PSA implementation of the Independent Core Cooling and New EOPs/SAMGs at Oskarshamn 3

Francesco Di Dedda[a], Anders Olsson[b], and Thomas Augustsson[c]
[a] Vysus Group, Gothenburg, Sweden, *francesco.didedda@vysusgroup.com*
[b] Vysus Group, Malmoe, Sweden, *anders.olsson@vysusgroup.com*
[c] OKG Aktiebolag, Oskarshamn, Sweden, *thomas.augustsson@okg.uniper.energy*

Abstract: An independent core cooling function (OBH) has been installed in unit 3 at the Oskarshamn NPP (OKG) as one of the post-Fukushima actions. In conjunction with the OBH project an update of the Emergency Operating Procedures (EOPs) has been made and a set of the Severe Accident Management Guidelines (SAMGs) has been developed. A complete review and validation of both level 1 and level 2 PSA sequences for all operating modes was performed to achieve the goal of implementing the new system functions and new procedures in the full scope analysis.
Given the new system configuration, requirements on some systems affected the requirements on dependent systems functions. This interaction between different systems was challenging to assess in specific cases. Dedicated workshop activities with operating personnel were crucial to determine accident progression, especially when considering the new system functions and the manual actions according to the new EOPs/SAMGs. Changes in the electrical systems as well as the adoption of a new version the integral code MAAP and a new version of RiskSpectrum PSA software were also undertaken in the implementation.
The modelling detail and realism has generally been increased in the "base-line PSA" (full power level 1 and 2, internal events) while other assumptions and simplifications are still present for other operating modes.
The presentation will focus on the encountered challenges, how those were solved and on giving an overview on the updated results.

1. INTRODUCTION

In response to the Fukushima Daiichi event in March 2011 the Swedish Radiation Safety Authority (SSM) set out in 2014 a new requirement for all operating Nuclear Power Plants in Sweden asking to be equipped with an independent core cooling function (ICC, OBH in Swedish) by December 31st 2020. In practice the "OBH project" included not only the implementation of the ICC system but also addressed several other aspects of safety and the implementation of supporting system functions to the ICC system. The required functionality is that independent core cooling function shall be able to keep the nuclear core cooled for a duration of at least 72 hours without relying on the external electrical grid or any other auxiliary power supply i.e., Extended Loss of AC Power (ELAP). Even though, the requirement from SSM was clearly defined for an ELAP scenario the OBH function was designed in order to also withstand a Loss of Ultimate Heat Sink (LUHS).

At Oskarshamn unit 3 (O3), a 1450 MWe BWR plant, an independent core cooling system has been installed which relies on its own dedicated diesel generator, independent from the other emergency diesel generators and other AC power supply (gas turbines) on site, a cooling water supply and residual heat removal that is independent from those dedicated to other safety systems.

An important part of related activities, other than the design and installation of the independent core cooling function at Oskarshamn 3, has been to update the Safety Analysis Report (SAR) including the Probabilistic Safety Assessment (PSA).

The focus of this paper is to provide a summary of all the work that has been done to update the PSA study for Oskarshamn unit 3 with regards to the introduction of a new function for independent core cooling (OBH) including the update of the Emergency Operating Procedures (EOPs) and Severe Accident Guidelines (SAMGs) and a review of the challenges related to such work. It should be mentioned that SAMGs, formally, were not in place for O3. An additional requirement from SSM was to create SAMGs for all BWR NPPs in operation in Sweden by the same deadline as for OBH. The need for the update of EOPs was dictated from the need of creating a good interface between EOPs and SAMGs. Separate development projects were in place at OKG NPP for the update of EOPs and SAMGs namely project KENT and SAMR.

