

Event investigation on Cracks and Leaks Detected in the Reactor Coolant Pressure Boundary

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Outline

- The EU Clearinghouse on OEF
- Topical Studies
- Ageing Management at JRC-IET
- Event analysis on Cracks and Leaks in the RCPB

The EU Clearinghouse on OE for NPPs is a centralised EU initiative at the service of EU MS nuclear Safety Authorities, to improve the use of Operational Experience (OE) from Nuclear Power Plants (NPP)

- Created in 2008 with 7 participating EU MS
- Today **all EU MS having NPPs are participating**, together with international organisations (OECD, IAEA) and part of the nuclear industry.

EU Safety Authorities

- Belgium
- Bulgaria
- Czech Republic
- Finland
- France
- Germany
- Hungary
- Lithuania
- Netherlands
- Romania
- Slovakia
- Slovenia
- Spain
- Sweden
- Switzerland
- United Kingdom

OEF Clearinghouse Centralized Office (JRC)

Coordination & Communication
Technical & Scientific work
OE knowledge repository

- Main deliverables:**
- Topical reports
 - Quarterly reports on events
 - Improved draft IRS reports

EU Technical Support Organizations

- IRSN, GRS
- Bel-V

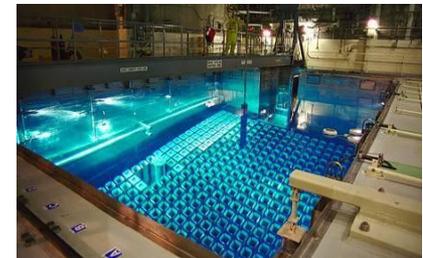
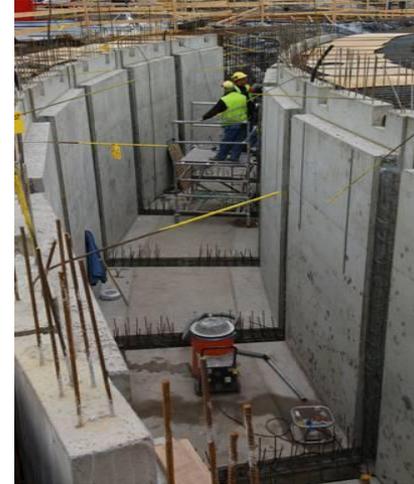
International Community

- IAEA 
- OECD-NEA 



Topical studies (1/2)

- 12 existing studies :
 - Shika NPP criticality event of 18 June 1999
 - Event at Forsmark NPP (25/07/2006)
 - Maintenance
 - Fuel.
 - Construction & Commissioning
 - Loss of safety-classified electrical equipment due to generator high voltage peak (IRS 7932 - Olkiluoto 1 & IRS 8062 - Forsmark 2)
 - Supply of NPP components
 - Modifications
 - **Ageing**
 - External hazards
 - Decommissioning
 - Emergency Diesel Generators



Topical studies (2/2)

- 6 on-going studies:
 - Digital I&C,
 - **Cracks and leaks of the Reactor Coolant Pressure Boundary,**
 - Events related to the cooling chain (ESW, CCS, RHRS)
 - one HOF Topic: Manager's role and management issues
 - Station Black-Out and Loss of Off-Site Power
 - Events at Shutdown states

Clearinghouse website

<http://clearinghouse.jrc.nl/>



The screenshot shows a web browser window displaying the Clearinghouse website. The browser's address bar shows the URL <http://clearinghouse.jrc.nl/>. The website header includes the European Commission logo and the text "JOINT RESEARCH CENTRE Institute for Energy and Transport (IET)". Below the header, there is a navigation menu with the path "European Commission > JRC > IET > OEF Clearinghouse".

The main content area features a large image of a nuclear cooling tower with a circular logo overlaid that reads "European Clearinghouse on Operational Experience Feedback for Nuclear Power Plants". To the right of the image, the text reads:

Learning from Others

In the European Union, a regional network has been established to enhance nuclear safety through improvement of the use of lessons learned from Operational Experience. This network's hub is located at the European Commission Joint Research Centre (JRC) in Petten, the Netherlands.

This organisation is known as the European Clearinghouse on Operational Experience Feedback for Nuclear Power Plants. The 'Clearinghouse' is comprised of dedicated staff from JRC and member states that have joined the organisation. Membership is mainly composed of nuclear safety regulatory authorities and their Technical Support Organizations within the EU region.

Below the text is a search bar with the placeholder text "Search News, Nuclear events, Nuclear stations, Documents..." and a "SEARCH" button.

