BHR Group
EXPERTS IN FLUID ENGINEERING

Modelling Rapid Gas Decompression in Elastomeric Systems

Physical testing and numerical prediction of seal material chemical and mechanical performance under HPHT conditions

The Challenge

Seal damage and observed gas leaks caused by Rapid Gas Decompression (RGD) in elastomeric seals have been reported in many types of equipment in the oil and gas industry. In the past 20 years, there has been substantial advance in understanding the failure mechanism, decompression resistant material development, seal function, test specification and software prediction techniques.

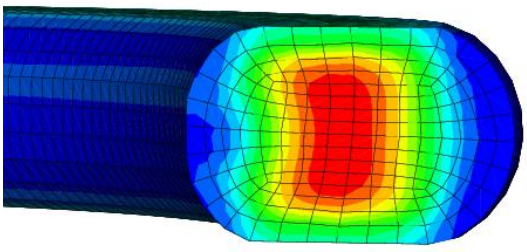
Many of the best performing decompression resistant materials are however non-conventional elastomers with very special material characteristics. This follow the industry trend of producing stiffer elastomer formulations, which have low elongation at break. This RGD performance increase is counter-intuitive and brings compromises in terms of ease of installation and compression set. The move to more exotic material and more aggressive or extreme operating environments places new demands on the qualification and certification of these materials for which industrial best practices and guidelines are urgently required.

RGD Fatigue in Elastomer

Project Goal and Approach

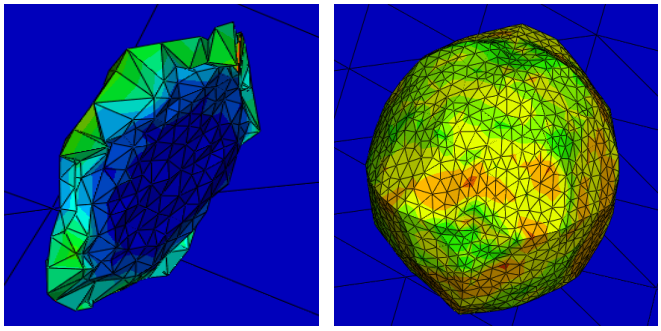
MODES (Modelling of Decompression in Elastomeric Seals) consortium programme has developed predictive tools to help engineers decide how to design or operate safely process plant, pipelines and other systems where there is the possibility of Rapid Gas Decompression (RGD) from elastomers or other rubber-like components.

Typical challenges faced by engineers that the programme addresses include selection of seal materials which is highly dependent on operational environments. It is therefore not appropriate to simply define a rapid decompression resistant material by a single test as many factors can contribute to RGD. It is also important for designers and operators to appreciate that there are other mechanisms that can cause damage or failure to a seal in high-pressure environments although these are not classed as RGD. Typical examples include seal extrusion damage, low temperature embrittlement and excessive thermal expansion.



Stress in an O-ring Seal in housing after thermal expansion

The MODES research programme has led to the development of a predictive modelling approach that can provide good approximations of RGD performance of many commercially available RGD materials. The parameters that the model addresses includes mechanical strength, fatigue, gas permeation, material variability, volumetric expansion, hardness and defect size and distribution. The research programme has focussed on:



Void compressed under thermal expansion and during RGD at 400bar showing gas expansion effects

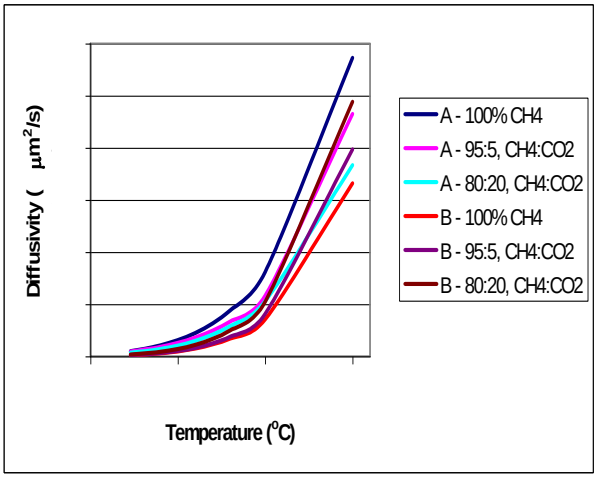
- developing functional test specifications and methodologies for elastomeric seals
- generating RGD data against industrial standard, NORSOK M-710 on a range of materials including FKM, HNBR, Aflas, nitrile
- developing a loosely-coupled void-failure Finite Element (FE) model for predicting and mitigating against RGD damage
- providing sponsors with an advanced model describing the plastic/elastic behaviour of highly filled seal materials.

The Results and Benefits

The MODES consortium has helped industry develop a common level of understanding, testing methods, sealing system design, validation criteria as well as cross assessment between historical test methods of processes where RGD may take place. These methods and the associated modelling software are provided to each member enabling them to:

- select appropriate seal system designs, seal and housing
- select appropriate sealing materials
- identify and quantify the potential for seal failure
- avoid downtime due to Rapid Gas Decompression failures
- assess the effect of RGD events on an existing installation
- define operating scenarios that avoid RGD conditions
- aid in understanding the RGD damage process
- work to relevant standards such as NORSOK M-710
- work to industrial guidelines such as such as those promoted

  by the UK Health and Safety Executive.



Diffusion properties at various gas compositions

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