


SAMPO-project

Improved Lifetime Estimation and Acceptance Criteria for Polymer Components

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Improved estimation of lifetimes for polymer components in NPPs




Identification of relevant and critical components in all NPP's

- Workshops and meetings with all nordic NPPs




Possibility to extraction the components from plants

- Many relevant and critical component could not be extracted



If available, procure virgin components

- Few reference components available



Estimate total lifetime and residual lifetime of relevant components

- Accelerated aging and testing

Components/materials of interest

- Cables – PVC, EPR, CPE
- O-rings – EPDM rubber
- Valve membranes – Chloroprene rubber
- Cable penetrations
- Joint sealants
- Joist sealants – EPDM rubber

Availability of components from NPPs was very limited!

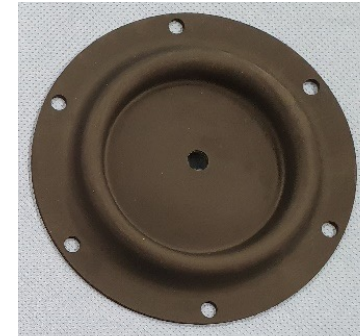


Selected materials for testing

- EPDM O-rings (will be covered separately)
- Neoprene valve membranes from Ringhals
 - Removed from NPP Sept 2018 after 8 years of service
- Reinforced EPDM joist seal from TVO
 - Installed in 2005, planned removal 2025, exposed to 45 °C N₂
- Cables with CPE jacket and EPR isolation from Forsmark
 - In service for 30 years

Neoprene valve membranes

- Two different membranes with diameter 17.5 and 19.0 cm received and reference membranes (19.0 cm) from Ringhals
- 8 years in service with exact service conditions unknown for the individual samples (ambient temperature / air)
- Accelerated aging conditions for reference membranes: 70, 90 and 110 °C
- Tensile properties and m-IRHD hardness



