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USNRC's 21st Annual Regulatory Information Conference (RIC)
Technical Session : "New Developments in Seismic Hazard Assessment"

Equipment Fragility Tests by JNES

11 March 2009

Incorporated Administrative Agency
Japan Nuclear Energy Safety Organization (JNES)
Seismic Safety Division Hiroshi ABE

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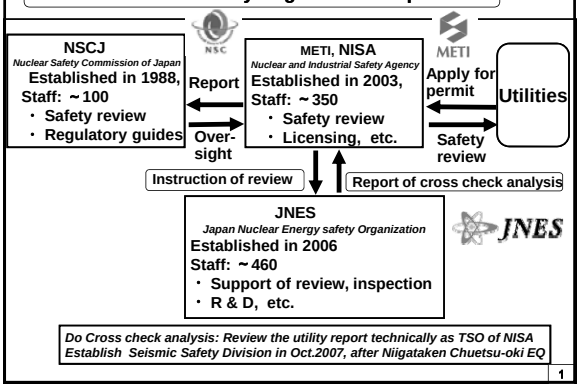
Ⅰ. Nuclear Safety Regulation in Japan



Do Cross check analysis: Review the utility report technically as TSO of NISA
Establish Seismic Safety Division in Oct.2007, after Niigataken Chuetsu-oki EQ

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Ⅱ. Major Subjects and typical items of JNES Seismic Safety Research

1. Basic Ground Motion Ss, Deterministic Assessment for Structure Integrity

1-1 Earthquake and Seismic Ground Motions
- Observation of seismic motion **in deep ground structure**

1-2 Issue Accompanying Earthquakes
- Slope/foundation soil-stability
- Tsunami-analysis **including the sediment movement**

1-3 Structure Integrity
- 3-D response assessment **considering the flexibility of the building floor**

1-4 Integrity assessment **considering aging**

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2. Residual Risk* Assessment (External Events PSA)

* plant risk due to beyond design earthquake

2-1 Seismic PSA
- Fragility test
- Risk assessment improvement **in the multi-unit site**
- Improvement of the measures for **earthquake risk mitigation**

2-2 Tsunami, Fire, and Flooding PSAs

3. Assessment for the Seismic Margin
- Quantitative assessment of the seismic margin
- Improvement of the loss-of-function assessment of the structure and equipment

4. Plant Integrity Assessment after Large Earthquake ,
- **Communication** establishment and plant restart procedures

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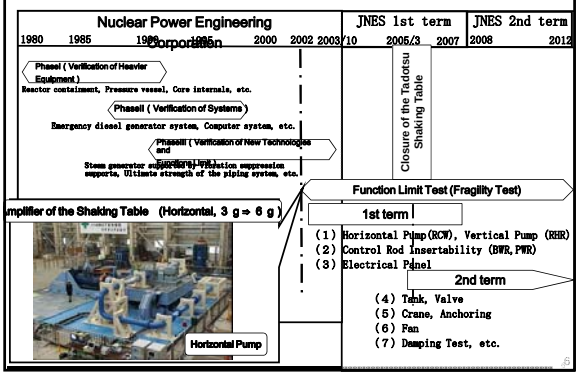
Ⅲ. Fragility test for Assessment of Seismic Margin and Seismic PSA



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1.Background of the tests

Revision of Seismic Design Guide

Old Seismic Guide:1987

Prevent to become inducible factors of big accidents against all earthquakes to be assumed

Revised Seismic Guide:2006

Cannot deny the possibility of occurrence of the earthquake which exceed assumed ones. "Residual risk" should be considered.

Shift of Objective of Tests

Design Proving ⇒ **Investigation of Fragility**

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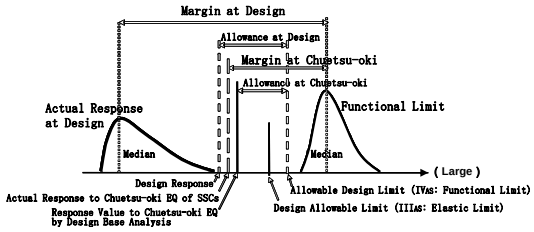
Background : Margin

Seismic Safety is Secured by the Design which has Certain Margin

(「Seismic Margin」=「Functional Limit」/「Actual Response」)



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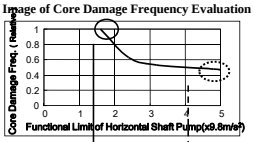
Background : Necessity of Fragility Test

(1)Current Fragility Data

Currently Used	Issue
Estimation from Domestic Previous Research	Thought to be smaller than the actual value, and may overestimate core damage frequency
Partial Diversion of the U.S. Data	

Image of Core Damage Frequency Evaluation



(2)Objective of Tests

Grasp Realistic Fragility Data for Accurate Seismic Margin Evaluation and Seismic PSA

Fragility Value	Small	Large
Damage Probability	Large	Small
Core Damage Freq.	Large	Small

Current Fragility Values → **Large Fragility Value=Small Core Damage Freq.**

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Background : History of Test Method

Test Objective

Proving of Seismic Design ⇨ **Investigation of Fragility and Functional Limit**

Test Method

○Proving Test :

Shaking Test based on Design Response Spectra up to a Little Larger Level than Design Base

○Fragility Test

Beyond Design Test to Acquire Fragility Data, using Sub-Table to Amplify Acceleration on Main Table. Up to 6G

○Functional Limit Test

Shaking Test to Acquire Functional Limit or Fragility Curve Combining Partial Tests

