



NRA Japan
Nuclear Regulation Authority



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Future Direction of International Research for Reactors and Fuel Cycle Safety



Tsunami Simulation Tests

Safety Research in Nuclear Regulation Authority

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
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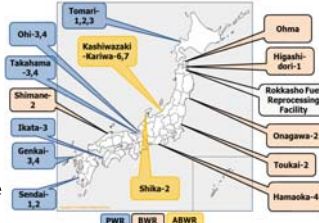
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Current Status of Safety Regulation

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- The NRA's new regulatory requirements for NPPs came into force in **July 2013**.
 - **All the 48 units** have been shut down **since Sep. 2013**.
 - A total of **21 units (12 PWRs, 9 BWRs)** have applied for **conform to the new regulation**.
 - As of March 2015, the NRA has granted the permissions for 4 units: **Sendai -1, 2** and **Takahama - 3, 4**.
- In **Jan. 2014**, JNFL applied for review of the fuel **reprocessing facility**, MOX fuel fabrication facility, etc. at Rokkasho.
- The former **JNES** was merged **with NRA** in **March 2014**.
- The NRA invited the **IAEA IRRS mission** to be taken place in the **end of 2015** or **Jan. 2016**.



Some Excerpts from New "Strategic Energy Plan" (April 2014, GOJ)

http://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/4th_strategic_energy_plan.pdf

- **Introduction**
 - ... We will do our utmost to achieve the reconstruction and recovery of Fukushima ... will review from scratch the energy strategy that it mapped out before the Earthquake. Japan will **minimize its dependency on nuclear** power. ...
- **Position of Nuclear Power (Sec. 2 in Chapter 2)**
 - ... Nuclear power is an **important base-load power source** as a low carbon and quasi-domestic energy source, ... on the major premise of ensuring of its **safety** ...
- **Re-establishment of the nuclear energy (Sec. 4 in Chapter 3)**
 - ... Regarding the nuclear **fuel cycle policy**, GOJ will steadily **promote reprocessing and plutonium use in LWRs** ...
 - ... GOJ will take leadership and strengthen its effort to find proper solutions of **final disposal of high-level rad-waste** without putting off implementing measures into the future.

New Framework for Safety Research

- The former **JNES** was merged with **NRA** and a new department for **Regulatory Standard and Research** consisting of mostly research engineers from JNES was created as **"internal TSO"**
- Cooperation with **NSRC** (Nuclear Safety Research Center) in **JAEA** and **NIRS** (National Institute for Radiological Sciences), **"external TSOs"**, has been strengthened.
 - Access to **technical expertise**
 - Use of **test facilities**
 - **Human resources development**
- The **NRA** has succeeded basically all the **international cooperative activities** which JNES had participated in.

Summary of Safety Research in NRA (1/2)

BSAF: Benchmark Study of the Accident at the Fukushima Daiichi NPS
SAREF: Senior Expert Group on Safety Research Opportunities Post-Fukushima

- **Reactor Safety**
 - Safety analysis and **code development**
 - **Fire safety**
 - Cable, Oil, HEAF (High Energy Arching Fault) → OECD/NEA HEAF Project
 - **Severe accidents (SA)**
 - Hydrogen behavior → OECD/NEA CSNI WGAMA, THAI Project, etc.
 - Seawater injection, MCCI, scrubbing, ...
 - Fukushima accident analyses → OECD/NEA BSAF Project, Senior Expert Group on SAREF
 - **PRA** → OECD/NEA CSNI WGRisk
 - Seismic, tsunami, internal flood, fire → OECD/NEA Database Fire
 - **Fuel Safety** → OECD/NEA CSNI WGFS, Halden Project
 - **Aging / life extension** → OECD/NEA CSNI WGIAGE, Databases CODAP and CADAK
 - Metal, cable, concrete, etc.
 - **Human and organizational factors** → OECD/NEA CSNI WGHOF

Summary of Safety Research in NRA (2/2) 6

- **External Hazards** → OECD/NEA CSNI TGNEV
 - Seismic **ground motion** and **land slides**
 - Probabilistic seismic / tsunami **hazard** evaluation
 - **Fragility** evaluation
 - **Volcano** eruption, tornadoes, airplane crash, toxic gasses, ...
- **Fuel Cycle / Waste Disposal**
 - Fuel reprocessing, fabrication facilities, etc.
 - SA, PRA / ISA, material, ... → OECD/NEA CSNI WGFCs, WGFS
 - Interim storage and transportation
 - Shallow / deep underground **waste disposal**
- **Fukushima Daiichi**
 - **Waste Management** → OECD/NEA RWMC activities
 - Transportation of **damaged spent fuel**
 - **Criticality** evaluation of **fuel debris**

Research on External Natural Hazards: Impact of Tsunami on Seawall 7

Background

- Generally, seawalls are designed according to the MLIT's guideline that provides a method for estimating the **max. tsunami pressure** based on a **coefficient** (< 3) to the **run-up tsunami height h** assuming without seawall.
- The NRA/former-JNES has conducted the **scaled tests** on the **loads on seawall** since FY 2012 at PARI (Port and Airport Research Institute).

Findings

- The **run-up height coefficient** increased with the **Froude number (Fr)** and **exceeded 3** when the **Fr became larger than app. 1.5**.

Large Scale Test (1/10) **Middle Scale Test (1/40)**

Relationship between Froude number and Run-up Height Coefficient

Ref.: MLIT, "Interim Guideline on Structural Requirements for Tsunami Evacuation Building or the like", 2011.

