European Commission

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

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*Stimulating innovation*
*Supporting legislation*

# 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*

## EU Technical Support Organizations

*IRSN, GRS*
*Bel-V*

## 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

## International Community

IAEA

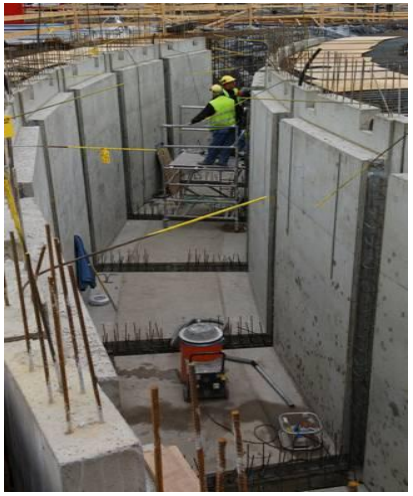
OECD-NEA

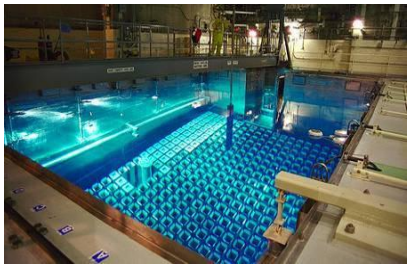
*+ Areva*

Joint Research Centre

# 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/

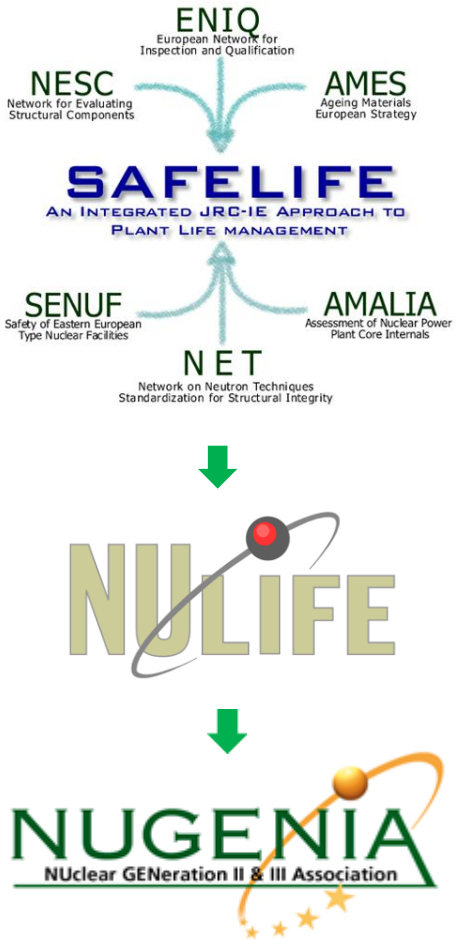
# Ageing Management (AM)

**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.



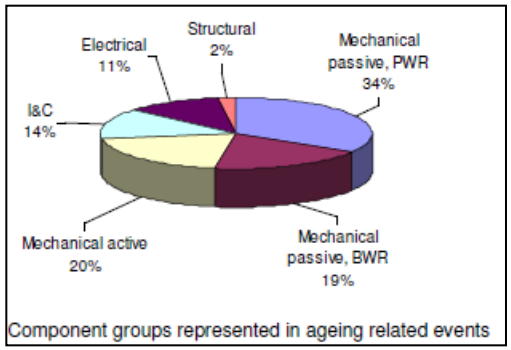
# Some JRC reports related to Ageing Management

- **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.



