

# Energiforsk - Polymers in nuclear applications 2021

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Qualification of NBR-material in heat exchangers

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# Content

- Polymeric material issues in nuclear applications – industry perspective
- Recent experience of installed polymeric materials in Forsmark NPP
  - Operation beyond original service life
  - Degradation of polymer in storage
- Methodology for prolongment of replacement interval
- Conclusions and lessons learned

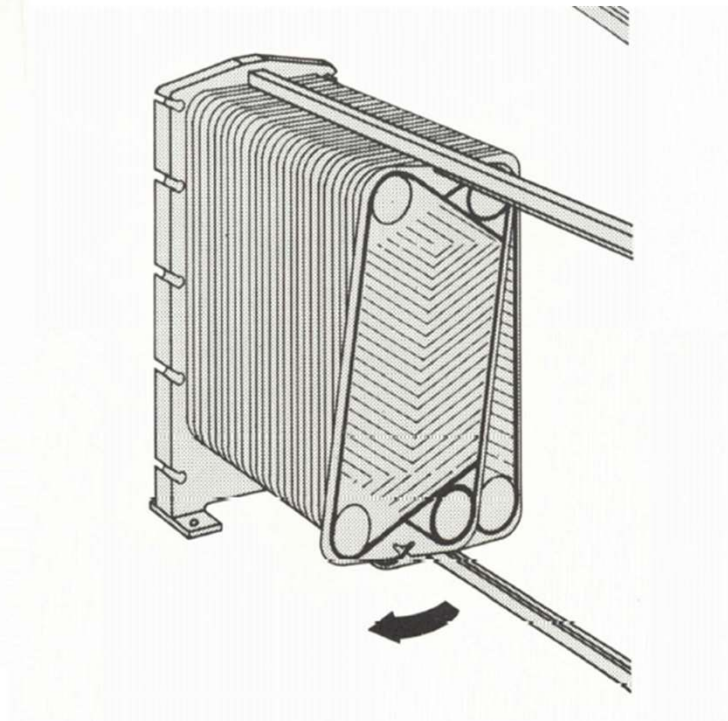
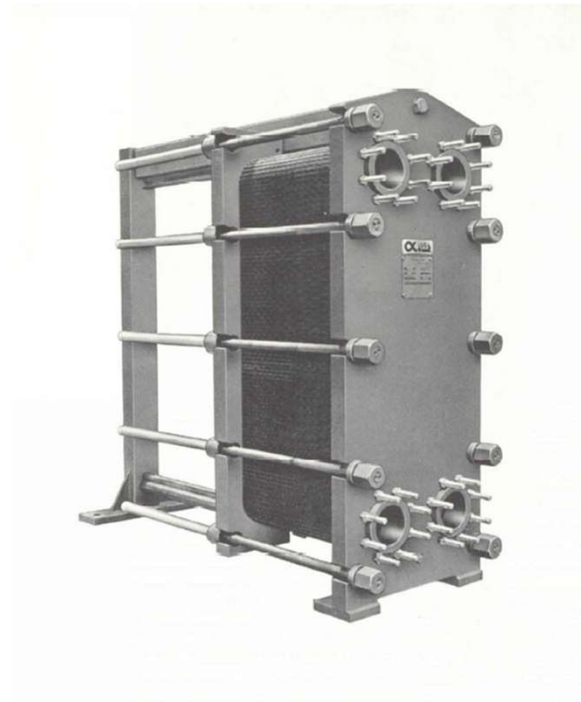
# Polymeric material issues in nuclear applications – industry perspective

- Assessments of properties and long-term performance of great importance to ensure good material properties
- Replacement of polymeric materials
  - Based on supplier recommendations or environmental qualifications
  - Condition-based approach, based on the actual condition and function of a component

**Condition-based approach recently utilized for gasket materials at Forsmark NPP**

# Recent experience at FKA - Plate Heat Exchangers in some safety systems

- The objective was to prolong the replacement cycle for gaskets in heat exchangers in a safety system
  - original procedures: replace after 15 years of operation



## Recent experience at FKA – Interval for replacement

- Supplier recommends change of gaskets (NBR) after 15 years of operation.
- EPRI recommends change of gaskets of NBR after 15 years
- Replacement of gaskets is a costly and time-consuming work
- Experience from the same type of heat exchangers in non-safety related systems shows that the material can work for >40 years.
  - Technical possibility to extend the frequency of replacing the gaskets.

