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 Nuclear Power Plant (NPP) cable research, including one cable manufacturer, renowned research institutes and academia and NPP industry:

1. Electricité De France (EDF)
2. Framatome GmbH (Former Areva GmbH)
3. Institut De Radioprotection Et De Sureté Nucléaire (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. Université d’Aix Marseille (AMU)
12. Ecole Nationale Supérieure d’Arts et Métiers (ENSAM)
Rationale

- 1 Nuclear Power Plant unit
  - ~1,500 km of electrical cables
  - ~25,000 connections

- Electrical cables are the nerves and blood vessels of NPPs
- In the context of the long term operation (over 40 years) of the NPPs, complete cable replacement is not economically viable
- 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
  - Generic accurate predictive lifetime models
  - Generic methods and tools for on-site monitoring of cables

Photo of a nuclear cable

Cable ageing ~ polymer layers ageing
TeaM Cables innovation

The main innovation of the project is the radically 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.
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 multiscale 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).
Specific scientific and technical objectives

- Carry out accelerated ageing representative of service conditions inside a reactor building on model materials and on real cables to identify polymer additive contribution in ageing mechanisms.
- Identify the impact of ageing on the behaviour of cables subject to accidental conditions.
- Develop and validate a kinetic model for polymer ageing.
- Develop multiscale models (mechanical, physical, electrical) based on output data of the kinetics models.
- Contribute to standards on cable ageing characterisation.
- Define criteria and deployment protocols for on-site monitoring techniques.
- Provide and promote a tool for cable ageing management and lifetime prediction integrating the models developed.
Scientific approach

- Polymers with growing formulation complexity to allow the role of each ingredient during the polymer ageing to be identified and modelled.
Scientific approach

- Identification and modelling of the impact of each ingredient at the micro scale.
Scientific approach

- Identification and modelling of the impact of changes at the micro scale on the macro scale.
Multiscale characterisation and modelling

- **Polymer oxidation, antioxidant depletion**
  - FTIR, UV-visible, OIT, EPR, gas mass spectrometry

- **Chain scission**
  - Swelling tests, DMTA

- **Crystallinity evolution, filler repartition**
  - DSC, SEM

- **Macroscopic properties evolution**
  - Mechanical tests, S-matrix experiments, dielectric spectroscopy, hardness, terahertz, microwaves

- **Localisation of ageing heterogeneities**
  - Reflectometry

**Scale**
- **Molecular** (-Å)
- **Macromolecular** (~100 nm)
- **Microscopic** (μm)
- **Macro** (cm)
- **Global** (meters)
TeaM Cables tool for cable ageing management

User → Database filling → Diagnosis and prognosis of cable wiring

« COMSY Cables »
Database:
- Plant data (ageing conditions)
- Cable data (cable design ...)
- Cable material data (material parameters)

Interfacing
Input parameters for modelling
Prediction of material parameters

« Virtual Polymer »
Multiscale models

TeaM CABLES production
Workplan structure

**Research and Innovation WPs**

- WP2 – Cable provision and ageing
- WP3 - Cable and material characterisations
- WP4 – Development of new kinetic and multiscale models
- WP5 – Non-destructive testing techniques
- WP6 – Development of the open access TeaM Cables tool and integration of models
- WP7 – Dissemination, training, exploitation, standards and end-user group

**WP1** – Project management and Technical Review
Expected project outcomes

- A partly publically available database with experimental results.
- A new multiscale modelling approach to predict polymer ageing addressing the problem of complex polymer formulation. This approach will be generic, thus applicable/transposable to various polymers families and formulations.
- Proposals for elaboration and revision of standards of characterisation tests.
- New methodologies for on-site monitoring giving access to data usable for residual lifetime calculation.
- An improved “TeaM Cables tool” integrating modelling and monitoring developments of this project for supporting the cable ageing management and lifetime prediction, and so leading to a more accurate level than what is possible today.
- 2 workshops, 1 symposium, a website, a leaflet, dissemination of tools (training sessions ...)
Expected impact

- Reinforce safety of generation II and II reactors
- Increase the confidence in the predictability of the lifetime of NPP cables in the context of long term operation
- Improve innovation capacity and integration of knowledge
- Contribute to new or improved standards within IEC/TC45 A, IEC/SC45A and CENELEC TC45 committees
- Improve the market profile of EU-based reactor designs
- New knowledge on polymers and cables useful also in other industry sectors
- Improve public perception of nuclear safety through specific dissemination actions
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