TeaM Cables

Tools & Methodologies for an efficient ageing management of nuclear power plant CABLES

Project presentation

International Meeting on Equipment Qualification
In Nuclear Installations
UJV Rez, Czech Republic
May 20 – 23, 2019

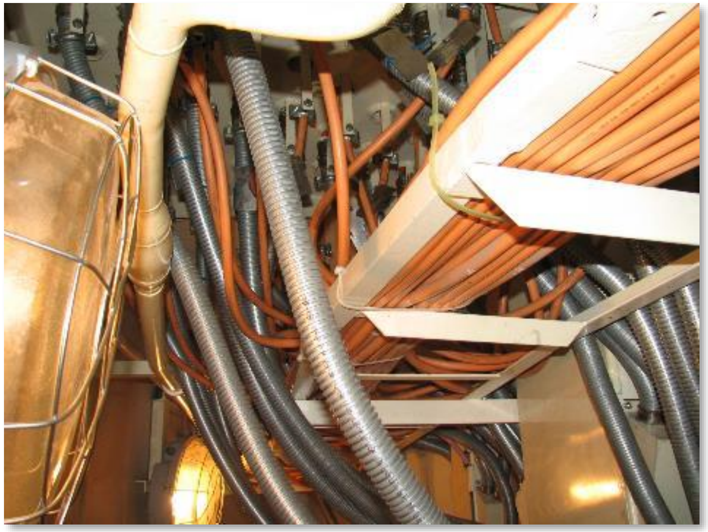
TeaM Cables– facts and figures

13 partners – 6 countries
Start: September 2017
Budget: 5.5 M€
EC Funding: 4.2 M€
End: February 2022

The TeaM Cables consortium involves participants covering the main players of the NPP cable research, including one cable manufacturer, renowned research institutes and academia and NPP industry:

1. Electricite De France (EDF)
2. Framatome GmbH (Former Areva GmbH)
3. Institut De Radioprotection Et De Surete Nucleaire (IRSN)
4. Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA)
5. UJV REZ, A.S.
6. ARTTIC
7. Nexans France S.A.S
8. Instytut Chemii i Techniki Jadrowej (INCT)
9. Fraunhofer Gesellschaft Zur Foerderung Der Angewandten Forschung E.V. (IZFP)
10. Teknologian tutkimuskeskus VTT Oy
11. Universite d'Aix Marseille (AMU)
12. Ecole Nationale Superieure d'Arts et Metiers (ENSAM)
13. Alma Mater Studiorum – Universita di Bologna

Rationale



- Nuclear Power Plant Temelin (Czechia)
  - ~15 600 cables important to safety / unit
  - 1,000 km total length
- Electrical cables are everywhere
- Complete cable replacement is expensive
- Electric cables are diverse with different designs and materials
- Polymer ingredients impact dramatically polymer properties and ageing (at least 5 ingredients in one industrial polymer)

Need for:

- **Accurate predictive lifetime models**
- **Methods and tools for on-site monitoring of cables**

TeaM Cables innovation

The main innovation of the project is a new way of estimating the lifetime duration of cables, using much more precise information and more relevant methods for analysing the data.

The approach is based on multi-scale studies of the materials.

Project aim

- TeaM Cables aims at providing NPP operators with a novel methodology for efficient and reliable NPP cable ageing management by

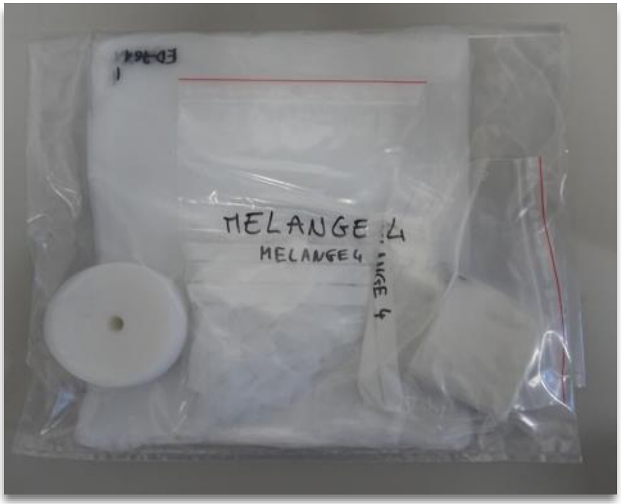
1. developing cable ageing models and algorithms based on multi-scale studies and addressing the problem of complex polymer formulation

