Summary of Session 3

IEM on

"Strengthening R&D Effectiveness in the Light of the Accident at the Fukushima Daiichi NPP"

IAEA Headquarters, Vienna, Austria
16-20 February 23015

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Session 3

- Topic of Session:
  - Severe Accident Analysis
- Presentations:
  - 2 Keynote Speeches
  - 16 Technical Presentations
  - 5 Related Posters

Key Points from Presentations & Posters (1)

- Roadmap on R&D and Human Resource for LWR safety in Japan was presented
  - importance of risk-informed analyses to improve prevention, mitigation, response to nuclear emergency and safety infrastructures highlighted
  - SA issues: SA codes, source term, scrubbing, seawater effects, SFP
  - Importance of long term issues highlighted: wastes management, decommissioning

Key Points from Presentations & Posters (2)

- Analysis of Fukushima's accident, improvement of SA codes:
  - EPRI/MAAP: MAAP5 was improved to model BWRs specificities, modeling accurately the corium/debris relocation paths for the actual reactor configuration is challenging and critical for supporting decommissioning and enhancing emergency procedures and guidelines
  - EU CESAM/ASTEC: ASTEC is being improved to model BWRs specificities (in-vessel degradation) and to become a diagnosis tool
  - IAE/SAMPSON: Fukushima forensic analysis highlight the importance of having a good knowledge of systems functioning (e.g. RCIC) and leakage paths to understand the accident progression
  - CIEMAT/MELCOR: Fukushima's calculations performed as part of the BSAF1 project, need to pursue forensic investigations and extend calculations to source term (BSAF2)
  - TEPCO: need to pursue forensic investigations of Fukushima's accident (HPCI behavior, neutron detection)

Key Points from Presentations & Posters (3)

- Containment behavior under challenging SA conditions:
  - JAEA is launching the ROSA-SA project to study the effect of high temperatures, H_2 risk and FP behavior in CV (more challenging conditions than in other relevant facilities)
- SFP accidents:
  - IRSN is conducting the DENOPI project on SFP loss-of-cooling and loss-of-coolant accident. The project consists of 3-scales experimental investigations (rod, assembly, pool) and related computer code analysis to assess mitigation strategies and safety margins
  - USNRC conducted consequence analyses (MELCOR/MACCS) of a B-DBA earthquake on SFP for US Mark-I BWR. The likelihood of releases and the LCF risk are considered appropriately low and the SFP storage safe.

Key Points from Presentations & Posters (4)

- Level-3 PSA of CAP-1400 reactor presented
- Source term modelling and issues:
  - Significant R&D and progress made for ST evaluation
  - Necessity to develop methodologies to appreciate uncertainties on ST (IRSN/ASTEC, JAEA/THALES2/KICHE) and prognosis/diagnosis tools highlighted
  - Necessity to do research on B_4C effect on FP transport (JAEA) and on FP revaporization processes (JAEA/IRSN)
  - Open issues: “delayed” ST, FP retention by pool scrubbing, releases mitigation (underlined by CIEMAT/IRSN/AREVA), sea water effects (JAEA), chemistry in the environment

Key Points from Presentations & Posters (5)

- SAM and corium progression issues
  - UJV Rez. summarized research for SAM improvement in Czech NPPs with a focus on remaining issues for the application of IVMR and ex-vessel corium cooling strategies
  - KAERI is conducting research on the in-core-instrumentation tube ejection failure at APR1400 RPV lower head which consists of several experimental and analytical studies
  - COG summarized research for BDBA management improvement in Canadian Candu NPPs (core and containment response) with a focus on remaining issues for the application of IVMR strategies
  - JAEA presented on-going research on in-vessel TH and core degradation behavior focusing on BWR specificities to support understanding of corium progression in 1F and decommissioning

Key Points from Presentations & Posters (6)

- SAM and corium progression issues (continued)
  - AREVA underlined the importance of research to support the application of IVMR and ex-vessel corium cooling strategies
- Reactor applications
  - GRS presented the analysis of a SBO sequence with multiple safety systems failures in a German PWR with ATLAS/ATHLET-CD/COCOSYS codes
- Human and organizational factors
  - EDF conducted analysis of the 1F accident from a human and organizational perspective, highlighting issues and perspectives for SA management

Key Points from Discussion (1)

Discussion was made from the following view point.