2. PROJECT PLANNING

As a first step in approaching the update of the PSA for O3, a project planning was established with the requirement of meeting the project milestones by the deadline of December 2020 set by SSM. The plan stretched between the end of 2018 until 2020 with some additional work regarding the update of PSA documentation planned for 2021. The extension of some tasks to 2021 was due to the fact that an updated PSA with related documentation was to be delivered to SSM by December 2021. During the planning work it was decided that the PSA update should also include support to the verification and validation of the EOPs and SAMG. It was in fact decided that both EOPs and SAMGs were to be updated in combination with the implementation of the independent core cooling system (OBH).

Three project phases with additional sub activities were identified for development of the PSA and support to the EOPs and SAMGs, each phase to be addressed on a yearly basis.

The work to update the PSA study for O3 with regard to OBH, EOPs and SAMGs included the following phases and "milestones".

Phase 1 – FMEA, reliability analysis and first *CDF* estimation including OBH (2018-2019)

- FMEA and preliminary reliability study for OBH.
- Initial estimation of core damage frequency after the implementation of OBH.
- First update of the PSA study for O3 based on preliminary design for OBH and new EOPs draft including first review of manual actions.

Phase 2 - Development of the PSA study for O3 to include OBH (2019- 2020)

- Further development of the basic model (Level 1 PSA, power operation) from phase 1.
- Level 1 PSA update (Low Power operation).
- Level 1 PSA update (Shutdown reactor).
- Further development of level 1 PSA for power operation with respect to OBH and new EOPs.
- Update of level 2 PSA for power operation with respect to OBH and the new SAMG.
- Review of manual actions credited in level 2 PSA.
- Update of HRA for level 1 PSA for power operation and shutdown.

Phase 3 - Further development of the PSA study for O3 to include OBH (2020-2021)

- Further development of the model for Level 1 PSA internal events (all operating modes).
- Analysis of manual actions within level 1 PSA for all operating modes including dependencies.
- Further development of the model for level 2 PSA for power operation as well as low power operation.
- Analysis of manual actions within level 2 PSA for all operating modes.
- Review and update of the area events’ analysis.
- Update of the model for level 2 PSA for shutdown reactor.

- Update of the analysis of external events after the introduction of OBH including detailed analysis for those events that are not screened out.

Phases 1 and 2 focused on including the OBH function in level 1 PSA and analyzing the effect that the new EOPs and SAMGs have on the PSA study for O3 [1] [2]. The focus in phase 3 was to include the OBH function in all remaining parts of the PSA study and to use as-built data as a basis for the analyses as much as possible [3].

Other performed studies related to OBH and EOPs/SAMGs implementation (2020-2021)

- Analysis and model update related to changed pump curve for the ICC system.
- Analysis of room cooling requirements for areas containing OBH components.
- Implementation of manual actions including dependencies in the PSA model - according to the analysis developed during phase 3.
- Reliability analysis with regard to availability, operational safety and maintenance.
- Merger of PSA models – ordinary/as-built PSA with PSA-model developed during the OBH project.

Table 1 shows how the development in the project phases (with relevant tasks) matching the PSA scope for the Oskarshamn 3 NPP.

Table 1: Project Phases and Tasks matching the PSA scope – Matrix showing IEs and Operating Modes

<table>
<tr><th rowspan="2">Initiating event</th><th colspan="3">Level 1 PSA</th><th colspan="3">Level 2 PSA</th></tr>
<tr><th>Power</th><th>Low power</th><th>Shutdown</th><th>Power</th><th>Low power</th><th>Shutdown</th></tr>
<tr><td>Transients</td><td rowspan="3">Phase 1, 2.0, 2.3, 2.4, 3.0</td><td rowspan="3">Phase 2.1, 3.0</td><td rowspan="3">Phase 2.2, 2.4, 3.0</td><td rowspan="3">Phase 2.3, 3.1</td><td rowspan="3">Phase 3.1</td><td rowspan="3">Phase 3.3</td></tr>
<tr><td>CCI</td></tr>
<tr><td>LOCA</td></tr>
<tr><td>Area events</td><td colspan="6">Phase 3.2</td></tr>
<tr><td>External events</td><td colspan="6">Phase 3.4</td></tr>
<tr><td>Shutdown specific events</td><td>N/A</td><td>N/A</td><td>Phase 2.2</td><td>N/A</td><td>N/A</td><td>Phase 3.3</td></tr>
</table>

3. GENERAL OVERVIEW AND ADAPTATION OF THE PSA MODEL

In this section a general overview of the analyses that led the OBH implementation in the PSA for Oskarshamn 3 NPP is provided. Some details on the modelling aspects and regarding the V&V process for EOPs and SAMGs are also mentioned. Specific OKG methodology for all aspects of PSA (identification and analysis of initiating event, sequence analysis, area events, quantification, etc) was applied.

