EMRP Call 2013 – Energy and Environment

Selected Research Topic number: **SRT-g11**
Version: 1.0

Title: Metrology for safe and secure fission energy

Abstract

Nuclear energy is a part of the energy mix that will positively contribute to a competitive economic environment in Europe as well as climate change issues and the strict targets set for green-house gas emissions. However, the safe operation of existing and future nuclear power plants can only be achieved through the careful monitoring of important physical parameters such as temperature, thermophysical and thermodynamic properties, neutron cross-sections and radioactivity as well as the investigation of parameters related to possible accident scenarios and abnormalities in operation. More accurate nuclear data and improved, traceable monitoring closer to the core and in waste streams is needed.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on "Grand Challenges" related to Energy and Environment on pages 8, 10 and 23.

Keywords

Nuclear energy, safety, fission, ionising, radiation, radioactive, activation, thermal, neutrons, nuclear data, thermophysical properties, modelling. reactor dosimetry

Background to the Metrological Challenges

The Fukushima Daïchi accident in 2011 has led to a renewed attention to the safety of nuclear power plants, in particular in respect of extremely severe external hazards. Safety improvements for existing or future nuclear power plants rely on core monitoring as, the closer the monitored location is to the reactor core, the faster a counter response can be initiated. However, current radioactivity monitors need further development as their methods rely on ensuring the redundancy of the measurements by multiplying the number of sensors and their locations. The stability of the sensors under irradiation and at high temperature is also an issue.

There have been a number of approaches used to model accident scenarios (e.g. the release of gaseous fission products into the atmosphere, corium – concrete interaction during core meltdown), although such approaches have been limited by the speed of the computations available and their access to comprehensive reliable thermodynamic and kinetic data. Therefore, there is a need to provide a wider range of tools for an interactive assessment of hazards as potential accident scenarios unfold.

The thermal behaviour of nuclear fuels and irradiated materials is currently studied at very high temperatures, up to 3000 °C for thermal diffusivity and specific heat in particular, by European nuclear research institutes. However, their apparatus must be calibrated or validated at such operating temperatures using reference materials in order to guarantee the accuracy and reliability of the measurements and the traceability of these measurements cannot currently be ensured at temperatures above 1500 °C for emissivity and specific heat, and above 2000 °C for thermal diffusivity.

Recent dosimetry evaluations have revealed data inconsistencies or deficiencies and that the uncertainty of spectrum average (SPA) cross sections is often very large. In addition, no evaluated experimental SPA data is available for a number of reactions. Further to this, existing primary circuit monitoring of radionuclides is non-spectrometric due to high activity levels. Therefore, ^{252}Cf SPA cross sections should help to resolve discrepancies in measured data and new background suppression systems and detector types could significantly improve monitoring during operation and hence accident prevention.

Scientific and Technological Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the JRP-Protocol.

The JRP shall focus on the traceable measurement and characterisation of physical parameters for the safe operation of existing and future nuclear power plants.

The specific objectives are

1. To develop temperature sensors suitable for harsh environments and measurements up to 2000 °C. As well as developing and characterising remote instrumentation for temperature measurements in reactors from distant control stations.
2. To develop thermodynamic data and models based on thermodynamic/kinetic calculations used in modelling for the safe operation of nuclear power plants.
3. To improve the characterisation of thermophysical properties of advanced materials at very high temperatures (up to 3000 °C) used in nuclear power plants. This should include:
    - design and implementation of facilities based on absolute measurement methods for thermal diffusivity, specific heat and spectral emissivity, and an assessment of their measurement uncertainties at the highest temperatures,
    - traceable methods for the calibration of high temperature calorimeters and phase transitions.
4. To validate dosimetry evaluations and improve SPA cross section measurements in the ^{252}Cf fission neutron spectrum. In addition, to improve nuclear data for radionuclides with relevance to nuclear safety, security and forensics as well as the determination of the beta spectra of decay schemes with forbidden spectra.
5. To develop or improve instrumentation for the measurement of radioactivity in primary circuits, discharges and accident monitoring.

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the R&D work, the involvement of the user community such as industry, and standardisation and regulatory bodies, as appropriate, is strongly recommended.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. In particular, proposers should outline the achievements of the EMRP project ENG08 (MetroFission) ‘Metrology for new generation nuclear power plants’ and how their proposal will build on those.

EURAMET expects the average size of JRPs in this call to be between 3.0 to 3.5 M€, and has defined an upper limit of 5 M€ for any project. The available budget for integral Research Excellence Grants is 30 months of effort.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (e.g. letters of support) is encouraged.

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to the energy and industrial sectors.

You should detail other impacts of your proposed JRP as detailed in the document “Guide 4: Writing a Joint Research Project”

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology and includes the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards

- the metrology capacity of Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.