RIC 2010

W13, Regulatory Applications of International Operating Experience

March 10, 2010

Regulatory Response to Lessons from International Operating Experience:
Examples from Finland

Jukka Laaksonen
Director General
STUK

Principle of continuous safety enhancement

- The principle of continuous safety enhancement was adopted in Finland already in the 1970's when the nuclear power plant operation was started.

- This principle is today included in the Government Degree on the Safety of NPPs:
  - the licensees are required to gather operating experience and to analyze it with the aim to enhance safety

International Operating Experience provides insights for enhancing nuclear safety

- International reporting on Operating Experience is a well established practice and provides a lot of useful information for those who want to learn from it
- As part of its regulatory oversight and enforcement policy, STUK requires that the licensees utilize the reported foreign operating experience for
  - improving staff competences and management of operations,
  - modernizing and back-fitting of operating plants, and
  - addressing the lessons learned in improved design of new facilities
- STUK also uses foreign operating experience for planning its inspection programs and safety assessment

International OEF process at STUK (1)

- STUK is the national co-ordinator of IRS reports
  - STUK has requested a direct access to the IAEA/NEA's web-based IRS system to more than 100 experts representing different organizations in Finland
- STUK also gathers information directly from its cooperation with other regulators
- STUK's own IOEF processes are described in STUK's Quality Manual

International OEF process at STUK (2)

- STUK has a dedicated group that works on international OEF (full-time co-ordinator and ten participating experts)
- The group is tasked to
  - make screening of
    - IRS-reports disseminated through the IAEA
    - other information or reports received directly from other sources
  - assign the received foreign information to categories with respect to actions to be taken
  - maintain a database on the received information
  - make within the limits of its competence or propose other staff to make a detailed review and assessment of experience found of special interest and suggest actions if needed
  - oversee the utilization of international OE by licensees
  - prepare the IRS-reports on events at NPP's in Finland

Examples on Utilisation of IOE

- Foreign events that have recently resulted in plant modifications at Finnish NPP's:
  - ECC recirculation filter blockage (Barsebäck 1992)
  - Disturbance in electrical power system (Forsmark 2006)

- Examples on modifications or actions based on US NRC Generic Communications in 2009:
  - ECCS Gas Accumulation (NRC Information Notices 2008, 2006)
  - Biodiesel in Fuel Oil of Safety Related Engines (NRC Information Notices 2009, 2006)

- Other examples on STUK's review on utilization of US NRC Generic Communications to Finnish NPPs

Emergency Core Cooling (ECC) recirculation blockage at Barsebäck NPP in 1992 (1/4)

- coolant recirculation is required for long term post-LOCA cooling
- large break jets destroy and dislodge insulation; insulation debris transports easily with water to the sump screens
- original sump screens were developed late 70's for both Olkiluoto and Loviisa NPPs
- design of sump screens was based on extensive large scale experiments; tests were carried out using fresh mineral wool
- Barsebäck incident showed that amount of debris reaching the sump screens was underestimated because behavior of thermally aged insulation material in water is completely different from that of fresh material (brittle, migrates more easily, sinks more rapidly)
- it was obvious that the risk for early clogging of the sump screens after LOCA could not be ruled out without additional experiments and redesign of the screens.

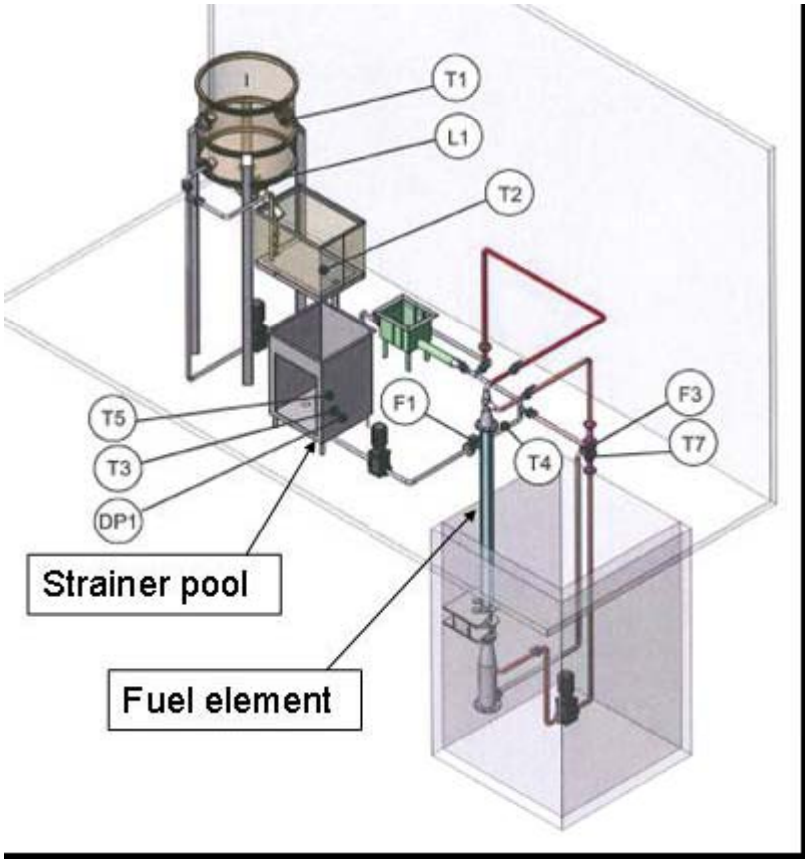
Emergency Core Cooling (ECC) recirculation blockage at Barsebäck NPP in 1992 (2/4)

