Use of PSA for the Analysis of Operational Events in Nuclear Power Plants

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Abstract:
An operational event is a safety-relevant incident that occurred in an industrial installation like a nuclear power plant (NPP). The probabilistic approach to event analysis focuses on the potential consequences of an operational event. Within its scope of application, it provides a quantitative assessment of the risk significance of this event (and similar events): it calculates the risk increase induced by the event. Such analyses may result in a more objective and a more accurate event severity measure than those provided by commonly used qualitative methods. Probabilistic event analysis complements the traditional event analysis approaches that are oriented towards the understanding of the (root) causes of an event.
In practice, risk-based precursor analysis consists of the mapping of an operational event on a risk model of the installation, such as a probabilistic safety analysis (PSA) model. Precursor analyses result in an objective risk ranking of safety-significant events, called accident precursors. An unexpectedly high (or low) risk increase value is in itself already an important finding. This assessment also yields a lot of information on the structure of the risk, since the underlying dominant factors can easily be determined. Relevant "what if" studies on similar events and conditions can be identified and performed (which is generally not considered in conventional event analysis), with the potential to yield even broader findings.
The findings of such a structured assessment can be used for other purposes than merely risk ranking. The operational experience feedback process can be improved by helping to identify design measures and operational practices in order to prevent re-occurrence or in order to mitigate future consequences, and even to evaluate their expected effectiveness, contributing to the validation and prioritisation of corrective measures. Confirmed and re-occurring precursors with correlated characteristics may point out opportunities for safety improvements that might otherwise have remained unaddressed. Precursor program results can be included in performance indicators, or can be used for the statistical monitoring and trending of the risk level in plants, sites or entire industries. Last but not least, precursor analysis results can be used to communicate in a more objective way on the safety significance of events, e.g. between regulators and utilities.
The paper recapitulates on some methodological steps, and then gives an overview of the objectives and the results of the Belgian precursor program, showing some recent analysis examples. In a second part, the paper attempts to summarise the various activities worldwide in this field: it elaborates on some similarities and differences in various aspects, such as objectives, screening, analysis and modelling methodology, results, uses and achievements. It also discusses some international trends and perspectives.

1 INTRODUCTION

In the framework of the – recently completed – periodic safety reviews of the Belgian nuclear power plants, PSA studies have been performed for all plants. Initially, these plant specific PSA studies were mainly seen as design (re)evaluation tools in order to verify the soundness of the deterministic design. This (re)evaluation process has led to a number of modifications to safety equipment and operating practices.
However, many other potential PSA applications can be envisaged. This paper is focused on one of these applications: the risk-based analysis of operational events, also called risk-

based precursor analysis, or (probabilistic) precursor analysis, or PSA-based event analysis (PSAEA).

2 RISK-BASED PRECURSOR ANALYSIS

A probabilistic precursor study provides a complement to the root cause analysis approach in event analysis by focusing on how an event might have developed adversely. It implies the mapping of an operational event on a probabilistic risk model of the plant in order to obtain a quantitative assessment of the safety significance of the event.
There have been early applications of probabilistic approaches to event analysis [1] in some countries[1], some of them even dating back to the early 1980s. With the exception of the Accident Sequence Precursor (ASP) program of US-NRC – which is still operating today in an evolved form –, these were punctual efforts at that time. In order to benefit from state-of-the-art PSA features, but also to ensure repeatability of the analysis, a comprehensive set of PSAEA guidelines [2] has been developed in an international project in the mid-nineties. The first experiences of AVN with the subsequent application of this PSAEA methodology have been promising. Pilot studies have confirmed the feasibility and regulatory interest of such precursor studies [3]. In 2000, AVN started to perform a regular precursor program.

2.1 Methodology

The PSAEA guidelines define preliminary requirements for the PSA model and code, and identify input requirements such as information on plant status, event sequence chronology and causes. The guidelines then elaborate details for the following tasks: pre-analysis tasks, understanding the event, modelling the event, quantification, “what if” analysis, analysis & interpretation of results, and conclusions & reporting. This has already been described in more detail in earlier publications [4-7]. For the purpose of this paper, only the following aspects are briefly mentioned.

2.1.1 Failure Memory Approach

Special attention is devoted to the analysis of what could have happened but what did not necessarily happen during the real event sequence. Therefore, the so-called failure memory approach is applied: all known failures that occurred during an event sequence will be modelled as failed basic events, but all known successes – such as known equipment and operator action successes – will be modelled by basic events with nominal – and not perfect – behaviour.