Fire Safety Research on HEAF: High Energy Arcing Fault 8

- The NRA/former-JNES has conducted the tests for **cable fire, filter fire, oil fire, HEAF**, etc.
- At **Onagawa-1**, fire took place due to short circuit inside **MC 6-1A** during the 2011 Tohoku Earthquake.
 - **High energy gas** generated by **arcing fire** was **propagated to the other cabinets** through the control cable duct, and triggered the large fire.

Arc energy [MJ] vs **Arc duration time [s]**

- **In 2012**, NRA (JNES) started **HEAF tests** at KEMA in U.S.
- **Preliminary results** suggested an energy of **25 MJ** was required for causing the **arcing fire**.
- **Electrical cabinets** were heavily damaged and mostly burned like in the Onagawa HEAF event.
- **U.S. NRC** has participated in NRA tests with technical discussions and advice, and instrumentation support.

HEAF Tests at KEMA in U.S.

Source: Kabashima et al., Proc. 2013 Fall Meeting of the AESJ, GS1; Kabashima et al., Proc. 2014 Annual Meeting of the AESJ, 128.

Risk Assessment of Fuel Cycle Facilities

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Background

- The NRA developed the new Regulatory Requirements for fuel cycle facilities requiring to take **measures against severe accidents (SA)** for **fuel reprocessing facilities** and **fuel fabrication facilities**.

Ongoing Research:

- Seismic ISA** (Integrated Safety Assessment) for a model **MOX fuel fabrication facility** and **seismic PRA** for a model **reprocessing facility**
- Tests at JAEA** on **entrainment and aerosol transport** of typical FPs such as **Ru** during **boiling to dryness** of **high level waste storage tanks** as a SA scenario
- Analytical study on **fire, hydrogen explosion and release of UF₆** (Uranium Hexafluoride)

Data taken at JAEA: Airborne release fraction (ARF) vs. initial FP concentration

Source: NDL(National Diet Library) call no.: YH233-L1601, 2014 (in Japanese)

Safety Assessment of Disposal Facilities for Wastes Generated by Decommissioning, etc.

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Background

- The NRA developed the new Regulatory Requirements for **shallow underground disposal (trench, pits)** that are being applied.
- There's a need for disposal of rad-wastes generated by decommissioning, etc. that **include long-life nuclides** typically in **core internals** incl. **control rods**.
 - Under decommissioning: Tokai (GCR), Hamaoka-1 and 2 (BWRs) and Fugen (ATR)
- The NRA started discussion on regulatory framework for such disposal.

Keys for Safety Assessments

- Human intrusion scenarios** and their time frames to be considered and **treatment of uncertainties**
- Safety function** of the depth and **physical resistance of the repository** required to be relied on against human intrusion
- Passive / active institutional control** before / after closure

Fukushima-Daiichi Accident: Criticality Evaluation of Fuel Debris

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Background

- It is needed to confirm the adequacy of the **criticality control measures** to be taken when the fuel debris retrieval is planned in the future.

Planned Experiments

- To evaluate the **risks associated with criticality** during fuel debris retrieval, **basic criticality experiments and analyses** will be done at **NUCEF in JAEA** by using various **simulated fuel debris samples**.
- Such **long-term research** is also expected to contribute to:
 - Maintaining technical expertise and facilities**
 - Human resources development**

Criticality Experiments

Fukushima-Daiichi Accident: Contribution to OECD/NEA BSAF and SAREF 12

- The NRA/former-JNES have **step by step updated the SA progression analyses** with MELCOR on receiving the information from the site, and we have contributed to the **OECD/NEA Fukushima Benchmark study (BSAF)** by using **the plant geometrical data** supplied from the Project.
- Also, the Japanese organizations TEPCO, METI/NDF/IRID and JAEA together with NRA are contributing to **OECD/NEA SAREF** to identify opportunities for addressing safety research gaps **based on information from Fukushima.**
- It is hoped, in the future, **SAREF** could lead to the international collaborative efforts similar to OECD/NEA **TMI VIP** Project.

Needs for additional safety knowledge of common interest:

Potential topic areas

- Source terms
- Hydrogen behaviour
- Containment behaviour
- Chemistry effects of seawater
- Human factors
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Identification of possible safety research activities in the common denominator

BSAF Project: Ongoing

Decommissioning activity at Fukushima

Information/data that could be made available from Fukushima

OECD/NEA SAREF: Senior Expert Group on Safety Research Opportunities Post-Fukushima

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- The NRA's safety research in both LWRs/FCFs keep focusing on resolving current **safety issues** of **high priority**:
 - **SA phenomena, external hazards** (natural/man-made), fire, internal flooding, PRA/ISA, ...
 - **Disposal of wastes from decommissioning**, geological disposal, ...
 - Topics relevant to **Fukushima-Daiichi**
- Glowing needs for research in the area of **natural sciences** such as **volcanology, seismology**, etc.
 - National/**International networking** with natural scientists, etc.
- Glowing importance of **international cooperation**
 - Needs to **stay vigilant on new findings** and **state-of-the-art** knowledge and be **proactive for emerging future needs**
 - Needs to **maintain technical expertise** and **facilities, human resources development**, etc.
 - **Effective and high quality safety research** through international corroboration, cost-sharing and information-sharing.

Main Contributors 14

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