INFORMATION SHEET

COORDINATED RESEARCH PROJECT – No T130115

ON

MANAGEMENT OF SEVERELY DAMAGED SPENT FUEL AND CORIUM

1. Title:

Management of Severely Damaged Spent Fuel and Corium – New CRP

2. Summary:

The accident at Fukushima Daiichi (March 2011) resulted in severe damage and reported fuel core meltdown of three of the nuclear power plants on the reactor site. A fourth reactor, although shutdown, suffered severe damage to its structure from a hydrogen explosion and resulted in plant and roofing materials being deposited in the fuel storage pool. The fuel in this pool may also have been damaged due to loss of cooling water and the introduction of seawater as a replacement. In terms of multiple failures, an accident of this scale has not been experienced previously resulting in an unprecedented remediation challenge.

Considerable R&D effort will be required to remediate Fukushima Daiichi. To maximise the benefit from R&D being performed by the international community, it is important that R&D is accurately targeted, duplication avoided and where superior knowledge is available this expertise is passed on to the team undertaking the R&D. CRPs have been used effectively in meeting these aims through bringing together the R&D community into a forum where R&D activities can be peer reviewed. It is also important that the information being generated is captured and shared with the international community.

In the context of this proposal the term "severely damaged spent fuel" will be used. Severely damaged spent fuel covers: Material from post irradiation examination; fuel debris, fuel damaged during fuel handling operations; fuel damaged as a result of loss of cooling; corium; and melted core concrete interaction products (MCCI).

The objective of the CRP will be to expand the existing knowledge base and identify optimal approaches for managing severely damaged spent fuel and corium.

3. Background Information:

Management of Severely Damaged Spent Fuel and Corium is a new Coordinated Research Project (CRP).

The accident at Fukushima Daiichi (March 2011) resulted in severe damage and reported fuel core meltdown of three of the nuclear power plants on the reactor site. A fourth reactor, although shutdown, suffered severe damage to its structure from a hydrogen explosion and resulted in plant and roofing materials being deposited in the fuel storage pool. The fuel in this pool may also have been damaged due to loss of cooling water and the introduction of

seawater as a replacement. In terms of multiple failures, an accident of this scale has not been experienced previously resulting in an unprecedented remediation challenge.

The Fukushima 'Mid-and-Long-Term Roadmap" indicates complete removal of the spent fuel from the storage pools at the Fukushima reactors within 10 years and in the longer term retrieval of the fuel debris, corium and melted core concrete interaction products. The international community now has the opportunity to contribute to the achievement of these targets.

Previous learning in this area comes from the related loss of cooling accident at Three Mile Island and the accident at Chernobyl. In the early 1990s a number of technical documents were produced to preserve the learning from the accidents at Three Mile Island (TMI) and Chernobyl. Closeout reports [1-4] document the successful retrieval and removal of fuel debris and Corium from TMI-2 reactor and transport to Idaho National Laboratory. Complementary reports on computer models and validation by experimentation and PIE from the INL Severe Fuel Damage tests and the OECD LOFT programme are also available.

In the case of Chernobyl the material is being monitored whilst plans are put into place for its eventual recovery; after the reactors have been stabilised. The long-term management of these materials has yet to be determined.

Further experience has also been gained on the retrieval and conditioning of fuel debris at PAKs NPP [5], which had been subject to degradation through overheating, and from the remediation of fuel which has become damaged through routine fuel handling operations[6].

To maximise the benefit from R&D performed by the international community, it is important that R&D is accurately targeted, duplication avoided and where superior knowledge is available this expertise is passed on to the team undertaking the R&D. CRPs have been used effectively in meeting these aims through bringing together the R&D community into a forum where R&D activities can be peer reviewed.

Whilst it is recognised that the R&D required to support the characterisation, recovery and ultimate disposition of material arising from Fukushima will be case-specific, it is believed that R&D in support of spent fuel behaviour, the remediation of damaged spent fuel and the management of PIE can be used to inform this R&D and will have some elements which will have direct application to the Fukushima 'Mid-and-Long-Term Roadmap". Additional R&D on the treatment of corium is also likely to be valuable in planning the roadmap.

In the context of this CRP the term "severely damaged spent fuel" will be used. Severely damaged spent fuel covers: Material from post irradiation examination; fuel debris, fuel damaged during fuel handling operations; fuel damaged as a result of loss of cooling; corium; melted core concrete interaction products (MCCI).

4. Overall Objective:

To expand the existing knowledge base and identify optimal approaches for managing severely damaged spent fuel.

