BIOSCIENCE AND MATEIALS
CHEMISTRY AND MATERIALS

WP2 COMRADE
- Identification of available polymers and their data from Nordic NPPs

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Content

Background

Polymer ageing studies involve usually accelerated ageing procedures where the ageing phenomenon is speeded up by using more aggressive environmental parameters, such as high temperature and high dose rate. The accelerated ageing procedures are generally simplifications of the real ageing environments and they presume that there is one dominant ageing mechanism that governs the molecular and microstructural level changes in the polymer matrix. When sufficient amount of changes occur in these structures, their yield is ultimately observed in the macroscopic material properties. Thus it is likely that some environmental factors and their effects to polymer ageing occurring during normal service life are neglected in the accelerated ageing treatments. However, acquiring aged components from real service conditions and studying their material properties could provide more detailed information on degradation mechanisms and kinetics occurring in real service conditions. This information would be valuable when accelerated ageing treatments that aim to simulate the real ageing conditions are validated. Within this pre-study, polymer materials available for research use from nuclear power plants (NPP) under decommissioning (e.g. Barsebäck) and materials taken from outages in running Nordic NPPs are mapped. The available materials can be used to verify the O-ring condition monitoring method developed in COMRADE-project (WP1) and degradation processes studied in (WP3). Also obtaining EPDM components from sealant applications provides a possibility to study how the ingredients mixed in the polymer have effect on their ageing behaviour.

Goal of the study

The goal of this study is to identify polymers that are available for research purposes from Barsebäck NPP or currently running NPPs participating in this project via industry group meetings. Also polymer service conditions are under interest as well as procedures related to moving polymer components out from the plant. The pre-study survey on Barsebäck materials was conducted in 2016 and compilation of the data from currently running NPPs in 2017.

Methods

Two contacts were interviewed related to Barsebäck polymer materials. Lars-Uno Berg which is head of business operations at Barsebäck Kraft AB and his colleague Lars Appelgren who was presenting their response. A questionnaire with a table of properties to be filled in was sent to the material expert through the COMRADE industry group to investigate what possible materials can be obtained. Discussion of materials of special interest for the project was held at the COMRADE workshop at VTT, Espoo in September 27-28th 2017.

Results and discussion

Barsebäck NPP

Barsebäck Kraft AB (BKAB) is fully owned by Sydkraft Nuclear Power AB and part of the Uniper group. They have about 50 employees most of them work with service operation and a few with business operations. Business operations handles lease premises, sell components and holds training courses and this division of Barsebäck Kraft AB is not financed by the Nuclear Waste Fund, but is self-sufficient. This means they need funding for further investigations because they are not able to work in kind.

Barsebäck plant was contacted to investigate the possibilities for retrieving used polymeric materials from the closed down containments. They did inform that they possibly can provide polymer materials with documentation. They had selected a plastic impeller and o-rings from a certain small pump inside the reactor containment as suitable candidates. The pump has been serviced yearly so the polymeric materials have not been in service for a very long time. No deeper investigation has been made to identify what polymer types the material consists of. They have not found any candidate joint sealants or cable transits that have been exposed to radiation and if there existed any, they would not be well documented.

Barsebäck plant does not have the ability to give radiological clearance in situ so an external authorized regulator must be engaged. Also it should be noted that it is not certain that the equipment that has been in the enclosed premises could be given a radiological clearance at all. If the polymeric material cannot be given radiological clearance the examination must be done in the controlled area. If the investigations will be done in situ the following things must be arranged: admission, training of personnel in handling radioactive materials which would consist of two to three day-course (I), use of dosimeters (II) and the used testing equipment will have to be given radiological clearances afterwards (III). This would increase the cost significantly compared to testing conducted at standard material testing laboratory.

Another aspect against using materials from Barsebäck is that after the outtake of the reactors the materials have been stored for many years in different temperatures and atmosphere than the normal service conditions. Because of these difficulties and based on the discussion between project team and industry group, the search of aged (i.e. aged at real service conditions) polymeric materials has been broaden to include the NPPs in service and plants that just have been or soon will be taken out of service.

As the results from Barsebäck interviews indicate, obtaining polymer components from there would be tedious and costly. Also uncertainties related to the history of service conditions would complicate the use of these materials as reference to artificially aged ones. Thus obtaining polymer components from running plants during outtakes seems to be more feasible option.