The page is divided into two columns of text:

The 'Clearinghouse' objectives

The overall objectives of the European Network on Operational Experience Feedback for Nuclear Power Plants are to facilitate efficient sharing and implementation of operational experience feedback to improve the safety of Nuclear Power Plants, in particular:

1. Improvement of NPP safety through strengthening co-operation between licensees, regulatory authorities and their Technical Support Organisations staff to collect, communicate, and evaluate reactor operational events information and apply systematically and in a consistent manner lessons learnt throughout European countries participating in the project.
2. Establishment of European best-practice for assessment of NPP operational events, through the use of state-of-the-art methods, computer aided assessment tools and information gathered from different national and international sources, such as EU National Regulatory Authorities event reporting systems, Incident Reporting System (IRS) jointly operated by IAEA and OECD/NEA, etc.

Do you know the 'Clearinghouse' tasks?

1. Fostering the collection of operating experience from European nuclear regulators or operators, assessing the potential value of lessons learned, and ensuring that events relevant for the global OEF are reported systematically and in consistent manner to the IRS system operated by NEA/IAEA.
2. Screening of important operational events and keeping timely contacts with the authors of the reports as needed to improve the clarity and usefulness of the reported information.
3. Providing support to the original authors in categorizations of the European IRS reports (following the advice given in the IRS guidelines) to ensure consistent categorization and reduce the burden to the authors.

A "Read more" link is located at the bottom right of the second column.

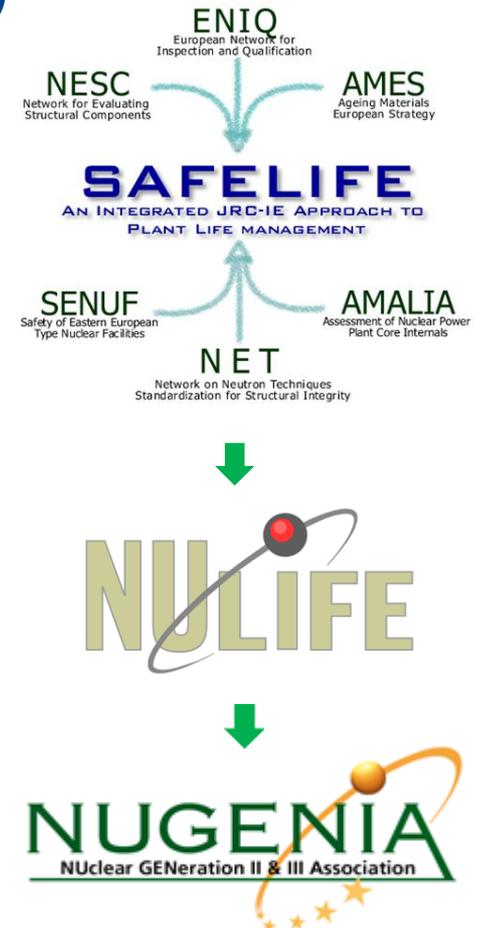
Ageing Management (AM)

AM always has been an important research area for JRC:

- First was AMES, later NULIFE and NUGENIA
- Participation in LONGLIFE, MULTIMETAL, STYLE,....

There is a strong interest in AM inside the EU Clearinghouse on OEF:

- Ageing related operating experience and lessons learned provide important feedback to the plant programmes that intend to manage the ageing degradations of SSCs.



Some JRC reports related to Ageing Management

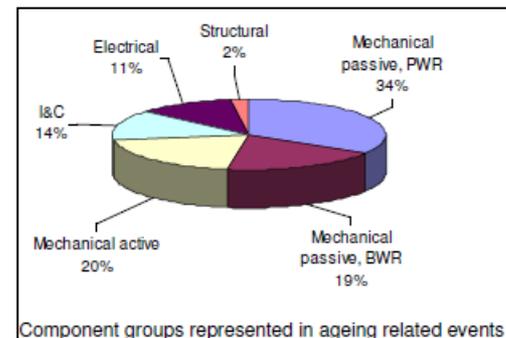
- **Operation of Ageing Reactors: Approaches and associated Research in the European Union (public distribution)**
- **Topical study on Ageing related Events (restricted distribution)**
- **Summary report on Ageing related Events (public distribution)**
- **Final draft report on Analysis of Leaks and Cracks Events (restricted distribution)**



Study on Ageing related Events

- What is the proportion of ageing related events from among all reported events?
- What are the most frequently represented components in ageing related events?
- What are the common degradation mechanisms?
- What are the consequences of ageing related events?
- What are the important lessons learned?

