RIC 2012
Regulatory and Safety Applications of International Safety-Significant Operating Experience
March 14, 2012

Regulatory Response to Lessons from Operating Experience:
Examples from Finland

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Outline

- General
- Use of PRA in the OEF process in Finland
- Some examples on the use of international operating experience
- Conclusions

Nuclear power plants in Finland

Fennovoima Ltd
- New utility, no operating reactors, DiP approved for HA1, Hanhikivi Site

Olkiluoto NPP (TVO)
- 2 operating units - ABB BWRs
- OL3 (EPR) under construction
- DiP approved for OL4

Photo: TVO

Loviisa NPP (Fortum)
- 2 operating units - VVERs

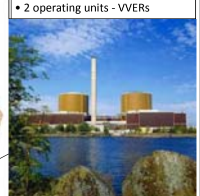


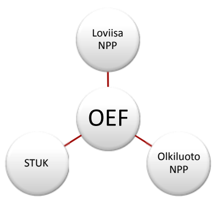
Photo: Fortum

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 Nuclear Energy Act and 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.
- More detailed requirements are given in STUK's regulatory guides.

Operating Experience Feedback (OEF) in Finland

- Roles and responsibilities of Licensees and STUK
- Sources of Operating Experience
  - WANO, Owner's/Users groups,
  - IRS system
  - International organizations and forums
  - Bilateral contacts
- Processes and resources to utilize operating experience



Utilisation of IOEF by Finnish licensees

- Most of the corrective measures at operating Finnish NPP's, which were based on inputs through international reporting systems (IRS, WANO) have been improvements in
  - management systems and operating practices,
  - procedures and instructions,
  - inspections and testing of equipment,
  - additional analysis, and
  - staff training, including simulator training.
- Almost all plant modifications (i.e., improvements in systems, structures, and components) that have emerged from foreign experience originate from plants that are of the same type as the Finnish plants.

Use of PRA in the OEF – General Requirements for PRA

- Utilities develop PRA in-house and models must be available to STUK
- PRA-models kept up-to-date, living PRA and applications
- Full-scope level 1 and 2 PRAs required including internal and external hazards, low power and shut-down states
- Quantitative regulatory requirements:
  - Average core damage frequency less than 10^{-5}/year
  - Average frequency for large radioactive release (> 100 TBq of Cs-137) less than 5×10^{-7}/year
- PRA-projects started in mid -80's
  - First versions of level 1 PRAs for internal events completed in 1989
  - Currently practically full-scope level 1 and 2 PRAs for operating units

Use of PRA in OEF

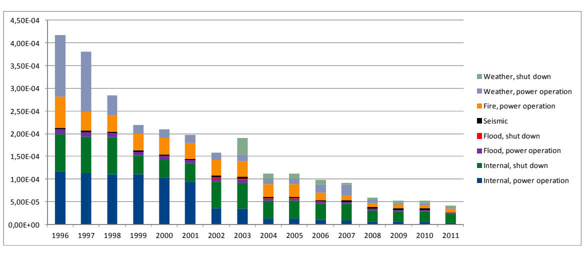
In some cases, risks revealed by occurred events indicate insufficient scope or coverage of PRA; more often risk reduction is difficult to model in PRA and quantify

- **some lessons learned from events have led to extension of PRA and quantified risk reduction**

However, main contribution to reduction of **predicted risk** (e.g. CDF) has been achieved by insights gained from PRA analyses when its scope has been extended to cover different potential hazards (equipment failures, fires, floods, external hazards) and different operational states (normal operation, low power, shutdown)

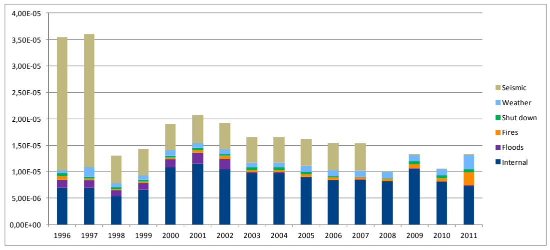
- **systematic PRA has revealed potential risks from rare events that have never occurred**

CDF development for Loviisa plant during 1996-2011



- Significant measures to reduce risk were started on the basis of qualitative judgements soon after first start-up of Loviisa 1 in 1977.
- Preliminary results of PRA analyses became available in 1989 and led to more systematic risk reduction.
- In some cases, lessons from occurred events have contributed to risk reduction.

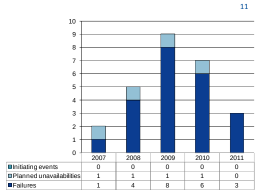
CDF development for Olkiluoto plant during 1996 - 2011

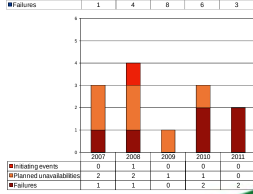


- Most reduction of predicted risk is based on the results of PRA analyses.
- Preliminary results of PRA analyses became available in 1989.
- Increase to risk has become from extension of PRA (weather, fire, shutdown risks).
- In some cases, lessons from occurred events have contributed to risk reduction.

