U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Assessment of Fukushima Lessons Learned for Research and Test Reactors

John Adams
Senior Level Advisor for Non-power Reactors
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
August 6, 2014

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Introduction

- Prompt Assessment of NRC-licensed RTRs
- NTTF Assessment of the Fukushima Accident
- JLD Assessment Guidance
- Assessment of RTRs
- Next Steps

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Post Event Prompt Assessment

Did the accident reveal conditions that challenge the current conclusion of RTR safety requiring immediate regulatory action?

Staff reviewed the following areas in light of the Fukushima accident:

- Natural events
- Electrical power
- Decay heat removal
- Spent fuel cooling
- Combustible gas control
- Confinement/containment

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Post Event Prompt Assessment

Prompt Assessment Conclusion

- No safety concerns were revealed by the Fukushima accident for which immediate actions were necessary, nor was any new information revealed that would contradict or invalidate assumptions used in the safety basis of any NRC-licensed NPR

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

NTTF Assessment and Recommendations

NTTF assessed only Power Reactors

- Provided 12 Recommendations related to:
  - Seismic and flooding hazards
  - Concurrent related events
  - Mitigation of extended loss of AC power
  - Containment overpressure protection
  - Combustible gas control
  - Spent fuel pool makeup and level measurement
  - Integration of emergency procedures
  - Emergency Preparedness considerations for multi-unit and extended loss of power events
  - Defense-In-Depth

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Assessment of RTRs (Cont.)

- Tasking Memorandum COMGBJ-11-002 (ML110820875) directed staff to assess the applicability of the lessons learned to non-power reactor facilities
- Japan Lessons Learned Directorate (JLD) issued review guidance in “NRC Regulated Facility Licensee Review Process.”
- The assessment was conducted by NRC staff through a desk top review of licensing documents, security assessments, and other analyses.

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Assessment of RTRs (Cont.)

- RTRs were assessed using the general guidance provided by the JLD that includes assessment of:
  - the 12 NTTF recommendation
  - postulated external events
- RTRs were considered in 2 groups based on power level:
  - Less than or equal to 2 MW_t (28 of 31 RTRs)
  - Greater than 2 MW_t (3 of 31 RTRs)

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Preliminary Conclusions

- RTRs ≤ 2 MW_t are highly resilient to the loss of electrical power, loss of reactor coolant inventory, and active decay heat removal systems without experiencing fuel cladding damage

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Preliminary Conclusions

- For > 2 MW_t RTRs:
  - It is less certain that air cooling can be relied on for adequate decay heat removal
  - availability of reactor coolant, a heat sink, and electrical power become more important
- Assessment uncertainty precludes a conclusion that radiological consequences from a beyond design basis external event would not exceed those assumed in the maximum hypothetical accident (MHA)

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Path Forward

- Present Assessment Results to the Japan Lessons Learned Directorate Steering Committee

- Submit the Staff Evaluation and Recommendations to the Commission via SECY Paper

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Questions

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Back Up Slides

- Back Up Slides

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Site and Event Description

Reactors at the Fukushima Dai-ichi Site

Unit	Net MWe	Reactor, Containment, AC Independent Cooling
1	460	BWR-3, Mark I, IC & HPCI
2	784	BWR-4, Mark I, RCIC & HPCI
3	784	BWR-4, Mark I, RCIC & HPCI
4	784	BWR-4, Mark I, RCIC & HPCI
5	784	BWR-4, Mark I, RCIC & HPCI
6	1100	BWR-5, Mark II, RCIC & HPCS

IC – Isolation Condense

RCIC – Reactor Core Isolation Cooling

HPCI – High Pressure Coolant Injection

HPCS – High Pressure Core Spray

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Site and Event Description

Plant Status at the Time of the Earthquake

Unit	Plant Status
1	Operating
2	Operating
3	Operating
4	Outage
5	Outage
6	Outage

- Automatic Shutdown of Operating Reactors
- Offsite Power Lost - Diesel Generators Started and Loaded all Units

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Site and Event Description

The Initiating Event

- March 11, 2011 – Magnitude 9.0 Earthquake
- Tsunami greater than 45 ft.
- Exceeded the plant design basis by 27 ft.
- AC power inundated by sea water and lost
- Decay heat removed by AC independent cooling systems
- Fuel cooling lost within several hours U1, 71 hours U2, and 36 hours U3

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Site and Event Description

- Cores become uncovered
- Metal water reaction results in formation of hydrogen
- Containment venting and failures results in the release of hydrogen to secondary containment
- Detonation of hydrogen and failure of secondary containment U1, U3, and U4

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

International Interaction

International Assessment Guidance

- OECD/NEA/CNRA/SORRTG
  - Application of EU stress test methodology excessive for RTRs
  - Tasked to provide appropriate guidance (graded) for NPRs
  - Overtaken by similar work by the IAEA
- IAEA
  - Developed and published assessment guidance – Safety Report Series No. 80
  - Recommended inclusion of graded approach application
  - Found to be generally consistent with JLD assessment guidance