3.1. Phase 1 – FMEA, Reliability Analysis and First *CDF* Estimation including OBH

3.1.1. FMEA

Whit the implementation of OBH at Oskarshamn 3, several new systems are added and changes are made to a number of existing systems. A preliminary FMEA (Failure Mode Effect Analysis) was initially performed to analyze failure modes and their effects based on a preliminary design for OBH. To some extent, this task was also used to check the FMEA for existing components, for example, those components adjacent to system components belonging to the OBH design.

The purpose of FMEA at this stage was to be able to develop a PSA model that could be used as a tool for making a preliminary safety assessment of the OBH design and give feedback to the detailed technical specification work which was still ongoing.

Four new systems, including the one related to actual independent core cooling system were added to the preliminary FMEA. For four existing system the FMEA were checked or updated.
Systems changes were discussed related to six existing systems, but not considered to have any impact on the FMEA.

The work with FMEA identified about 20 different components' failure modes that were relevant for implementation in the PSA. During this task a number of component types not included in the existing FMEA were identified for which failure data estimation was needed i.e., electrical components that are de-energized during normal operation, MG set, a diesel-powered centrifugal pump and a minimum flow check valve.

3.1.2. Preliminary reliability study

Based on the FMEA described in section 3.1.1., a preliminary modeling of the OBH function was done in the PSA model for Oskarshamn 3. The modeling was based on the information available at that time regarding the design of the systems concerned and, therefore, not a final and established detailed technical specification.

The main purpose of the analysis was to demonstrate the contribution of the OBH function in quantitative terms, more specifically, the reliability that can be obtained for the OBH function and the strengths and weaknesses of the system designs.

Based on the performed analyses, the following conclusions could be drawn:

- The reliability of the OBH function depends entirely on the reliability of the independent core cooling function, which is a one-train system, which means that the different types of single failures in the system are the most probable causes of errors.

- The component that in the analysis contributed the most to the unavailability of OBH was the diesel-driven pump in the independent core cooling system. However, it should be noted that the failure data adopted was based on data for diesel-powered fire water pumps, which may be considered too conservative for the analysis.

- Manual actions did not show to be of large significance in the analysis. This is because different types of technical errors in the ICC system dominated so strongly the result.

- The reliability of OBH is of the same order of magnitude as for single trains in the Auxiliary Feedwater (AFW) and the Emergency Core Cooling System (ECCS).

3.1.3. Initial estimation of core damage frequency

In addition to the preliminary reliability analysis described in section 3.1.2., a first estimation of the impact that OBH may have on the total core damage frequency (*CDF*) during power operation for O3 was performed. This was done by updating success block diagrams and event trees for transients and CCIs in accordance with what was done for ELAP and LUHS events in the preliminary reliability study. In this initial *CDF* assessment OBH is only credited for a specific set of initiating events i.e., transients and CCIs. This means that results for LOCA events was considered unchanged.

In the case of operator errors for the OBH function, an HEP of 0.01 was given to all manual actions related to the new systems. Other manual actions retained their previously estimated values.

A core damage frequency was then calculated for the consequences loss of core cooling (CC) and loss of residual heat removal (RHR) showing a significant decrease for these scenarios. As expected, results for core damage due to failure of reactor shutdown showed no changes.

