

**NRA Japan**  
Nuclear Regulation Authority

**RIU** MARCH 11-13

Current Activities in International Research



Terrain data of Fukushima Daiichi for CFD calculations for airstream

## Post-Fukushima Safety Research in Japan

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**NRA Japan** Contents 1

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**NRA Japan** Current Status of Safety Regulation 2

- The **NRA** was established in **Sep. 2012** and developed the **new regulatory requirements** which came into force in **July 2013**.
  - Legal requirements for taking **measures against severe accidents**
  - **"Specialized Facility"** against **intentional aircraft crash**
  - Prevention of **common cause failure** due to **extreme natural hazards**
  - **Limit of operation of 40 years** with an extension of 20 years just once
- All the **50 units** have been shut down since **Sep. 2013**.
- A total of **8 utilities** applied for conformance review of **17 units (PWR: 12, BWR: 5)** at **10 sites**.
- The new requirements for **fuel cycle facilities** came into force in **Dec. 2013**. In **Jan. 2014**, JNFL applied for review of the fuel **reprocessing facility**, MOX fuel fabrication facility, etc. at Rokkasho.
- These reviews are in progress by NRA extensively.




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**Merger of JNES with NRA** 3

- **JNES was abolished and merged with NRA on March 1, 2014.** The major objective is:
  - To enhance the **technical competence and capabilities of NRA.**
- "Regulatory Standard and Research Department" consisting of mostly research engineers was created for "**development of technical standards**" and "**conduct of safety research**".
  - Four technical branches: **Reactor System Safety, Severe Accident, Earthquake and Tsunami** and **Nuclear Fuel Cycle/Waste.**
- All the **research activities** having being done in NRA/JNES are continued or even enhanced, including all the **international cooperative research activities**, either bilateral or multi-lateral.
- Cooperation with **NSRC** (Nuclear Safety Research Center) in **JAEA** and **NIRS** (National Institute for Radiological Sciences) will be strengthened as external TSOs for NRA.

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**Safety Research in NRA** 4

- Special emphasis is placed on external/internal hazards leading to large scale **common cause failure.**
  - **Extreme natural phenomena:** Earthquake, tsunami, volcano eruption, etc.
    - Evaluation methods for **hazard curves** of earthquake/tsunami, **design basis earthquake/tsunami**, **SCC's fragilities**, etc.
    - Assessment methods for **volcano eruption**
  - **External/internal fire** and **internal flood**
  - **PRA methods/models:** Tsunami, fire, multi-units, multi hazards, etc.
- Research on **Severe Accident (SA)** and **SAM**
  - **Computer code development** for SA progression/source terms, ...
  - Experimental studies on **scrubbing, seawater injection, LOCA** at **SFP**, ...
- Research on "**Specified Nuclear Facility** (Fukushima Daiichi)"
  - Transportation of failed fuel, debris cooling/criticality, etc.
  - Effect of **salt contents in water on corrosion**, management of wastes /contaminated water, **risk evaluation**, etc.
- Other areas:
  - Fuel cycle facilities, backend (clearance, waste disposal, etc.), emergency preparedness, physical protection, radiation protection, etc. (cf. **Appendix**)

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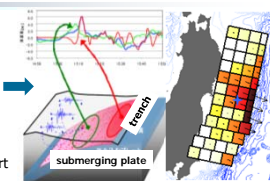
**Research on Extreme Natural Hazards: Tsunami** 5

**Hazard evaluation:**

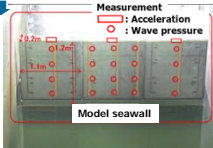
- For 2011 Tohoku Earthquake, We developed a **tsunami source model**. By generalizing this model, we are developing a **probabilistic tsunami hazard evaluation method**.

**Fragility data accumulation/application:**

- We have started the **tests on impact of tsunami on seawall** since FY 2012 at PARI (Port and Airport Research Institute) to obtain data on **load distribution on seawall**.