- **Tests in 90's were conducted both for Olkiluoto and Loviisa**
  - tests showed that the design of existing sump screens at Olkiluoto NPP was still adequate (i.e., met the pressure loss criteria) but not at Loviisa NPP
  - new type of screens with significantly increased flow area (100 m²) were installed at Loviisa NPP in 1993
  - back flushing system for screen cleaning was designed and installed at both Finnish NPPs (operating BWR's and VVER's) and will be installed also for the new EPR (OL3)

Loviisa NPP upgraded sump strainers and back flushing system (1993)

Emergency Core Cooling (ECC) recirculation blockage at Barsebäck NPP in 1992 (3/4)

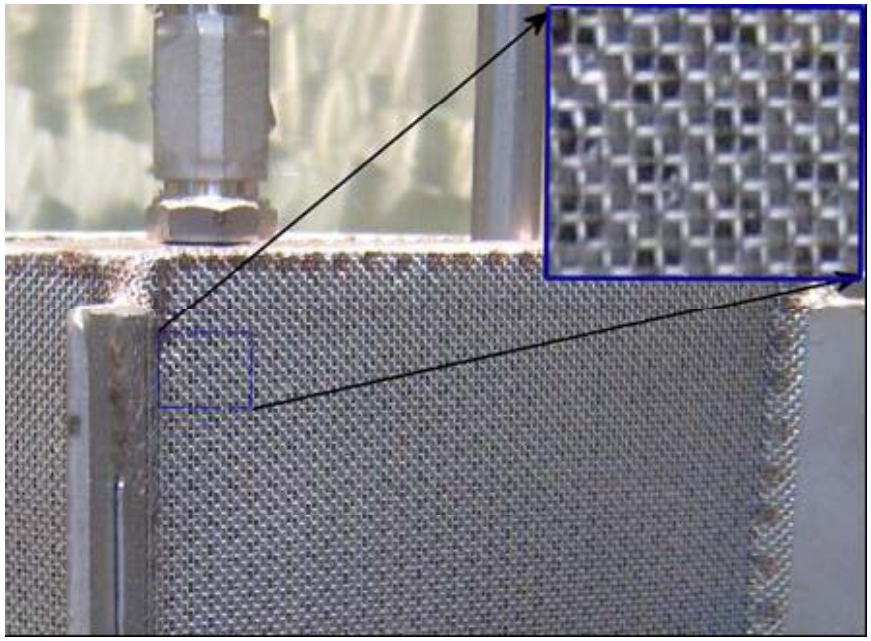
- **A new concern emerged in 2007 in German studies**
  - there was indication that tiny fibers penetrating the sump screens could accumulate on the spacers of the fuel bundle
  - utility of Loviisa NPP conducted in 2008 new tests to study whether fibers accumulating on the spacers could block cooling flow inside the fuel bundle
  - test facility consisted of a pool with debris, a pump, a replica of the basic element of the Loviisa sump screen, and a full-scale mock-up of a fuel bundle
  - geometry, flow, and the debris concentration were scaled to represent the plant conditions in a LBLOCA



Fiber penetration test facility for the Loviisa NPP sump strainers in 2008

Emergency Core Cooling (ECC) recirculation blockage at Barsebäck NPP in 1992 (4/4)

- **Conclusions from the fiber penetration tests of the Loviisa NPP sump strainers in 2008**
  - based on the tests, blocking of the fuel bundles could not be excluded
  - new sump screens with a smaller mesh size were designed
  - thermal hydraulic testing of the new screens were conducted in 2009
  - new screens will be installed in the 2010 annual refueling outage