A selection of ageing related events was performed through searching the IRSN, GRS, US NRC Licensees Event Reports and IAEA/NEA databases.



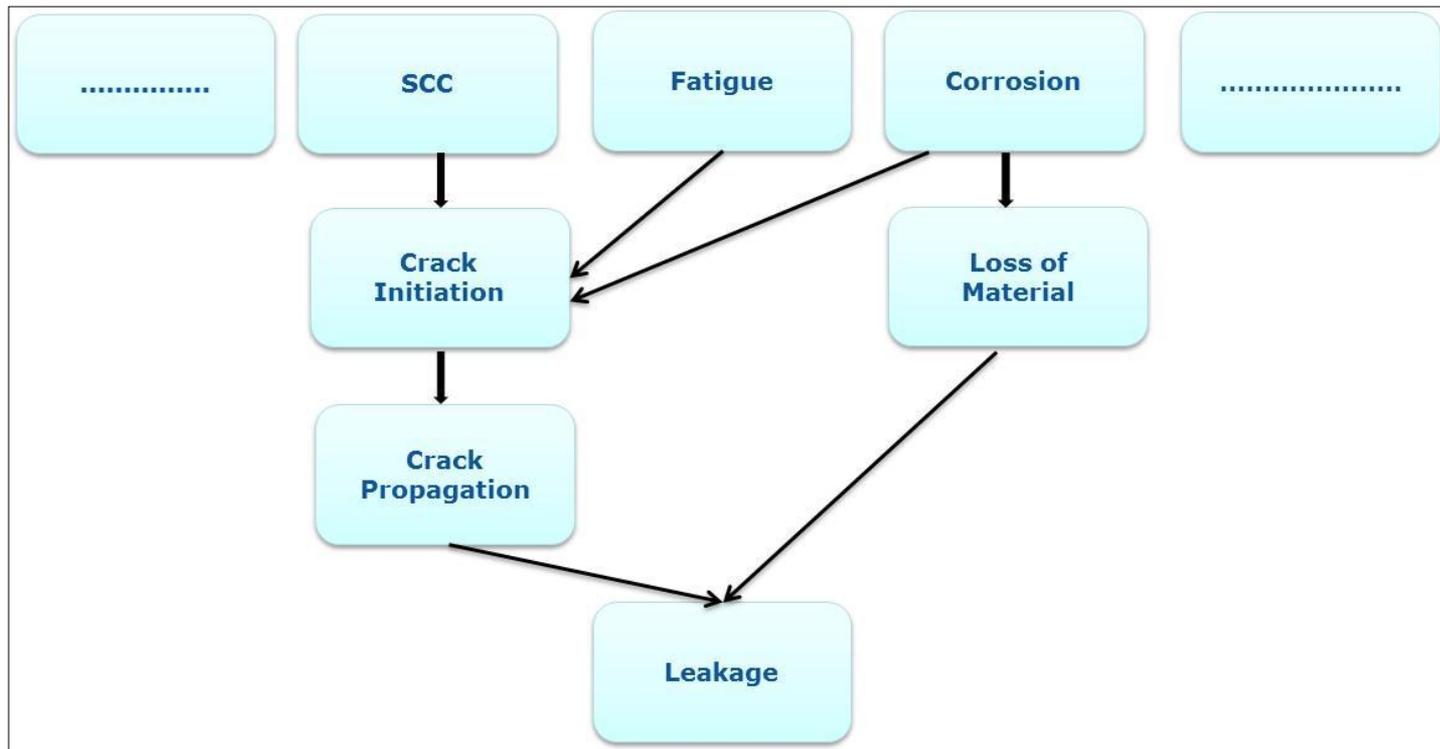
Study on Cracks and Leaks in the Reactor Coolant Pressure Boundary

