POLYMERS IN NUCLEAR APPLICATION CONFERENCE OF 2024

Estimating remaining lifetime of used polymer materials from nuclear power plants

Anna Bondeson – Senior RnD engineer

Polymer, fiber and composites department

Research Institute of Sweden AB

Service life of polymeric materials

- There are many types of polymers in NPPs with different purposes and service life.
- The service life is crucial when selecting materials and is affected by:
  - Application - insulator, structural, damping, prevent leakage
  - Environment – temperature, air, water, radiation
  - Possibilities to change
  - Durability
- The service life of polymeric materials can be estimated by accelerated ageing

RI.
SE

Lifetime prediction from WLF

- Standard method Rubber, vulcanized or thermoplastic - Estimation of life-time and maximum temperature of use (ISO 11346:2023)
- Accelerated ageing at different temperatures
  - Data is collected at several points in time and combined to a master curve
- End of lifetime criterias used (ref Sue Burnay and SAMPO)
  - Elongation at break 50 % decrease
  - Compression set 90 %
  - Stress relaxation F/F_0 50 %
- Limitations
  - Material will behave different at higher temperatures and tests are made in air

RI.
SE

Material selection

- Materials from SAMPO were selected based on:
  - Availability due to replacement or scheduled change
  - Access to reference material
  - Possible to discharge from the NPPs (non-radiated)
- Materials represented in this presentation:
  - CR (chloroprene rubber) membranes (Ringhals)
  - EPDM rubber (ethylene propylene diene monomer rubber) o-rings and (Ringhals)
  - CPE (chlorinated polyethylene elastomer) cables (Forsmark)

Membranes

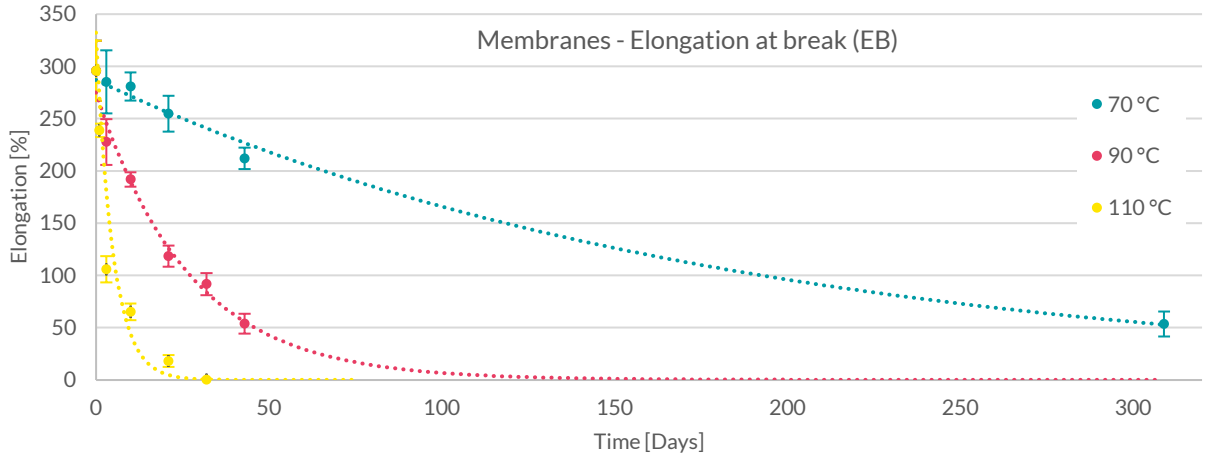
- Chloroprene rubber
  - Good for water application but does also withstand aliphatic carbohydrates
- The used membranes had been 8 years in service at ambient temperature and in air but exact service conditions unknown for the individual samples
- Two types/dimensions were tested for tensile and hardness properties
  - ~ Ø 190 mm (new and used)
  - ~ Ø 175 mm (used)

