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Investigating the recurrence of meteorological hazards

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ABSTRACT

The external hazards constitute a significant source of challenges for the safe operation of a NPP. An overview of the available operating experience is presented in this paper, in order to provide a better picture about the recurrence of meteorological hazards and their impact on the safety of nuclear installations. The IAEA International Reporting System was used as a reference database in the analysis.

The meteorological related events identified in the selected time window were analyzed in detail, and the contributions of each external hazard that have induced the meteorological related events, together with the lessons learnt are presented and discussed. The obtained results and the conclusions regarding the occurrence of extreme meteorological hazards, together with the distribution of recurrent events for EU and non-EU areas are highlighted.

1. Introduction

The nuclear power plants (NPPs) are very complex installations, having a lot of systems and components which operate all together. During the entire period of operation of the plant, is inevitable that many failures of systems or components will occur, and some of these failures are induced by external hazards. The operating experience contains records of these operating events, each of them being more or less analyzed in detail (NEA no.6159, 2006).

Each external hazard could be characterized in terms of its intensity, duration and consequences (impact induced on a specific facility). The occurrence of external hazards constitute a significant source of challenges for the safe operation of a NPP, and for this reason, to investigate the existing operational experience, targeting this kind of events, is quite important. There are many methods that can be used to analyze the operating experience, with the goal to analyze the external hazards influences on the performances of the plant (IAEA TECDOC-1278, 2002; Ziedelis and Noel, 2011). The investigations could have as objectives to determine the level of adequacy of NPP protection against the external hazards and the effectiveness of corrective actions, as well as to provide recommendations on how to prevent or mitigate the impact of external phenomena on NPP operation. Significant challenges are present in every step of the operating experience feedback, starting from events reporting, until the interpretation and understanding (Ramanujam and Goodman, 2011; Stoop and Dekker, 2012; Vinnem, 2013).

A good investigation methodology, used professionally by skilled and trained persons, will provide as results important quality insights, useful to be used for improving the operating performance of NPP.

Many of the occurred external hazards do not have, only by themselves, the power to induce significant consequences on the safety operation of NPPs, but if no appropriate measures are taken to correct the causes that have initiated these perturbing events, the possibility of re-occurring remains. At the next occurrence, the external hazard could occur in combination with other failures or in combination with human errors, and together they might lead to severe perturbations in the plant operation or even to an accident.

The results of analysis of operating experience are helpful in the effort of developing lessons learnt and recommendations for safety improvements. The implementation of these recommendations is useful for avoiding the recurrence of events induced by external hazards also (Pyy and Ross, 2004).

2. International initiatives on operating experience investigation

There is a strong relation between performing an efficient investigation of the operating events and obtaining a high operating performance of a NPP, at all levels. All nuclear organizations have a long history in examining the significant events from operating experience, with the goal to find and deepen the lessons learnt, in the attempt to maintain and continuously improve the

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availability and safety of the nuclear installations (Jacobsson et al., 2011; NEA Working Group on Operating Experience [WGOE], 2011). A careful investigation of the selected operating events will provide valuable insights into failure causes (Viveros et al., 2014) and system behavior (Reventós et al., 2010). An efficient program dedicated to operating experience may be a key factor in implementing and maintaining a robust and reliable defense-in-depth of NPPs. Having the aim to accomplish a desired defense-in-depth level, each NPP has to implement a program for collecting and analyzing the operating experience, in order to maintain and improve the capability to take the appropriate measures in order to reduce the risk of occurrence of similar events (IAEA TECDOC-1653, 2010).

There is a continuous effort at many levels (national and international) to collect and to analyze the operating experience (IAEA TECDOC-1581, 2007; Noël, 2010). A lot of information about external hazards events, including lessons learned and the appropriate corrective actions taken, can be found in the operational experience databases of international organizations (IAEA, suppliers owners groups, WANO, INPO, etc.).

2.1. IAEA IRS

The International Reporting System for Operating Experience (IRS) is operated jointly by IAEA and OECD/NEA. IRS is a worldwide system containing over 4000 incident reports, with a recording rate of approximately 80 events per year (International Reporting System (IRS) website, 2014).