2.1.2 Numerical Results

The probability of core damage conditional to the occurrence of the event is the main severity measure used in the procedure for PSA-based event analysis. Real – or potential – initiating events at one side, and condition events at the other side, have different characteristics and are treated differently in that the latter require the calculation of an instantaneous core damage frequency (ICDF) prior to obtaining the conditional core damage probability (CCDP).

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[1] These countries are Finland, France, Germany, Sweden and the USA. The IAEA also performed some early activities in the framework of the Incident Reporting System (IRS).

2.1.3 "What if" Analyses

This optional task provides a structured analysis of sensitivity issues of an incident. A number of "what if" analyses are proposed, among them, variations of plant operational state; unavailable equipment; common cause failures; generally poor operator performance; operator and system failures; modelling of a similar event in a different location; modelling with a missed test.

"What if" analyses are often useful to yield a more complete picture of the potential safety issues involved. In practice, not all possible sub-events and alternative conditions can easily be formulated in strict probabilistic terms: as their occurrence probability remains unquantified, they cannot be included in one overall probabilistic model to yield one global CCDP figure. If they are potentially relevant, they need therefore to be addressed as a "what if" case: an alternative case that is quantified separately.

So "what if" analyses can be used to identify and to assess credible scenarios that differ from the event sequence or from the particular conditions that prevailed in the occurred incident and which have unquantified occurrence probabilities, but which might induce a – perhaps significantly – higher CCDP. They might generate additional insights that are relevant for the definition of appropriate corrective actions.

3 PRECURSOR PROGRAM IN BELGIUM

Since 2000, AVN systematically performs PSA-based event analyses of selected operational events [5-6,8-11]. This activity is a part of the operational experience feedback process that exists within the regulatory organisation, and which supports the regulatory inspection of the licensees who are responsible for maintaining a properly working operational experience feedback process. Today, the PSAEA process has become an integrated part of the overall AVN process of follow-up of operating experience [11-12].

3.1 Objectives

The main objective of AVN's precursor program is the determination of the quantitative importance of well-selected operational events (after annual screening), and – if sufficiently significant – the identification of potential safety issues for improvement (amongst others based on relevant "what if" questions). AVN considers the identification of potential safety issues for improvement to be among the most important outcomes of the study, because they have the potential to lead to real safety improvements. Events with a CCDP greater than 1E-6 are considered to be precursors, and events with a CCDP greater than 1E-4 are considered to be important precursors.

Furthermore, the results of the precursor analyses are used in an AVN pilot project on performance indicators (PI). Important precursors are used for the PI "number of highly risk significant events", and precursors are used for the PI "number of safety significant events" (among other event categories that are defined on a deterministic basis).

In addition, the experience gained with the performance of a PSA application such as PSAEA is used to enhance the awareness of typical risk figures associated with both exceptional and more common events, and to generate relevant feedback on the PSA model itself.

3.2 PSAEA Process Steps

An annual screening is performed in order to draw up a shortlist of events to be analysed with a precursor study. This list should contain events with an anticipated CCDP of about 1E-

6 or higher. It is reviewed within AVN by PSA staff, by the plant inspection coordinator, and by operational experience feedback staff.
For each selected event, a PSA staffer establishes a full PSAEA analysis report. This analysis report is again internally reviewed by other PSA staff, by the plant inspector involved, and by operational experience feedback staff.
The final analyses and their conclusions are subsequently presented and discussed with the licensee (and its architect/engineer) by PSA staff of AVN, and in presence of the plant inspector involved. If necessary, a new emphasis is put on particular follow-up actions that were already decided, or additional follow-up actions are defined.

3.3 PSAEA Studies Performed To Date

In Belgium, there are seven pressurised water reactors (PWR) on two sites. Typically, the PSAEA screening process selects about 4 events per year for further precursor analysis, which is about 5% of all new reported events in AVN's incident database. Since the start of the systematic precursor program, a total of 29 detailed PSAEA analyses have been performed, including 13 initiating events and 14 condition events. For three events, it has not been possible to calculate a base case CCDP value (although a “what if” analysis has been quantified for one of those events – event 7).
Table 1 lists the most important events in decreasing order of CCDP. Event numbers 1 to 6 are important precursors.