Component groups represented in ageing related events

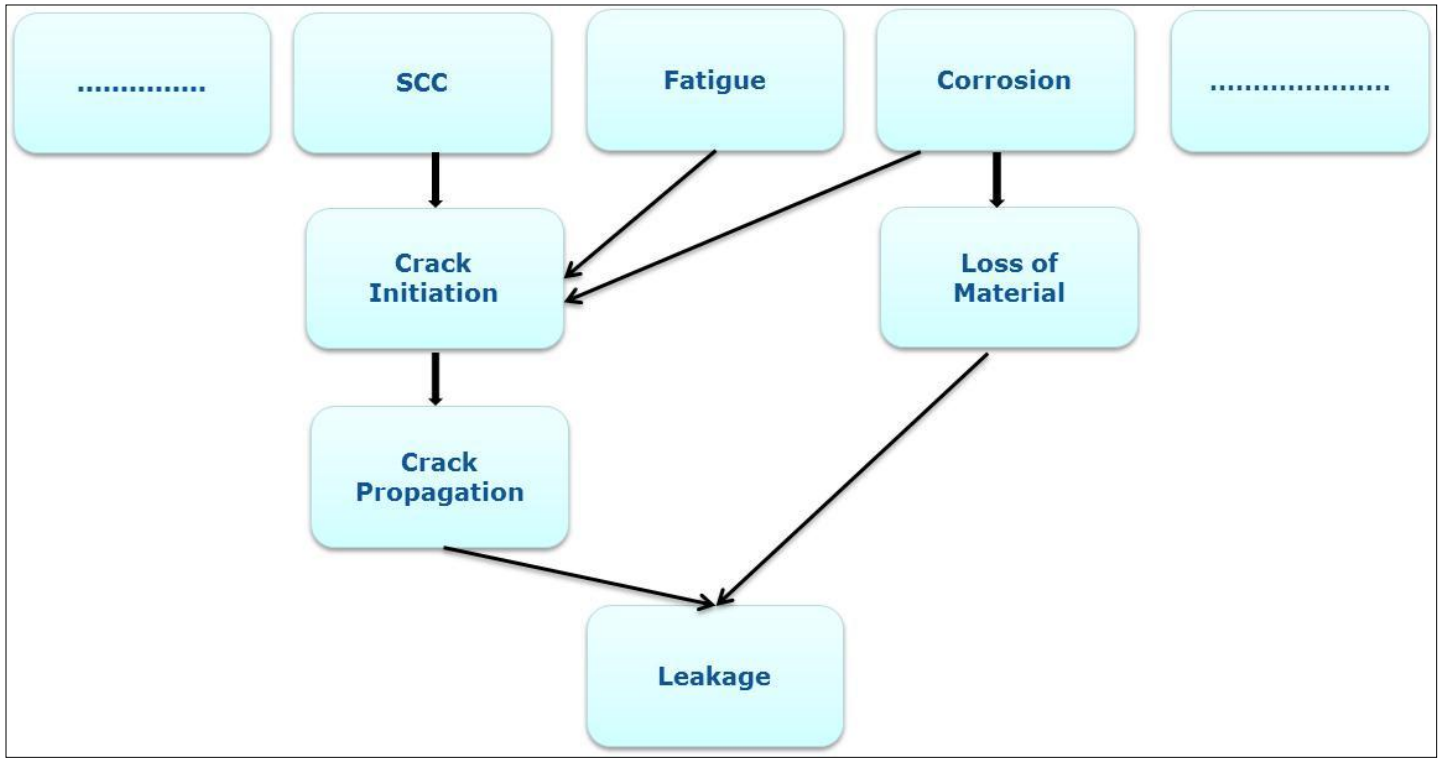
# Study on Cracks and Leaks in the Reactor Coolant Pressure Boundary