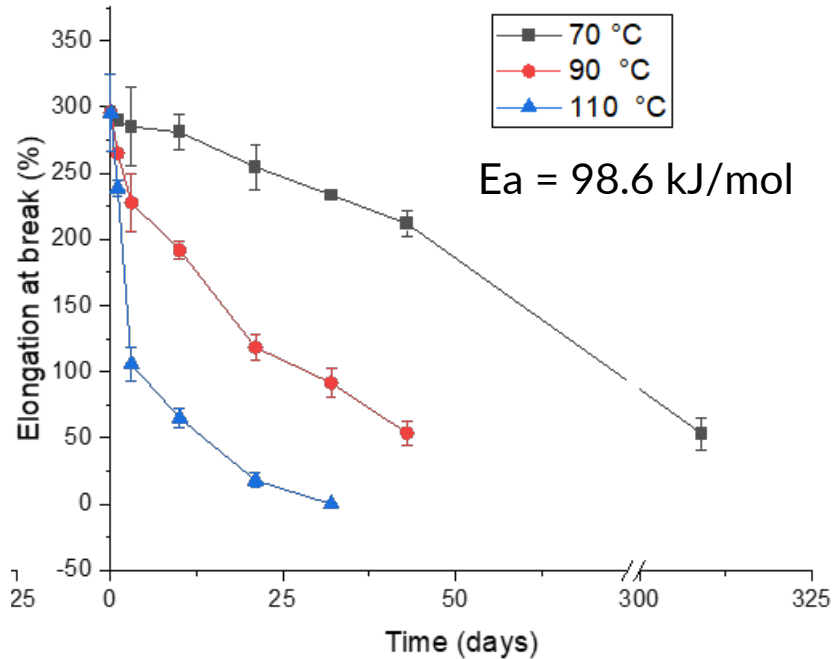
reference



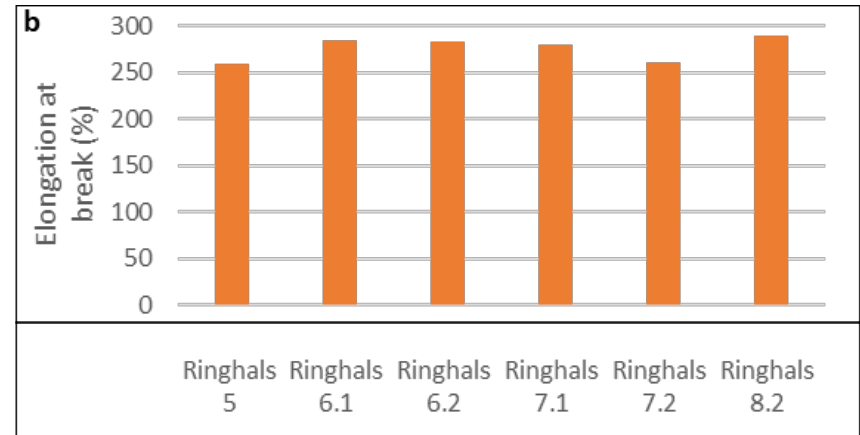
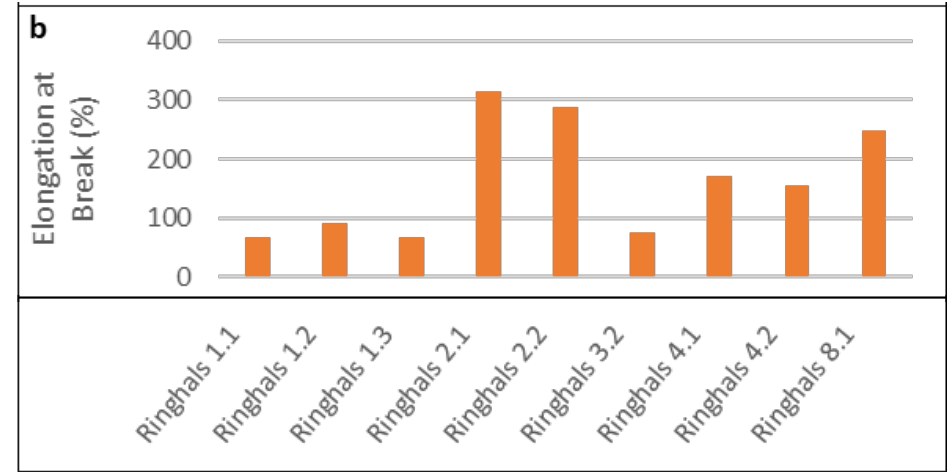
after service

Valve membranes

Elongation at break



Total expected lifetime: ~35 years at 25 °C



EPDM joist seal

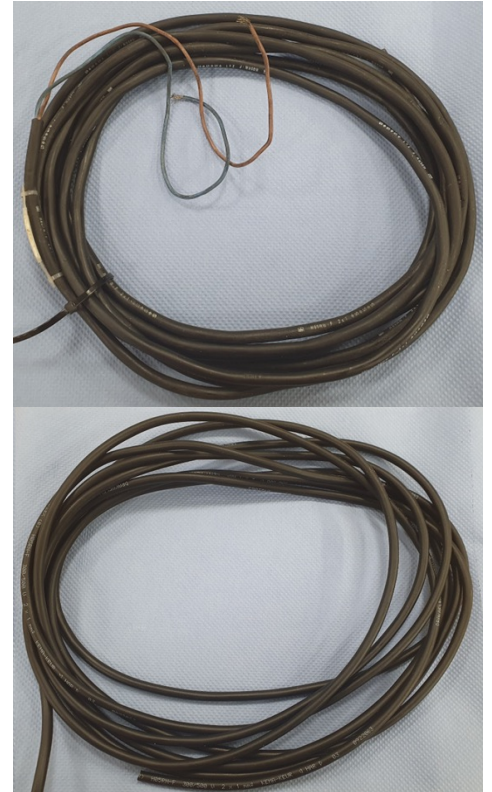
- In service at TVO for about 15 years under N2 at 45 °C
 - About 5 years of planned service remaining
- Little material provided and reference missing
- Accelerated aging of as-received material at 120 °C for 45 days

