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Research Program for the Evaluation of Fission Product and Actinide Release Behaviour, Focusing on Their Chemical Forms

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Abstract

We have launched a new research program for evaluation of fission product and actinide release behaviour under severe accident conditions, focusing on their chemical forms. In this research program, the fission product and actinide release models incorporated in the severe accident analysis code will be improved by implementing effects of chemical forms that are to be obtained by an experimental investigation on the fission product and actinide release behaviour from irradiated fuels. A novel in-situ measurement method of chemical forms of fission products and actinides just after their release as well as an off-line analysis method will be employed as the experimental means for evaluating the chemical forms at the release and their stability after release.

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1. Introduction

After the 2011 nuclear accident at the Fukushima Daiichi (1F) Nuclear Power Plant (NPP) [1], Tokyo Electric Power Company (TEPCO) decided to decommission the reactors at 1F-NPP and the corresponding road map was

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drawn up [2]. Research and development (R&D) project to address the technological challenges which are needed to accomplish the 1F-NPP decommissioning were devised by the Agency of Natural Resources and Energy and TEPCO in collaboration with all of the related organizations and 1F manufacturers. The Japan Atomic Energy Agency (JAEA) has implemented the basic and fundamental researches on the highly radioactive materials in the R&D project, specifically the fuel debris, radioactive waste and spent fuel [2]. In the hot laboratory complex in the Oarai branch of JAEA, the following experimental-based research programs have been launched based on the significant knowledge and experience of post irradiation examinations.

- Evaluation of the seawater effects on corrosion behavior of component materials of irradiated fuel assemblies, reactor pressure vessels and primary containment vessels for the integrity assessment of their materials that experienced a diluted seawater exposure
- Basic study on analysis techniques of fuel debris for the establishment of the effective nuclear material accountancy methodology in the debris which has various form
- Evaluation of fission product (FP) and actinide release behaviour for better accuracy of the source term issues prior to the precise evaluation of the accident progress and the status inside the damaged 1F core

This article describes details of the third research program, the evaluation of FP and actinide release behaviour.

Continuing research on source term issues is also of special importance for improvement of accuracy of the Probabilistic Safety Assessment (PSA) method [3,4] for both safety evaluation of NPPs and severe accident management (SAM) measures [5,6]. Since its development and first application to a regulatory process by the Nuclear Regulatory Commission (NRC) in 1978 [3], the PSA method has been continuously improved through analyses of commercial NPPs. In particular, as the Three Mile Island Unit 2 (TMI-2) accident gave little information on FP behaviour after release from the bundle in spite of the large core melt; about 50% [7], source term issues have attracted much attention and been the subject of many experimental and analytical studies. Outcomes of these studies have been reflected as improvements of the severe accident analysis codes such as MAAP [8,9], MELCOR [10] and THALES-2 [11-13]. Presently, there are several on-going experimental and analytical programs about source term issues. For instance, the VERDON program [14] focuses on Ru behaviour in a reactor especially at the time of air ingression in a severe accident scenario under the framework of the Severe Accident Research NETwork of Excellence (SARNET) [15].

The present situation since the 1F-NPP severe accident [1], on the other hand, has strongly shown the need for better accuracy of the source term issues because NPP safety must be reinforced by improvement of accuracy and rationality of the PSA method. Since the PSA is evaluated through the use of the severe accident codes, the improvements of their accuracy are required for the precise evaluation of source term issues. Therefore, the decommissioning work of 1F-NPP is a matter of top priority in order to incorporate the lessons learned from the accident as soon as possible. The severe accident analysis codes are to be improved for the precise evaluation of the accident progress and the status inside the damaged 1F core prior to the actual removal of fuel debris in the core [2].

We have launched a new research program for the evaluation of FP and actinide release behaviour, which is one of the important source term issues, focusing on their chemical forms according to the above-mentioned viewpoints of reinforcing nuclear safety and carrying out the R&D project for the 1F-NPP decommissioning. Chemical forms are the key factor that affects not only the FP and actinide release behaviour but also their transport behaviour.

In this article, previous experimental and analytical research studies on FP and actinide release behaviour are reviewed in order to specify the subjects to be resolved; based on this specified subjects, we introduce a research plan.

2. Review of previous research studies on FP and actinide release behaviour

Single-effect studies and integral studies have been carried out for the evaluation of FP and actinide release behaviour. The former focuses on a single phenomenon under a controlled condition, which can give deeper insights into the specific phenomena. The integral studies cover topics from the FP and actinide release from the fuel to their transportation in a reactor. The data obtained by these experimental studies have been analyzed by FP and actinide release models for further improvement of these models.

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