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EVALUATING ELASTOMERIC MATERIAL KIFK10 FKM GLT AED IN CARBON DIOXIDE DECOMPRESSION ENVIRONMENTS

Version Control

Revision	Date	Description of Change + Reason for Change	Prepared by	Reviewed by
Initial issue	18-May-2021	First issue	K.Somani	M.Lewan

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1. SYNOPSIS

Industrial Spares Manufacturing & Trading Co. (ISMAT) required Element Hitchin to assess the rapid gas depressurisation (RGD) resistance of their elastomeric compound KIFK10 FKM GLT AED. Testing was undertaken according to the procedure given in the NACE TM0192-2012 Item No 21222 standard. The O-ring seals were exposed unconstrained and subjected to a single cycle gas test with 100% CO_2 at 25 °C and 52 bar (750 psi); the gas venting rate was ≤1 bar/minute.

2. OBJECTIVES

Industrial Spares Manufacturing & Trading Co. (ISMAT) have contracted Element Hitchin to carry out testing on KIFK10 FKM GLT AED, according to NACE TM0192-2012.

This document summarises the work undertaken by Element Hitchin.

3. MATERIALS AND METHOD

ISMAT delivered elastomeric compound KIFK10 FKM GLT AED to Element Hitchin on 13th January 2021 in the form of O-rings, which were logged in with a unique reference number according to Element quality procedure (Table 3.1).

Table 3.1: Test materials

COMPOUND	Element Quality Reference Number	Samples delivered
KIFK10 FKM GLT AED	M25617	6 off O-rings 37.47mm ID and 5.33 mm CSD

Samples before exposure are shown in Appendix A.

The test gas (carbon dioxide, grade 4.5 – 99.95% purity) was procured from Compressed Gas solutions Ltd.

3.1 Test conditions

The RGD test conditions are summarised in Table 3.2.

Table 3.2: NACE TM0192 – test conditions

Temperature	25 °C (±5 °C)
Pressure	5.2 ± 0.3 MPa (750 ± 50 psig).
Gas	100 $_{mol}$% CO_2
No. of cycles	1
Initial soak before decompression	24 ± 1 hour.
De-pressurization rate	≤1 bar/minute

All materials were exposed together in the same vessel.

3.2 NACE 0192 Test Procedure

The following test procedure was followed:

- Measure cross-sectional diameter and hardness of three replicate samples.

- Measure tensile properties of three replicates
- Exposure tests shall be conducted with six replicate samples. (Three for tensile testing and three for the NACE rating.
- Place the test samples in the test vessel and close it.
- Purge the test vessel three times with test gas to displace air.
- Charge the test vessel with test gas to a pressure of 10 bar before heating.
- Heat vessel to the test temperature (25°C).
- Charge the test vessel with the test gas to the test pressure (52 barg).
- Maintain the test pressure and temperature for the exposure period (24 hours minimum), recording temperature and pressure at regular intervals.
- At the end of the test period, check and record temperature, reduce the test pressure at the rate of ≤1 bar/minute.
- Open the test vessel and remove the test samples.
- Measure cross-sectional diameter and hardness of three specimens.
- Carry out visual inspection on three samples in accordance with rating system given in NACE TM0192 (see Table 3.3).
- Measure tensile properties of the remaining three samples.

The cross section diameter of all test O-rings was measured (radially) in three places using a calibrated digital vernier and the mean value used.

Hardness was measured in 5 places on each O-ring using a calibrated Wallace Cogenix IRHD hardness meter. The average values were reported.

Tensile properties of O-rings were measured at 23°C (±2°C) using a Zwick Z050 screw-driven test machine equipped with a calibrated 1 kN load cell, in accordance with ASTM 1414.