One conclusion that can be drawn from this first *CDF* estimation was that OBH should have one positive effect on safety given the reduced *CDF*. A large contribution to the *CDF* in the unchanged PSA model came from sequences leading to loss of CC. Given that the OBH function adds an extra barrier in these very sequences, it was reasonable to obtain a positive effect in the *CDF* results.

3.1.4. First update of the PSA study based OBH design and new EOPs draft including first review of manual actions

At the same time as a project for the implementation of the independent core cooling function (OBH) was proceeding another project for the update of EOPs and SAMGs was having place at O3. As EOPs and SAMGs largely define which measures are to be implemented and which systems to use to put a nuclear reactor to a safe condition after an initiating event this has a major effect on the PSA model, primarily with regards to how incidental sequences are modeled in event trees as well as manual actions. Roughly speaking, it can be said that EOPs forms the basis for modeling part of level 1 PSA and SAMGs creates the basis for level 2 PSA.

Workshops with personnel involved in the EOPs update were organized in order to go through incidental sequences for level 1 PSA also considering the added core cooling alternatives offered by OBH and other system functions i.e., feed water tank.

The task performed resulted in the following achieved milestones:

- Preliminary evaluation of the impact of the new EOPs.
- Update of success block diagrams for level 1 PSA with regards to the new core cooling options (OBH and other alternatives).
- Identification of updated and new deterministic calculations to support PSA sequence analysis.
- Evaluation of the impact on *CDF* for internal events due to the implementation of OBH, changes in EOPs and additional manual actions.

Several findings from the evaluations performed with PSA were discussed together with personnel in charge of updating the EOPs to give feedback for further update of the new procedures. Some of these findings included the additional requirements on pressure relief systems as precondition for OBH operation, changes in independent RHR system actuation before core damage.

3.2. Phase 2 - Development of the PSA Study for O3 to include OBH

As a follow up after phase 1 (see section 3.1) phase 2 of the project focused on including the OBH function in level 1 PSA. In parallel, work on analyzing the effect of the new EOPs on sequences as well as a first update of level 2 PSA in relation to the updated SAMGs proceeded.

In table 2 below a short summary of the tasks addressed during phase 2 is given. During this work many modelling and project planning related challenges were addressed, for example, the fact that a new version of MAAP (integral deterministic code used for support analyses to the PSA) was validated and used as reference, a major change in the definition of SAMGs for O3 compared to previously adopted procedures for severe accident mitigation.

Table 2: Project Phase 2 task description

Phase.Task	Description
2.0	Further development of the basic model (level 1 PSA, power operation) from phase 1
2.1	Update of level 1 PSA for low power operation
2.2	Level 1 PSA update (shutdown reactor)
2.3	Level 1 and level 2 PSA further update and review of the HRA for level 2 PSA (part of the project EOPs/SAMG)
2.4	Update of the HRA for level PSA 1 for both power operation and shutdown reactor

3.3. Phase 3 - Further Development of the PSA study for O3 to include OBH

In phase 3 of the project the focus was on reviewing and further updating the model for level 1 and level 2 PSA in order to have a final implementation of the OBH function (including all relevant affected systems) according to final technical specifications and as-build information for systems and following the updated EOPs and the new SAMGs which were to be finalized at that time. This work was done for all operating modes included in the scope for the PSA for O3. In parallel, work for updating the analysis for area events and external events was also performed.

In table 3 below a short summary of the tasks addressed during phase 3 is given.

Table 3: Project Phase 3 task description

Phase.Task	Description
3.0	Further development of the model for level 1 PSA internal events (all operating modes)
3.0	Analysis of manual actions within level 1 PSA for all operating modes, including management of dependencies
3.1	Further development of the model for level 2 PSA power operation and low power operation
3.1	Analysis of manual actions within level 2 PSA for all operating modes
3.2	Review and update of the area events’ analysis
3.3	Update of level 2 PSA for shutdown reactor
3.4	Update of the analysis for external events with regard to the introduction of OBH

3.4. Other performed studies related to OBH and EOPs/SAMGs implementation

Following the tasks addressed during phase 3, some more studies were performed some of which were not planned at the beginning of the project.

