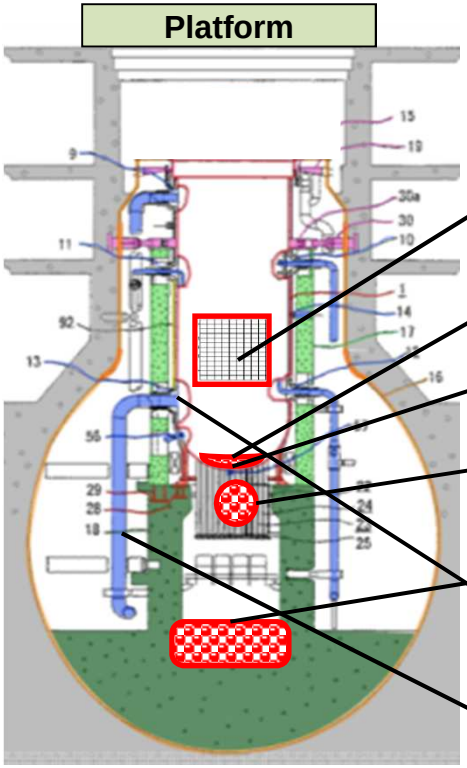
Selection of fuel-debris properties required for defueling work at post severe accident

Hirotomo IKEUCHI, Toru KITAGAKI, Ryohei WAKUI, Hidetoshi HIGUCHI,
Kenji KOIZUMI, Kimihiko YANO, Naoya KAJI and Tadahiro WASHIYA
Japan Atomic Energy Agency (JAEA)

Introduction

- JAEA started to obtain the characteristics data of simulated fuel-debris in order to contribute to the development of defueling tools,
  - ✓ by obtaining the essential physical properties, and
  - ✓ by finding out the appropriate candidate materials as non-radioactive surrogate debris for a mock-up test of the defueling tools.
- In this work, the essential physical properties of debris were selected.
  - Review of the defueling process and tools of TMI-2
  - Assumption of defueling process and tools for 1F
  - Rating on fuel-debris properties

Assumption of defueling process and tools for 1F
– Based on comparison with TMI-2 –



Estimation of damaged core of Unit-1

Defueling process	Feature	Defueling tool
1. Removal of the molten lower structure (core support plate, etc.)	Pin and plate-like structure	(b), (d), (e)
2. Removal of debris on the bottom of RPV	Particle debris	(d), (e)
3. Removal of the RPV bottom plate	Plate-like structure	(c), (d), (e), (f)
4. Removal of **control rod housing and ICM housing**	Massive debris, Pin structure	(b), (d), (e)
5. Removal of **MCCI products**	Particle debris, MCCI products	(a), (d), (e), (f)
6. Removal of the debris in the annulus	Particle debris	(c), (e)
7. Collection of **debris in the PCV and the cooling system**	Floating debris	(d), (e)

*** Major difference from TMI-2.**

(Functional categories of defueling tools used in TMI-2)

Cutting-tool

- A: impact fracture (a)
- B: shearing (b)
- C: fusion cutting (c)

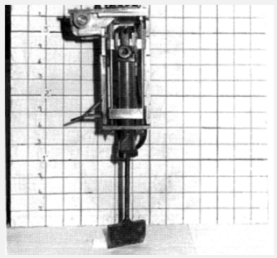
Pick-and-place (d)

Aspiration (e)

Core-boring (f)

Categories of defueling tools

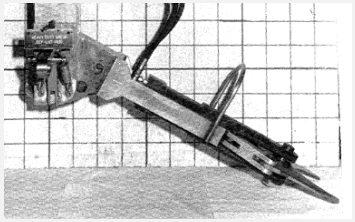
*Photos of tools are quoted from EPRI NP-6931 and EGG-TMI-7385



(a) impact fracture

e.g. air chisel

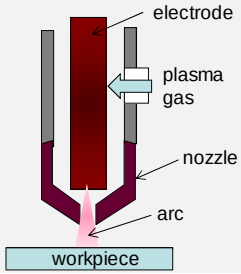
Target:
crust-like or massive debris



(b) shearing

e.g. heavy duty shears

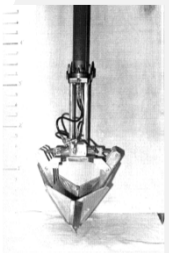
Target:
pin-like structures



(c) fusion cutting

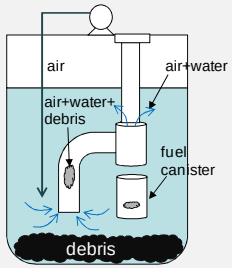
e.g. plasma-arc cutter

Target:
plate-like structures



(d) pick-and-place

Target: particle or fine debris



(e) aspiration

e.g. air lift pump

Target:
particle debris

(f) core-boring

e.g. rotary drill-bit

Target:
crust-like or massive debris

- Most defueling process would be conducted with similar tools for TMI-2.
- Physical properties of fuel-debris are selected from the viewpoint of their influences on the performance of defueling tools (a)–(f).

Rating on fuel-debris properties

Table *Tentative list of debris properties selected as essential for defueling tools*

* This table is subject to be revised according to the progress of R&Ds on debris properties.

Defueling tools	Shape	Particle size	Density	Thermal conductivity	Specific heat	Melting point	Hardness	Elastic modulus	Fracture toughness	Bending strength	Dynamic fracture toughness	Latent heat of melting
a. Impact fracture			○					○	●		○	
b. Shearing							●	●	●			
c. Fusion cutting			●	●	●	●						○
d. Pick-and-place	○	○	●									
e. Aspiration	○	○	●									
f. Core-boring			●	●	●		●	●	●	○		

Some data had accumulated by SA research

Need to be measured

Note: ●, Significantly affecting properties to the tool design; ○, Properties which is difficult to be measured on the 1F debris samples or can be replaced by other properties.

- Consequently, the mechanical properties such as hardness, elastic modulus and fracture toughness of fuel-debris are very short, and those properties are estimated to affect to the tool design.