The test seals were installed in a pressure vessel equipped with an external band heater, calibrated pressure transducer, digital pressure gauge, internal thermocouple (located among the test specimens) and isolation needle valve. Cell pressure and temperature were logged continuously by a PC running dedicated data acquisition software: the pressure and temperature logs are given in result section

Gas release from the vessel was undertaken automatically, using custom venting equipment; the rate was 0.8 bar/minute. The seals were then retrieved and inspected according to the rating system given in the NACE TM0192 standard (Table 3.3).

Table 3.3: Description of rating number system for physical damage

Description	Rating
No visible damage	1
Minimal damage confined to the surface (few blisters and cracks)	2
External and internal damage (many blisters and cracks)	3
Extensive damage, fragmentation.	4

4. RESULTS

Figure 4.1 shows the pressure/temperature plot for the RGD test. Figure 4.2 shows the decompression profile at test temperature. The test was run between 3rd and 4th February 2021.

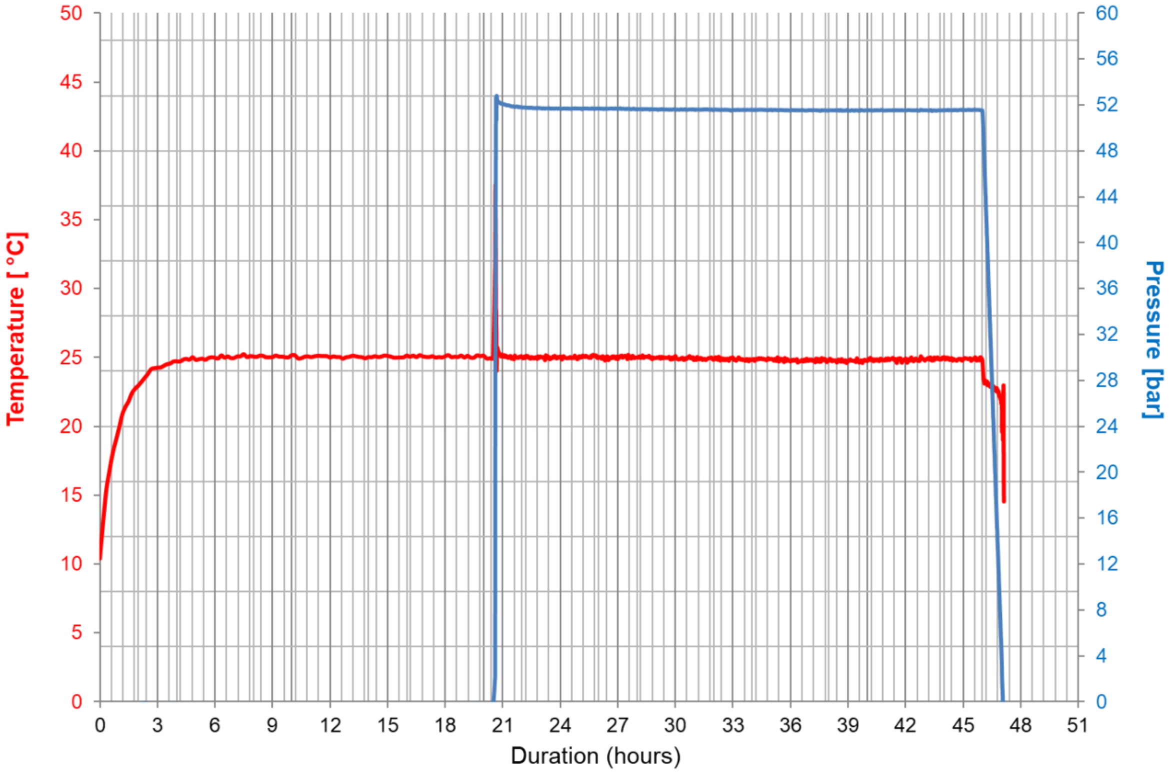

Figure 4.1: Temperature and pressure vs. time for RGD testing

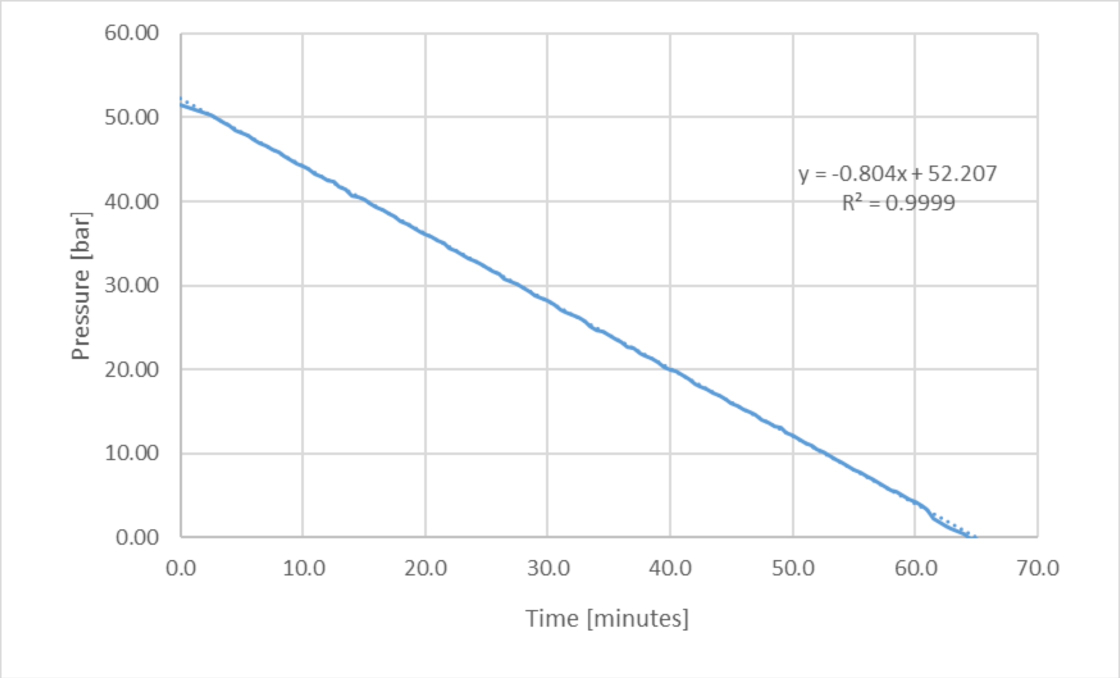