## Objective

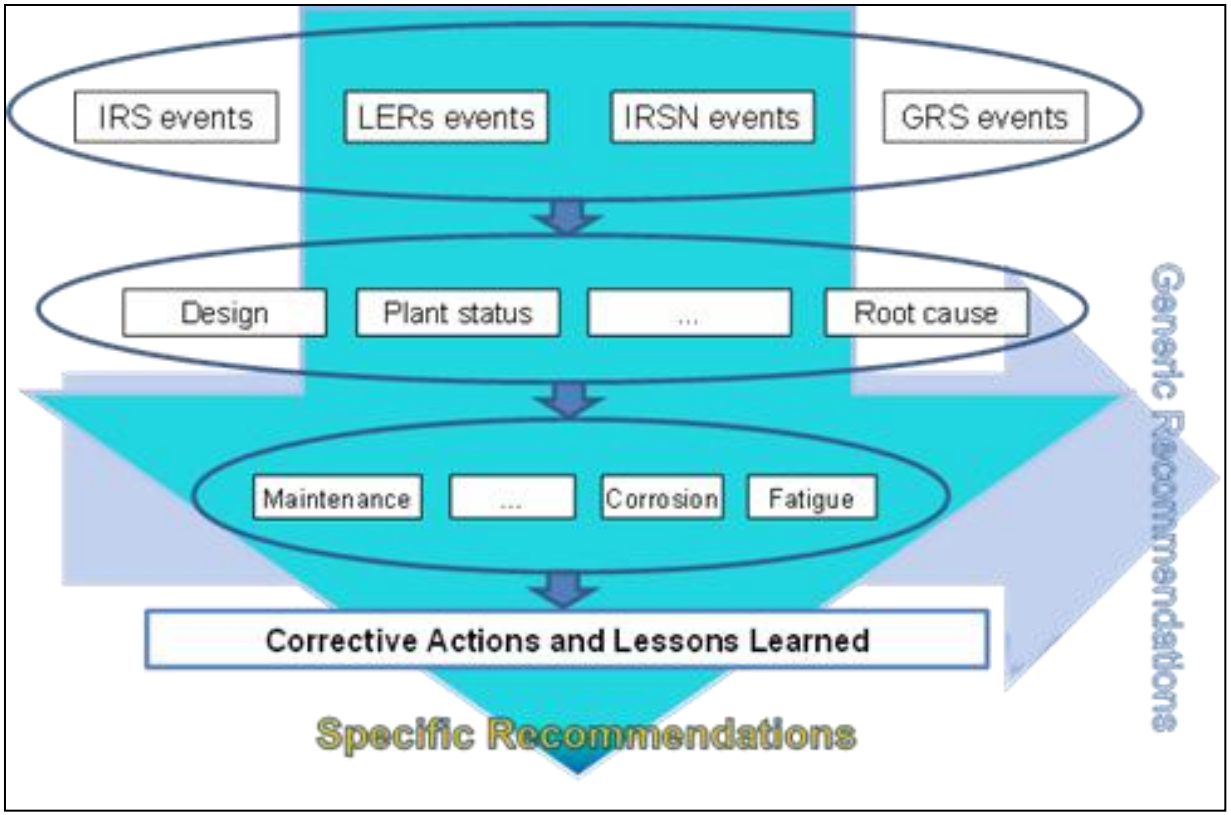
To perform an in-depth analysis of families of events related to cracks and leaks in the RCPB in order to:

