Experience with Severe Accident Management Review Missions at Nuclear Power Plants

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ABSTRACT

Many nuclear power plants (NPPs) today have Severe Accident Management Guidelines (SAMG) in place to mitigate severe accidents, in the unlikely case such an accident occurs. As such, these plants have increased their level of safety considerably. Yet, it appears that there is a wide scatter in the level of implementation and in the extent and quality of the implementation. NSC Netherlands has executed a number of reviews at NPPs, both in such review missions by the IAEA and on a bilateral basis. NSC Netherlands has also reviewed generic SAMG programs, including those by the PWR Owners Group and the BWR Owners Group and the SAMG program in Sweden. Although many positive experiences could be gathered, also a number of weak points have been found. Some plants even had quite a weak implementation, as many basic features of SAMG program were lacking. Also some generic programs were found to have weak spots, notably from the human engineering point of view. The conclusion is that in-depth external peer review of both generic and plant specific SAMG programs are essential to arrive at a credible risk-reducing set of SAMG.

1. INTRODUCTION

The International Atomic Energy Agency (IAEA) has developed a number of Safety Standards in the area of Severe Accident Management. These include a document on implementation of such programs, (1), a Safety Guide on Severe Accident Management SAMG, (2), and a document on the review of severe accident management program, (3). The IAEA has set up a SAMG review service to execute such review, known as the RAMP service (Review of Accident Management Program). NSC Netherlands has created a similar service, which includes, in addition, a review of generic programs, review or exercises and of regulatory requirements and standards in the area of SAMG. Experts from NSC Netherlands have taken part in various IAEA RAMP missions. Plants reviewed include GE Hitachi BWRs, Westinghouse PWRs, AECL PHWRs, and a Russian RBMK. The reviews have been executed mainly on the basis of (3), including the draft-revision of this document.

2. RESULTS OF SAMG REVIEWS

2.1 Plant-specific reviews.

Most plants reviewed used a generic product, which then has been transformed into a plant specific program. Hence, the review focussed on the proper implementation of this adapted SAMG product. The missions included study of advance material and interviews and study of materials on site. They included usually 3-4 experts and lasted usually about one week. Elements considered are e.g. (from (3)):

- Compliance of the overall Accident Management Program (AMP) approach with the national requirements;
- Quality and extent of the accident analysis to support the AMP in all levels;
- Technical correctness of accident management actions, in accordance with up-to date knowledge, proper management of uncertainties at all levels;
- Consistency of the accident management procedures and guidelines with other operating procedures;
- Level of verification and validation of the procedures and guidelines;
- Compliance of the responsibilities of the accident management staff with the plant emergency arrangements;

- Consistency of the interface between preventive and mitigative actions and procedures, including the entry and exit criteria; and
- Performance of the equipment and instrumentation during the severe accident conditions.

After the mission, the major findings were documented and directly communicated to the licensee (mostly). A full report was written later and sent to the licensee for comment on technical correctness. In a number of cases it was found that many elements of SVS-9 had been implemented correctly. Yet, also important non-conformances have been found, examples which are, in arbitrary sequence:

- lack of understanding of the generic product (i.e. EOP, SAMG) and absence of appropriate training by the vendor of the generic product;
- use of a generic product without proper transition to the actual plant or group of plants;
- incomplete or inadequate technical basis for the plant-specific procedures / guidelines;
- improper or undefined transition from the EOP- to the SAMG-domain;
- incomplete list of available resources and line-ups for water and/or power;
- use of equipment that has not been reviewed for use in severe accident environmental conditions;
- *not considering the impact of the severe accident environmental conditions on the instruments which are needed for SAMG execution* - extremely serious finding!
- use of rooms for the Technical Support Centre (TSC) and the Emergency Response Organisation (ERO) that had no protection against radioactive releases from the plant;
- use of laptops in the TSC without any provision for recharging the batteries, even in an SBO-initiated scenario (SBO = Station Black -Out);
- a very limited number of accident scenarios as the basis for the development of the accident management program;
- lack of clear command and control and, where these have been lost initially, lack of a system to restore command and control;
- lack of description of functions in the ERO and the associated responsibilities and lack of training for the ERO functions where these had been defined;
- focus on tasks which are not the responsibility of the TSC and neglecting tasks which are the responsibility of the TSC;
- lack of training for long-duration of the accident, including lack of training for shift transfer during the accident;
- lack of training to respond to sudden complications and deviations from pre-analysed paths;
- lack of indication / understanding of time windows in which the countermeasures must be initiated and completed;
- lack of understanding where the accident management will lead to (insufficient analysis of consequences of actions);
- lack of integration between various sets of procedures;
- lack of a proper verification and validation program.

It should be noted that a number of these shortcomings were either the consequence of incomplete or even absent nuclear safety regulation in the area of SAMG.