One specific study was done to evaluate the changes in the description of the ICC pump in deterministic analyses resulting in changes in the success criteria for level 1 PSA and definition of containment event trees (CETs) in level 2 PSA.

Another study was done to verify the system requirements on support systems for cooling of the OBH components modelled in the PSA, considering the mission time for the analysis in level 1 PSA (20 hours). It was demonstrated that the room temperature stays below 50 degrees Celsius during accidental conditions in the PSA analyzed time frame which, in turn, does not add additional requirements on cooling of systems and components in that location.

As a follow-up to the preliminary reliability analysis performed in phase 1 of the project, see section 3.1.3, a more detailed availability, functional safety and reliability study was done. The analyses demonstrated that the functional safety for the OBH function is similar or better compared to one train in the AFW and ECCS systems respectively and it also demonstrated that the OBH function is well constructed and adapted to handle an ELAP scenario.

As an important step in the PSA work for the entire project, a merge between the ordinary PSA model, with as-built system configuration before the implementation of OBH, and the PSA model with as-built system configuration after the implementation of OBH and EOPs/SAMGs was performed.

Several results' comparisons between baseline PSA with as-built system configuration and PSA at different stages of the implementation of the OBH function and EOPs/SAMGs were done, both in terms of *CDF* and for the total frequency of *unacceptable releases* (level 2 PSA). It should be noted that the frequency for *unacceptable releases* in level 2 PSA is a more conservative risk metric compared to LERF and it is the one adopted among other risk metrics in Sweden for level 2 PSA results' presentation to SSM.

In table 4 below a list of the additional studies addressed in conjunction or soon after the end of phase 3 is shown.

Table 4: Additional Studies performed during Phase 3 of the OBH Project

Evaluation and PSA model update according to new pump curve for the ICC system
Analysis of room cooling requirements for OBH components
Reliability analysis
Merger of PSA models (as-built and OBH-model)
Results' comparison

4. RESULTS

As described in section 3.4, a number or results' comparisons regarding *CDF* and total *unacceptable release* frequency for different plant operating modes and type of initiating events were performed during the four years of the project. Although the project was aiming at implementing the OBH function in the PSA model, several other aspects were accounted for and included in the PSA i.e., new EOPs, SAMGs and other updates due to plant changes (not due to OBH project). This was found to be one of the challenges both on a project management standpoint but also considering the result presentation and evaluation of PSA results for delivery to SSM and for internal use at OKG. Nevertheless, a result comparison which focuses solely on the effect and contribution of the OBH function, and the effect of new procedures (EOPs/SAMG) was possible to achieve and is described here below*.

*The results obtained from the PSA for all operating modes after this project show some additional reduction in the risk i.e., both the CDF and radioactive release frequency decrease. This is mainly due to additional systems for AC Power supply being credited in the PSA as well as the reduction of conservative modelling in several parts of the base-line PSA model addressed in other PSA update activities. Such results were delivered to the Swedish Radiation Safety Authority (SSM) as part of the updated SAR for O3. Although, such final results are not described in this paper as it only focuses on OBH and EOPs/SAMGS implementation.

The combined *CDF* for power operation and low power operation decreased by 88% compared to before the PSA update due to OBH and EOPs/SAMG. In a similar way, the combined frequency of *unacceptable releases* during power operation and low power operation decreased by 57% after the introduction of OBH. For shutdown reactor, OBH cannot be credited directly in the baseline analysis due to the acceptance criteria regarding manual operations in this operating mode. The comparison in the figure below, therefore, shows the results for the sensitivity analysis performed where OBH is credited. The reduction in *CDF* frequency and frequency of *unacceptable releases* in this specific sensitivity analysis is calculated to be approximately 97% each for shutdown operation.

In figure 1 and figure 2 below is shown the decrease of CDF and *unacceptable releases'* frequencies for power operation, low power operation and shutdown individually.

