Stress test on Norwegian research reactors

NKS Fukushima seminar Stockholm 8th – 9th January 2013

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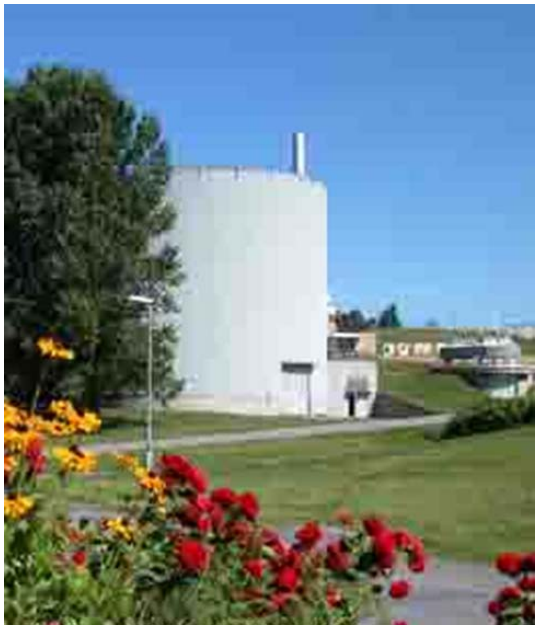


Stress test -initiative

- **Fukushima initiating event (earth quake): 11. March 2011.**
- **Meeting at IFE safety Committee (18 March 2011)**
  - **Topic: Safety at IFE in light of Fukushima accident**
  - **Discussions on 3 scenarios:**
    - Total blackout when reactor in operation.
    - Total blackout during design basis accident
    - Total blackout during beyond design basis accident.
  - **<u>Decision</u>: The thermo hydraulics calculations for both reactors for a new review by the safety committee.**

Re-assessment of thermal hydraulics

- **Reactor coolant thermal hydraulics**
  - **Verify cooling by natural heat transfer in all shut down situations**
  - **Theoretical / experimental**
- **Cladding temperature/integrity**
  - **Show that local fuel damage would not occur for reactor fuel or experimental fuel.**

Assessment both of reactors and spent fuel.

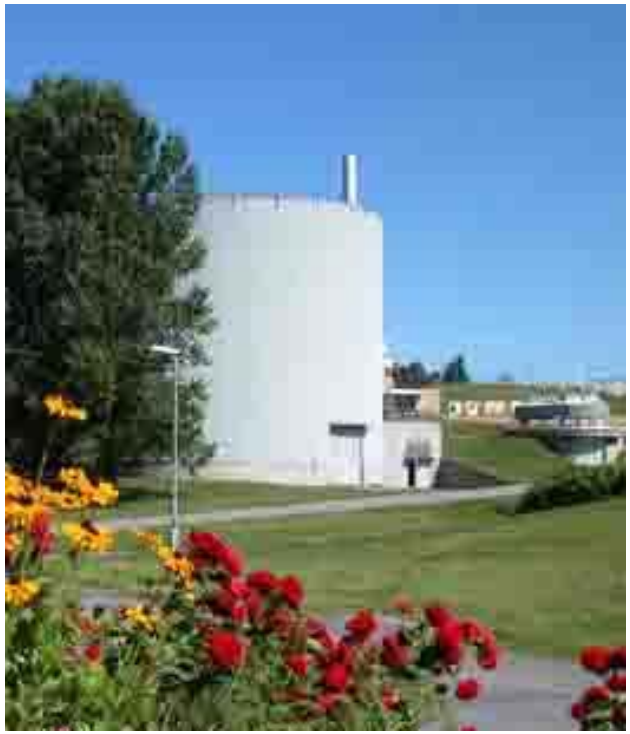
Regulatory requirement (of 18 Sept 2011)

- **IFE to prepare report focusing the following topics:**
  - **Initial events**
    - Earth quake, flooding, power loss.
    - Identification and assessment of potential cliff edge effects
  - **Consequences of loss of safety systems due to the initial events**
    - Assessment of time before fuel failure (reactor and fuel pool) at loss of support function (power)
  - **Emergency preparedness**
    - Evaluation of need for modification of preparedness plans due to stress test
- **Report was sent December 1st 2011**

Initiating events

- **Assessments of initiating events in SAR based on IAEA NS-R-4**
- **Reassessment of initiating events in light of stress test:**
  - **Geophysics, metrology, hydrology.**
  - **Airplane crash a separate assessment (Ongoing)**
  - **Malicious act a separate assessment (ongoing)**
- **Conclusion:**
  - **Assessment in SAR unaltered**

JEEP II



- Commissioned 1967
- «One of a kind»- design
  - Norwegian design
- Cooling and Moderation: D_2O
  - 4 m^3
- Operates at 2 MW, 55 °C and 1 bar
- Tank type reactor
  - -Vessel: Aluminium
- UO_2 fuel
  - average 3,4 % enrichment
- «Steel cylinder» - containment
  - All reactor systems within containment.

JEEP II results

- **Reactor coolant (D_2O):**
  - **Temperature increase at loss of cooling: 17,6 ºC (typical) - 47,1ºC (max)**
  - **Worst case; Maximum temperature (100,1 ºC) reached after 3,5 days. (Boiling point (D2O): 101,4 ºC)**
- **Fuel integrity:**
  - **Temperature of Fuel cladding (Al) well below safe limits at natural circulation.**
- **Spent fuel:**
  - **Fuel could in no circumstances be uncovered before 12 days after loss of coolant**

Halden Boiling Water Reactor (HBWR)

- Commissioned 1959
- «One of a kind»- design
  - Prototype
  - Norwegian design
- Cooling and Moderation: D_2O
  - 14 m^3
- Operates at 25 MW, 240 °C and 33,6 bar
- Tank type reactor
  - -Vessel: ferritic steel (60 mm) with Stainless steel cladding (5 mm)
- UO_2 fuel
  - average 6,6 % enrichment
- «Rock» - containment
  - The primary and parts of the secondary system are located in a mountain cage

HBWR results

- **Reactor coolant (D_2O):**
  - **Verify reactor cooling/ decay heat removal by natural circulations when shut down from up to 25 MW(t).**
  - **Normal operation: 18 MW(t)**
- **Fuel integrity**
  - **Experimental fuel in forced circulation could be uncovered already after 6 minutes.**
  - **Design modified: For test rigs on forced circulation (approx. 10 out of 30).**
- **Spent fuel pool**
  - **Worst case: Uncovering of fuel after 7,5 h**
  - **Design modified: New water line from outside containment.**

Emergency preparedness

- **Updated operational procedures**
  - **New procedures to cover both loss of power during normal operation and under accident conditions.**
  - **Loss of instrumentation is a challenging situation, even if power is not needed to maintain safety functions.**
- **Review of emergency preparedness during loss of power (ongoing).**
  - **Review of available equipment for characterization and communication.**
  - **Exercise planned.**

Regulatory review on report

- NRPA concludes that SAR and Emergency preparedness plans is still valid.
- IFE has identified some areas where there is a need for further assessments and measures
  - NRPA considers non of those to compromise the safety of continued operation.
  - Report by March 9th 2012 and approved thereafter by NRPA.
  - NRPA approval of the stress test report June 29th 2012

Lessons learned

- External focus at IFE during Fukushima accident
  - Important of show a pro active attitude.
- Stress test had a positive effect on safety
  - Identified gaps.
  - New focus on support infrastructure during emergency situations.
- Important to verify ability for natural heat transfer.
  - Low vulnerability for most initiating events
  - Positive value of reassessing thermal hydraulic calculations
- WENRA stress test requirement as guidance
  - Guidelines for RR could be useful.