Objective

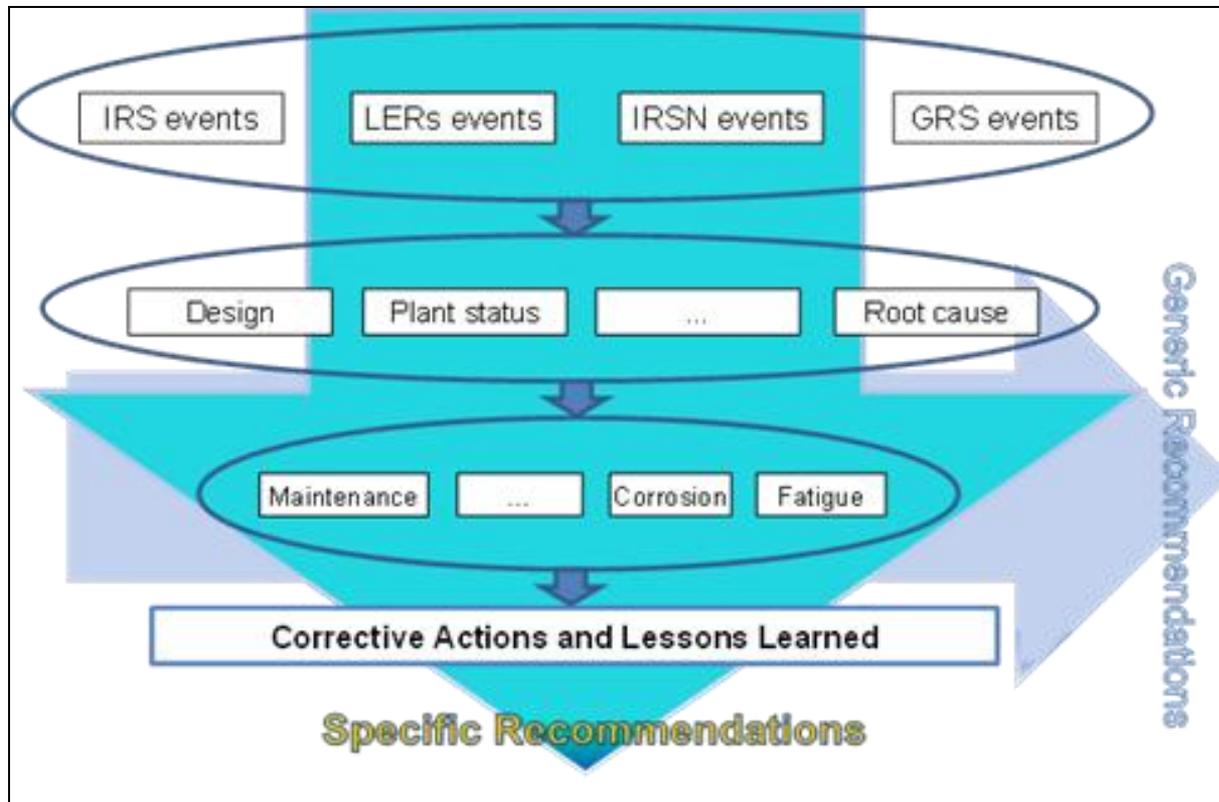
To perform an in-depth analysis of families of events related to cracks and leaks in the RCPB in order to:

- Identify the main recurring causes,
- Identify the contributing factors,
- Identify trends,
- Lessons learned,
- Elaborate recommendations to reduce the recurrence of similar events in the future.

Process leading to leakage

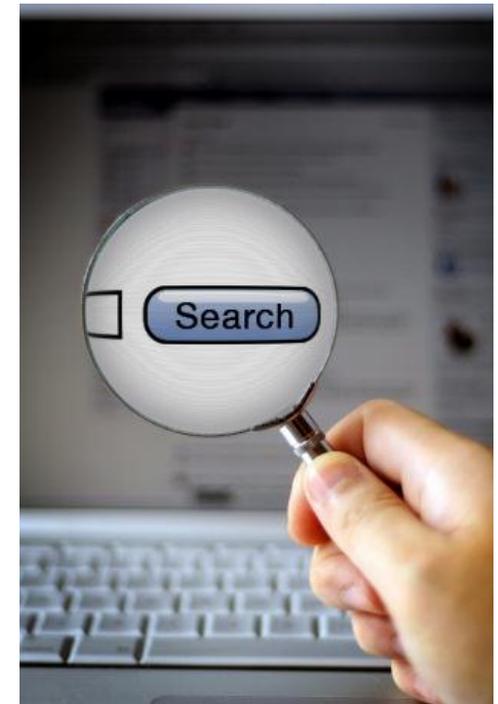


The Methodology used at a glance



Source of information

- ❑ Four different databases
 - ❑ IAEA-NEA IRS database
 - ❑ US NRC LER database
 - ❑ IRSN SAPIDE database
 - ❑ GRS KomPass database
- ❑ Other sources of information to address Safety Impact and Corrective Actions
- ❑ Screening the databases for a period of 20 years, between 1991 and 2011
- ❑ 409 events were selected for analysis