NBR= Nitrile rubber

## Recent experience at FKA – problem statement

- Can we increase the replacement interval for the gaskets that are mounted in the heat exchangers today from 15 years upwards?
- Can we use prolonged replacement interval also for the gaskets we are mounting in the heat exchangers from now on?

**Westinghouse and FKA initiated a joint project to evaluate the possibility to prolong replacement interval**



# Prolongment of replacement interval – Westinghouse methodology

- The general methodology of prolonging the replacement cycle for polymeric materials
  - Reducing the frequency of replacement
  - Allowing for replacement over several years
  - Time-consuming work to replace gaskets in heat exchangers

⇒ Considerable cost saving for the plant

# Prolongment of replacement interval – Westinghouse methodology

- To be able to argue for an extension of the replacement interval beyond the original procedures, the material ageing properties need to be investigated for the specific conditions
- Evaluation performed based on:
  - Reference material from similar conditions (end of life)
  - Newly delivered material
  - Replacement material exposed to accelerated ageing



# Prolongment of replacement interval – Westinghouse methodology

## Determine the properties of the samples & reference material

Sample 1  
- New material to be installed

Sample 2  
- Reference material

Characterization and measuring properties



## Thermal accelerated ageing

Additional ageing



## Analysis of results

Characterization and measuring properties of aged material

Evaluation of changed properties



**Assessment of an appropriate replacement interval**

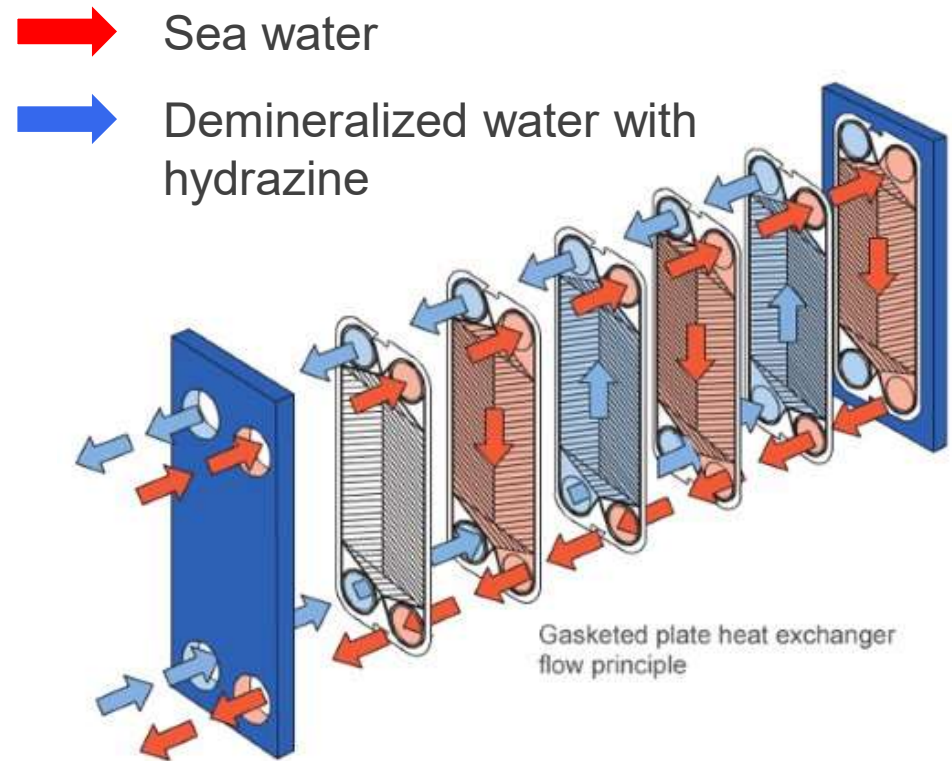
# Recent experience at FKA – Measuring material properties