Figure 1: CDF Variation as a result of the Implementation of the OBH Function and EOPs/SAMG

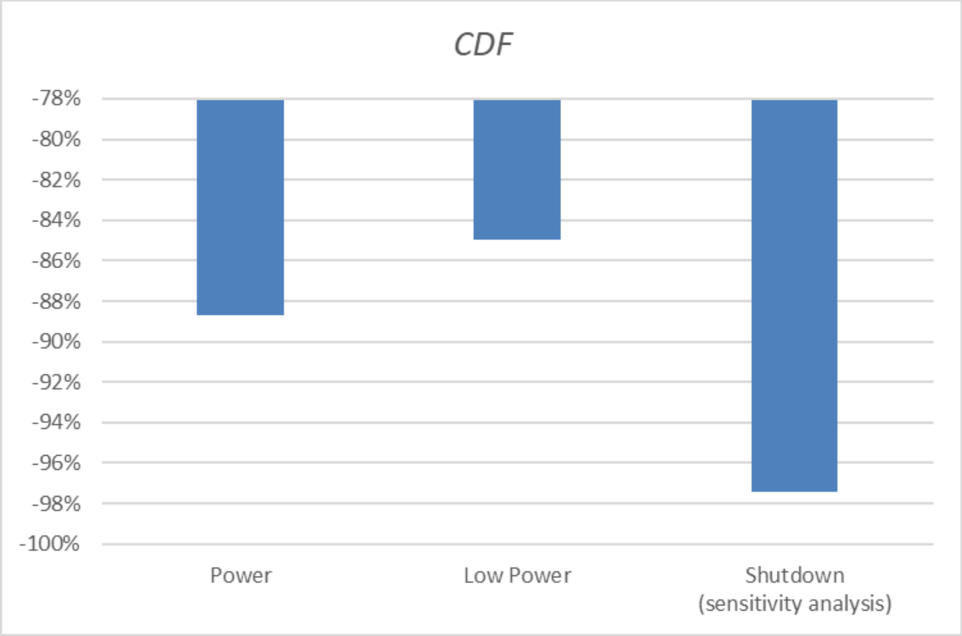
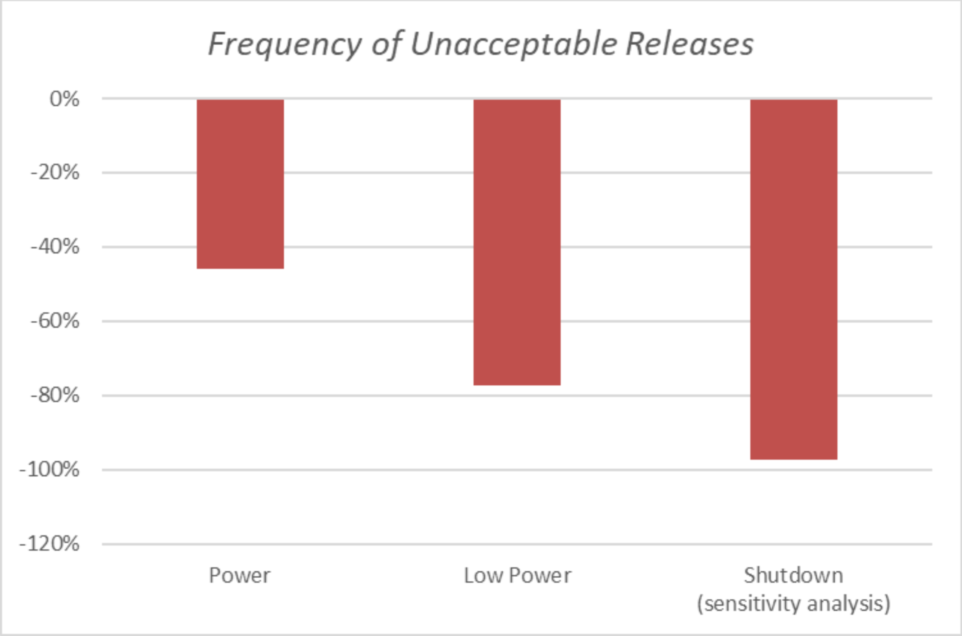


Figure 2: Variation of the Frequency of *Unacceptable Releases* as a result of the Implementation of the OBH Function and EOPs/SAMG



The plant is still found to have good safety barriers after the introduction of OBH and new EOPs/SAMGs as there are very large margins against acceptance criteria for PSA for O3.

