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

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Extended Abstract

1. INTRODUCTION

Evaluation of operating experience is a powerful tool for the safety assessment of nuclear power plants (NPP) [1]. When applied to cracks and leaks related events, the analysis aims to find response to critical questions, such as:

- How relevant are the events, treated together, to their categorization (design, plant status, component, event cause, etc.)?
- What conclusions can be drawn on the safety impact and the corrective measures taken?
- What are the lessons learned for each category of event?
- What are the recommendations for the prevention of reoccurrence of such events?

2. EUROPEAN CLEARINGHOUSE

The EU Clearinghouse on NPP Operational Experience Feedback (OEF) [2] carries out on a regular basis technical work to disseminate the lessons learned from past operating experience as well as background scientific research in OEF. Additionally, the EU Clearinghouse is conducting work on exchange of OEF, as well as collaborating with international organizations. The EU Clearinghouse is managed by the JRC of the European Commission and fosters the collection of operating experience from European nuclear regulators and/or operators, assessing the potential value of lessons learned, and providing support for events relevant for the global OEF to be reported systematically and in consistent manner to the IRS system operated by NEA/IAEA.

One of the EU Clearinghouse tasks is to provide topical reports of events with similar features or causes, conducting precursor studies of events at selected European NPPs facilitating the trend analyses and enabling better understanding of the main patterns in operational experience events. This paper is based on the results of the topical study on cracks and leaks related events performed by the JRC in collaboration with IRSN and GRS for the EU Clearinghouse. Other two independent analyses conducted recently are on events involving emergency diesel generators and NPP modifications.

3. METHODOLOGY

Four different databases were used in this study. Namely, the IAEA International Reporting System database IRS, the US Licensee Events Reports database LER, the French (IRSN)

database SAPIDE and German (GRS) database KomPass. The screening period runs for 20 years, from 1991 to 2011 for IRS and LER, and from 1990 to 2010 for French and German databases. After screening, 145 IRS reports and 75 LERs were found to be applicable, to which 129 French event reports and 61 German event reports were added. The total number of events considered is 409.

To help identify generic recommendations, the events were classified into families and sub-families according to their safety significance. To evaluate the lessons learned the following approach was applied:

1. Data preparation: extraction of the relevant information from each database.
2. Categorization of the events according to previously agreed families, such as design, plant status, component, sub-component, event cause and type of detection.
3. Additional information on safety impact and corrective actions were derived for the analysis.
4. Screening of the most relevant cracks and leaks events, classified according to families.
5. Deriving lessons learned for each category of events.
6. Elaboration of recommendations for the prevention of reoccurrence of such events.

4. RESULTS

The event investigation was performed from different angles. Namely, by components (pipes, vessel, pressurizer, steam generator, valves and flanges), sub-components, degradation mechanisms, plant conditions, etc., and the study was very exhaustive. All the 409 events analysed involving cracking or leakage of reactor coolant have different root causes or sources. In more cases, the events did not have just one cause, but a combination of them. The causes of the analysed events are the following:

- Corrosion of different types for 35% of the cases.
- Manufacturing defect (e.g., ferritic pollution of stainless steel) for 15% of the cases.
- Maintenance anomaly (e.g., improperly placed seal, insufficient torque, etc.) for 11% of the cases.
- Control or operating error (e.g., manual valve in inappropriate open position or in incompletely closed position, etc.) for 9% of the cases.
- Fatigue for 11% of the cases
- Unknown or other causes in 19% of the cases.

Corrosion is the main root cause of the events analysed. In France, many corrosion induced events are due to Inconel 600 (SG tubes and vessel head penetrations). If we do not take into account these events, which are numerous, corrosion is not the main degradation mechanism. In France, corrosion is often a consequence of an external leak (boric acid).
Manufacturing defects are the second largest root cause. These events are nearly all related to welding faults, but also it could be founded cases in which the manufacturing defect was just the "apparent cause", while it's precursors were dealing with inappropriate QA measures at

the manufacturer. Fatigue is also an important degradation mechanism for the analysed events. Both thermal fatigue and mechanical fatigue were identified during the analysis. Mechanical fatigue appeared in certain cases in combination with another cause, like manufacturing or maintenance defects, especially on welds.

The event investigation showed that the crack and leak related events occurred in specific equipment, components or sensitive areas. SG tubes; SG nozzle dams and associated drain plugs required and operated during outages; reactor vessel head penetration areas; small lines for bypass, instrumentation, venting and drainage and corresponding isolation valves; RCS pumps; RCS relief valves and associated control cabinets; valve housings; all the lines, components and accessories located in such areas where they are exposed to various hazards and quality failures during outages when manual operations are required; flange joints and their seals, as well the mechanical couplings or fittings, in particular those subject to frequent operating or maintenance interventions.

5. CONCLUSIONS

Event reporting has become an increasingly important aspect of the operation and regulation of all public health and safety related industries. Diverse industries such as aeronautics, chemicals, pharmaceuticals and nuclear all depend on operating experience feedback to provide lessons learned about safety. For events involving failures in operating devices or in human and organizational performance, it is important to analyze the event, to identify its causes and draw lessons, in order to avoid the recurrence of similar events or to ensure with additional defences that their consequences remain small.

Numerous recommendations have been elaborated in the analysis of the cracks and leaks related events and are extensively documented in [3]. The analysis was performed from different perspectives. Only a summary of the methodology used and some relevant results are presented in this paper.

6. REFERENCES

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