- Compositional analytical methods
- Swelling properties
- Compression set
  - Connected to the sealing function of the material
    - Is a commonly used parameter to study gasket properties, but in real life it is the tightness that matters
  - Relate a compression set criteria to the material property on a reference material that fulfills the function

**Different properties used for the  
acceptance criteria to be able to do the  
assessment**

# Recent experience at FKA – Selection of material sampling point

- NBR have better compatibility with sea water (excellent) than with demineralized water and hydrazine (good).
- Conservative approach:  
A material sample was hence selected from the side with demineralized water with hydrazine.

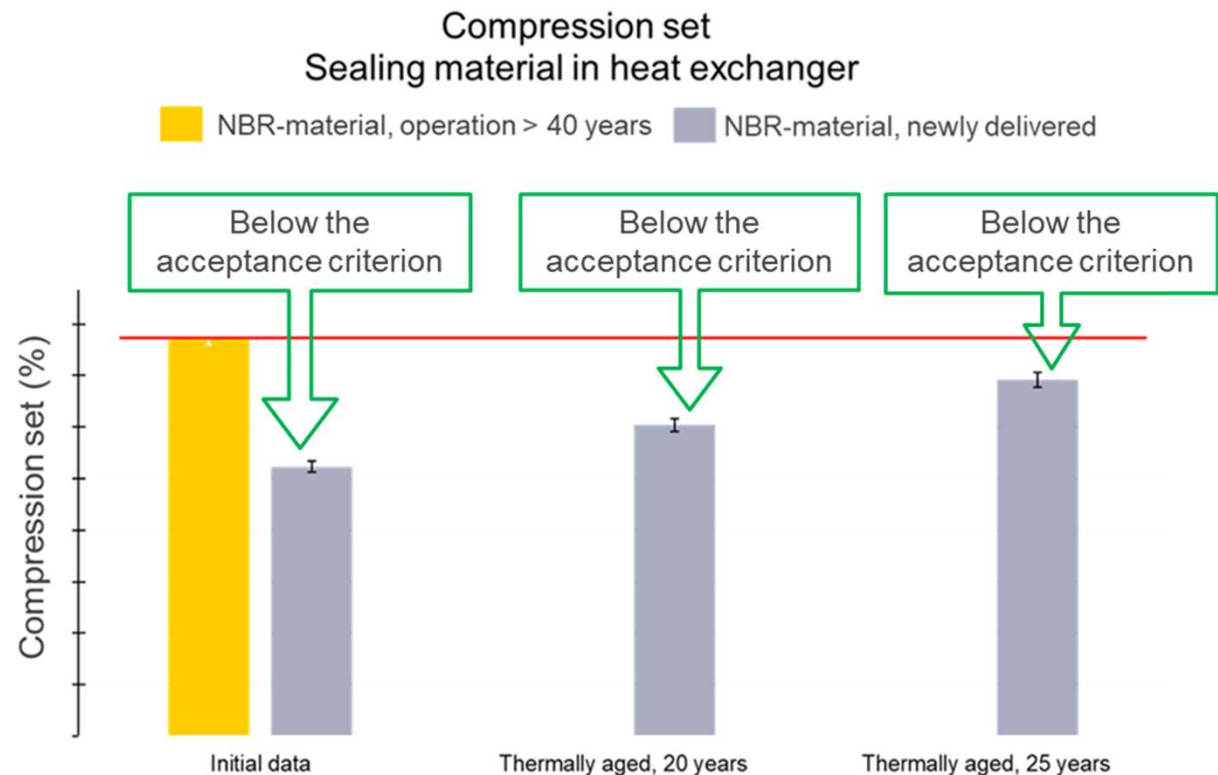


**Important to select material samples with the most conservative conditions**

# Recent experience at FKA – Primary acceptance criterion – Compression set

Compression set measures the material property connected to the sealing function of the material