Risk Follow-up of OE at STUK

- Provides additional information for deterministic analysis
- Gives a comprehensive picture of safety related component failures and other events
- Approximately 70 cases per unit (own events / unavailabilities) are evaluated annually
  - Initiating events
  - Component failures, preventive maintenance and unavailability of systems regulated by Technical Specifications
- Conditional core damage probability (CCDP) is used as a measure.
  - Figures indicate the number of most important events (CCDP ≥ 1E-7) for Loviisa 1 and Olkiluoto 1





Examples on events led risk reduction measures

Event Plant(s)	Year(s)	IRS No.	Improvement / Upgrading	Risk reduction
Several big turbine hall fires; Belojarsk, Armenia, Vandellos, Chernobyl, Narora	1978 - 1993		Fire safety improvements; New safety systems: ensuring cooling and residual heat removal	-85 % (Loviisa 1,2)
Feedwater pipe brakes Loviisa1, Loviisa 2	1990 1993	1102 1352	Decreasing pipe break risk (both probability and consequences)	- 66 %
Electrical arc incident and switchgear fire Olkiluoto 2	1991	1183	Fire safety improvements of electrical systems; Separation of subsystems and switchgears	accident sequence practically eliminated
Blockage of sea water intake due to frazil ice Olkiluoto 1, Olkiluoto 2	1988 1995 2008	908 7921	Ensuring sea water intake regardless of under cooled seawater	- 15 %
Internal over voltage Olkiluoto 1	2008	7932	Improvement of over voltage protection	- 4%
Blockage of diesels air intake due to snow; Olkiluoto 2	1995		Ensuring supply of suction air to DGs	- 32 %

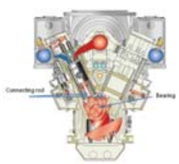
Examples on Utilisation of IOE (1)

- Precursor existed
- Following the accident there have been two parallel activities in Finland:
  - Shortly after the accident the National Safety Reviews of the operating plants, the plant under construction, and new plants and sites were requested from the utilities.
  - EU "Stress tests" started at the beginning of June 2011 and continue until 2012.
- Safety improvement needs will be decided during 2012 as well as changes in regulatory requirements and programmes.

Examples on Utilisation of IOE (2)

- Response to non-compliance of Wärtsilä Emergency Diesel Generator bearings were initiated as receiving INES Level 2 Report on 18 February 2011 from Tricasting (France) and IRS-reports of Germany (#8147) and France (#8164).

- Fire in the containment of Ringhals 2 (Sweden) on 10 May 2011 during maintenance outage.



Loviisa 1 and 2 Emergency Diesel Generator Connecting Rod Bearing failure

- In January 2011 licensee's staff identified a similar type of EDG under maintenance at subcontractor's premises in Finland
- It was found out that the EDG (from EdF, France) had had a connecting rod bearing failure
- Similar bearing type (PAAG 129161 (MIBA)) were in use at one of the eight EDGs at Loviisa plant
- Licensee inspected the EDG and discovered damaged bearings
- Bearings were changed during the next week to original type (SIC DLT123351)
- Reason for bearing failure has been studied in Finland

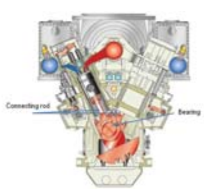


Photo: Fortum

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EDG Connecting Rod Bearing failures – Studies

- Licensee decided in the beginning of 2011 that reason for bearing failures are to be studied at the Research Centre (VTT) of Finland.
- Two damaged bearing of Fortum and one of EDF were studied
  - One Loviisa bearing originating from the same batch as that of EDF's Miba 1109 (second generation bearing) and the other Loviisa bearing originated from batch 1009 (first generation = sequential batch / previous year).
- VTT studied the material structures: layers' compositions and thicknesses, and metal compositions
  - According to the preliminary results there are differences in the micro structures and metal compositions of Miba bearings from different production batches supporting the visual findings and probably also the failure behavior of bearings

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EDG Connecting Rod Bearing failures – Actions Internationally

- Licensee did not receive information about the EDG connecting rod bearing failures from other operators or through operators' international OEF systems (i.e. WANO).
- Diesel manufacturer is looking for other types of EDG connecting rod bearings and has started test in fall 2011.
  - Several plants in Europe don't have spare bearings for their EDGs.
- STUK asked in the beginning of April 2011 EU Clearinghouse actions on international level to clarify:
  - root cause(s) of these events and the efficiency of International OEF arrangements (operators, regulators, subcontractors) for informing about these problems, utilizing International OE, and needs for improvement.

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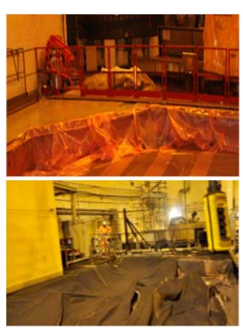
Fire in Containment at Ringhals unit 2

- During the outage in a decision was made to reschedule the containment pressure test to shorten the outage.
- Change was inadequately planned and implemented
- When the containment pressure reached the pressure of 3.16 bar operators detected that temperature and pressure increased inside the containment
- The cause of the fire was an electrical arc in a vacuum cleaner connected to the wall socket with a burnable material in the vicinity of the vacuum cleaner
- Independently of the fire but as a result of the clean up, welding material (wires, plugs used in pipes for protection during welding) was found inside the containment spray system (similar findings on R4 unit).



Photos: SSM

Fire in Containment at Ringhals unit 2 - Actions in Finland

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- STUK took the event and licensees' actions as one item in its periodic inspection program inspection on "Utilization of International OE".
- Olkiluoto plant
  - Revision of the Containment Pressure Test procedure (control of fire load in the containment)
  - Those parts of containment spray system pipelines which are not covered in testing by pressurised air are inspected by endoscope.
  - Re-evaluation of periodic testing methods (scope, criteria, conditions)
- Loviisa plant
  - Amount of Plexiglas in the containment was explored and needs to decreased (e.g. fences around the pools do not need to transparent).

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Conclusions

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- Maintaning plants at original safety levels is not enough in Finland; substantial improvements, modifications and modernizations have and will take place
- Many improvements have been made based on deterministic engineering judgement or insights from PRA.
- Lessons learned from OE have also led to improvements.
- ***Learn from others' mistakes – don't wait for yours***
- ***Never waste a crisis***

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