	Tensile strength (MPa)	Elongation at break (%)	Hardness (IRHD-m)
as received	6,9	295	72
120 days 45 °C	7,0	283	78



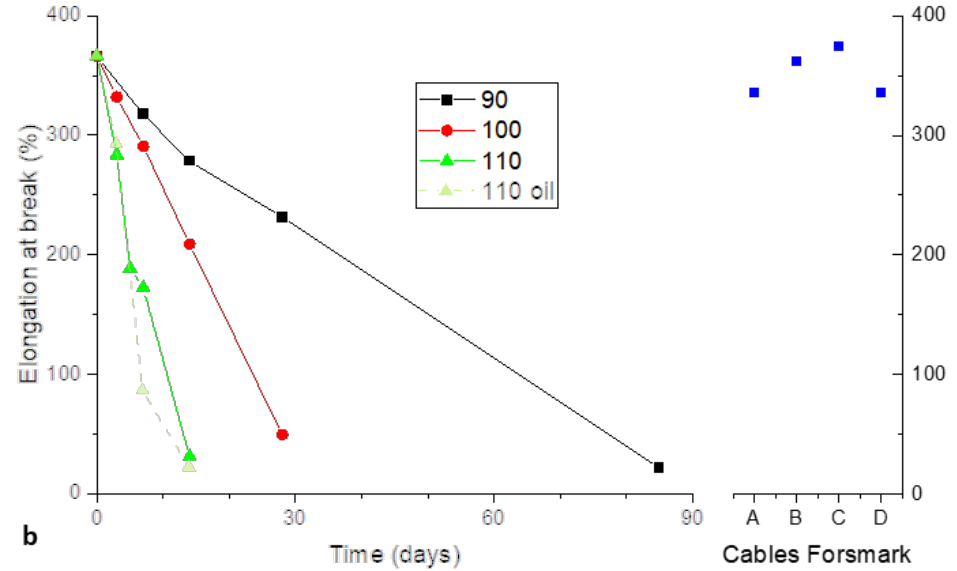
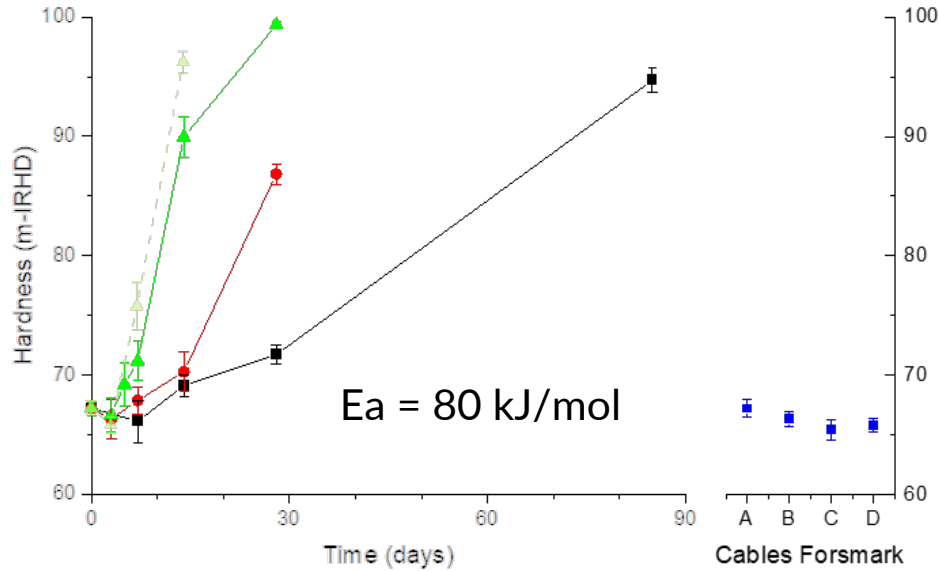
CPE cables

- Cables were removed from Forsmark after about 30 years of service at a temperature slightly above room temperature and exposed to mineral oil fog
- Reference cable with similar specification was procured from Draka
 - Accelerated aging at 90, 100 and 110 °C
 - Tensile properties and m-IRHD hardness



CPE cables

Elongation at break & hardness

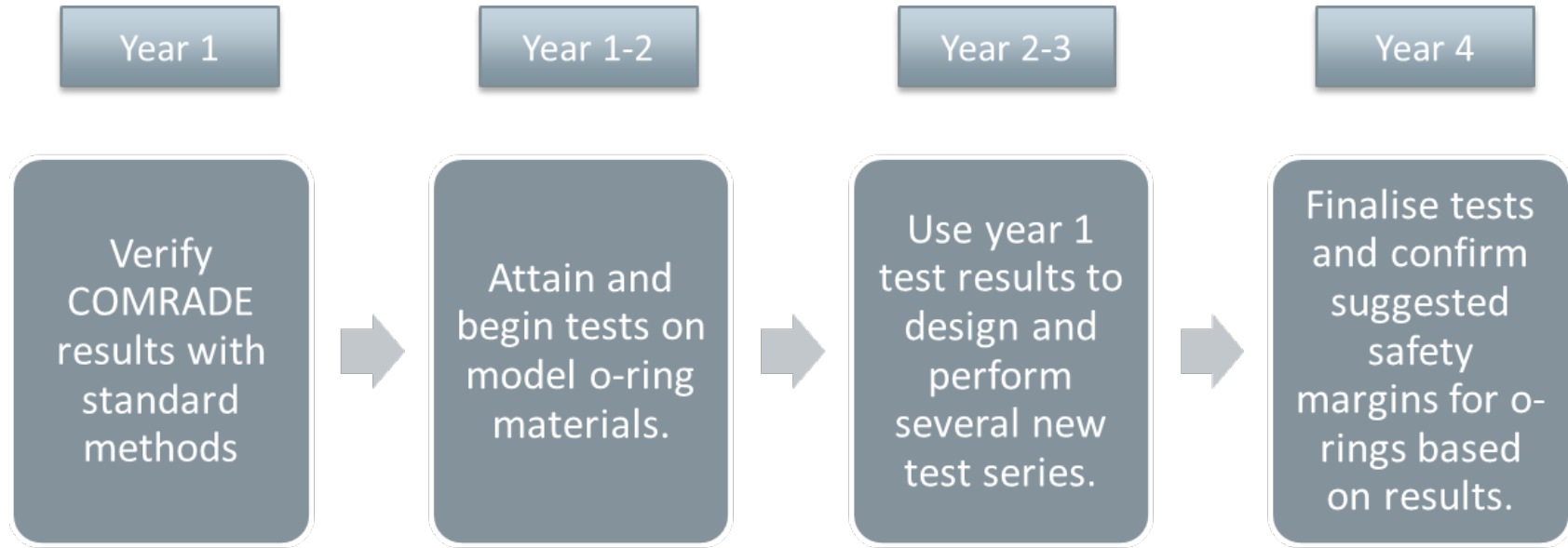


Total expected lifetime: ~23 years at 25 °C (50% reduction of elongation at break)

Conclusions

- Many relevant components with demand for better aging management in NPPs
 - Difficult to retrieve critical components due to staff shortage and necessary documentation and administration
 - Reference values or materials missing in many cases, i.e. lifetime estimation not possible/meaningful
- Lifetime estimation of membranes suggests that significantly longer service life may be possible

