

# Conceptual Study on Retrieval Method of Fuel Debris by Retrieval Machine Using Shielding Materials in the Air

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## Purpose and Goal

Study on fuel debris retrieval method in the air (dry method) is required as an alternative retrieval method in case that the submersion method could not be applied to remove fuel debris in the core and on the pedestal at the Unit1-3 of Fukushima Daiichi nuclear power station. This C/S was conducted to devise scenarios and procedures of the retrieval method aiming to establish the concept of the alternative method

## Overview and Feature

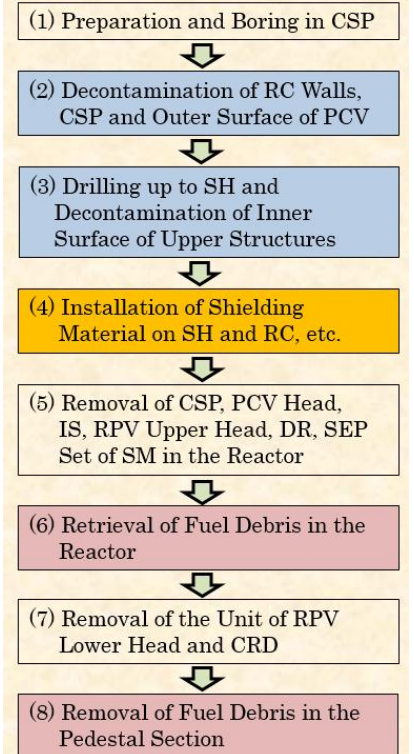
The alternative method proposed is that the fuel debris is retrieved by a manipulator machine, which accesses to the debris from the operating floor above the reactor in the air, using radiation shielding materials (steel balls). In the C/S following items were studied:

- (1) Scenarios and Procedures of Fuel Debris Retrieval
- (2) Devices, Equipment and systems for Fuel Debris Retrieval
- (3) Safety-related Issues (Radiation Dose Rate Estimation, Criticality Safety, Fuel Debris Cooling, Aseismic Safety, etc.)
- (4) Issues to be Developed and R&D Program

## Outcome obtained

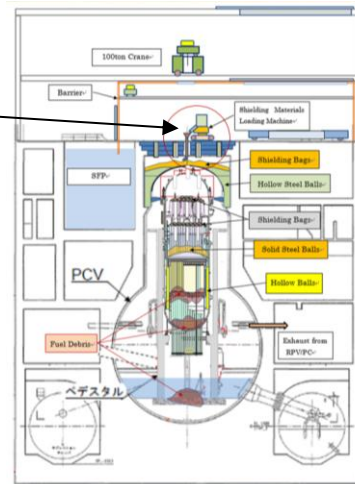
As the results of the Conceptual Study, following conclusions were obtained:

- Scenarios and procedures of the fuel debris retrieval accessed from the operation floor in the air were studied and a basic scenario and procedures were made. Proposed basic scenario and procedure is that Removal of upper structures (CSP, PCV head, RPV, etc.)→Retrieval of fuel debris in the RPV→Removal of the Unit of RPV lower head and CRD→Retrieval of fuel debris in the pedestal is conducted step by step using shielding materials of steel balls in the air.
- Conceptual structures of the equipment and related systems for retrieval of fuel debris were studied. Issues of the equipment for further were shown.
- Safety related issues were studied. Radiation dose rate on the operation floor during fuel debris retrieval was estimated and it was revealed that the radiation from Cs-137 attached on the upper structures such as CSP, PCV head and reactor cavity walls is greater than radiation from fuel debris in the reactor. Decontamination of these structures before fuel retrieval in the reactor is necessary to reduce radiation exposure dose on the floor in addition of shielding by shielding materials.
- Regarding to criticality safety, subcriticality condition is maintained in the case of TMI-2 conditions. However a criticality monitoring device should be installed. As to the cooling of fuel debris, fuel debris is cooled by supplying water which is filtered and recycled.



