting that there is a risk of leakage occurring in the long term would have been observed where a ‘Fair’ has been given. These observations include and are not limited to trends in leakage and torque levels and changes in seal condition.

The results in this paper focus on Bi-O-Lion®, our new material specifically designed for compatibility with EALs in marine propulsion applications. Other materials have been included in the test programme, though their results are not included in this report. We are happy to provide test results for other elastomers and discuss their implications on request.

Compatibility results for static / semi-static & dynamic application testing of Bi-O-Lion® fluoroelastomer compound

	EAL	Static / semi-static Without water	Static / semi-static With water	Dynamic oil / water interface
46 Viscosity	Castrol BioBar 46	Recommended	Recommended	Not tested
	Greenstar Hydraulic Safety Bio 46	Recommended	Recommended	Not tested
	Klüberbio LR 9-46	Recommended	Recommended	Not tested
	Panolin HLP Synth 46	Recommended	Recommended	Not tested
	Panolin HLP Synth E 46	Recommended	Recommended	Not tested
	RSC EnviroLogic HF 46 HP	Recommended	Recommended	Not tested
68 Viscosity	Castrol BioBar 68	Recommended	Recommended	Not tested
	Castrol Biostat 68	Recommended	Recommended	Not tested
	Greenstar Hydraulic Safety Bio 68	Recommended	Recommended	Not tested
	Klüberbio EG 2-68	Recommended	Recommended	Recommended
	Klüberbio Bio LR 9-68	Recommended	Recommended	Not tested
	Neptune AW 68	Recommended	Recommended	Fair
	Panolin HLP Synth 68	Recommended	Fair	Not tested
	Panolin HLP Synth E 68	Recommended	Recommended	Not tested
	Panolin Stella Maris 68	Recommended	Recommended	Recommended
	RSC Envirologic GO 68	Recommended	Recommended	Not tested
	RSC Futerra HF68	Recommended	Recommended	Not tested
	Shell Naturelle S4 Gear Fluid 68	Recommended	Recommended	Not tested
	Vickers BioGear XP68	Recommended	Recommended	Not tested
	Vickers Ecosure EAF 68	Recommended	Recommended	Not tested
	Vickers Ecosure HSE 68	Recommended	Recommended	Not tested
Vickers Hydrox Bio 68	Recommended	Recommended	Recommended	
100 Viscosity	Castrol Biostat 100	Recommended	Recommended	Not tested
	Fuchs Plantogear 100S	Recommended	Recommended	Not tested
	Klüberbio EG 2-100	Recommended	Recommended	Recommended
	Panolin EP Gear Synth 100	Recommended	Recommended	Recommended
	Panolin Margear 100	Recommended	Recommended	Recommended
	RSC Envirologic GO 100	Recommended	Recommended	Not tested
	RSC Futerra HF100	Recommended	Recommended	Not tested
	Shell Naturelle S4 Gear Fluid 100	Recommended	Recommended	Not tested
	Vickers Biogear XP 100	Recommended	Recommended	Recommended
	Vickers Hydrox Bio 100	Recommended	Recommended	Not tested
	Neptune AW 109	Recommended	Recommended	Not tested

Cont'd

Recommended	Fair	Unsuitable	Not tested
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Fig 2: Compatibility results for static / semi-static and dynamic applications of Bi-O-Lion® fluoroelastomer compound

Compatibility results for static / semi-static & dynamic application testing of Bi-O-Lion® fluoroelastomer compound cont'd

EAL		Static / semi-static Without water	Static / semi-static With water	Dynamic oil / water interface
150 Viscosity	Castrol Biostat 150	Recommended	Recommended	Fair
	Klüberbio EG 2-150	Recommended	Recommended	Recommended
	RSC Envirologic GO 150	Recommended	Recommended	Not tested
	Shell Naturelle S4 Gear Fluid 150	Recommended	Recommended	Not tested
	Vickers BioGear XP 150	Recommended	Recommended	Fair
220 Viscosity	RSC Envirologic GO 220	Recommended	Recommended	Not tested
Grease	Panolin Margrease EP0	Recommended	Recommended	Not tested
	Vickers Bio Grease EP2	Recommended	Recommended	Not tested
		Not tested	Not tested	Not tested

Recommended	Fair	Unsuitable	Not tested
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Fig 2: Compatibility results for static / semi-static and dynamic applications of Bi-O-Lion® fluoroelastomer compound

Static		Dynamic
Minimal changes in volume and mechanical properties. No, or minor evidence of a long term risk of elastomer incompatibility	Recommended	Seal and lubricant combination that has completed the test duration exhibiting low leakage, in addition to having torque within acceptable limits. No, or minor evidence of a long term risk of leakage occurring
Some changes in volume and mechanical properties. Some evidence of a long term risk of elastomer incompatibility	Fair	Seal and lubricant combination that has completed the test duration but may have shown higher than recommended leakage rates, or have torque greater than recommended limits. Some evidence of a long term risk of leakage occurring.
Unacceptable changes in volume and mechanical properties. Strong evidence of a long term risk of elastomer incompatibility	Unsuitable	Seal and lubricant combination may not have completed the test duration exhibiting higher than acceptable leakage. The torque levels could be greater than the recommended amount, or there may be evidence of excessive seal degradation.

Fig 3: Compatibility criteria for Static / Semi-static immersion testing and Dynamic testing

Our research on the use of EALs with James Walker seals and materials continues, using the methods and parameters laid out in this document, and we continue to develop materials to meet the changing requirements of the marine market.

The number of EALs on the market continues to grow so our compatibility testing programme will continue and our results will be published regularly on the James Walker website.

If a specific oil is not currently included in our results and you would like it to be tested, please ask your EAL supplier to contact us.

If you require any further information regarding the testing regime and compatibility of EALs with James Walker products, do not hesitate to contact your local representative using the contact details on the back cover of this document.

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