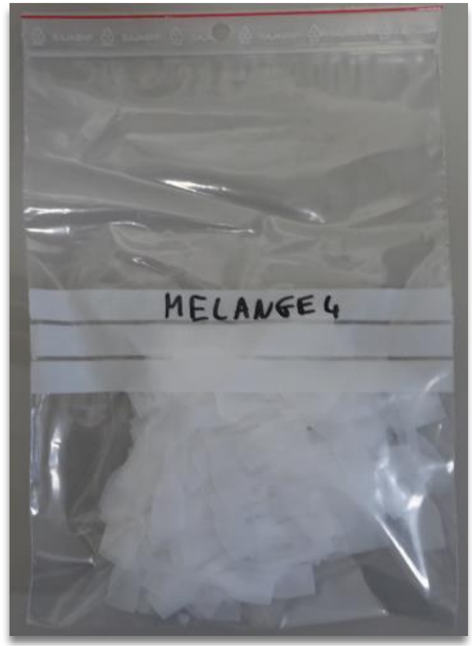
2. developing methodologies for on-site monitoring and identifying associated criteria from multi-scale relations

3. developing a novel numerical tool integrating the models developed and providing the residual lifetime of cables by crossing on-site measurements with predictive models and knowledge of cable exposure conditions (wiring network in the NPP).

Samples to be studied

Material
Silane crosslinked PE
Silane crosslinked PE + phenolic antioxidant
Silane crosslinked PE + thioether antioxidant
Silane crosslinked PE + phenolic antioxidant + thioether antioxidant
Silane crosslinked PE + x phr of ATH
Silane crosslinked PE + y phr of ATH
Silane crosslinked PE + ATH + phenolic and thioether antioxidant
Coaxial model cable. LSZH jacket, XLPE insulation, not filled, just antioxidant and stabiliser
Twisted pair model cable. LSZH jacket outer, standard NPP insulations material: • XLPE insulation, not filled, just antioxidant and stabiliser XLPE • XLPE insulation + antioxidant + ATH (material No 7) • EVA/EPDM


