

Effects of Severe Accident Conditions on Integrity of RPV Pedestal of Fukushima Daiichi Nuclear Power Plant

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Abstract

The Fukushima Daiichi Nuclear Power Plant lost its core cooling function due to the massive tsunami generated by the 2011 off the Pacific coast of Tohoku Earthquake, which caused core meltdown, resulting in high temperature inside the containment vessel and exposing the RPV pedestal, a reinforced concrete structure, to an unusually high temperature environment. After the earthquake, water was poured into the containment vessel to cool the molten core, and the concrete structure was gradually cooled in the process. Since it will take at least 40 years to remove the fuel from the core, the integrity of the RPV pedestal is a major concern for the decommissioning of the Fukushima Daiichi Nuclear Power Plant. In order to assess the long-term integrity of the RPV pedestal, a horizontal loading test was conducted using a 1/6 scaled model of the RPV pedestal of Unit 1 considering the effect of the high temperature heating and subsequent wet conditions. And then, the static stress analysis of the RPV pedestal was performed considering the degradation phenomena revealed by the experiments. As a result, it was confirmed that the RPV pedestal of Unit 1 would be structurally sound for 40 years against the current design basis earthquake even if the material degradation due to severe accident and aging was considered.

1. Introduction

The Fukushima Daiichi Nuclear Power Plant (FD-NPP) was hit by a large earthquake ground motion caused by the 2011 off the Pacific coast of Tohoku Earthquake. FD-NPP has six power units, and Units 1 through 3 were in normal operation according to TEPCO (2011a). All the control rods of the operated units were auto-

matically inserted following detection of the large seismic ground motion, and the reactor was safely shut down. However, a huge tsunami generated by the earthquake then hit the plant, causing the loss of power supply and, more importantly, the loss of the core cooling function, leading to core meltdown.

As a result, the inside of the primary containment vessel (PCV) reached high temperature and high pressure, the containment vessel function was impaired, and the pedestal of the reactor pressure vessel (RPV pedestal), which is a reinforced concrete structure, was exposed to an unusually high temperature environment. As an emergency measure to cool the molten core, seawater was initially injected, but this was later switched to fresh water and then to water treated in the stagnant water purification system. In these processes, the temperature and the chloride ion concentration were greatly reduced. Since it will take at least 40 years from the time of the earthquake to remove the fuel from the core, however, the effects of high temperature and aging on the integrity of the RPV pedestal are a major concern for the decommissioning of FD-NPP. The RPV, PCV, and the RPV pedestal are illustrated in Fig. 1 according to Tanaka *et al.* (2021).

Currently, it is almost impossible to repair the RPV pedestal because access to the containment vessel is very difficult due to the radiation conditions. It is necessary to evaluate the integrity of the RPV pedestal in its current and long-term states considering the influence of severe accidents, subsequent environmental conditions, and aging. Therefore, the International Research Institute for Nuclear Decommissioning (IRID) has conducted various experimental studies to evaluate

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RPV Integrity and Fracture Mechanics Dominique Moinereau, 2004 *Proceedings of the Topical Meeting on Safety of Operating Reactors* , 1995 **Nuclear Power or a Promise Lost** Edward T. Burns, 2020-05-01 This book captures the status of current electrical energy markets including the principal forces affecting decisions on selecting an energy source It represents a seminal work that lays out the electrical energy decision tree for selecting an energy source in a world that is on the verge of catastrophic global warming because of the choices that have been made in the name of cheap energy The impetus for this book includes the dire need to mitigate continued anthropogenic causes of global warming by turning to carbon free energy sources Nuclear energy represents such a carbon free energy source and could be a partial solution to the existential threat facing future society the threat of a warming planet and its consequential catastrophic effects on future generations The world is at a crossroads in human interaction with their environment The effects of radiation and the relationship of nuclear power to nuclear weapons are both discussed in an understandable and compelling manner Nuclear energy is contrasted with other energy sources including fossil fuels and renewable energy sources regarding the risks and benefits imposed by each Important personalities and world events that shaped nuclear power s development are recounted The historical origins of nuclear power are outlined and the continued impetus to include nuclear power as part of the electric grid energy mix is assessed exposing the obstacles and road blocks to the continued use of nuclear power Specific attention is paid to revealing the causes and lessons learned from the three severe accidents in commercial nuclear plants

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Nuclear Thermal Hydraulic and Two-Phase Flow Jun Wang, Kaiyi Shi, Zhaoming Meng, Shripad T. Revankar, 2018-10-11 Nuclear energy is one of the most important clean energy and contributes more than 10% electric power to human society in the past decades of years The nuclear thermal hydraulic and two phase flow is one of the basic branches of nuclear technology and provides structure design and safety analysis to the nuclear power reactors In the new century the basic theoretical research of thermal hydraulic and two phase flow and innovative design for the next generation nuclear power plants especially for the small modular reactor and molten salt reactor along with other nuclear branches constantly support the development of nuclear technology

Proceedings of the International Topical Meeting on Advanced Reactors Safety, 1997 JSME International Journal, 2004 Energy Research Abstracts, 1994 Semiannual with semiannual and annual indexes References to all scientific and technical literature coming from DOE its laboratories energy centers and contractors Includes all works deriving from DOE other related government sponsored information and foreign nonnuclear information Arranged under 39 categories e g Biomedical sciences basic studies Biomedical sciences applied studies Health and safety and Fusion energy Entry gives bibliographical information and abstract Corporate author subject report number indexes

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