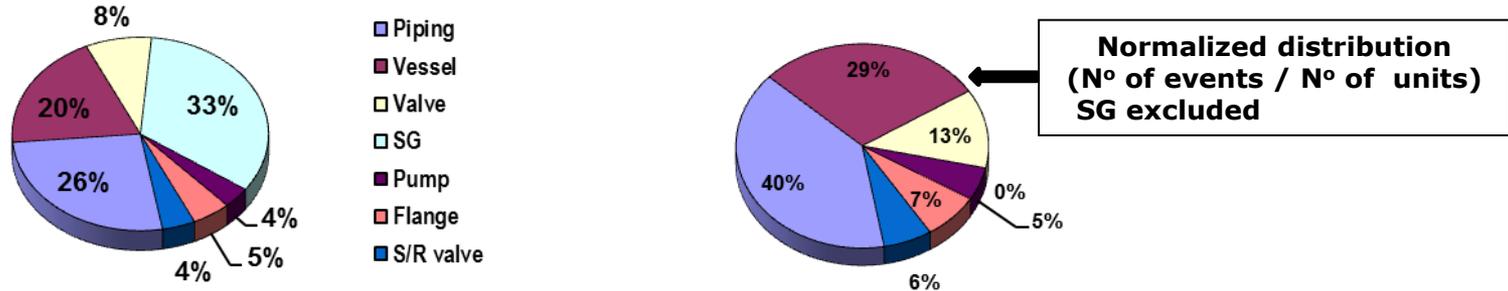
Classification of events

Events were characterized according to families:

- ❑ Plant Design
- ❑ Plant Status
- ❑ Component
 - ❑ RPV, pressurizer, SG tubes, pumps, piping, flanges, S/R valves, other valves
- ❑ Part of component
 - ❑ Base metal, welds, HAZ, seals
- ❑ Event cause
 - ❑ Manufacturing defect, maintenance anomaly, operating error, SCC, fatigue
- ❑ Type of detection



Example: IRS leaks and cracks distribution by components



IRS events on:	Leaks	Cracks	TOTAL
RPV and Pressurizer	24	4	28
SGs	34	14	48
RCPs	5	0	5
Piping	32	6	38
S/R valves	6	0	6
Valves	11	1	12
Flanges	6	1	7
TOTAL	118	26	144

Degradation mechanisms affecting RCPB components

Corrosion

- General corrosion
- Flow-accelerated corrosion (C & LAS)
- Pitting, crevice corrosion
- Intergranular corrosion
- Standstill corrosion
- Boric acid corrosion

Embrittlement Mechanism

- Thermal ageing (Cast SS)
- Neutron embrittlement (RPV)
- Hydrogen embrittlement
- Low-temperature embrittlement
- Dynamic strain ageing

Crack initiation and crack growth

- Low-cycle and high-cycle fatigue
- Stress corrosion cracking
- Strain-induced corrosion cracking
- Corrosion fatigue

Event causes

- Corrosion of different types for 35% of the cases.
- Manufacturing defect for 15% of the cases.
- Maintenance anomaly for 11% of the cases.
- Control or operating error for 9% of the cases.
- Fatigue for 11% of the cases.
- Unknown or other causes in 19% of the cases.

	IRS	US NRC	SAPIDE	KomPass	TOTAL
Base Metal	78	38	41	31	188 (46%)
Welds	33	35	5	23	96 (23%)
Seals	33	2	37	5	77 (19%)
Other	0	0	46	2	48 (12%)
TOTAL	144	75	129	61	409 (100%)

Number of events by part of component

Example: RPV and Pressurizer

- ❑ The main cause of failure identified was corrosion.
- ❑ The events dealing with corrosion pointed to various causes (e.g.):
 - ❑ steam impingement,
 - ❑ high oxygen concentration,
 - ❑ use of materials containing water-soluble chlorides (asbestos) as an insulation material.
- ❑ 9 of all the 66 events selected were found dealing with inadequate material selection (mainly alloy 600).
- ❑ Other events were caused by the following deficiencies (e.g.):
 - ❑ deviation from modern design recommendations,
 - ❑ inadequacy of the detailed written procedures,
 - ❑ improper process of manual electric arc welding,
 - ❑ debris on the vessel flange,
 - ❑ post weld heat treatment at the manufacturer's works.

Conclusions

- ❑ it is important to analyze any event, to identify its causes and draw lessons, in order to avoid the recurrence of similar events
- ❑ Numerous recommendations and lessons learned were elaborated in the analysis of the cracks and leaks related events and are extensively documented in a dedicated EU Clearinghouse's topical study.
- ❑ Plants should periodically analyze the trend in the unidentified and identified leakage rates. Evaluating the increase in the leakage rates is important to verify that the plant will continue to operate within acceptable limits.