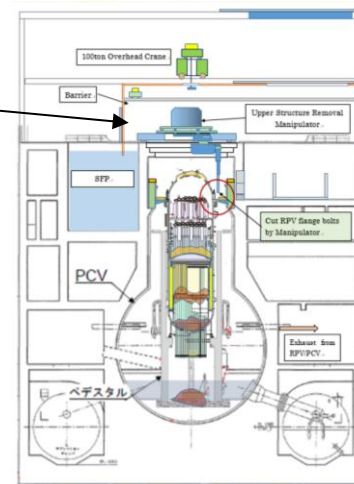
Basic Scenario

Filling Machine of Shielding Materials



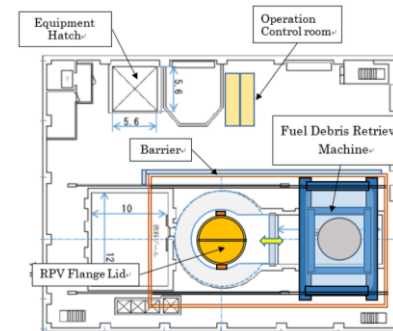
Filling of Shielding Materials in the RC and RCV

Manipulator for Removal of Upper Structure

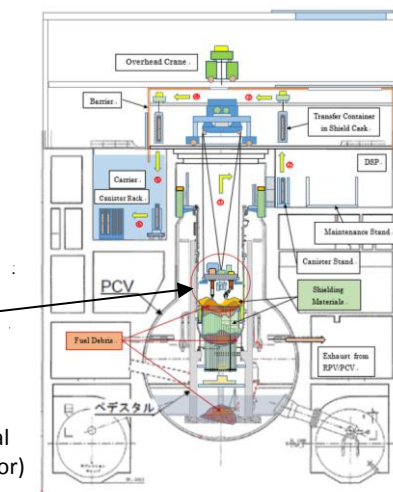


Removal of RPV Upper Head

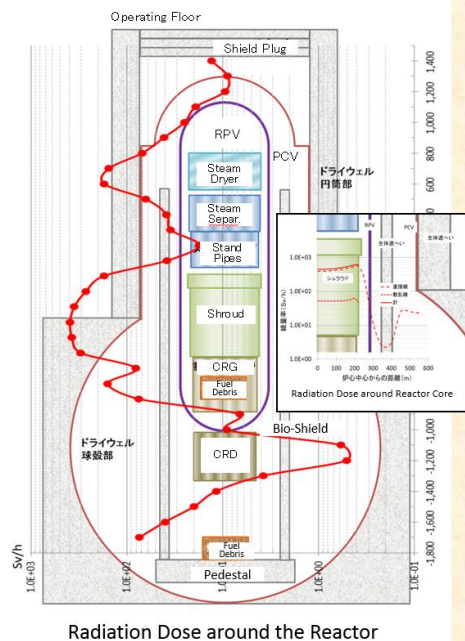
Fuel Debris Retrieval Machine (Manipulator)



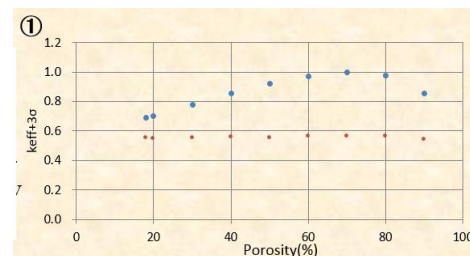
Fuel Debris Retrieval in the RPV



Fuel Debris Retrieval in the Pedestal



Radiation Dose around the Reactor



Subcriticality Analysis for Fuel Debris at the Pedestal

- CRD: Control Rod Drive Mechanism
- CSP: Concrete Shield Plug
- DR: Steam Dryer
- DSP: Dryer & Separator Pit
- IS: Mirror Insulator
- PCV: Pressure Containment Vessel
- RC: Reactor Cavity (Well)
- RPV: Reactor Pressure Vessel
- SEP: Separator
- SFP: Spent Fuel Pool
- SH: Shroud Head
- SM: Shielding Material
- SST: Sliding Shield Table (Plate)

## Challenges and Issues in the future

### 1. Major Technical Issues

- (1) Steel balls : Performance of shielding, criticality, cooling, handling(filling, retrieval, treatment in cutting debris and structures)
- (2) Fuel debris retrieval equipment : mechanism, function, maintenance, and cutting method
- (3) Removal of existing large, heavy and contaminated structures such as PCV head and RPV head : cutting, transportation, decontamination and storage
- (4) Specific equipment such as fuel debris retrieval machine and steel ball filling machine : Development and function, endurance and treatment

### 2. Process of Development

Development of specific technology⇒Trial fabrication and development test (function, endurance and handling)⇒Mock-up test