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2 Test Example 1st term: **Electric Panel**

(1) Specimens

Panel (partial model of real size)	Mass (t)
Main Control Board	1.0
Reactor Auxiliary Board	2.5
Logic Circuit Panel	1.0
Reactor Protection Rack	2.2
Instrumentation Rack	0.7
Reactor Control Center	0.6
Power Center	4.0
6.9kV Metal-Clad Switch Gear	5.6

(2) Input Motion and Test Condition

Item	Condition
Basic Excitation Motion	Synthetic Motion Enveloped Actual Design Spectra (Max:1.2x9.8m/s^2)
Excitation Level	Basic to 6x9.8m/s^2
Electrical Condition	Active Simulating Real Operating Condition
Excitation Direction	Front to Back and Side to Side

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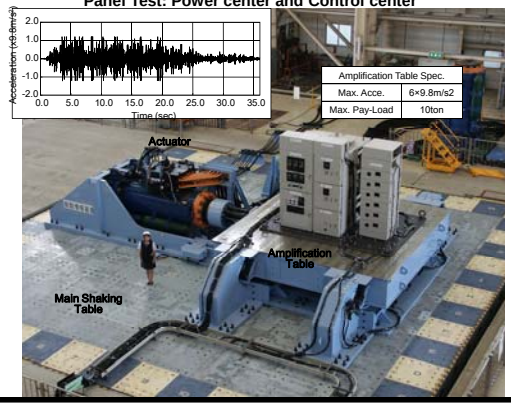
Panel Test: Power center and Control center



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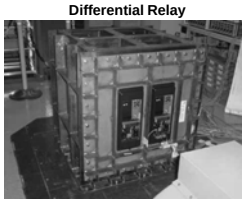
Element test for electric panel

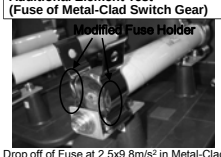
Test Condition

Item	Condition
Basic Input Motion	T.H. from Response Analysis of Panels
Input Level	Design Value to 10 x 9.8m/s²
Electrical Condition	Same as Operation Condition
Excitation Direction	Front to Bach and Side to Side

Differential Relay



Additional Element Test (Fuse of Metal-Clad Switch Gear)



Drop off of Fuse at 2.5x9.8m/s² in Metal-Clad S.G. Test

After Modification of Fuse Holder : Function Maintained up to 6x9.8m/s2 (Element Test)

Summary of 1st term

Specimen	Summary of Test
Concrete Containment	- Boundary Integrity is Secured until Destruction of Concrete - Margin against S_2 : 6 Times for PCCV, 7 Times for RCCV
Piping	8.5 Times of Design Allowable (Pipe Break Occurred at Fifth Excitation of 8.5 S2 Test)
Electric Panels	-No Abnormality in 6G Excitation for Main Control Board etc. -Malfunction Occurred in Some Panels around 2.5G Excitation, but Robustness can be Increased around 4G by Relatively Small Modification for Heavy Moving Parts or Fuse Holder
Vertical Shaft Pump	Functional Integrity was Confirmed up to 12G at the Top of Motor
Control Rod Insertion	PWR：Insertion Integrity was Confirmed up to 45mm Fuel Bundle Displacement BWR：Insertion Integrity was Confirmed up to 80mm Fuel Bundle Displacement
Horizontal Shaft Pump	Functional Integrity was Confirmed up to 8.4G Excitation

2nd term: **Overhead Crane**

Revised Seismic Design Review Guide requires assessment of dynamic vertical response.

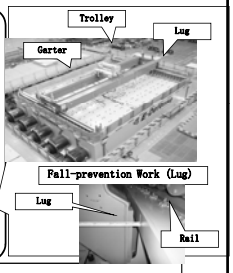
At the Chuetsu-oki Earthquake a overhead crane in the Kashiwazaki-Kariwa NPP was damaged.

■ Test Object
- Overhead crane with garters, a trolley, a hanging load, lugs, etc.

■ Contents of the Test
- Component Tests (in FY 2007)
  - (1)Factor analyses of the functional limit
  - (2)The mutual uplift and the collision assessment of garter/trolley/hanging load
  - (3) The assessment of the restitution coefficient of wheels
- Reduced Scale Model Test (in Oct. 2008)
  - (1) Additional investigation point from NCE
    ⇒ Effect confirmation of the fall-prevention work (lug) , etc.
  - (2) Analysis is ongoing.
    - Effectiveness of lugs was con
    - The uplift behavior was understood.

Video of Whole View

Video of Wheel Part



⇒ The nonlinear analysis of uplift mechanism for the vertical motions will be improved. The results will be applied to the integrity criteria in the seismic re-evaluation.

IV. Summary

Application of Fragility Test is;

Evaluation of Residual Risk*
* Risk due to beyond design earthquake

Where is Functional and Structural Limit?

How far can Design Endure?

Is Designed Function Maintained?

How SSCs Response to Earthquake?

Thank you for your attention

After Niigataken Chuetsu-oki earthquake, JNES refined the road map of seismic safety research for;

1. Earthquake ground motion evaluation
2. Residual risk assessment
3. Seismic margin assessment
4. After earthquake action

Today I present outline of fragility test for item 2 and3. If we have next opportunity, we hope to report the updated status of these researches.

We continue, through collaboration with NRC or the chance like RIC or contribution to IAEA seismic safety program, to inform and to share our data and knowledge to worldwide nuclear community.

Thank you for your attention