The introduction of OBH and the new EOPs/SAMGs led to a significant increase in reactor safety for all operating modes as the risk of core damage and unacceptable releases decreased since the OBH function adds an additional safety barrier which strengthens the plant resilience for the majority initiating events.

The risk contributions for area events can be neglected in the evaluation of the nuclear plant as a whole. This has not to do with the implementation of the OBH function but rather due to the results of a previous project in which the aim was to reduce conservatism in the model regarding the calculation of the failure of reactor shutdown systems.

Concerning the external events, the barriers have been improved through the introduction of OBH and new EOPs/SAMG.

Overall, it is seen that the introduction of OBH and of new EOPs and SAMGs provides an extra safety barrier against both core damage (level 1 PSA) and radiological releases (level 2 PSA). The fact that in many event combinations (sequences) it is possible to identify OBH as an additional barrier also means that the PSA study verifies that the OBH function is in fact independent from other system functions which also were included in the PSA model due to the updated emergency procedures.

5. CHALLENGES

During the three phases of the project several challenges arise. Here below is some of the challenges which affected the PSA modelling activities. A short description of the issue and the resolution adopted is provided.

5.1. New approach and interface between EOPs and SAMGs and changes in CC/RHR alternatives

EOPs are symptom-based procedures for operators dealing with disturbances beyond design at NPPs. The EOPs aim at describing for the operators a simple way to bring the reactor into a safe state; this is done by using intuitive diagrams and specific procedures offering alternative solutions for system operability to ensure the correct functionality of safety systems. The new EOPs at OKG includes a new structure of the safety organization whit a revised hierarchy of responsibility for personnel handling the emergencies (KENT project). Moreover, a new and clearer interface between EOPs and SAMGs (when it is time to leave EOPs and move forward to SAMGs) was introduced. This generated several additional tasks to the already fully specified planning for the PSA implementation of the OBH function.

The additional systems included in the OBH function with the corresponding function-oriented and system-oriented emergency procedures were created and updated during the first three years of the project (2018-2020) with a pace that not always reflected the timing for the PSA modelers' needs in retrieving background information.

SAMGs was introduced for the first time at O3 as severe accident management was previously addressed with several system-oriented procedures which were not described and structured in a systematic way as it is usually done for EOPs. Replacing the old procedures with more consistent SAMGs was a major step forward for safety which required a lot of effort by all personnel working in the project (SAMR project).

By using workshops between personnel responsible for updating the EOPs and SAMGs and experts responsible of updating the PSA, the major differences were identified, discussed, and tackled. An example of such differences is the addition of several alternatives for core cooling in the EOPs as well as the removal of the independent RHR (independent sprinkling of containment) which is only described in SAMGs. Specific studies were conducted to assess the success criteria and to adapt the additional CC alternatives to the PSA modelling. Specific deterministic analyses performed with MAAP5 were done to assess the system requirements for the new systems to correctly model these into the sequences in the PSA.

An additional CC alternative described in the EOPs was included in the PSA in addition to the ICC system for which the OBH function was meant to support. In total, two new CC alternatives were modelled in the PSA with their specific system requirements and success criteria. These CC systems serves today both as CC as well as RHR functions in the sequence description for all initiating events analyzed in the PSA.