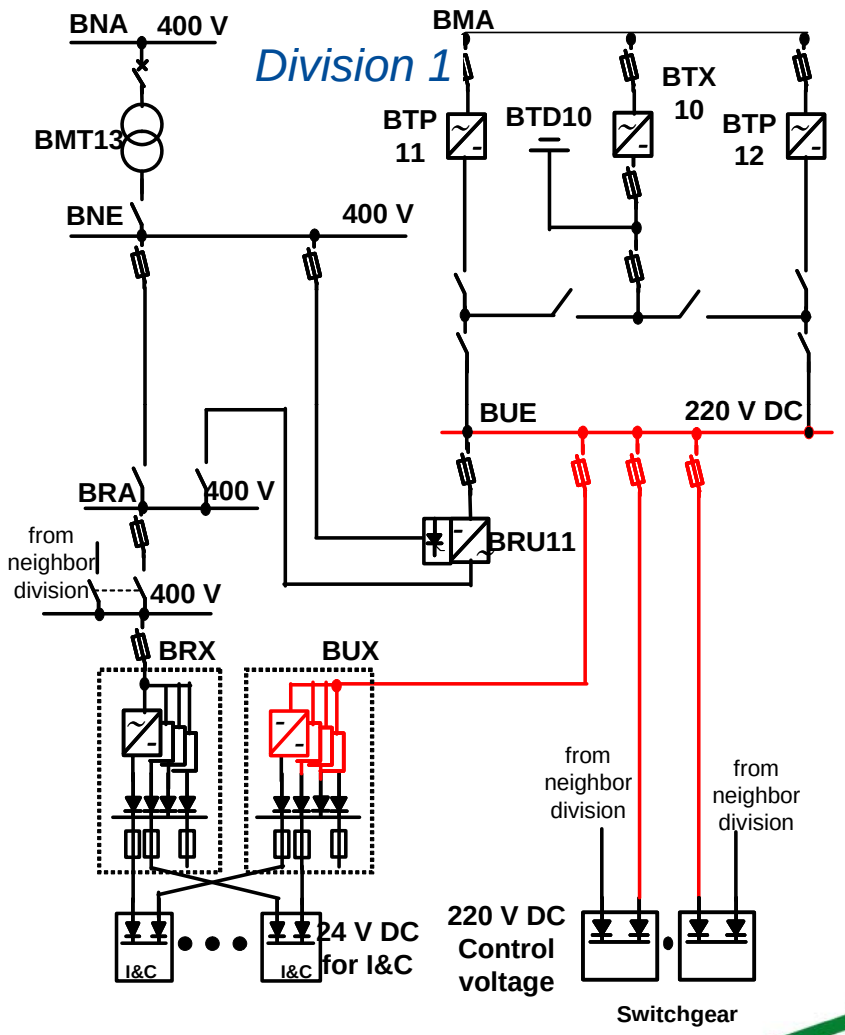
New strainer surface mesh (# 0.7 mm)

Forsmark 1 event (IRS 7788) - over-voltage transient (1/2)

- Disturbance in the offsite 400 kV switchyard generated two transients in the power supply to the Forsmark unit 1
  - first, an over-voltage transient damaged two out of four UPS units (rectifier/inverter) that provide start-up signals to the EDGs
  - second, a low frequency transient caused disconnection of the offsite power and operation of EDGs was necessary to supply power to the safety systems (especially to the emergency feed water system)
- Olkiluoto 1 and 2 units are sister units of Forsmark 1 (and 2), but a similar event was not deemed possible because these plants had implemented different modernizations of their electrical systems
- However, under a similar initiating event some disturbances could not be excluded and a series of technical investigations were started in Finland
  - modeling the main on-site electrical systems and analyzing their tolerability to the worst case (off-site) fault
  - reconsidering the design bases for electrical systems
  - testing the transient tolerability of rectifiers (at Loviisa plant site).

Forsmark 1 event (IRS 7788) - over-voltage transient (2/2)

- Investigations showed needs for technical modifications:
  - improving equipment protection from over-voltage and selectivity in UPS systems
  - decreasing dependencies to UPS systems by installing a direct DC supply in parallel with the UPS (AC) supply to DC consumers at Olkiluoto 3 (see figure).
- Current understanding is that Finnish NPPs can withstand possible over-voltage transients.
  - issue will also be addressed in the construction permit review of new plants being planned in Finland



Gas in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems (1/2)

- **NRC Generic Letter 2008-01; IRS 7950, IN 2006-21, IRS 7815**
  - numerous generic communications dealing with gas accumulation or similar issues
  - safety concerns related to inadequate gas control: air-binding, potential damage to pumps, inadequate discharge pressure, and water hammer
  - identified root causes of gas accumulation: bad design, improper filling and venting after maintenance, ineffective gas controls during operation, ineffective application of Tech Specs, problems with keep-full systems
- **Actions required in Finland**
  - licensees were asked to submit information to demonstrate that the subject systems are in compliance with licensing and design bases and applicable regulatory requirements, and that suitable design, operational, and testing measures are in place for maintaining this compliance.