5. Specific Research Objectives:

Specific research objectives are to develop and assess the following:

- Techniques for the in situ characterization and monitoring of severely damaged spent fuel;
- Characterisation of severely damaged spent fuel;
- Computer modelling applied to all physical and chemical phenomena for all stages from retrieval through to disposal;
- Tools and techniques for the sampling and handling of severely damaged spent fuel;
- Methods to mitigate adverse changes in the long-term behaviour of severely damaged spent fuel and packaged material (for example radiolysis, chemical and physical properties);
- Techniques for packaging materials/fuel debris;
- Tools and techniques for materials accountancy;
- Tools and techniques for conditioning severely damaged spent fuel for interim storage, and processing (including drying of fuel debris/materials, reprocessing, separation, vitrification) for disposal;
- Chemical and physical behaviour of severely damaged spent fuel during the transfer from one stage to the next stage (to support safety case development);
- Source term release during interim storage, transfer to next stage and disposal.

6. Expected Research Outputs:

The research outputs from the CRP will be published as a technical document at the end of the CRP cycle; with the same title as the CRP.

7. Expected Research Outcomes:

- A review of previous experience in the characterisation, retrieval, conditioning, interim storage and final disposition of severely damaged spent fuel;
- Information on tools and techniques for the recovery of severely damaged spent fuel;
- Accounts of current operating experience of the management of severely damaged spent fuel;
- The results from studies on the characterisation and behaviour of severely damaged spent fuel;
- The reporting of tools and techniques for conditioning severely damaged spent fuel;
- Design of packaging for severely damaged spent fuel;
- The reporting of R&D in support of safety case development for the safe storage and subsequent transportation or handling of packed severely damaged spent fuel;

- The reporting of R&D in support of reprocessing of severely damaged spent fuel;
- The reporting of R&D in support of disposal of severely damaged spent fuel.

8. Planned Activities:

General activities

- Review previous experience, on-going operations and research in severely damaged spent fuel;
- Establish a framework of research and development efforts in support of the management of severely damaged spent fuel;
- Review the results of the research efforts on severely damaged spent fuel over the long-term;
- Provide operating experience on the management of severely damaged spent fuel;
- Evaluate best practices for the management of severely damaged spent fuel.

For the following described activities, the international need and interest will be confirmed with representatives of potential participating Member States and Organizations.

Characterisation:

- Systematic review of potential degradation mechanisms and assessment of their relevance for the management of severely damaged spent fuel;
- Systematic review of techniques for the determination of physical and chemical characteristics of severely damaged spent fuel;
- Chemical and physical analysis of damaged or melted fuel and MCCI.

Retrieval:

- Tools and techniques for the retrieval of severely damaged spent fuel from the reactor pressure vessel and fuel storage pools;
- Tools and techniques for safeguarding material.

Conditioning:

- Techniques for the drying and sealing of severely damaged spent fuel;
- Techniques for the control of hydrogen evolution;
- Techniques to stabilize severely damaged spent fuel;
- Preparation for transfer from one stage to the next.

Interim Storage:

- Design of packages to minimise adverse changes to the stored severely damaged spent fuel;
- Techniques for monitoring conditioned packages and storage systems;

- Long-term evolution of conditioned packages and stored materials.

Processing:

- Review of treatment options and final potential waste-forms;
- Reprocessing of severely damaged spent fuel.

Disposal:

- Long-term chemical reactivity of package and final waste forms.

Regulatory Aspects of Managing Severely Damaged Spent Fuel:

- Risk base analysis of all stages.

List of potential participating countries:

Canada, France, Germany, Hungary, Japan, Korea, Kazakhstan, Russian Federation, Switzerland, United Kingdom, United States of America, European Union.

Standard IAEA Proposal forms are available on our website:

http://www-crp.iaea.org/html/forms.html

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Management of Severely Damaged Nuclear Fuel and Related Waste, Technical Report Series No. 321, IAEA, Vienna (1991).

2] INTERNATIONAL ATOMIC ENERGY AGENCY, Clean-up and decommissioning of a nuclear reactor after a severe accident, Technical Report Series No. 346, IAEA, Vienna (1992).

[3] ELECTRIC POWER RESEARCH INSTITUTE, The Cleanup of Three Mile Island Unit 2 – A Technical History: 1979 to 1990, EPRI NP-6931, March 1990.

[4] ELECTRIC POWER RESEARCH INSTITUTE, Final TMI-2 Technology Transfer Progress Report, EPRI TR-100643, May 1992.

[5] Z Hózer et al, Activity release from damaged fuel during the PAKs-2 cleaning tank incident in the spent fuel storage pool, Journal of Nuclear Materials No 392, pages 90-94, 2009.

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Management of Damaged Spent Nuclear Fuel, Nuclear Energy Series Nuclear Fuel Technical Report No. 3.6, IAEA, Vienna (2009).