Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 131 (2017) 258–263

Energy Procedia

www.elsevier.com/locate/procedia

5th International Symposium on Innovative Nuclear Energy Systems, INES-5, 31 October – 2 November, 2016, Ookayama Campus, Tokyo Institute of Technology, JAPAN

Characterization Study of Four Candidate Technologies for Nuclear Material Quantification in Fuel Debris at Fukushima Daiichi Nuclear Power Station

Taketeru NAGATANI[a*], Masao KOMEDA[a], Tomooki SHIBA[a], Yasushi NAUCHI[b], Makoto MAEDA[a], Hiroshi SAGARA[c], Yoshihiro KOSUGE[d], Masatoshi KURETA[a], Hirofumi TOMIKAWA[a], Keisuke OKUMURA[a], Cynthia HEINBERG[a], Keiichiro HORI[a]

[a]*Japan Atomic Energy Agency, Tokai-village Ibaraki-pref., Japan*
[b]*Central Research Institute of Electric Power Industry, Yokosuka-city Kanagawa-pref.,Japan*
[c]*Tokyo Institute of Technology, Meguro-ward Tokyo, Japan*
[d]*NESI, Tokai-village Ibaraki-pref., Japan*

Abstract

This paper provides an interim report for characterization study of four candidate technologies for nuclear material quantification in fuel debris at Fukushima Daiichi Nuclear Power Station (1F). The severe loss-of-coolant accidents of 1F produced fuel debris in the reactor cores of Units 1-3. Because the fuel debris would contain unknown amounts of minor actinides, fission products and neutron absorbers and the mixing rate of them would vary significantly, accurate quantification of nuclear material in fuel debris would be difficult by applying a single measurement technology. Therefore, we consider that an integrated measurement system that combines several measurement technologies would be required to complement the weakness of each technology. For consideration of an integrated measurement system, we conducted a characterization study for each technology. In order to compare the results of applicability evaluation of each technology, common set of simulation models for fuel debris and canister were developed. These models were used for the applicability evaluation of each technology. Then, the comparative evaluation of the result of applicability evaluation among four technologies was conducted.

© 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the organizing committee of the 5th International Symposium on Innovative Nuclear Energy Systems.

Keywords: Fukushima Daiichi Nuclear Power Station; Fuel debris; quantification of nuclear material; passive neutron; acvitive neutron; passive gamma; active gamma

1. Introduction

The severe loss-of-coolant accidents of Fukushima Daiichi Nuclear Power Plants (1F) caused by the tsunami on March 11, 2011 produced fuel debris in the reactor cores of Units 1-3 [1]. For decommissioning of 1F, measurement technology for quantification of the nuclear material in fuel debris will be required for appropriate nuclear material management. Fuel debris is considered to be solidified, mixed with surrounding materials such as zircaloy and concrete. Therefore, it is considered to be insoluble and inhomogeneous, which makes it unsuitable to apply destructive assay to fuel debris. Moreover, fuel debris contains

* Corresponding author. Tel.: +81-29-282-1133; fax: +81- 29-282-9490
E-mail address: nagatani.taketeru@jaea.go.jp

1876-6102 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the organizing committee of the 5th International Symposium on Innovative Nuclear Energy Systems.
10.1016/j.egypro.2017.09.447

minor actinides and fission products which are intense neutron and gamma ray sources generated by burnup of fuel in a reactor. It also contains neutron absorbers such as B-10 from control rods or boron added after the accident to avoid re-criticality. These materials make it difficult to apply conventional non-destructive assay to fuel debris. For these reasons, the development of a new fuel debris measurement system is required.

Under the collaborative program with United States Department of Energy (DOE), Japan Atomic Energy Agency (JAEA) and Central Research Institute of Electric Power Industry (CRIEPI) surveyed technologies for nuclear material quantification of fuel debris at 1F from 2012 to 2014[2]. Four research groups in JAEA and CRIEPI have evaluated independently the applicability for four technologies, passive neutron technique, passive gamma technique, active neutron technique and active gamma technique, by simulation and/or small scale measurement tests. Table 1 shows an overview of the four candidate technologies.