Setting up safety margins for O-rings



O-ring materials

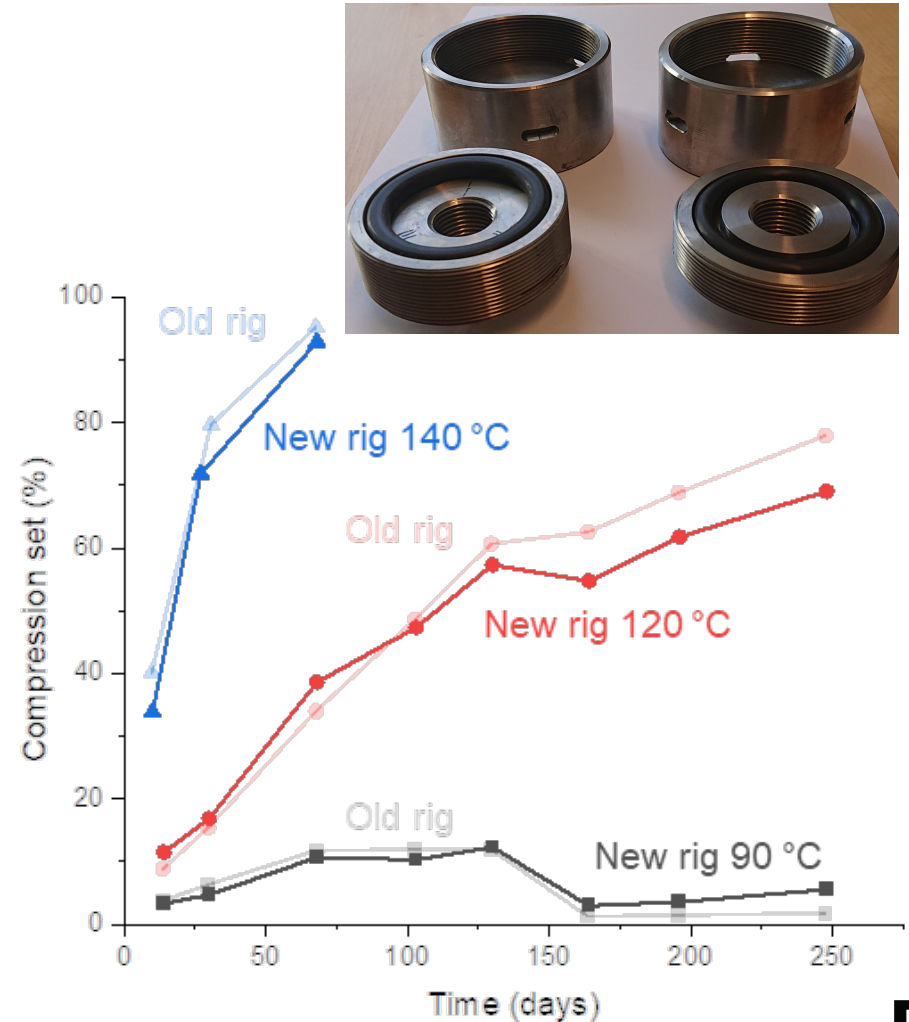
Three EPDM grades of different qualities were chosen for analysis
(all supplied by James Walker Ltd.)