Figure 4.2: Decompression profile

The O-rings subjected to the one-cycle RGD test according to NACE TM0192 are listed in Table 3.1.

Table 3.1: RGD test; seal dimension information

Material	Replicate	CSD Before test (mm)			CSD After test (mm)			Change in CSD[1] (mm)	Average Change in CSD (mm)
		1	2	3	1	2	3		
KIFK10 FKM GLT AED	1	5.14	5.18	5.16	5.21	5.26	5.23	0.1	0.1
	2	5.15	5.13	5.15	5.26	5.26	5.29	0.1	
	3	5.16	5.17	5.18	5.26	5.27	5.26	0.1	

[1] Cross Section Diameter - average of three measurements in radial direction

Table 3.2: RGD tests; hardness change

Material	Replicate	Hardness (IRHD)			Hardness (IRHD)			Change in Hardness (UNITS)	Average change in Hardness (UNITS)
		1	2	3	1	2	3		
KIFK10 FKM GLT AED	1	86	86	85	77	77	77	-9	-7
	2	87	85	85	78	78	77	-8	
	3	85	85	84	81	80	81	-4	

Table 3.3: Tensile property level changes

Material	Replicate	As -received				After expousre				% Change	
		Tensile Strength (MPa)	Ultimate Elongation (%)	Average Tensile Strength (MPa)	Average Ultimate Elongation (%)	Tensile Strength (MPa)	Ultimate Elongation (%)	Average Tensile Strength (MPa)	Average Ultimate Elongation (%)	Tensile strength	Ultimate Elongation
KIFK10 FKM GLT AED	1	8.7	64	11.2	84	4.9	43	5.9	55	-48	-34
	2	13.9	96			7.6	75				
	3	11.1	91			5.1	48				