Table 1. Description of the Most Important Events (Analysed in 2000-2006).

Event Nr	Short Description
1	Trip of all RW pumps inducing a short but total loss of cooling of service water
2	Long-lasting unavailability of the cooling of the mechanical seal packing of the HPSI pumps by the raw water system
3	Potential total loss of service water during midloop operation
4	Long-lasting presence of rags in the recirculation duct of one safety injection train
5	Long-lasting potential internal flooding of AFWS equipment
6	Wiring error compromising operability of normal power supply to 3 safety trains
7	Excessive torque on various external and internal screw bolts of check valves in several systems, detected before start-up (what-if undetected before start-up of the plant)
8	Long-lasting presence of foreign objects in the primary circuit, affecting 1 out of 3 LPSI hot leg injection paths
9	Incipient reactor trip and unavailability of water supply to auxiliary feedwater tank due to inoperability of all main feedwater pumps
10	Inadvertent level drop of primary coolant during midloop operation, requiring safety injection
11	Air binding of a RHRS pump during intervention at midloop conditions

The following sections summarise some of the more important events that have been analysed in the last three years (which are respectively event numbers 2, 3, 4, 8, 12 and 17 in Figure 1 and in Table 1).

3.3.1 Unavailability of the Cooling of the Mechanical Seal Packing of the HPSI Pumps by the Raw Water System

While measuring the flow in the raw water system feed line to the heat exchangers that ensure the cooling of the mechanical seal packing of the HPSI pumps in recirculation mode,

flow rates ten times smaller than the design flow rate and 2 times smaller than the minimal required flow rate have been detected. Investigations lead to the conclusion that the circuit is partially clogged both upstream and downstream of the heat exchangers.
In the aftermath of this event, it was in addition discovered that – since first plant operation – the isolation valves of the heat exchangers for cooling the mechanical seal packing of the HPSI pumps would close on the reset of the safety injection signal (while they should remain open). As a result, the mechanical seal packing of the HPSI pumps would not be cooled in recirculation mode. This would lead to the loss of the HPSI pumps during recirculation phase in the very short term. Moreover, there is no position indication of these isolation valves in the control room. Hence, no operator recovery is credited. The modelling of this design error in fact envelops also the clogging condition mentioned above.
The resulting CCDP for this long lasting condition event over 19 years amounts to 8E-4. The event is to be considered as an important precursor.

3.3.2 Potential Total Loss of Service Water during Midloop Operation

At the beginning of a refuelling outage, a long test is performed on the movement and leak tightness of check valves on the service water system. The test involves the intentional pressurisation of isolated parts of the service water system. Errors in test procedure and execution lead to overpressurisation and to water spills through safety valves and through heat exchanger leaks at two primary pumps.
The event is a potential initiating event “total loss of service water” during midloop operation. Its occurrence probability has been quantified by assuming the occurrence – during the test – of a significant leak in the common part of the service water system inside the reactor building. The significant leak is either compensatable or not compensatable by make-up. The compensation of the leak, as well as the isolation of the leak, require operator diagnosis and operator action.
The resulting CCDP amounts to about 1E-4 (important precursor). Although the uncertainties associated with the quantification of human factors are traditionally quite high, the obtained numerical results are not very sensitive to individual changes in the specific quantification proposed in this study. However, the most dominant human reliability parameter in this simple model is the human failure of diagnosis in the case of a compensatable leak.

3.3.3 Presence of Rags in the Recirculation Duct behind the Recirculation Filters of 1 / 3 Safety Injection Trains

The main risk involved is the decreased reliability of the affected recirculation train. Over the 19 years of plant operation, this long lasting condition event yields a base case CCDP of about 1E-4 and is an important precursor. Even the existence of this condition during only one year is still a precursor.
In the PSAEA study, this event has also been transposed on a plant of a previous generation. This has led to some considerations on the interpretation of CDF and CCDP for condition events. A comparison of the CCDP for the same condition event transposed on different plants is not always straightforward. In terms of CCDP (which is a relative measure based on risk increase), some kinds of condition events might generate higher values for better protected plants because they have the potential to lose more safety margin. Therefore, CDF remains useful as an absolute measure of plant performance (either under normal conditions or in an event case). For a detailed comparison between plants, it is moreover important that the reference PSAs of both plants have a similar modelling cut off.