The events are reported on a voluntary basis, with reporting criteria varying from country to country (IAEAINSAG-23, 2008). Still, as a general rule, in the following situations, the event should be reported and registered to IRS:

- when the event is important from safety point of view, and induces a significant reduction of plant defense in depth;
- when the event reveals important lessons learnt that once implemented could help the international nuclear community to prevent its recurrence as a significant event, in terms of safety, in more severe conditions or to avoid the occurrence of a critical event;
- when the event is similar with another event, previously reported, and highlights important new lessons learnt for safety.

The information about events is available in a web-friendly network, with a full-text database and powerful search engine that allows a complete search (IAEA Safety Standards Series NS-G-2.11, 2006). The system capacity for data entry and storage has been continuously increased. IRS system has become a very useful and efficient tool in the effort to improve the nuclear safety, thanks also to the user-friendly access to written, numerical and graphical information, and to the reporting and analysis capabilities (Zhang et al., 2011).

2.2. EU clearinghouse project

Since most of the European countries have only one or few operational NPPs and correspondingly a moderate nuclear program, their national authorities have only a limited capacity to collect and to evaluate the international operating experience. In order to help gaining the access to larger information regarding the operating experience, the European Commission has set up the European Clearinghouse project (European Operating Experience Feedback System - OEF system) in 2008 (EU Clearinghouse project website, 2014).

The EU Clearinghouse project is a joint effort of the EU countries with operating NPPs (Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, Lithuania, Romania, the Netherlands, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom). The project is dedicated to improve the nuclear safety of NPPs by supporting an effective and efficient use of the operating experience feedback. The initiative was organized as a network, gathering together EU safety authorities and TSO, and is operated by a centralized office located at the Joint Research Centre Institute for Energy (Petten, the Netherlands).

The EU Clearinghouse project has the role to centrally evaluate and subsequently communicate data relating to operating experience to all its members (a quarterly report containing a selection of relevant events and accidents that have occurred in NPPs around the world is issued by the Clearinghouse members).

The project activities cover the following topics (EU Clearinghouse project website, 2014):

- external events (natural and man-induced);
- reactivity management;
- events related to maintenance;
- fuel failure events;
- events related to plant modifications;
- components ageing;
- events related to construction and commissioning of new NPP;
- events related to NPP decommissioning;
- supply of NPP components.

Numerous topical reports have been prepared by the Clearinghouse project members (Zerger and Noel, 2011; Bruynooghe and Noel, 2010; Duchac and Noel, 2011; Ramos et al., 2010; Vuorio et al., 2011).

In addition to highlighting important insights gained from the analyzed events, the topical reports contain information on the actions taken by different countries participating in the project, as response to an external hazard occurrence. Some insights from evaluations of the events reported in the IRS database that are similar to or have commonalities with the events subject of the topical reports are presented also.

2.3. FP7 ASAMPSA_E project

The Advanced Safety Assessment Methodologies: extended PSA (ASAMPSA_E) project aims to examine in detail how efficient is the probabilistic safety assessment (PSA) methodology in identifying any major risk induced by the interaction between a NPP and its environment, and to derive some technical recommendations for PSA developers and users (ASAMPSA_E, 2014).

Launched after the Fukushima accident, the ASAMPSA_E project pays attention to the risks induced by possible natural extreme external events and their combinations.

The project gathers experts from 28 organizations (19 European countries) and is open for collaboration with organizations that have responsibilities in the development and application of PSA. US-NRC, TEPCO and Japan Nuclear Safety Institute (JANSI) have joined the project.

The project will be developed in three phases: in the first phase important topics were identified; the second phase is dedicated to the development of recommendations and guides, and the last phase will be focused on the development of conclusions and validation of the results obtained in the frame of the project.

The project includes activities on: (ASAMPSA_E, 2014).

- characterization of hazards (internal, external) and their dependencies for PSA studies;
- hazard implementation in level 1 PSA;