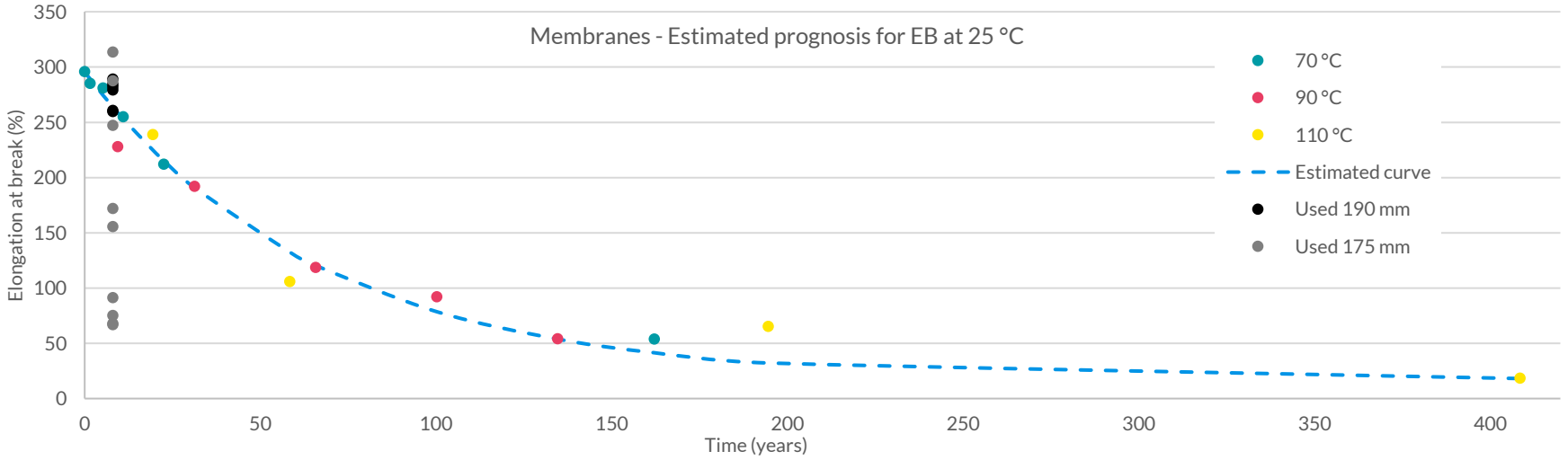
New reference

After service

Membranes result

- Combining data for elongation at break into a master curve gives an estimated service life of 50 years at 25 °C