- What are the remaining key issues or phenomena to be investigated/clarified to enhance accident analysis (BDBA and SFP)?
- What are the remaining key issues or phenomena to be investigated/clarified to enhance accident management (BDBA and SFP)?
- Ways to prioritize R&D issues for accident analyses (e.g. weight to be given to risk and consequence analysis and to more deterministic analyses supported by R&D)?
- What issues are effectively and efficiently covered today by using international collaborations?

Key Points from Discussion (2)

- What remains to be improved in SA modelling and SA codes? Need for prognosis/diagnosis tools?
- Issues related to containment behavior and source term? To mitigation of corium progression? To SFP accident analysis? To human and organizational factors? To management of post-emergency phases?

Key Issues and Areas to be Addressed in Future R&D

- International effort to improve the accident understanding already undertaken but need to pursue forensic analysis of Fukushima's accident underlined:
  - Systems functioning (e.g. RCIC, …)
  - Corium/debris relocation paths in support of decommissioning
  - Effect of suppression pool thermal stratification
  - Fission products behaviour
  - Existing framework: OECD/BSAF project

Key Issues and Areas to be Addressed in Future R&D

- SA codes:
  - Scaling still an issue
  - Further well-targeted benchmarking proposed
  - Development of uncertainty analyses (source term evaluations)
  - Search for the development of prognosis/diagnosis tools (H2020 FASTNET project starting in 2015) for consequences evaluation
- Source term:
  - Need to progress on scrubbing modelling (scrubbing in suppression pools and in liquid FCVS)
  - Need to progress on reemission processes from deposits on RCS and containment walls
  - Chemistry in the environment is an issue for assessing consequences of releases

Key Issues and Areas to be Addressed in Future R&D

- Management of corium progression:
  - IVMR: H2020 IVMR project starting in 2015 to assess IVMR strategies for existing (VVER, AP) and future reactors
  - Ex-vessel corium cooling by top flooding: potential subject for international collaboration
  - Steam explosion: analysis of stratified configurations and OECD/TOP initiative to be done, may lead to international collaboration in the future

- SFP: no international initiative foreseen at short term (following OECD/SFP projects) , analysis still on-going on national basis

Key Issues and Areas to be Addressed in Future R&D

- Human and organizational factors:
  - Interest expressed for an international initiative around the analysis of such aspects for the Fukushima's accident
  - Issue of organization resilience to a major crisis
- Issues related to post-emergency phase
  - In relation with maintaining core and containment cooling on the long term, physico-chemical processes (effect of sea water, corrosion, radiolysis, …)

Lessons Learned with regard to Session Topic

- International collaborations through existing framework: NUGENIA/SARNET, EC (H2020), OECD/NEA
  but some issues only covered in national R&D initiatives and potential remaining key issues could be addressed in international collaborative projects
- Prioritizing remaining R&D issues is challenging due to:
  - Consideration of ≠ risks for ≠ sites
  - Consideration of ≠ reactor technologies and SAM approaches
  - Consideration of ≠ safety requirements and criteria
  - Consideration of ≠ assessment methods (probabilistic versus deterministic)

Lessons Learned with regard to Session Topic

- A lot of basic research done or on-going on SA, many programs launched in the aftermath of Fukushima's accident but, in addition to providing knowledge for understanding the accident, one should keep in mind that R&D programs should be useful for improving SA management for many other existing and future reactors
- Prioritizing remaining R&D issues is challenging due to:
  - Consideration of ≠ risks for ≠ sites
  - Consideration of ≠ reactor technologies and SAM approaches
  - Consideration of ≠ safety requirements and criteria
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Recommendations for Further International Collaborative Work

- Stronger Interaction and better complementarity between international initiatives (NUGENIA/SARNET, OECD/NEA, IAEA)
- Promote international collaborations/exchanges on uncovered topics
- Promote information sharing
- Key issues for international cooperation:
  - Deepen understanding of Fukushima's accident
  - Progressing in ST modelling and evaluations
  - Lessons learnt from Fukushima's accident for HOF

…Thank you for your attention!