Slips in sub-fault in JNES source model (Inversion analysis)



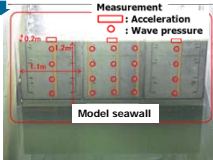
Measurement  
○ : Acceleration  
○ : Wave pressure

Model seawall

- We have developed the "**Review Guide for DB-Tsunami and Basic Design against Tsunami**" for the new regulatory requirements.
- The test results are expected to be used for updates of these documents.



**Large Scale Channel Test:**  
184m x 3.5m (12m in depth)



**Model Seawall (1/10 Scale)**  
1.1m x 1.2m x 0.2m

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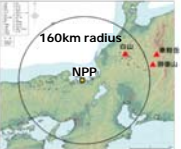
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### Research on Extreme Natural Hazards: Volcano Eruption

- It is required to take measures against **volcano eruption, tornadoes, forest fire** and so on.
- We have developed the **Evaluation Guide for Impacts of Volcanic Phenomena**:
  - It is required to assess all sources of **volcanic activity** within **160km**.
  - If the potential that **"severe volcanic phenomena which design cannot cope with"** reach to the site during the plant life is **not low enough**, siting is **unsuitable**.
  - Even if such potential is low enough, it is required to conduct **monitoring** and **develop policy** on **reactor shutdown, fuel unloading, etc.** when the volcanic unrest is identified.
- In FY2013, We started a study on **assessment methods for the possibility of volcanic activities** (indices/criteria), **monitoring methods**, etc. in order to **enhance objectivity of the Guide** by compiling the historical data, numerical simulation, petro-chemistry approach, etc.



[http://www.nsr.go.jp/committee/kisei/data/0013\\_06.pdf](http://www.nsr.go.jp/committee/kisei/data/0013_06.pdf)



Pyroclastic flows at **Mayon Volcano** Philippines, 1984.

[http://en.wikipedia.org/wiki/File:Pyroclastic\\_flows\\_at\\_Mayon\\_Volcano.jpg](http://en.wikipedia.org/wiki/File:Pyroclastic_flows_at_Mayon_Volcano.jpg)

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### Fire Safety Research on HEAF: High Energy Arcing Fault

- We have conducted tests for **cable fire, filter fire, oil fire**, etc. as fire safety research.
- We have developed the **"Review Guide for Fire Protection"** and **"Guides for Fire Hazard Analysis (internal/external)"** for new regulatory requirements.
- 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.
- In 2012, we started **HEAF tests** at KEMA in U.S. to:
  - Well understand the **phenomena** involved,
  - Develop models for damage prediction and setting **Zone of Influence (ZOI)**, and
  - Develop **regulatory guides** for **fire hazard analysis** for HEAF.
- U.S. NRC has participated in our tests with technical discussions and advice, and instrumentation support.



HEAF simulation Test at KEMA in U.S.



No. 8 cabinet

Source: Tohoku Electric Power, May 2011, <http://www.nsr.go.jp/archive/nisa/earthquake/files/houkokoku230530-2.pdf>

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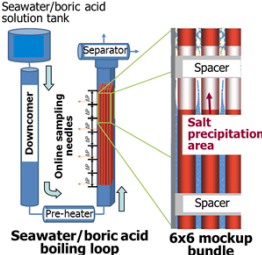
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### Experimental Study on Seawater and Boric Acid Injection

- We are conducting a study on seawater/boric acid injection to identify the **salt and boric acid crystallization/precipitation** characteristics and its **influence on fuel/debris cooling** such as **flow blockage** for improving AM measures.
- Test with a 6x6 full length mockup fuel bundle
  - Preliminary test was done for **visualization** of salt crystallization using **X-ray CT scan**.
  - Shape of crystallization/precipitation and its distribution on fuel surface will be obtained.


