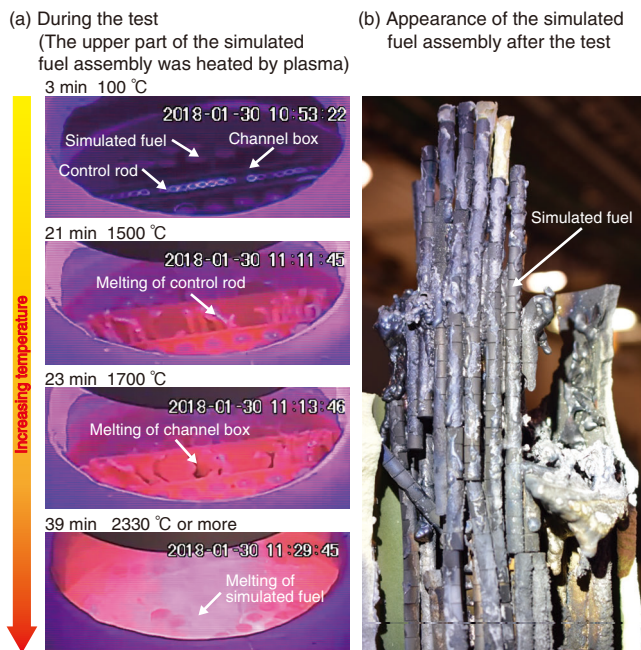


# 1-1 Estimate the State of the RPV and PCV after a Severe Accident

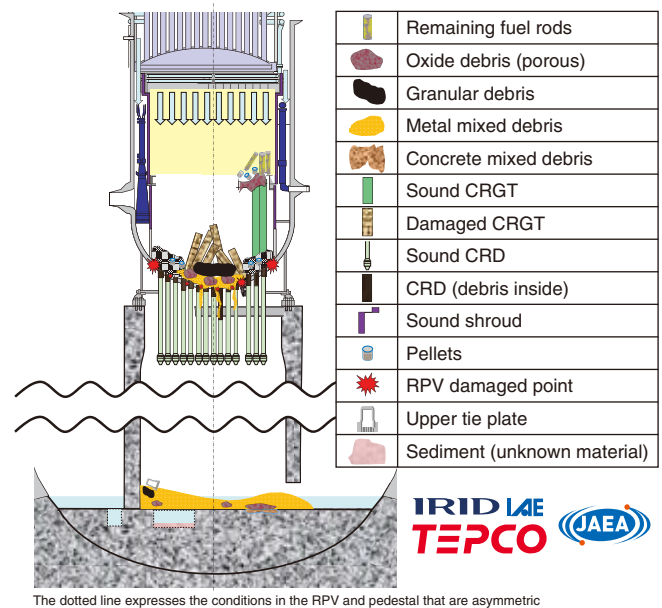
## — Upgrading of the Comprehensive Identification of Conditions Inside Reactor —



**Fig.1-2 Core-material melting and relocation (CMMR) test**  
The simulated fuel assembly at the top was heated by plasma. A  $ZrO_2$  pellet was used, rather than  $UO_2$ . (a) A downward flow was observed in order of materials with lower melting points. (b) The simulated fuel retained the column shape until its melting temperature.

The decommissioning of the TEPCO's Fukushima Daiichi NPS (1F) has been underway since its severe accident (SA) in March 2011. Estimating and comprehending the state of the remaining fuel debris and fission products inside the nuclear reactor is essential for this process. However, understanding the state the reactor pressure vessel (RPV) and primary containment vessel (PCV) is extremely difficult after an accident, as direct observation of the reactor interior is difficult due to the high radiation environment. Additionally, as Unit 1–Unit 3 at 1F lost their cooling functions during the tsunami, as well as their direct-current electric power supply, measurements cannot easily be collected from the onboard meters. Thus, information measured during the accident progression is in short supply. To make up for this lack of accident information, SA models based on knowledge of the Three Mile Island (TMI-2) accident and some experimental work can be applied. However, core degradation in a boiling water reactor (BWR) like the 1F has not been comprehensively studied. Since the TMI-2 accident, many researchers have focused on the initial core melting process and aspects related to the rupture of the pressure vessel in a pressurized water reactor (PWR). The differing structure between a BWR and a PWR may result in different core damage, melting, and slumping in the 1F accident.

In the “Upgrading of the comprehensive identification of conditions inside reactor” project, core-material melting and relocation (CMMR) tests were conducted to understand the collapsing, melting and relocation of core materials during 1F accident (Fig.1-2). A fuel assembly simulating the core of a BWR



**Fig.1-3 Estimated debris distribution and the RPV and PCV conditions in Unit 2**

The state of residual fuel in the lower plenum were estimated via the results presented in Fig.1-2.

using  $ZrO_2$  pellets rather than fuel pellets was heated by high-temperature plasma. The simulated fuel assembly at the top was heated above the oxide melting temperature, not yet achieved in prior tests simulating the BWR system, reproducing the axial temperature gradient at the initial stage of core material melting and relocation in the 1F accident. The results indicated that the macroscopic gas permeability of the heated core remained intact until the ceramic fuel melting point. Furthermore, as hot fuel remained in columns, effective fuel relocation, i.e., the removal of hottest fuel from the middle of the core to heat the support structure, was shown to be unlikely. These results will assist in the development of better BWR-specific SA progression models. The 1F plant data collected from CMMR testing, SA analysis, and the 1F internal investigation was then further analyzed to estimate post-accident reactor conditions. The resulting estimation of debris distribution in the Unit 2 RPV/PCV is shown in Fig.1-3.

Future work will involve analyzing the data from 1F internal investigations to further understand reactor conditions and upgrade estimated diagrams of debris distribution in the RPV and PCV. These estimations will contribute to the development of effective policies for removing fuel debris from the 1F site.

This work was the result of the subsidy for Project of Decommissioning and contaminated Water Management, “Upgrading for Identifying Comprehensive Conditions inside the Reactor”, supported by the Agency of Natural Resources and Energy (ANRE), the Ministry of Economy, Trade and Industry (METI), Japan.

### Reference

Yamashita, T. et al., The CMMR Program: BWR Core Degradation in the CMMR-4 Test, Proceedings of the 9th European Review Meeting on Severe Accident Research (ERMSAR 2019), Prague, Czech Republic, 2019, 012, 13p.