Questionnaire to COMRADE industry group

A questionnaire was introduced to NPP polymer material experts (via COMRADE industry group) to obtain data on different polymers available to study. The filled in questionnaire is presented in Table 1 and Table 2 and it compiles the materials which are interesting for industry and the project team, materials available from different Nordic NPPs and their service history. The table is a working document and will be continuously filled in as more information will be obtained. There are missing detailed data on some of the components since there are cases where no proper knowledge was available on the exact environmental parameters. Also, there are components missing that area available from Ringhals NPP.

Selected materials for testing

Materials selected as special point of interest were EPDM o-rings, while these materials are easy to obtain and may be compared to the tested materials for verifying results and simulations in COMRADE WP1. The EPDM materials available from Loviisa NPP and Ringhals (not included in Tables 1 and 2) are considered to be interesting and their use as reference materials is considered. As a first step for testing, the availability and dimensional properties of o-rings from Vattenfall and Fortum will be clarified in more detail in regard to compare them to the materials tested in COMRADE project.

Example of test methods of interest are the same as at other project work packages; DSC OIT, elongation at break, relaxation, compression set and hardness.

This work will be continued within COMRADE-project during year 2018.

Conclusions

Two material experts related to Barsebäck polymer components were interviewed in order to clarify whether the used components could be taken out from the plant for ageing studies. The polymer components available for ageing study and which service conditions are well documented are few in numbers. Also radiological clearances and the related precautions to working with decontaminated materials yield in complicated and costly material acquisition. More feasible way to obtain used materials from properly documented service environments would be acquiring materials from running plants during annual take outs.

A questionnaire was sent out to investigate the polymeric materials possibly obtained from the participating NPPs and properties of the materials were filled in by NPP material experts. According to the questionnaire there are some EPDM o-rings available for testing that are similar to those materials tested in WP1 and 3.

At the COMRADE workshop in September 2017, o-rings were pointed out as a feasible first choice for testing. The obtaining and testing of the o-rings will be done during 2018.

Table 1 Filled-in questionnaire

Designation of component	**Test material for WP1; o-ring from James Walker**	**Test material for WP3; Lipalon (HHSO-type) cable jacketing from TVO**	**Loviisa NPP PCP shaft seal**	**Power cable from Forsmark NPP**
Type of component (eg o-ring for pump, gasket for valve)	o-ring; pipe seal	cable jacketing	o-ring	cable jacketing and part isolation
Polymer type	EPDM	CSPE (chlorosulphonated polyethylene, Hypalon)	EPDM	PVC
Time in use (operation)	accelerated aging corresponding to ~16 years	accelerated aging corresponding to ~40 years	at the NPP three years	~ 35 years
Operating temperature	23 °C (accelerated heat aging: 90 °C, 120 °C and 140 °C)	23 °C	60 °C	~25◦C
Operating Pressure	1 atm (testing at 110 bar)	1 atm	Dp 6 Mpa p 12.7 Mpa	1 atm
Operating atmosphere (eg Air, nitrogen, water, humidity)	Air	Air	Borated water	air
Approximate dose rate during operation	14 - 18 kGy	40 kGy	570 (- 850) Gy	Very low, most of the cables are in blue areas
Storage time after removal	<1 week	-	> 1 kk	Can be taken out during outage at Forsmark 1 (25/6-20/7)
Temperature after removal (approximate)	~23 °C	~23 °C	~23 °C	N/A
Pressure after removal (approximate)	1 Atm	1 Atm	1 Atm	N/A
Atmosphere (eg Air, nitrogen) after removal	Air	Air	Water	N/A
Possible to test outside NPP (clearance)?	Yes	Yes	Yes	Yes

Table 2 Filled-in questionnaire continued

Designation of component	**TVO V106 and V107**	**Cables from OKG**	**o-ring from reactor enclosure at Barsebäck**	**Cable transit (Brattberg) from Barsebäck**	**Cables from enclosure pump at Barsebäck**
Type of component (eg o-ring for pump, gasket for valve)	o-ring	Cable jacketing	o-ring for pump in enclosure	Cable transit	Cable jacketing
Polymer type	EPDM		EPDM (?)		
Time in use (operation)	ca. one year		~1 year		
Operating temperature	Elevated				
Operating Pressure					
Operating atmosphere (eg Air, nitrogen, water, humidity)					
Approximate dose rate during operation					
Storage time after removal	years		>10 years	>10 years	>10 years
Temperature after removal (approximate)					
Pressure after removal (approximate)					
Atmosphere (eg Air, nitrogen) after removal	Air		Air	Air	Air
Possible to test outside NPP (clearance)?	Yes	Yes	No/clearance may be given from external operator	No/clearance may be given from external operator	No/clearance may be given from external operator

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