It also appeared in discussions with the licensee(s) and their regulators, that the regulator had limited understanding of SAMG and, hence, missed adequate tools to interact with the licensee(s) program. In a number of such cases, the review was preceded by a course to the regulator about the main elements of SAMG, in order to facilitate discussions and assessments.

2.2 Generic SAMG reviews

NSC Netherlands had been approached by a member of the PWR Owners Group (PWROG) as well as by the chair of BWR Owners Group (BWROG) to review their generic SAMG programs, which was done with the IAEA NS-G-2.15 as a basis, (4), (5). In addition, a re-

view was made of the Swedish SAMG program, (6), and comments and suggestions have been presented to the Canadian Owners Group, (COG), (7), based on observations to one of the PHWR plants (8).Major findings here were:

1. *The PWROG SAMG* showed overall good compliance with the IAEA Safety Guide and has added value over the preceding Westinghouse Owners Group (WOG) SAMG. Yet, worthwhile to consider is:

- There is too much focus on plant parameters for execution of SAMG, where the TSC should primarily be concerned and follow the underlying threats to the fission product boundaries (FPBs); this will notably be valuable if the accident evolution deviates from anticipated paths and deviating/improvised measures must be found and executed.
- There is an intermix between protection of fission product boundaries (FPBs) and reactor coolant system (RCS) injection. However, these two should follow different paths, in the sense that repair or replacement work on RCS injection/cooling goes on uninterruptedly, while simultaneously the TSC does all it can do to protect the FPBs. This has been more extensively discussed in (4).
- A too limited use of the concept of Plant Damage Descriptors, as has been extensively described in the well-known EPRI Technical Basis Report, (9). This concept is of great value if negative consequences of proposed actions must be found, which is a part of the plant-specific implementation.

A valuable item is that the PWROG also has developed an adaptation for use at European NPPs, (10), which have a number of additional hardware features to mitigate severe accidents, such as Passive Autocatalytic Recombiners (PARs) for hydrogen mitigation, as well as filtered containment vents (FCV).

Another valuable item is the use of the advanced system of Technical Support Guidelines, derived from the equivalent approach in the BWROG SAMG.

2. *The BWROG SAMG* shows less compliance with the IAEA Safety Guide. Although it contains high-level technical considerations, it does not focus on the protection of the FPBs as it is described in the Safety Guide - such protection is only included in a larger set of guidelines. It results in a large series of actions which the operator is supposed to take concurrently, which easily may be beyond his capabilities. Notably where these actions include a consideration of uncertainty of the measurements involved, and include difficult questions such as whether the RPV has failed or whether it can be concluded that the RPV will not fail. In order to not only deliver critics, NSC Netherlands has developed, together with Mr. Bob Lutz (former prime Westinghouse SAMG developer, now consultant) a different logic diagram, more focused on the integrity of the FPBs, somewhat similar to the Diagnostic Process Guideline (DPG) of the PWROG SAMG, (5).

In a number of cases actions on the RPV are recommended, even where this may lead to site releases in excess of applicable release limits. Such actions confirm the focus on the RPV cooling, rather than protecting the FPBs and preventing releases.

Some of the questions in the BWROG SAMG may be difficult or even impossible to answer, such as whether the RPV may remain intact or will fail - hence, it should be recommended to develop also guidance for these cases, i.e. guidelines which are independent from such recognition.

Both approaches assume inherently that much equipment in a severe accidents is still available, and do not specify the time frames in which the actions must be taken, including eventually the hooking-on and use of portable equipment.

Neither approach gives any guidance what to do if the SAMG actions fail and the TSC and plant operators must find alternate ways to mitigate the accident. This is remarkable as both approaches refer to their methods as guidance, i,e. deviations may need to be considered.

For both Owners Group approaches it was found that little - if any - use had been made of the large severe accident research work going on in the European Union (EU), notably the work carried out in the SARNET Network of Excellence (11).

3. *The COG* has committed to review the findings reported in the Point Lepreau review (8), including the technology transfer used for its SAMG, (7).

3. CONCLUSIONS

A number of reviews have been carried out on the SAMG programs of existing NPPs as well as on some generic programs, on the basis of the IAEA Safety Guide on Severe Accident Management, NS-G-2.15, and the associated guideline for such reviews, SVS-9.

It was observed that notably the implementation of the SAMG programs showed many weak points - even substantial errors had been found.

The PWROG SAMG showed quite good compliance with the IAEA Safety Guide; this could not be concluded for the BWROG SAMG, as it did not show a clear priority for protection of fission product boundaries, as is requested in the IAEA Safety Guide.

Both approaches, however, showed no visible connection to the results of the extensive EU research program on severe accidents.

It is concluded that there should be much more peer review of SAMG programs, IAEA RAMP missions or similar missions, executed by teams such as those of NSC Netherlands.

4. ACKNOWLEDGEMENTS

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