3.3.4 Presence of Foreign Objects in the Primary Circuit Affecting 1 / 3 LPSI Hot Leg Injection Paths

The event is considered as a condition event that lasted at least for two fuel cycles of 18 months. On the one hand, it affects LPSI isolation organs protecting against an intersystem LOCA (IS-LOCA) outside the containment, and on the other hand it affects the LPSI train 1 injection path into hot leg 1 (during a potential mission of the LPSI system).
Assuming the absence of a potential common cause failure (CCF) between the various isolation organs protecting against IS-LOCA as well as the absence of a potential CCF between the check valves on the three LPSI hot leg injection paths, this event is to be considered as an important precursor (CCDP only just below 1E-4). The dominant contribution is due to the risk for an IS-LOCA outside containment.
In the assumption of a potential CCF, the resulting CCDP could be as high as in the order of 1E-3 in either of these cases. However, there was no evidence to support such a hypothesis.

3.3.5 Trip of the Turbine-Driven AFW Pump Due to Overspeed

The turbine-driven auxiliary feedwater pump is tested every 3 months, but without feedwater actually being injected into the steam generators. During the last real secondary-side transients of the plant, however, it tripped due to overspeed. The identification of the cause of the anomaly eventually pointed out that it could be considered unavailable since the last intervention on this pump during the outage; i.e. for a total period of 11 months.
The event implies a condition event during 11 months, as well as two initiating events (loss of normal feedwater) during which the turbine-driven auxiliary feedwater pump failed to run.
The CCDP of this event amounts to about 1E-5. The event is a precursor.

3.3.6 Adjustment Errors in Protection Relays of Safety Grade Electrical Boards

During a periodic test of an emergency diesel sequence, the (standby) pump of the chemical and volumetric control system (CV) did not start after takeover by the diesel generator. This was caused by support equipment not being fed by its safety grade 380V electrical board. The board is part of a first batch that has been replaced during the previous refuelling outage. Protection relays, located between the board and some of its consumer equipment, had an overvoltage detection setpoint that was systematically adjusted too low, and caused automatic load shedding in the early phase of takeover by the diesel generators. There are no possible operator recovery actions in this event. Three 380V boards in the first replacement batch are affected; the other batches are not yet installed. Several dependencies of individual safety equipment in different trains are affected (cooling and lubrication of equipment in CV, AFW, SI, containment spray, second level protection diesel generators). A subsequent design review of the 380V board replacement campaign revealed additional faults in setpoints of overcurrent protection relays (without major impact).
During the time the plant spent in intermediate shutdown and in power operation, the condition event induced a CCDP of about 4E-6. This event is a precursor. What-if cases are considered regarding the time of discovery of the anomaly, the definition and the sequence of the replacement batches, some plant configuration alternatives, and air-cooled motor pump failure rates in case of loss of room ventilation.

3.4 Results of the Precursor Program

A compilation of the results of the PSAEA analyses to date is provided in Figure 1.