MELANGE 4
MELANGE4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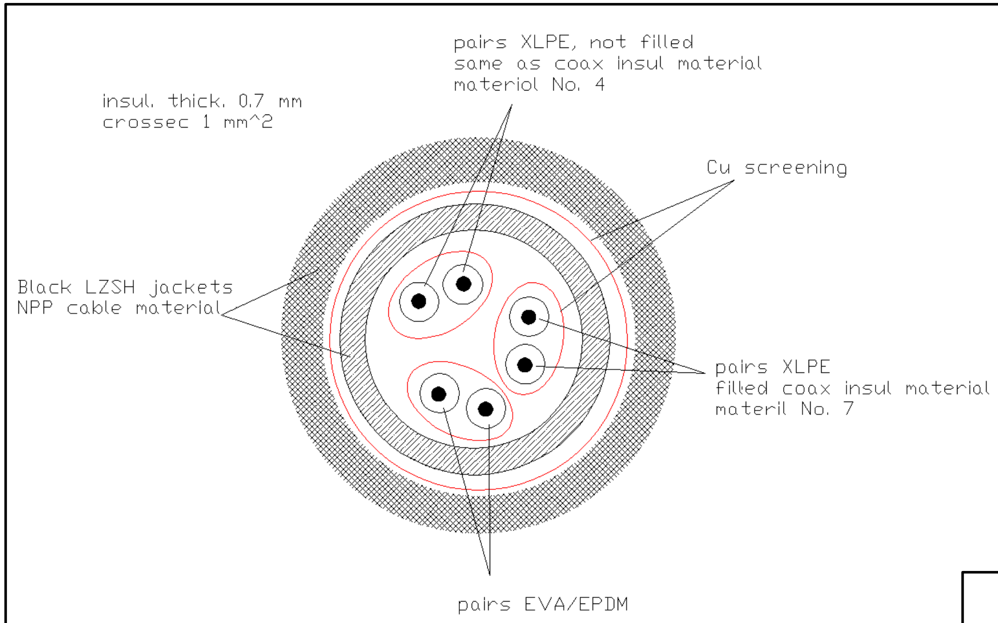
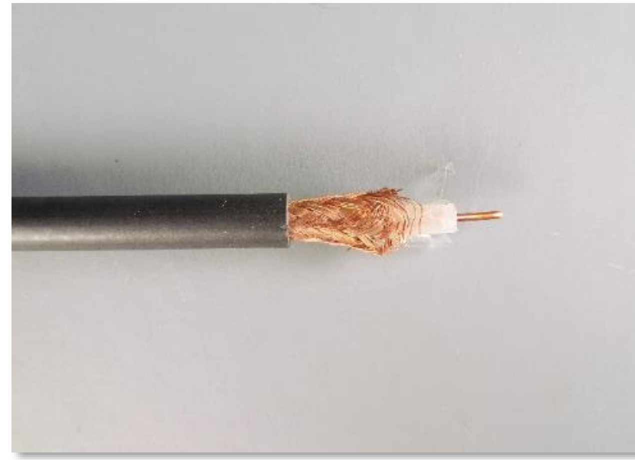
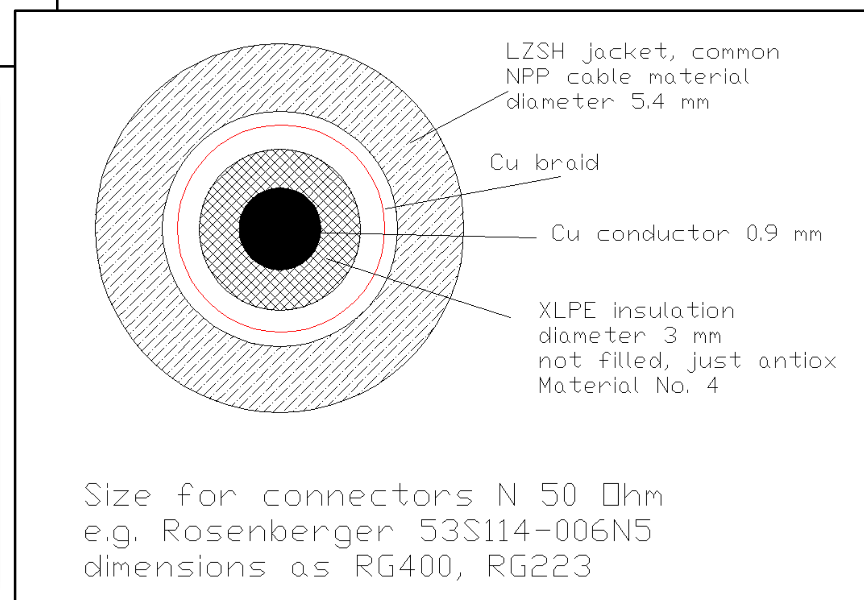

pairs XLPE, not filled
same as coax insul material
materiol No. 4
insul. thick. 0.7 mm
crossec 1 mm^2
Cu screening
Black LZSH jackets
NPP cable material
pairs XLPE
filled coax insul material
materil No. 7
pairs EVA/EPDM




LZSH jacket, common
NPP cable material
diameter 5.4 mm
Cu braid
Cu conductor 0.9 mm
XLPE insulation
diameter 3 mm
not filled, just antiox
Material No. 4
Size for connectors N 50 □hm
e.g. Rosenberger 53S114-006N5
dimensions as RG400, RG223