Gas in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems (2/2)

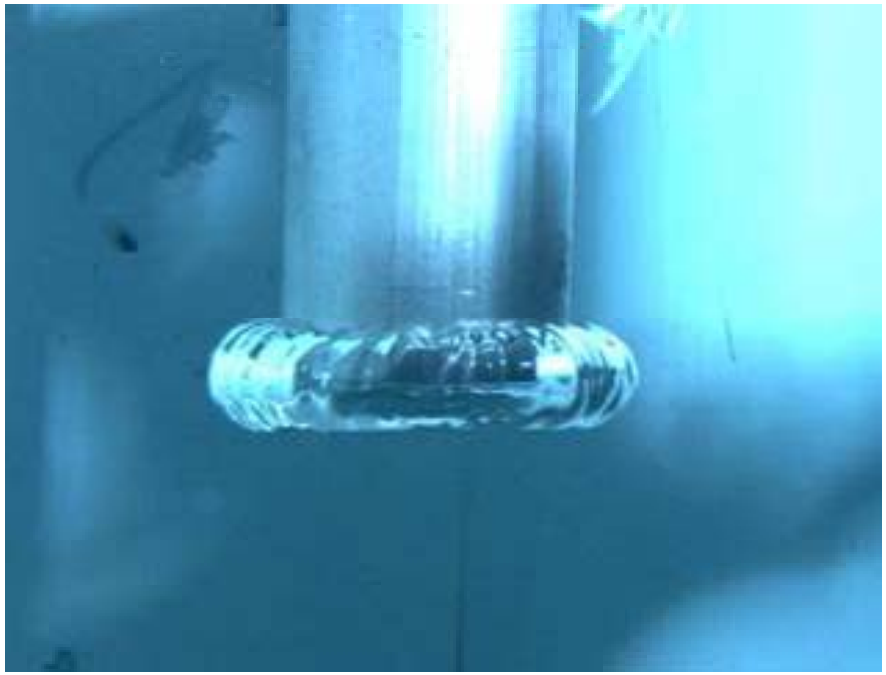
Loviisa NPP:

- vortex-phenomena were evaluated in emergency core cooling pump suction lines in case of low water level in water storage tank.
- vortex-plates were introduced in the emergency core cooling water storage tank in 2009 annual maintenance outage.

Gas in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems (2/2)

Olkiluoto NPP:

- concern had been addressed already in 2001 (before receiving NRC letter) by testing whether nitrogen could jeopardize emergency cooling pumps in case of steam line break in the upper containment and consequent blow down into the condensate pool (blow down pipes are nitrogen filled).
- no actual problems were identified



Adverse Impact of Biodiesel mixed in Diesel Oil

- NRC Information Notice 2009-02
  - properties associated with bio diesel raise several concerns on scenarios that could lead to DG common-cause failure
  - specifications of diesel generators of Finnish NPPs do not allow the use of biodiesel (design of materials, filter systems, tank size)
  - however, European Commission requires oil refineries to mix gradually increasing amount of bio component into the diesel fuel and it is difficult to get special diesel for NPP's
  - STUK has raised the concern to the licensees
    - for each delivery sampling and analysis is required that only pure fossil diesel oil is used in the safety related diesel generators
    - STUK met in January 2010 with the oil refinery's representatives, the fuel supplier and the utilities; oil companies are reluctant to make long term commitment on supply of pure fossil diesel oil
    - it is still an open question how acceptable diesel fuel can be provided after some years

Examples on STUK's Review of NRC Generic Communications

Potential Failure of Fire Water Supply Pumps to Automatically Start due to a Fire - NRC IN 2009-29	Relevance of concern to be investigated in a future inspection
Transformer Failures - NRC IN 2009-10	Issue had been addressed earlier with proper actions
Emergency Diesel Generator Voltage Regulator Problems - NRC IN 2007-36	Relevance of concern has been investigated; no action needed
Recurring Events Involving Emergency Diesel Generator Operability - NRC IN 2007-27	Need for improved work practices and procedures to be discussed with licensees
Combustibility of Epoxy Floor at Commercial NPPs - NRC IN 2007-26	Issue was adequately addressed in original design
Design Deficiency in Pressurizer Heaters for PWRs - NRC IN 2006-04	Relevance of concern to be reviewed for new plants
Inadvertent Reactor Trip and Partial Safety Injection actuation Due to Tin Whisker - NRC IN 2005-25	Issue had been addressed earlier with proper actions
Fires at NPPs Involving Inadequate Fire Protection Administrative and Design Controls - NRC IN 2007-17	Lessons to be discussed with licensees for possible actions

Conclusions

- the Finnish nuclear regulations require continuous NPP safety enhancement, considering operating experience and results of safety research;
- STUK follows systematically information received from the IRS and other international sources
- major plant modifications have been conducted at Finnish plats to enhance safety;
- many modifications were started on the basis of international operating experience
- a major plant modification always requires plant specific confirmatory research to demonstrate the expected improvements