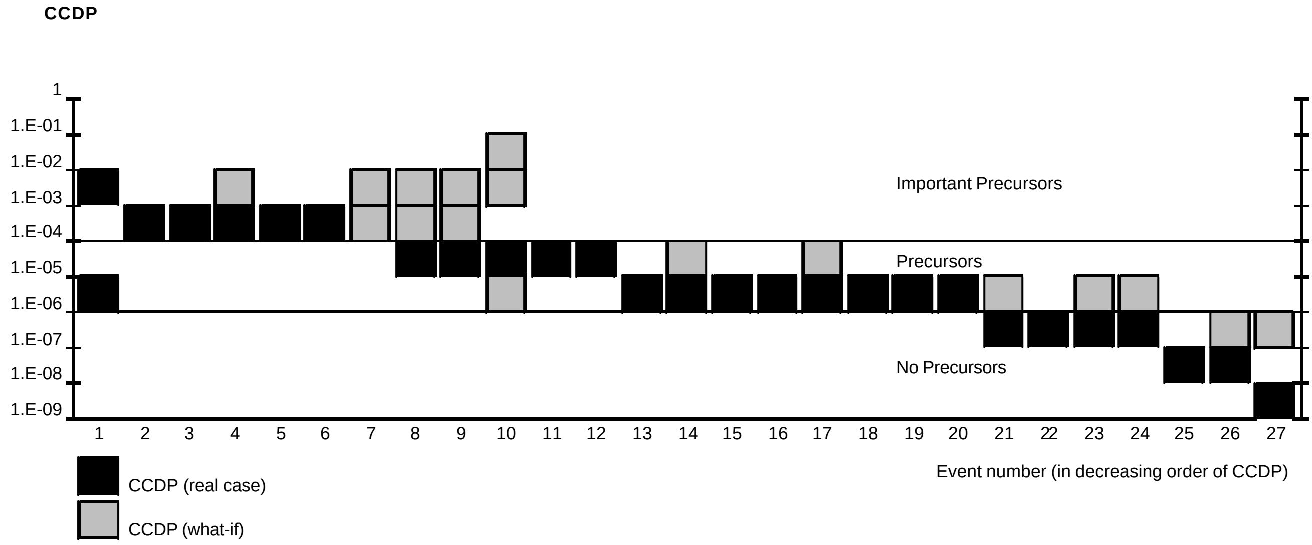

Figure 1: Overview of PSAEA Results (Analysed in 2000-2006).

Several general observations can be made in view of all these analyses. The important precursors are found to be either related to initiating events affecting an entire safety system, or to long lasting condition events. Globally, there is no clear prevalence of initiating events over condition events, or vice versa. Also, quite some event analyses involve at the same time the modelling and quantification of (real or potential) initiating events and condition events. A few condition events require the modelling of several event phases. In order to obtain realistic results, it is often important to adequately model very particular potential operator recovery actions in the course of the event – which are seldom readily provided by the reference PSA model.
In some cases, PSAEA produces a different perception of the risk significance of the event. This can be caused by a particularly high (or low) CCDP value of the occurred event, or also by a high CCDP value induced by some "what if" analysis cases. As an example, one can mention the high risk significance of some events that occur during midloop operation (cold shutdown for intervention), and in particular – according to a former practice – if steam generator nozzle dams would have been installed (event number 10, "what if").

4 INTERNATIONAL MEETINGS ON PRECURSOR ANALYSIS

In order to ensure a close contact with other experiences and developments in this field, and initially also to confront its PSAEA analysis approach with those of other practitioners, AVN has taken the initiative to organise an annual technical meeting on probabilistic precursor analysis in the nuclear industry.
Since 1998, nine international meetings have welcomed representatives from regulators, industry and research institutes from in total 17 countries[2] and from the IAEA. The meeting reports are widely distributed, for instance to the Working Group Risk of OECD/NEA/CSNI. In 2001, AVN has also hosted an OECD/NEA/CSNI workshop on precursor analysis [4,8].
In the following sections, an attempt[3] is made to reflect some import observations that are mainly based on the experiences gained at this forum.

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[2] Organisations from the following countries have participated (not necessarily to all meetings): Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Japan, Korea, the Netherlands, Slovenia, South Africa, Spain, Sweden, Switzerland, UK, USA.
[3] The statements and views developed in this paper are an interpretation of the author, performed to the best of his knowledge and on the basis of his experience in this field. They have however not been submitted for formal approval to any of the other organisations cited in this paper. Hence, any mistake or mispresentation in this paper is solely to be attributed to the author.

4.1 Objectives and Intended Use

Considering the existing precursor programs, one can observe quite different objectives that have been set out. There are precursor programs of very different amplitude.
Some precursor programs, like the ASP program of NRC/RES in the USA, are primarily used for the monitoring of the safety level of licensees and the entire industry. They require a large but stable screening program, as well as a stable analysis approach. Moreover, a probabilistic assessment of some inspection findings – including condition events – is also performed by NRC/NRR in the framework of the Significance Determination Process (SDP).
Other precursor programs are primarily intended to support the operational feedback process, e.g. to help generate (and validate) corrective actions such as engineering improvements. Large such programs are for instance run by EdF and IRSN in France (usually with a lot of attention for potentially generic issues). Smaller programs are for instance performed by AVN in Belgium and by CSN in Spain. Without a specific objective to monitor and to trend safety levels in a statistically significant way, the completeness of the screening process and the resulting analysis efforts becomes less important.
In the general case, a precursor program is run by the regulatory organisations rather than by the licensees, but there are exceptions. Interesting to be mentioned is the unique situation in France where the licensee performs a full precursor program and where the regulator's technical support organisation (TSO) independently performs its own screening and analysis (which is also based on its own PSA models). Regular meetings are held to compare results.