- Relate the criterion to the material property of a reference material NBR gasket that had been in operation for > 40 years and non-leaking
  - yellow bar
- Newly delivered material – fresh and aged
  - grey bars



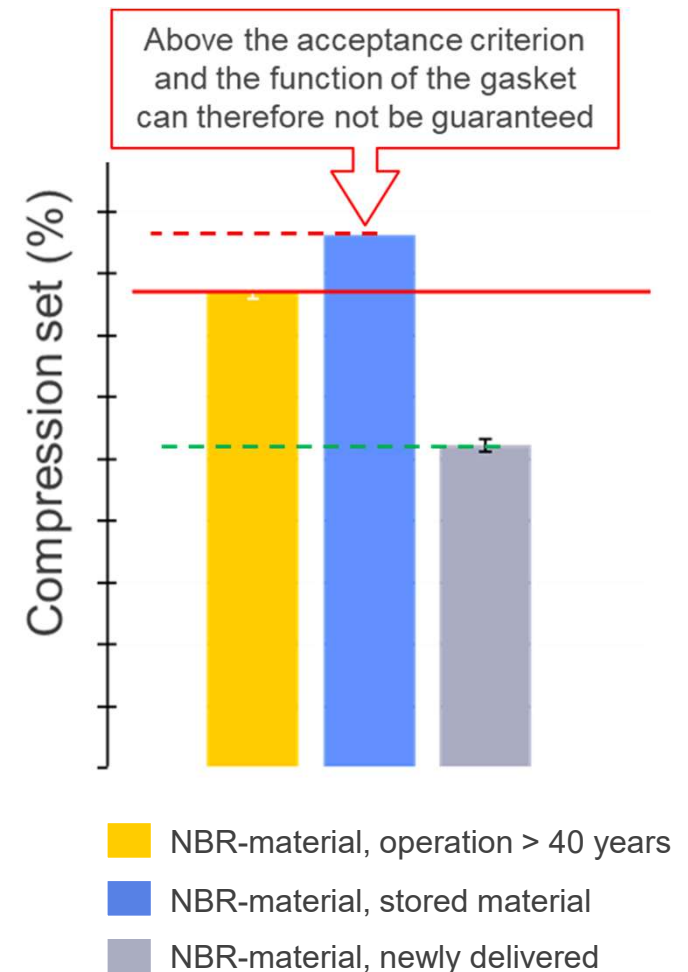
## Recent experience at FKA – Assessment

- Results showed that the newly delivered material met required criteria after accelerated thermal ageing up to 25 years.
- Newly delivered material was determined to be highly similar in composition to installed service materials.
  - Allowed for assessment of replacement interval using newly delivered materials.

# Recent experience at FKA – Unexpected effects of traditional storage in air

- Increased awareness of the importance of storing polymeric materials in a controlled environment
  - Minimizing the effect of oxygen and elevated temperatures
- Stored material revealed significant degradation.
  - Example of NBR being severely degraded after a few years in storage, hence indicating importance of quality control for stored material.

NBR= Nitrile rubber



## FKA experiences

- People from different departments were involved in the project:
  - Maintenance department
  - Engineering department
  - Technical support regarding polymeric materials, chemistry
- Continuous dialogue between FKA and Westinghouse
  - Ensures that different perspectives are considered
  - Utility was involved in the whole process.

**Significant cost reductions by prolonging replacement intervals**

## Lessons learned

- This study showed that condition-based approach for prolongment replacement intervals is feasible and result in cost reduction
  - Allows for gasket replacement at a later stage and in a controlled manor spread over several years
- Degradation during storage can be severe, but vary a lot depending on material type
- The composition and properties of polymeric materials can differ between batches and between different delivery years, hence of importance to have good quality control and confirm material properties and ageing behavior
- Good collaboration between different disciplines crucial for maintaining good quality control of polymers (maintenance, engineering, chemistry etc)