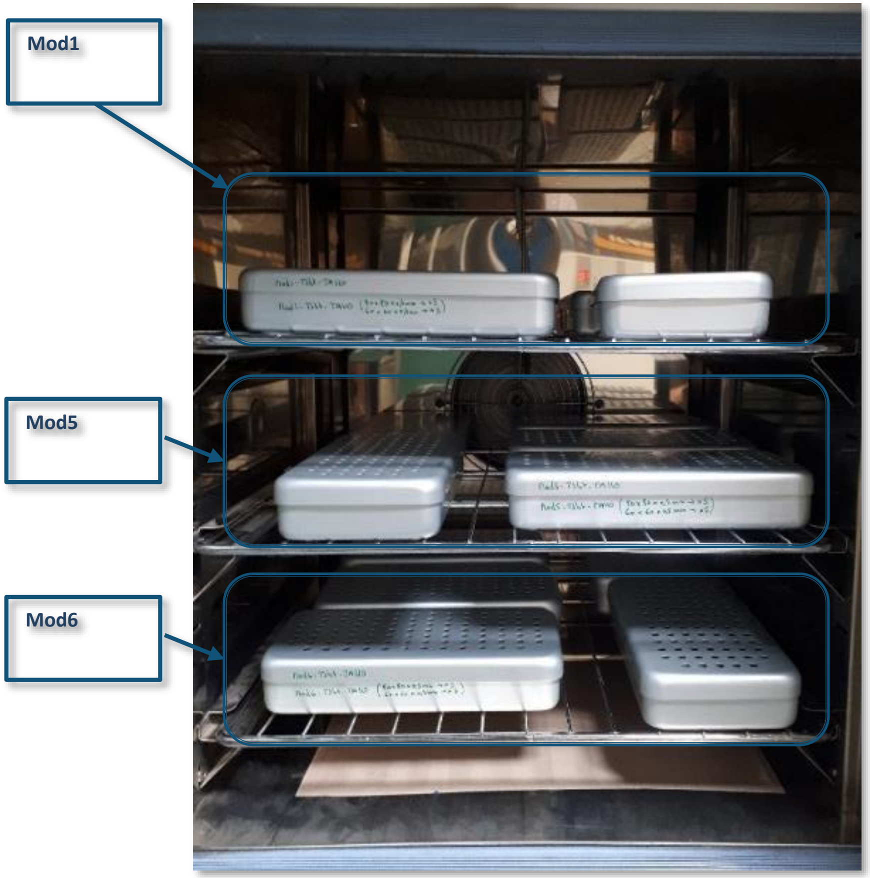
Sample ageing

- Thermal ageing:
  - at 3 temperatures 87 °C, 110 °C and 130 °C

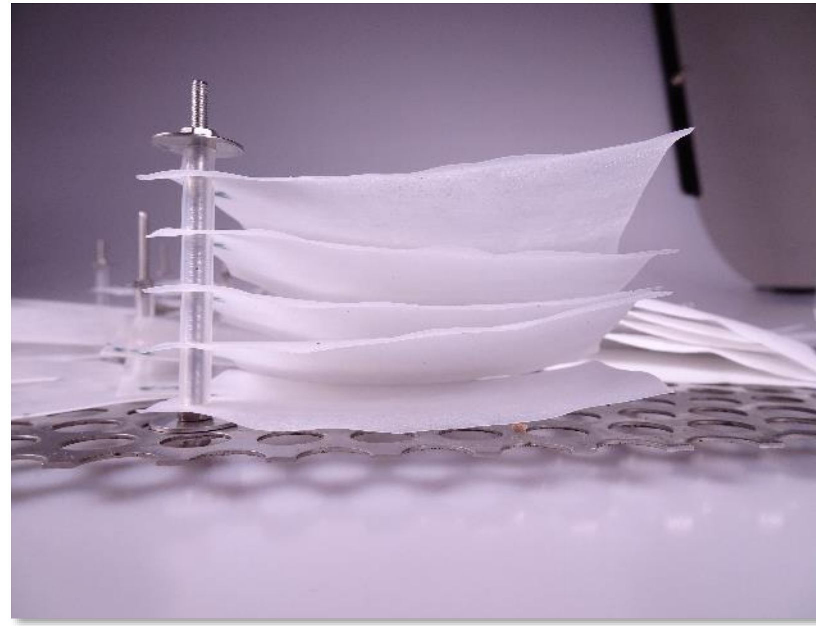
- Radiation ageing:
  - At 87 °C and 6 Gy/h
  - At 45 °C and 6 Gy/h
  - At 45 °C and 70 Gy/h
  - At 21 °C and 500 Gy/h