5.2. Low-Power and High-Power mode for the ICC Injection

The diesel-pump driven ICC system introduced with the OBH function can operate at two different flow levels depending on the reactor water level and subsequent need during an accidental scenario i.e., high-power and low-power mode. The water flow pumped into the reactor vessel is autoregulated by the available pump head and the pressure level in the vessel, the flow that is not injected into the vessel is redirected to the water storage tank (central spent fuel pool) through a minimum flow check valve. In a situation in which the pressure level in the reactor vessel is low enough for the ICC to start the water injection, there is the possibility that the water flow is continuously directed into the vessel and eventually dispersed into the condensation pool via depressurization valves, in turn, leading to the depletion of the water supply in the storage tank. Operator procedures are in place to avoid injecting water with a water level in the reactor vessel exceeding the maximum allowed for the system.

The OBH function is designed with support functions and systems with the task of replenishing the water supply in the water storage tank as soon as certain thresholds are reached. Moreover, clear operator procedures are in place for regulating the flow level between the two power-modes depending on the needs and to actuate support function for water storage replenishing.

Even though the design is solid and the procedures in place clearing indicate the manual actions to perform given plant indications, as part of the PSA update an HRA was performed for the new systems and procedures. This resulted in the identification of a set of manual actions with related Human Error Probabilities (HEPs) which led to a sequence analysis far more detailed than initially expected. Sequences due to failed manual actions in operating the two power-modes and subsequent actions for water filling were described and introduced in the PSA model with different requirements depending on the initiating event and requirements on other systems. Such level of detail in the modelling was found to better describe incidental sequences and resulted in a higher level of detail in the modelling of other systems with more insights gathered from the results.

5.3. Feed Water Tank

The feed water tank (water filled from the main feedwater) is a passive and pressure-driven system function. This function is not a new function at O3 but it was never implemented in the PSA as it is not a viable CC function for the mission time for the level 1 PSA (20 hours). The system was implemented in connection with the OBH project as an additional CC alternative in those sequences where AFW and ECCS are failing initially. As previously stated, the feed water tank function is not sufficient as CC function but in view of the other CC alternatives introduced in the EOPs and modelled in the PSA (see section 5.1) creates preconditions for sequences in which timing for manual actions is facilitated since this passive system can alone keep the core cooled for at least 2 hours when no other CC system is available.

The implementation of the feed water tank in the PSA model creates new possibilities and also generates a more complex HRA and sequence description. The use of house events, branch alternative in event trees and boundary condition sets in RiskSpectrum PSA makes the modelling feasible and readable by PSA users but demands a thorough description in the PSA documentation to be fully understood.

The introduction of the feed water tank in the PSA model makes the analysis more realistic and makes the results more correct with regard to contribution of human errors to the CDF.

5.4. Multiple Ongoing Large Projects and their effect on PSA update tasks

As described in the sections above, at least other two important development projects were ongoing at the same time as the OBH project at OKG during 2018-2020 dealing with the update of EOPs and SAMGs (project KENT and SAMR). Personnel from several departments at OKG was involved in such projects and, on some occasions, the same resources needed to take part in all these projects.

At the same time, a new version of MAAP (MAAP5.0.3+) was under validation and verification and was decided to be adopted as the version in which all deterministic analyses should be run to support the PSA update in the OBH project and other projects. This was not an easy task for those resources performing the deterministic analyses and for the QA-process involved. Although, the new version of MAAP was found to generate reliable and trustworthy results which could easily adopted as basis for further analysis.

6. CONCLUSION

Due to the implementation of the OBH function, the facility has added safety barriers that have reduced the risk of core damage and radioactive releases to the environment for all operating modes. Based on the results obtained from the PSA, the risk of core damage and radioactive releases to the environment after the introduction of the OBH function and the new EOPs and SAMGs meet the expectations in terms of acceptance criteria and contributes to significantly increasing the safety of the Oskarshamn 3 NPP.

The challenges identified in the project, those related to the PSA modelling and those more related to project management provided a stimulus for all involved personnel to address the problems in effective manners. A higher level of detail was achieved in the PSA model leading to more insightful results facilitating cooperation in several ongoing projects at OKG and opening for further work of certain aspects of safety analyses.

7. REFERENCES

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