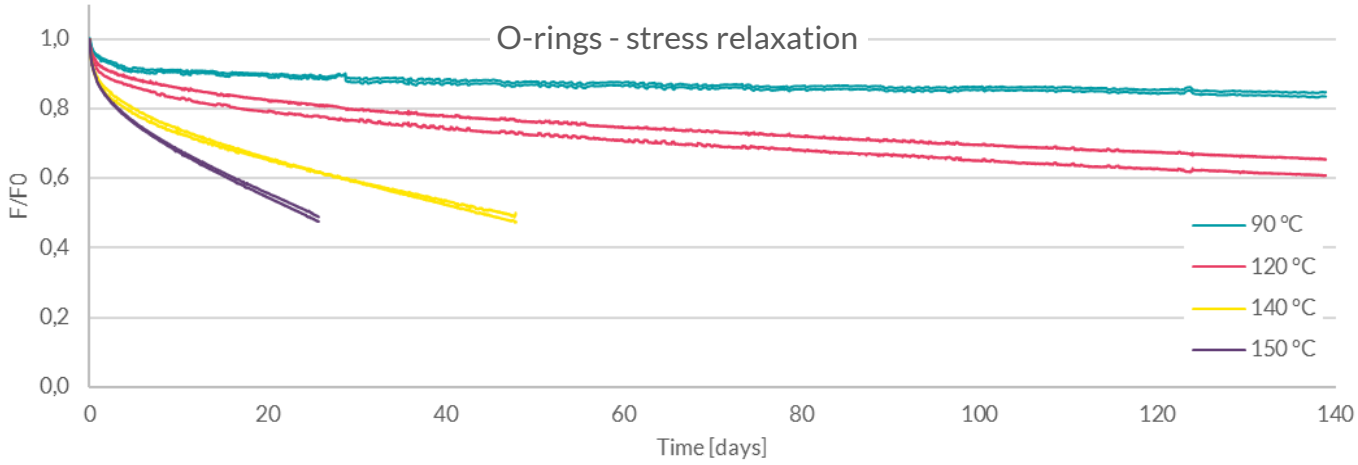


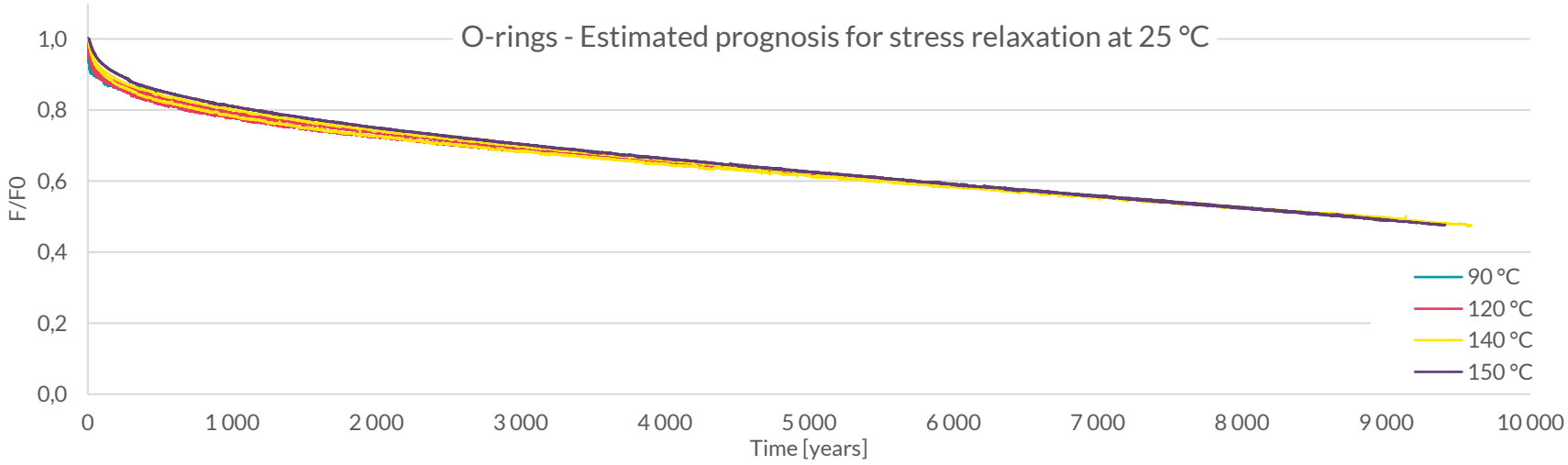
O-rings

- EPDM
  - Good for water applications and polar medium and have good mechanical properties
- The O-rings were used in moderate service temperatures, but he exact service conditions were not known
- The reference were tested for stress relaxation, compression set, tensile and hardness properties and used was tested for tensile and hardness properties

O-rings result

- Combining data for elongation at break into a master curve gives an estimated service life of 8 500 years at 25 °C