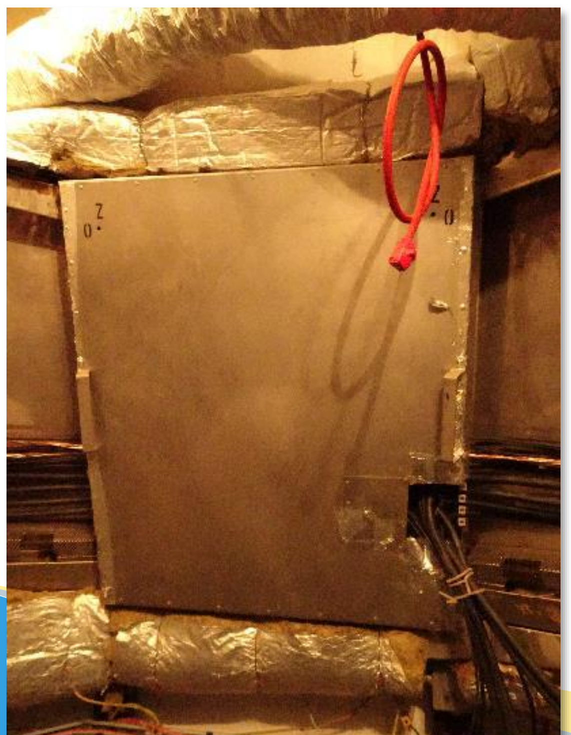
- Accident simulations

Thermal ageing in ENSAM



Radiation ageing at UJV





TeaM Cables and Equipment Qualification

EQ Accident and post-accident simulations

Design basis event (DBE) or severe accident (SA) simulation consists in:

- Accident dose irradiation
- Thermodynamic profile
- Post accident period
- Functionality testing

Accident simulation

Typical procedure is sequential test:
Accident dose irradiation followed by thermodynamic profile simulation

TeaM Cables
Both approaches will be tested and compared:
1. Sequential tests, irradiation followed by steam load
2. Simultaneous action of irradiation and steam load

Properties will be evaluated on new as well as on already aged cables.

Post-Accident simulation

Following the DBE, a post DBE period in submerged conditions has to be simulated. This may take 1 year or even more for severe accidents. Such a long period needs to be accelerated.

- at elevated temperature and pressure
- influence of chemicals
- electrical loading

Questions about appropriate time for simulation:
→ How to accelerate the test?
→ What is the minimum time for testing?

Post-Accident simulation

Typical procedure for 1 year post-accident period:
Acceleration using Arrhenius approach, 1 month test

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Both approaches will be tested and compared:
1. Full 1 year post-accident period will be simulated
2. Accelerated at higher temperature, 1 month test

Cables will be loaded throughout the period with rated voltage and current, and properties will be evaluated.

Expected impact

Reinforce safety of generation II and III reactors

Improve the market profile of EU-based reactor designs

Confirm a safe extension of the lifetime of NPP cables

New knowledge on polymers and cables useful also in other industry sectors

Improve public perception of nuclear safety through specific dissemination actions

Improve innovation capacity and integration of knowledge

Contribute to new or improved standards within IEC/TC45 A, IEC/SC45A and CENELEC TC45 committees

Thank you!

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