# Innovation in cable ageing management for nuclear safety in long-term operation of generation II and III reactors

TeaM Cables Consortium

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## ABSTRACT

*With an average of ~1500 km of cables per Nuclear Power Plant (NPP) unit, all organisations involved in the nuclear industry have recognised the importance of cable qualification, condition monitoring, and ageing management - electrical cables are the nerves and blood vessels of NPPs.*

*TeaM Cables – European Tools and Methodologies for an efficient ageing management of NPP cables – is a research project aiming at providing NPP operators with a novel methodology for efficient and reliable NPP cable ageing management. It has received 4,2 M€ of funding from the European Commission's EURATOM programme, which is part of the Horizon 2020 framework programme for Research and Innovation. The project is coordinated by Electricité de France (EDF) and will run until 2022.*

## KEYWORDS

TeaM Cables, long-term operation, safety, cables, multi-scale physics, ageing, numerical tool, modelling, accident testing, polymers, non-destructive techniques, on-site monitoring

## INTRODUCTION

In the coming years, the need for energy will significantly grow in developed and developing countries. To satisfy this growing demand in a context of research of low-carbon energy, many countries are looking for the extension of nuclear power plant (NPP) operations. The lifetime of existing NPPs can potentially be extended to between 60 and 80 years if safety and operability of facilities can be guaranteed. This means that all equipment must keep satisfactory characteristics in regards to those specified in the plant design time, with respect to normal operation but also during design basis accidents (DBA) and design extension conditions (DEC) respectively. This requires efforts in terms of equipment qualification and ageing management to support stakeholders and decision makers. This has become even more important with the amended Nuclear Safety Directive (Council Directive 2014/87/EURATOM of 8 July 2014) which requires countries to give the highest priority to nuclear safety at all stages of the lifecycle of a nuclear power plant (NPP). If the components of an NPP were considered as the organs of a body, the electrical cables would be its nerves and blood vessels. These electric cables are diverse with different designs and different materials depending on the voltage, the functionality and the polymer industry evolution over time. With an average of 25 000 cables for a total length of 1 500 km per NPP unit (an NPP containing several units), all organisations involved in the current and next generation of NPPs have recognised the importance of cable qualification, condition monitoring, and ageing management.

TeaM Cables aims at providing NPP operators with a novel methodology for efficient and reliable NPP cable ageing management by i) developing cable ageing models and algorithms, which are based on multi-scale studies and can be tailored to cover variations in fillers, additives and degrees of crosslinking, ii) developing methodologies for non-destructive testing techniques and their associated criteria identified from multiscale relations, iii) developing a novel "open access" tool, hereinafter referred to as the "TeaM Cables tool", integrating all the models developed and providing the residual lifetime of cables by crossing non-destructive measurements with predictive models and knowledge of cable exposure conditions (wiring network in the NPP). Current models only distinguish the type of polymer (e.g. EPR or XLPE). Cable lifetime estimation accuracy and adaptability will be greatly improved by TeaM Cables, as models will be based on several composition parameters (e.g. polymer type, filler type, antioxidant type).

## STATE OF THE ART

Cables, especially their insulation and jacket materials made of polymers, are vulnerable to ageing degradation during normal operation and accidents and means must be established to ensure that cable ageing does not lead to unsafe operation. The Workshop "Cable ageing in Nuclear Power Plants; R&D current status and Forecast" held at UJV Rez, Czech Republic in May 2016 depicted the European R&D on the topic. The 67 participants from 30 organisations and 14 countries discussed the current methods and gaps which need to be filled for an efficient cable ageing management enabling long term operation (LTO) of NPPs:

- Qualification tests. General standards for cable qualification exist. Nevertheless, these procedures are country-specific and their scientific relevance is questioned in terms of representativeness of ageing conditions and ageing understanding.
- Databases with data on cable ageing. Some previous studies led to the characterisation of many cable properties for different ageing conditions. However, polymers used in cables are varied and complex materials typically composed of about ten components (basic polymer component, one or two antioxidants, fillers, other additives). Each component can play a role during the ageing, depending on the nature of the degeneration process. The lack of knowledge about these phenomena leads to the impossibility to extend results of one cable reference to another. This is a current limit of existing polymer databases.
- Non-destructive testing (NDT) techniques. The end-of-life criterion for cables use in nuclear environments is