Grade	Type	Number
1	Nuclear	LR9444
2	Industrial	LR9678
3	Consumer, stabilized	NA

Grade 2 O-rings

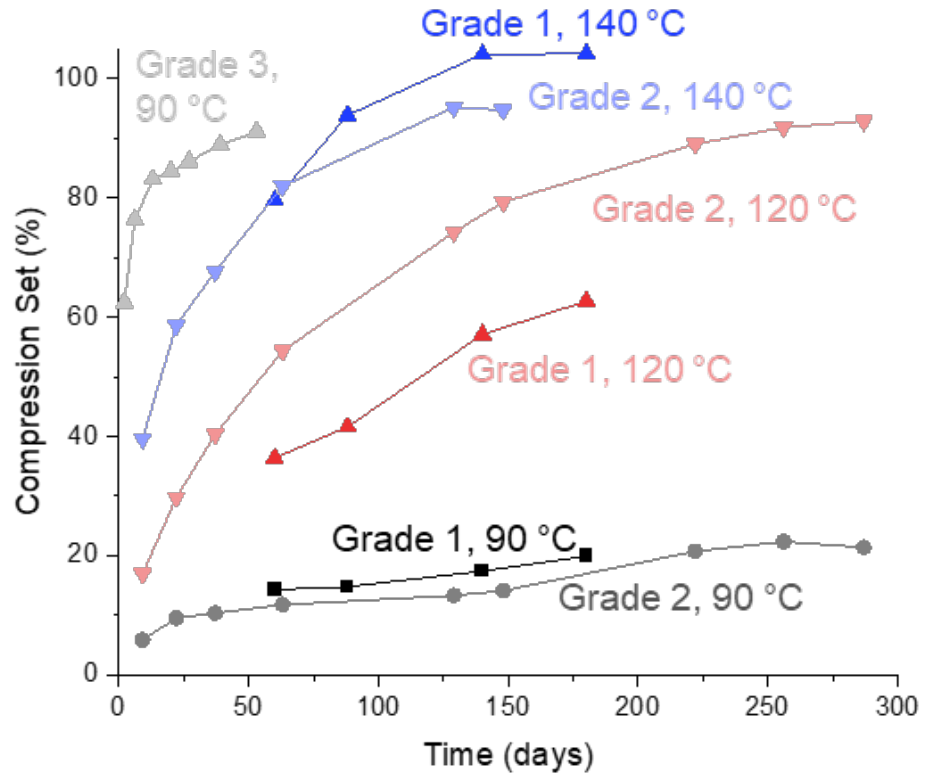
Compression Set and Leak test

- Accelerated aging at 90, 120, and 140 °C
- Leak test passed for 90 and 120 °C
- Continuous leaking after 70 days at 140 °C