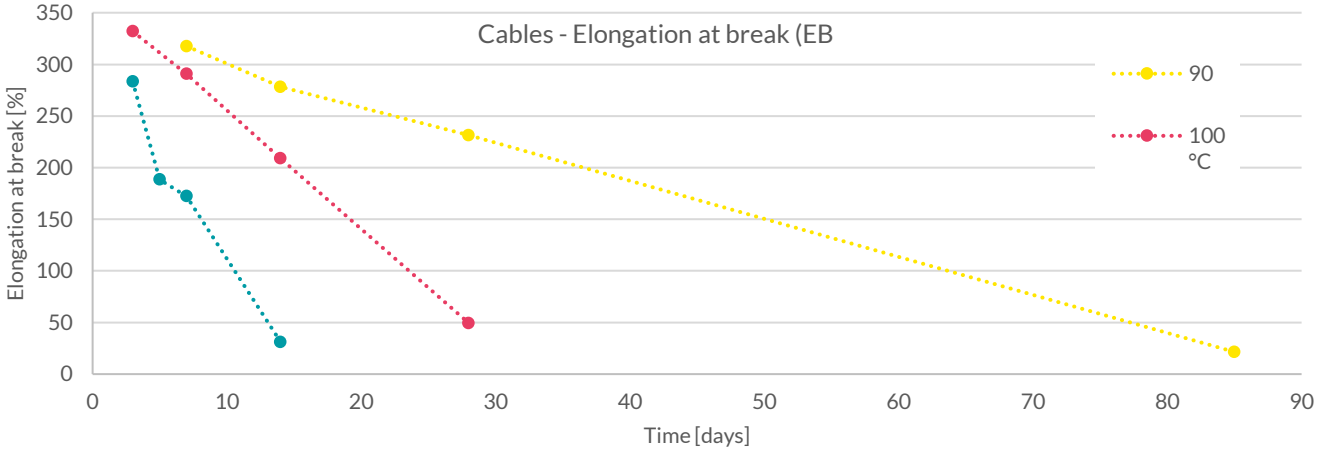


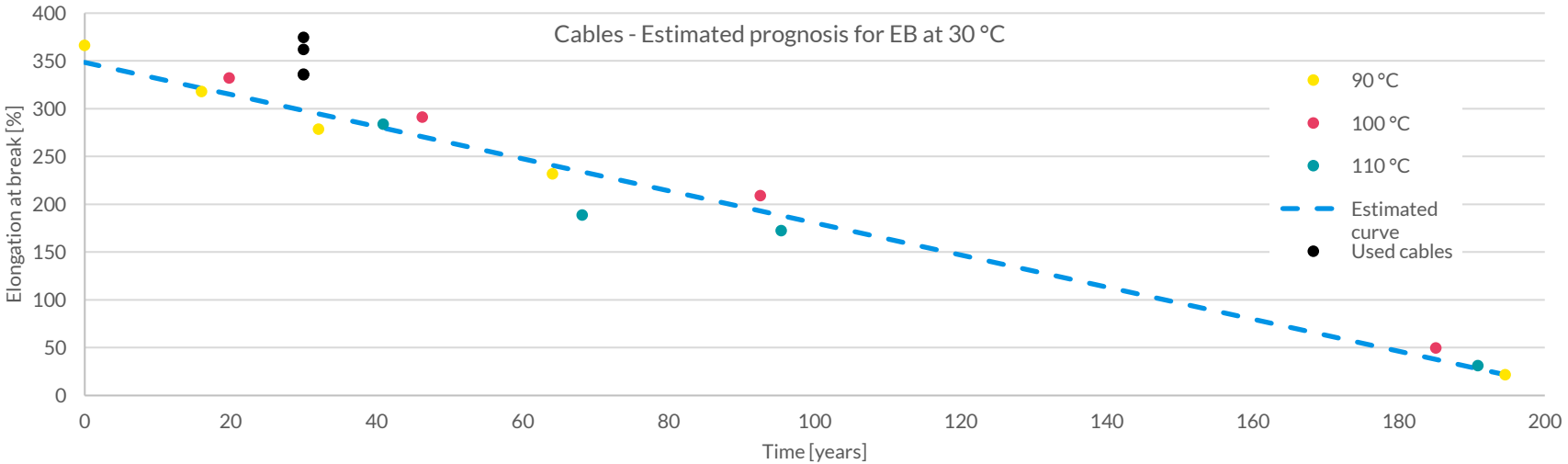
Cables

- CPE
  - Good physical and mechanical properties, such as resistance to oils, chemicals and improved thermal properties
- 30 years of service at slightly above room temperature and exposed to mineral oil fog
- A cable with similar specification was purchased from Draka cables for reference
- The reference and used cables were tested for tensile and hardness properties

Cables results

- Combining data for elongation at break into a master curve gives an estimated service life of 98 years at 30 °C





Conclusions - How to make a good estimation of the service life

- Monitoring and tests for lifetime predictions on used material
  - To motivate a change in replacement intervals
  - It is important to have a lot of real data which can be obtained by collecting and documenting when changing materials
- Material specification at inventory and purchase
  - Product specification standards
  - Material specification tests by supplier or in house

RI.
SE

Study of qualification for polymers and rubbers used in NPP commissioned by Energiforsk

Following questions will be considered and hopefully answered during the study:

- How are polymeric materials to be used in nuclear power plants in different countries qualified?
- What are the rules and how do suppliers meet these requirements?
- Is it possible to see the pros and cons of the different ways of dealing with the issue?
- Are there differences in different areas, such as cabling and gaskets?
- Are there differences depending on where the component is used? For example, regarding LOCA.
- What kind of work is going on in these issues in standardization committees and how are the Swedish and Finnish agencies involved in this?
- What methodology do suppliers use to follow up on their quality?

RI.
SE

Study of qualification for polymers and rubbers used in NPP commissioned by Energiforsk

- In this study RISE will clarify how the Swedish and the Finish NPP industry work with this matter, as well as the supply chain
  - If you have any input, you are more than welcome to contact us
  - Interviews will be made with relevant personal at NPPs and suppliers

- The study will be presented in a report in early summer 2024.

Thank you for listening!