4.2 Screening

In fact, the PSAEA guidelines [2] did not address the process of selecting the events to be analysed, but were exclusively focused on an in-depth analysis of any event that was selected for whatever reason. However, it is almost never feasible to quantitatively analyse every single operational event. Therefore, a screening process is installed that is expected to yield the "interesting" events to be analysed in detail. This is typically any event with the potential to have a CCDP value that is greater than a given threshold value (which is often 1E-6, or sometimes lower), but this could for instance also include events showing aspects not previously analysed (first of a kind).
Different precursor program objectives will entail different screening practices, e.g. as to completeness in view of a statistical trending of industry performance.
In general, the screening is performed using a set of more or less formalised screening rules that end up in identifying event families to be selected, such as events that involved the call for an accident procedure, a safety system actuation, the occurrence of a CCF on a safety system, a long lasting condition affecting safety system components, a violation of AOT of a certain extent, etc. One can also use negative screening rules, like the elimination of events that are beyond the scope of the available PSA model, or represent only limited individual breaches of technical specifications, or are occurrences of class 1 and class 2 initiators without additional complications, etc. Yet the screening process very often also allows for selection on basis of engineering judgement. It is remarkable that a large portion of selected events is indeed found to be selected on basis of engineering judgement, and that these events often account for important or non-negligible CCDP values.
The experience shows that practitioners can be quite confident with their current screening practices, provided that a stable screening team and an adequate internal review is ensured.

4.3 Analysis Methodology

Over the years, the use of precursor analysis has become widespread. The results of precursor analysis are now generally acknowledged to have its merits. As it is the case for all

other techniques, it has of course also its limitations. In particular, the probabilistic analysis of events inherits some – not all[4] – of the limitations of the underlying PSA models. An adequate documentation of these results, as they are to be understood in view of the particular limitations involved, can be considered to be an important part of the precursor analysis itself.
Since the PSAEA guidelines [2] have been drawn up in 1998, the underlying methodological approach for all procedural steps to be performed for a precursor analysis has been put to practice many times (e.g. by CSN and AVN). Of course, other practitioners of precursor studies may apply other approaches, whether they are formalised to some degree or not. The growing experience with all kinds of precursor studies, and the regular exchange of findings and ideas at this forum, has enhanced the development of quite some punctual technical improvements towards better practices, and has also resulted in a broader view on some of the issues. It has however not been an objective of this group to further develop and maintain formal technical documents on state-of-the-art precursor analysis, although a few organisations dispose of in-house methodology documents and/or are working on the development and improvement of such documents (e.g. EdF and US-NRC). Anyway, as mentioned before, the objectives that are put forward in any particular precursor program have a strong influence on the approach to (and the focus of) many technical issues. Consequently, there is generally spoken simply not just one “best practice” in the field.
It can be acknowledged that a lot of learning continues to take place by presenting and discussing case studies at this forum. Moreover, several methodological issues have received a particular focus, e.g. during dedicated discussion sessions. For example, one can mention the screening approach, the modelling of operator recovery actions, the modelling of standby equipment found in a failed state, human reliability analysis aspects, “what if” analysis (cf. 2.1.3), the modelling of potential CCFs and the event specific quantification of such CCFs.
There is also an issue in either trying to integrate all aspects of an event explicitly in probabilistic terms (e.g. considering a weighted average of relevant plant configurations), or, alternatively, to model as closely as possible the event as occurred (e.g. only considering the actual plant configuration during the event, and not considering “what if” cases at all). A separate quantification of “what if” cases can be situated in between these two approaches.
Furthermore, discussions at this forum included the comparison exercise of accident precursor analysis approaches that was conducted by IRSN, NUPEC and GRS. Also the updates on the pursued conciliation of off-line in-depth analysis at one hand, and faster on-line analysis at the other hand (ASP and SDP programs of NRC), equally receive a lot of interest. Finally, links have also been made with more general topics, like the – centralised versus on-site – use of PSA by utilities and related tools (EdF), and like precursor analysis as it could be considered in a generalised concept of safety margin (CSN).