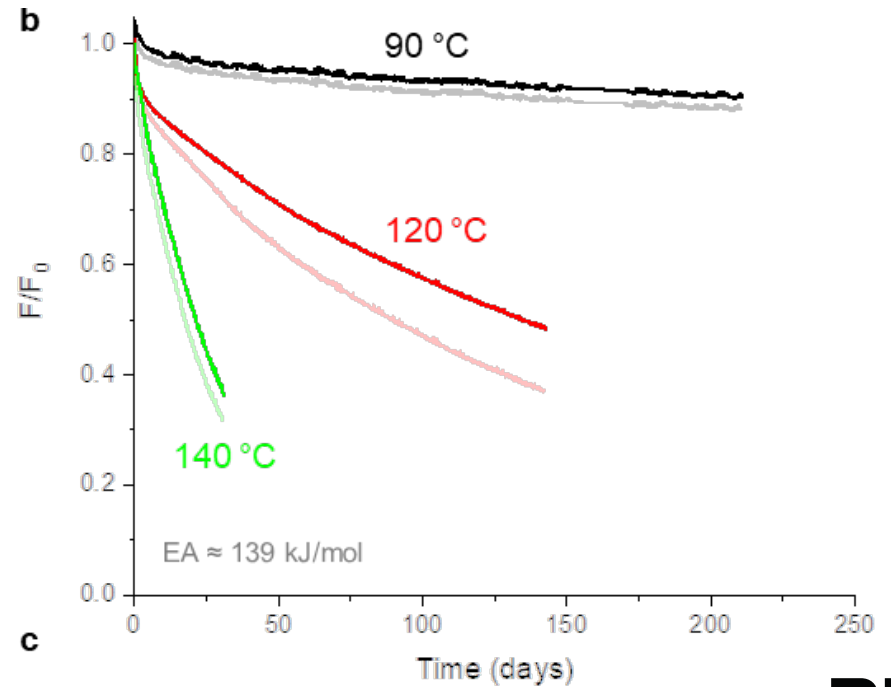
Compression Set

	Activation Energy
Grade 1	100 kJ/mol
Grade 2	103 kJ/mol
Grade 3	75 kJ/mol



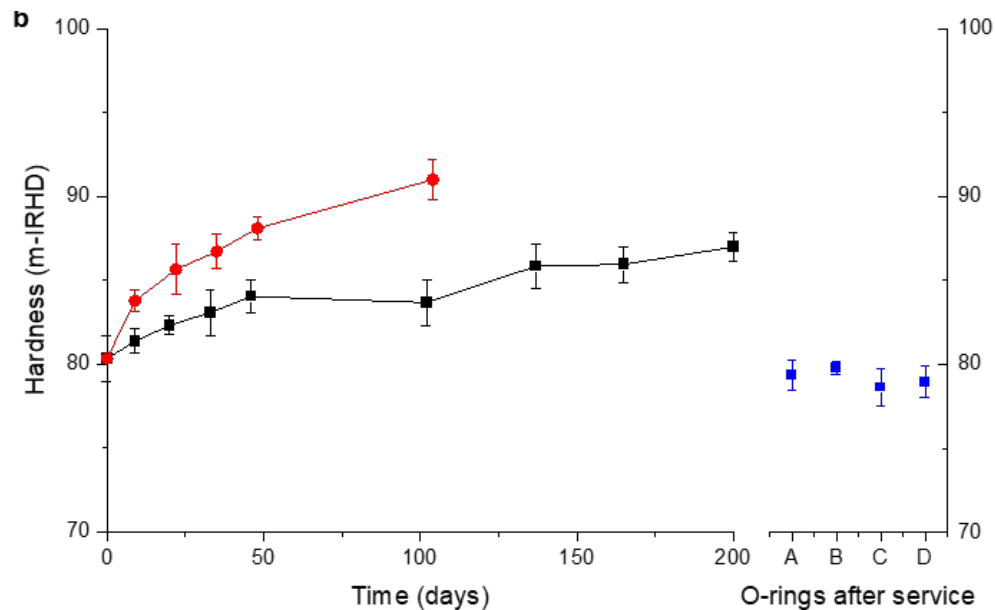
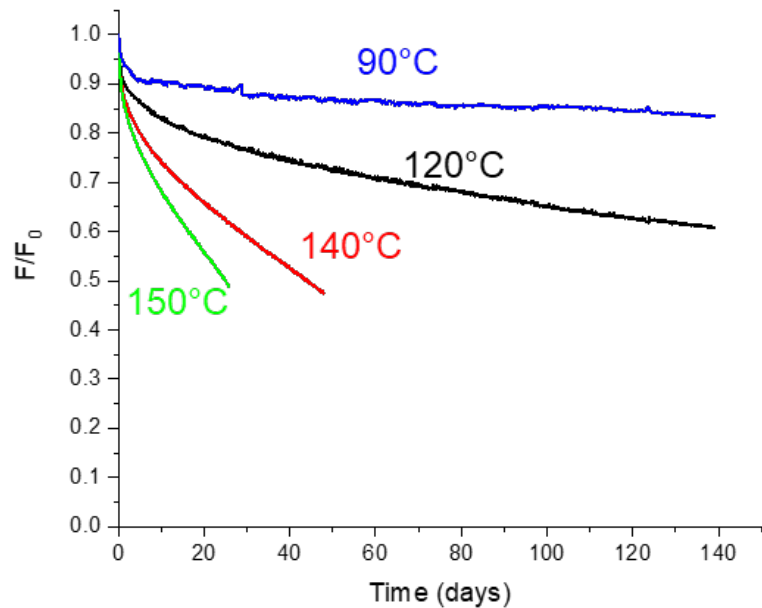
Compression stress relaxation

T	Grade 1	Grade 2	Grade 3
	Time to F_{50} [days]		
80 °C	-	-	9.9
90 °C	-	-	3.7
100 °C	-	-	1.6
120 °C	193	112	0.3
140 °C	45	19	0.1



EPDM O-rings from Ringhals

Stress relaxation and hardness



Conclusions

- Three different EPDM grades for O-rings tested using compression set and stress relaxation
- Leak test passed up to more than 80% compression set
- Accelerated aging at three different temperatures
- Large difference in performance
 - Two top grades considered suitable ((1)Nuclear and (2) industrial grade)
 - Commercial grade (3) not suitable