**Test for precipitation at core**



Seawater/boric acid boiling loop

6x6 mockup bundle

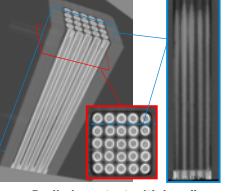
Appearance of salt crystallization in a preliminary test with simple geometry



Preliminary test with bundle

Cross-sectional view at TAF-15mm

Vertical-sectional view



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**Analysis of Fukushima-Daichi Accident: SA Progression and Source Terms**

**Background:**

- We continue to analyze the accident progression with MELCOR. By using the **source terms with MELCOR**, an environmental consequence analysis was done in JAEA with OSCAR.

**New development:**

- In order to compare the **source terms** obtained by MELCOR with the **monitoring data** at the **main gate**, CFD calculations are being done for **airstream around the site** by using the terrain data and GPV meteorological data (5km x 5km).

**Preliminary results of airstream around the site**

**Terrain data**

**MELCOR - OSCAR analysis**

**CFD resolution**  
 5m x 5m x 1m (by the bldg.)  
 10m x 10m x 1m (other region)

**Ca-137 Concentration measured by HEST (Dec. 9, 2011) (Bq/m³)**

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**Summary**

- JNES was merged with **NRA**.
  - "**Regulatory Standard and Research Department**" was created while referring to "RES" in U.S.NRC as a model.
- "**Safety research**" needs to contribute to resolving **regulatory issues** at high priority.
  - Methods and models for **seismic/tsunami hazards** and **fragilities**
  - Evaluation methods for **fire, flood, volcano eruption**, etc.
  - Technical guides for effectiveness **evaluation of SA measures**, etc.
- Also, we need to **maintain technical competence/expertise**
  - Long-term research, human resources development:** Cooperation with NSRC/JAEA, NIRS, academia, international activities, etc.
- Cooperation/communication with industries**, etc. with due consideration of regulatory independence becomes important.
  - For example, to obtain **experimental data with common interests** jointly but evaluate/apply them independently.
- International cooperation** is an essential element not only for effective/efficient conduct of safety research but also for being **proactive for emerging future needs**.

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**Appendix Summary of Safety Research in NRA**

Categories	Safety Research Topics/Subjects	
1. Nuclear Reactor	Safety analysis and code development	Seawater Injection → Slide 8 SA Progression and Source Terms → Slide 9
	Thermal-hydraulic phenomena during accidents at LWRs	
	Sever accidents	
	Regulatory criteria for fuel	
	Aging technical evaluation and extension of operation limit	
2. Fukushima Daiichi	Management of radioactive wastes including liquid wastes	Extreme Natural Hazards/Tsunami → Slide 5 Extreme Natural Hazards/Volcano → Slide 6 Fire Safety on HEAF → Slide 7
	Criticality evaluation methods for molten fuel debris	
	Transportation of damaged spent fuel	
	Evaluation of design basis earthquake and assessment of seismic ground motion/land slides	
3. Internal or External Hazards	Evaluation of design basis tsunami and probabilistic tsunami hazard	Extreme Natural Hazards/Volcano → Slide 6
	Structural integrity assessment for earthquake and tsunami	
	Research on volcano eruption for new regulatory requirements	
4. Nuclear Fuel Cycle	Evaluation techniques for fire protection	Fire Safety on HEAF → Slide 7
	Risk evaluation for internal and external hazards leading to common cause failure	
	Evaluation techniques for interim storage and transportation of radioactive materials	
	Assessment for aging management for fuel reprocessing facilities	
5. Backend	Methods for verification of clearance	
6. Emergency Response	Evaluation techniques for safety review of underground waste disposal	
7. Physical Protection	There's no specific topic at the moment.	
8. Radiation Protection and Monitoring	It needs to maintain technical capabilities.	
9. Cross-cutting Issues	Human and organizational factors	
	Criticality assessment of spent fuel Maintaining technical capabilities	

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