- 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

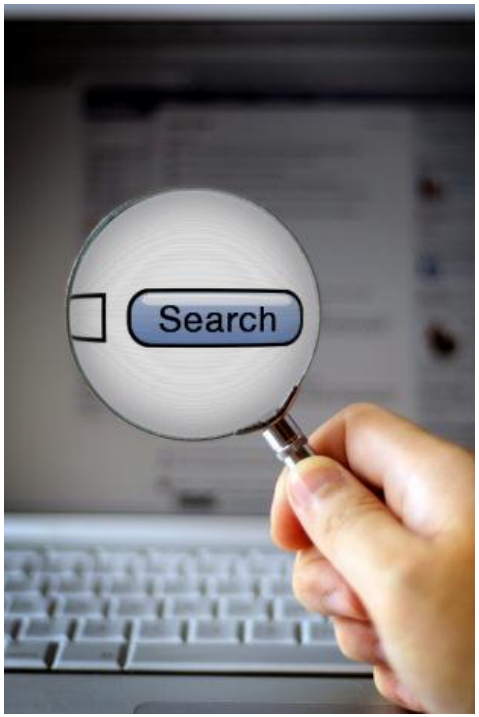


# The Methodology used at a glance



# 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

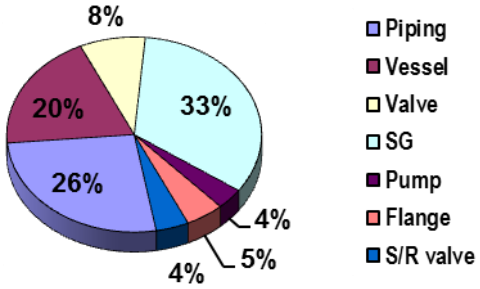


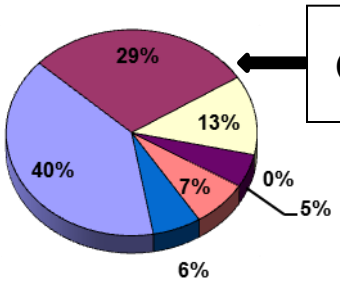
# Classification of events

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

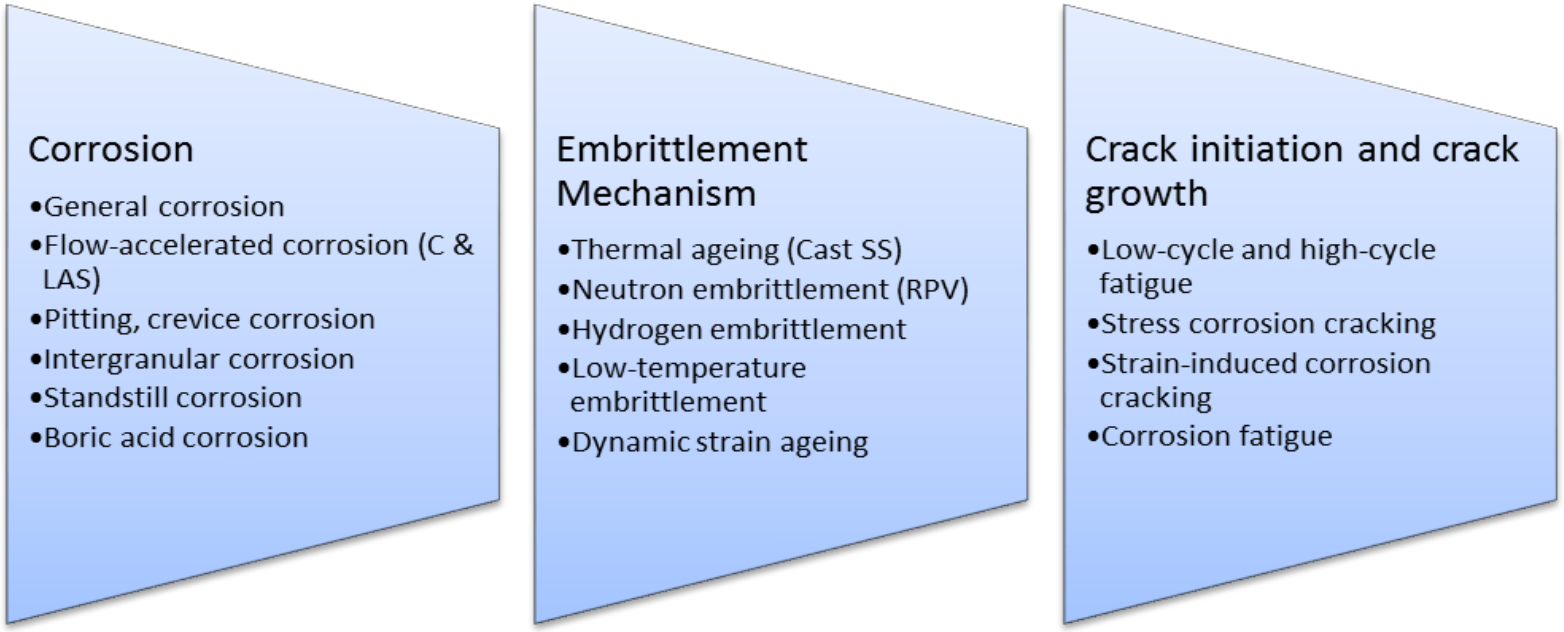



**Normalized distribution (Nº of events / Nº of units) SG excluded**

| 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



# 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.