4.4 Achievements

The achievements of precursor analysis in assessing and ranking the quantitative safety importance of events are abundantly clear. This structured assessment is based on a detailed, plant-specific risk model of the plant. It includes by definition the potential

[4] It is not always possible to map all the relevant aspects of the event straight away on the reference PSA model. Indeed, the PSA does not contain an explicit model for all plant equipment, for every specific and maybe exceptional plant configuration, or for every potential human error. Hence, the PSA might exhibit at some point a modelling cut-off or a specific working hypothesis, which causes the aspect of interest to be outside the model.
In many of these cases, however, a limited modification of the PSA model is sufficient to address the issue of interest, or a small bounding study is sufficiently accurate to characterise the issue, and a CCDP figure can still be established – albeit sometimes with a greater degree of uncertainty. In some other cases, the PSAEA can contribute relevant considerations on at least partial aspects of the issue.

consequences of the event, and – in case of “what if” studies – also of relevant scenario’s that are similar to the event as it occurred (which are generally not considered in conventional event analysis because they never actually took place). Furthermore, an unexpectedly high (or low) CCDP value is in itself already an important finding. These aspects present a clear added value that is complementary to the findings of conventional approaches to event analysis, such as deterministic root cause analysis.

Moreover, a precursor analysis not only provides for a total CCDP figure, but also yields information on the structure of the risk: the underlying dominant factors can easily be determined, for instance in terms of initiators, equipment failure modes, operator actions, plant operational states, or particular plant configurations. These findings can be used for different purposes. The operational feedback process can be improved by helping to identify design measures and operational practices in order to prevent re-occurrence or in order to mitigate future consequences, and even to evaluate their expected effectiveness, contributing to the validation and prioritisation of corrective measures. Confirmed and re-occurring precursors with correlated characteristics may point out opportunities for safety improvements that might otherwise have remained unaddressed. Their occurrence can also point out apparently important issues that might have been underestimated in the reference PSA models, e.g. regarding occurrence frequency.

Precursor program results can be included in performance indicators, or can be used for the statistical monitoring and trending of the risk level in plants, sites or entire industries.

Last but not least, precursor analysis results can be used to communicate in a more objective way on the safety significance of events, e.g. between regulators and utilities.

4.5 Trends and Perspectives

The close network of many PSAEA practitioners and the better understanding of many methodological issues has certainly enhanced some harmonisation, but differences remain. However, such differences may also have their origins in the adherence to different objectives to be pursued, or by different limitations in quality and scope of the underlying PSA models. In practice, there may also exist differences due to limitations of the time and resources available to perform the analysis. Further developments in technical approaches and a further improvement of analysis consistency can still be expected, but – as it is so often the case – without necessarily leading to one single standardised approach to precursor analysis.

Given the common acceptance of precursor analysis as it is achieved today, it may be worthwhile to revisit the role of the various stakeholders in the processes involved. Whereas in many countries precursor analyses are still performed by regulatory organisations or their TSOs, there are arguments to have these analyses rather performed by the licensees and reviewed by the regulator. This would indeed bring the PSAEA process more in line with the established process of experience feedback.

The interactions between practitioners of deterministic and of probabilistic event analysis, however, are in general less developed. An OECD precursor workshop in 2001 [4,8] has made an attempt to bring these two communities together. Although there are of course close contacts between the practitioners of both approaches in at least some countries, one has for instance not yet seen the consolidation of precursor analysis within documents on the process of operational feedback. Incident reporting systems don’t yet explicitly provide or invite for the possibility to include PSAEA results as a measure of event importance. In this context, it is also worthwhile to mention the Finnish initiative to risk-inform the conventional INES[5] ratings for events in Finnish plants. Indeed, the absence of a clear correlation between the INES ratings of events (at least for INES ratings 1, 0 and out-of-scale) and the corresponding CCDP has already been observed many times.

[5] International Nuclear Event Scale.

5 CONCLUSIONS

In Belgium, a precursor program is routinely performed since 2000. This activity is a part of the operational experience feedback process within AVN to support the regulatory inspection of the licensees who are responsible for maintaining a properly working operational experience feedback process. Today, the PSAEA process has become an integrated part of the overall AVN process of follow-up of operating experience.
The interaction with a wide audience of other practitioners and stakeholders in international meetings has not only advanced the understanding of many technical issues, but it has also contributed to the evolution of a broader view on the process itself of precursor analysis. There is a confirmed interest in the continuation of this international forum.

6 ACKNOWLEDGMENTS

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