After the RGD test the tensile strength and elongation at break of KIFK10 FKM GLT AED reduced significantly due to gas absorption. No pass-fail criteria is cited in the standard. RGD rating of all O-rings are given in Table 3.4. Photographs of all O-rings are shown in Appendix B. KIFK10 FKM GLT AED O-ring have some minor defects on the surface; microscopic images of O-rings are shown in Appendix C; O-ring rated as 2.

Table 3.4: RGD Rating

Material	Replicate	EXTERNAL RATING AS PER STANDARD
KIFK10 FKM GLT AED	1	2
	2	2
	3	1

5. CONCLUSIONS

Industrial Spares Manufacturing & Trading Co. (ISMAT) required Element Hitchin to evaluate the RGD resistance of elastomeric compound KIFK10 FKM GLT AED in the form of O-ring seals having a nominal cross section diameter (CSD) of 5.33 mm and 34.47 mm ID. The test was undertaken according to the NACE TM0192 standard. Six replicate seals were subjected to a single cycle RGD test using 100% CO_2 at 25 °C and 52 bar, with a depressurisation rate of 0.8 bar/minute.

APPENDIX A As-received materials and before RGD

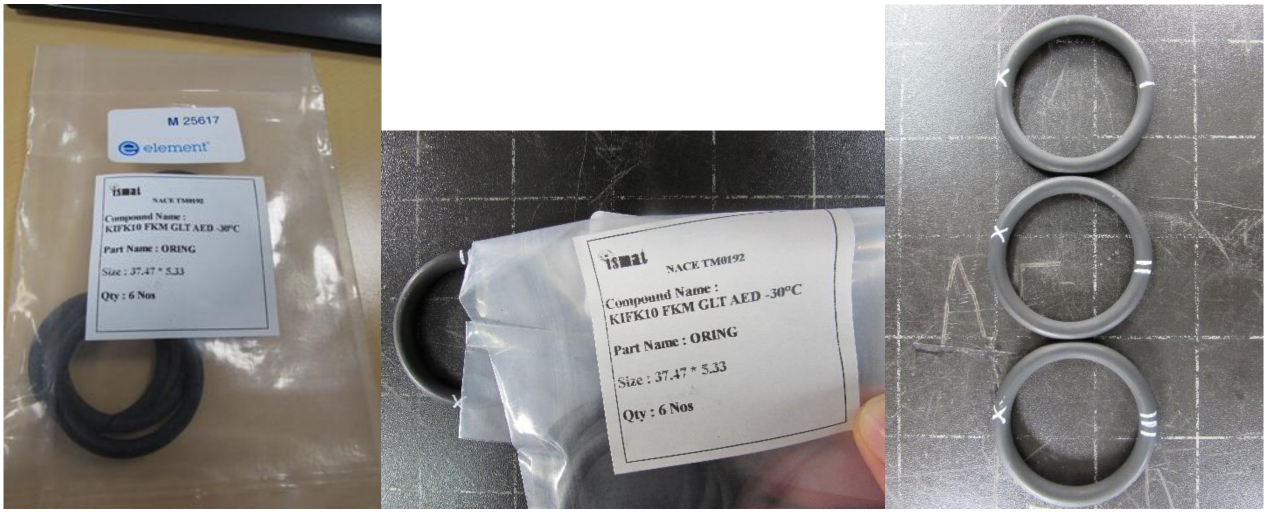

Figure A.1: As received material/before start of RGD: KIFK10 FKM GLT AED -46C

APPENDIX B Photograph of samples after RGD

Figure B.1: After RGD: KIFK10 FKM GLT AED -46C