Table 1 Overview of four candidate technologies

	Methods	Measurement target	Principle
Passive Neutron (PN)	➢ Differential Die-away Self-Interrogation (DDSI) ➢ Neutron Coincidence	➢ Cm-244 effective mass (Cm244e) ➢ Pu and U mass are determined by isotopic composition obtained by code or measurement.	➢ DDSI evaluates the leakage multiplication. ➢ Cm244e is evaluated by the correlation multiplication corrected doubles and Cm244e.
Active Neutron (AN)	Fast Neutron Direct Interrogation (FNDI)	➢ Fissile mass (sum of U-235, Pu-239 and Pu-241)	➢ Fissile mass is evaluated using induced fission neutron counts ➢ The die-away time is utilized to correct matrix factor.
Passive Gamma (PG)	Gamma spectroscopy of low-volatile and high energy γ-emitting fission products	➢ Eu-154 mass that coexists with U and Pu in the fuel debris ➢ Burn-up and isotopic composition	➢ Eu-154 is evaluated and U and Pu mass are estimated by utilizing FP/nuclear material correlation. ➢ Burn up is estimated by the ratio of Cs134/137 and/or Eu154/Ce144 for example.
Active Gamma (AG)	Neutron induced gamma ray spectroscopy (NIGS)	➢ Mass (number) ratio of U-238 and Pu-240 ➢ Mass (number) ratio of U-238 and fissile ➢ (Possibly, U238 mass by combining with PN and/or AN.)	➢ Gamma ray spectroscopy to obtain reaction rates of capture and fission reactions. ➢ Mass ratio is deduced assuming cross section.

Because the fuel debris would contain unknown amounts of minor actinides, fission products and neutron absorbers and the mixing rate of them would vary significantly, accurate quantification of nuclear material in fuel debris would be difficult by applying a single measurement technology. Therefore, we consider that an integrated measurement system that combines several measurement technologies would be required to complement each other. Fig. 1 shows block diagram of an integrated measurement system under consideration.

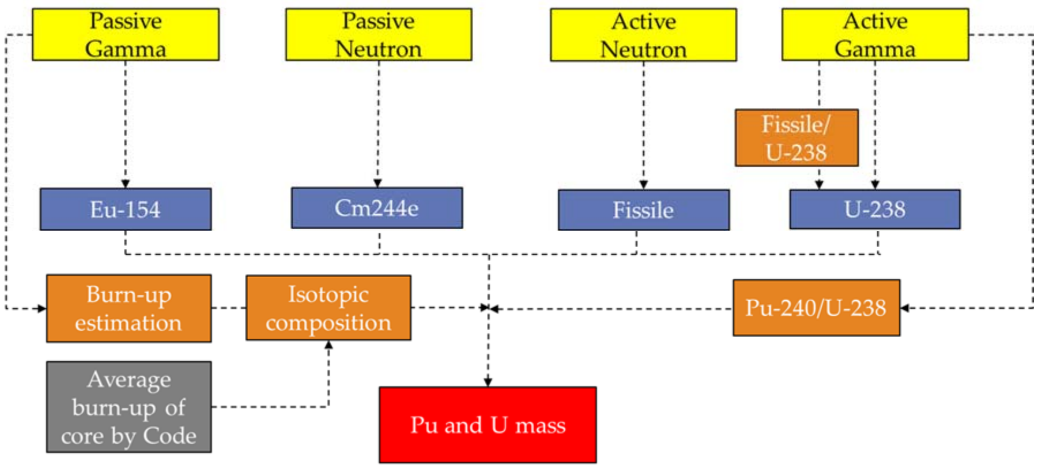

Fig. 1 Block diagram of an integrated measurement system under consideration

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات