OSART Good Practices
ACCIDENT MANAGEMENT
Development of procedures and guidelines

Koeberg, South Africa

Mission Date; 22 Aug.-8 Sep., 2011

Severe Accident Management Guidelines (SAMG) have been expanded to scope accidents during shutdown conditions and accidents involving the spent fuel pool. This includes plant modifications and training.

Koeberg was the first nuclear power plant to include severe accidents at shutdown (2006) and the mitigation of fission product releases in the fuel building (2006), when the new revisions of the SAMG were implemented.

- The plant specific risk assessment highlighted the potential significance of accidents occurring during shutdown and in the spent fuel pool. This resulted in the necessity of updating the SAMGs to address these risks and progressed to the installation of plant modifications to reduce the impact of these potential severe accidents.
- Several severe accident equipment modifications have been identified that will greatly enhance the capability of mitigating a severe accident condition as confirmed by the PSA Level 2. These modifications include passive autocatalytic recombiners, alternative containment spray system, basemat thermocouples, emergency seal injection and extended range pressure measurement capability in containment. A modification to facilitate remote make-up to the spent fuel pool has also been installed.
- Extensive regular formal training is being given in the use of the SAMGs which includes both table top and simulation exercises. The recent focus has been on external events (such as seismic activity), severe accidents during shutdown plant states and spent fuel pool accidents.

Gravelines, France

Mission Date; 12-29 Nov., 2012

Use of an industrial network for continuous and proactive monitoring of external industrial activity around the site.

Owing to the density of industrial installations around the site, the plant has set in place a continuous monitoring system in order to monitor its industrial environment. This consists of a network with different committees. Each network member has to submit their projects if they are creating or planning any significant modification to an operating facility. Information received through this network is supplemented by information from local information committee meetings and consultation of Seveso (industrial hazard analysis requirements) on classified facilities. The plant has access to the results of relevant risk studies carried out by these facilities.

Monitoring is supplemented by following the local news in order to identify any projects that were submitted for impact assessment.

All the above mentioned activities allow for early identification of projects or planned modifications that could affect the plant or potentially influence the results of different hazard and risk studies documented in the Final Safety Analysis Report.

Gravelines, France

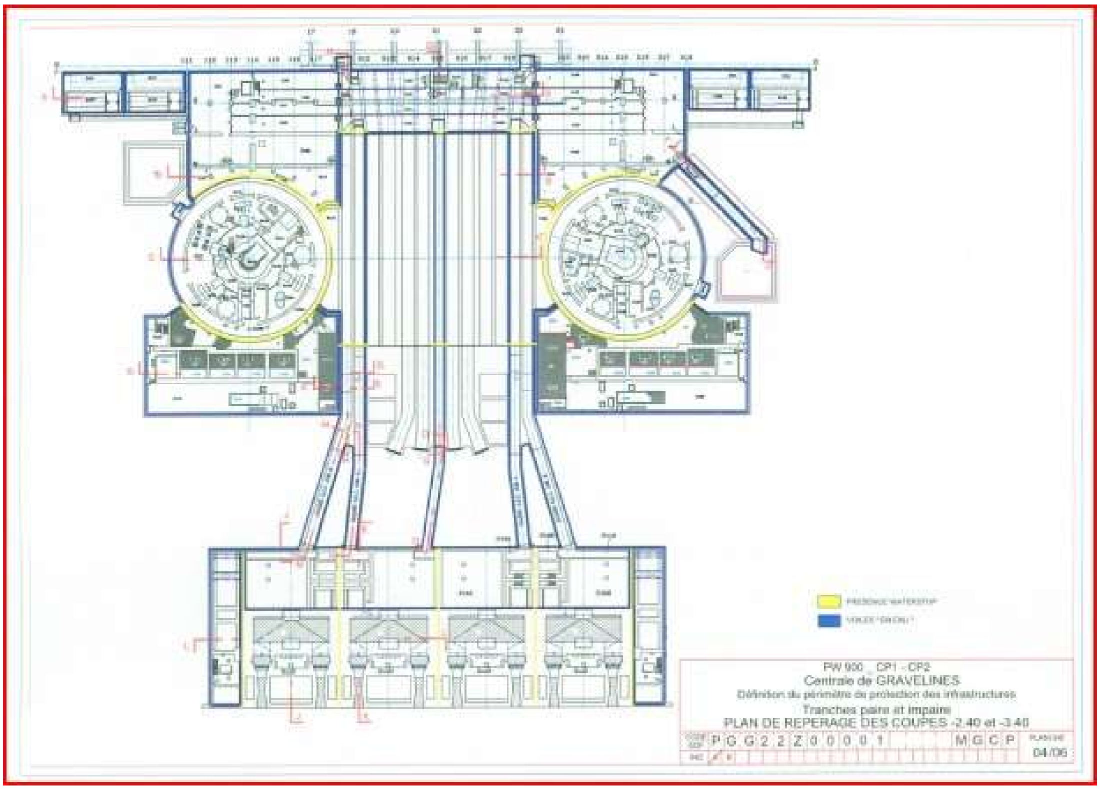
Mission Date; 12-29 Nov., 2012

Volumetric flood protection of the plant is supported by special technical guidance documents.

A complex and robust solution has been implemented to increase flood protection on the site. In the event of an alert for an expected outside flood or heavy rainfall, the ERP called "Nuclear safety and climate effects" would be triggered. A dedicated flood operating procedure is in place for the necessary closures and lock-outs around the volumetric protection lines. The volumetric protection system is separately applied for each twin-unit set and as it can be seen on the attached drawing, it encompasses all safety-related buildings with their walls, ceiling, floors, and all sealed penetrations (a few hundred items).

A dedicated procedure exists for periodic surveillance and for monitoring the tightness of all sealed penetrations and the status of other protective devices during an alert.
Control room personnel are continuously informed about the status of penetrations by means of the SYGMA information system.

In order to find penetrations in a complex building within the limited time that is available during the alert phase, a handy technical guide with layout plans and photographs of the penetrations is provided for response teams.



Chooz, France

Mission Date; 17 Jun.-4 Jul., 2013

The accident management of the plant is supported by a set of special aids and guidance documents

Any non-compliances that are temporary and recognized by the regulator until they are addressed can still have an impact on accident management. The plant regularly updates the list of these non-compliances, the majority of them are related to the seismic or other environmental qualifications of different systems. For all those deviations their potential impact on accident management is assessed, the potential failure modes are identified and documented.

The assessment results are incorporated into training and made available as a computerized aid to the emergency technical support teams.

With this aid the accident management response can be planned in an optimal and deliberate way taking into account any potential failure, limited availability or reduced performance of the non-qualified equipment or systems. With the help of this aid the technical support team can be aware of any potential leaks or damages of non-qualified tanks in case of certain events, i.e. an earthquake on the site. By using this aid some of the necessary
compensation or contingency actions could be determined in advance.

The list of all connections which are used for mobile equipment is also available to the technical support team in order to suggest, properly plan and perform any contingency line-ups using these connections and any available mobile equipment.

In case of a station black out event on one of the units there is a possibility to supply safety systems from the diesel generators from the other, possibly non-affected unit. A procedure is used by the technical support teams to set-up cross connections from the neighboring unit and supply the 6.6 kV safety bus-bars. This procedure was validated with a simulated key path which confirmed its operability. This ensures that if at least one emergency diesel generator is available on site, then all the safety systems could get electrical supply.

Borssele, Netherlands

Mission Date; 1-18 Sep., 2014

Management of Severe Accident Management Guidelines (SAMG) process diagrams (PIDs) with coloured flow paths

The SAMGs contain attachments with system line-ups that can be used to achieve certain flow paths (e.g. the non-standard flow path to inject water from the containment sump into the spent fuel pool by use of a residual heat removal pump). In order to assess and to configure these possibilities during an emergency, staff will mark the flow paths on process diagrams. This work is time consuming when several flow paths are to be assessed. Therefore EPZ has a complete set of up-to-date process diagrams available for every system line-up that is mentioned in the SAMG with the intended flow path marked by a coloured line.

To consistently maintain a second set of PIDs and to keep them in accordance with the as built PIDs that are normally used is challenging. Deviations between almost identical sets of documents can easily occur. EPZ uses a CAD program to draw and alter all drawings including PIDs. The process diagrams are multi layered drawings. The coloured SAMG process diagrams are produced by using the existing digital PID layers of the according process diagrams and adding one additional coloured layer representing the intended flow path of the SAM guideline. Every time a process diagram is changed this is recorded in a database which directly informs the engineer which SAMG PIDs must be changed. Because almost all modifications to the process diagrams are minor changes, the SAMG PID can be changed by simply printing new copies of it based on the modified underlying PID and the existing coloured layer. Occasionally the coloured flow path has to be altered when a major change is made to a system. The use of the database ensures that every SAMG PID is revised when the underlying process diagram is changed. The revision number and date of the original PID are also printed on the SAMG PID this enables an easy check whether the drawing matches its source.

Benefits associated with the management of SAMG process diagrams.

The use of coloured SAMG PIDs guarantees easier and quicker assessment and configuration of possible flow paths and error reduction in the interpretation of possible system line-ups described by the SAMG attachments. The QA process for the management of the SAMG PIDs guarantees that the information in these drawings is also up to date after a plant modification and in compliance with the as built PIDs.

Borssele, Netherlands

Mission Date; 1-18 Sep., 2014

Requirements for SAM equipment in separate Plant Technical Specifications. Plant equipment and features intended to be used for Severe Accident Management are described in the Plant Technical Specifications (BTS in Dutch). This is a set of Technical Specifications that is separate from the formal set of Technical Specifications of requirements for the safety systems of the plant (based on NUREG 1431), but they use the same structure and layout. Availability requirements, allowed outage times, required actions and surveillance requirements are prescribed by this BTS in the same way as it is done by the formal Technical Specifications (TS). The authorisation of the BTS is carried out by the plant's Nuclear Safety Manager. Deviations from these self-imposed requirements are primarily reported to the Nuclear Safety Manager who is also authorized to grant exemption requests. The management expectation is that staff makes no distinction between the use of the TS requirements and the BTS requirements.

Benefits associated with the use of Plant Technical Specifications.
The availability of SAM equipment is controlled in a similar way to the plant's safety equipment. The management expectation that the BTS requirements must be considered as important as the Technical Specifications requirements guarantees that the SAM equipment is not neglected but well maintained. The BTS also ensures clear requirements and SMART actions to maintain or restore AM availability.

Flamanville 3, France

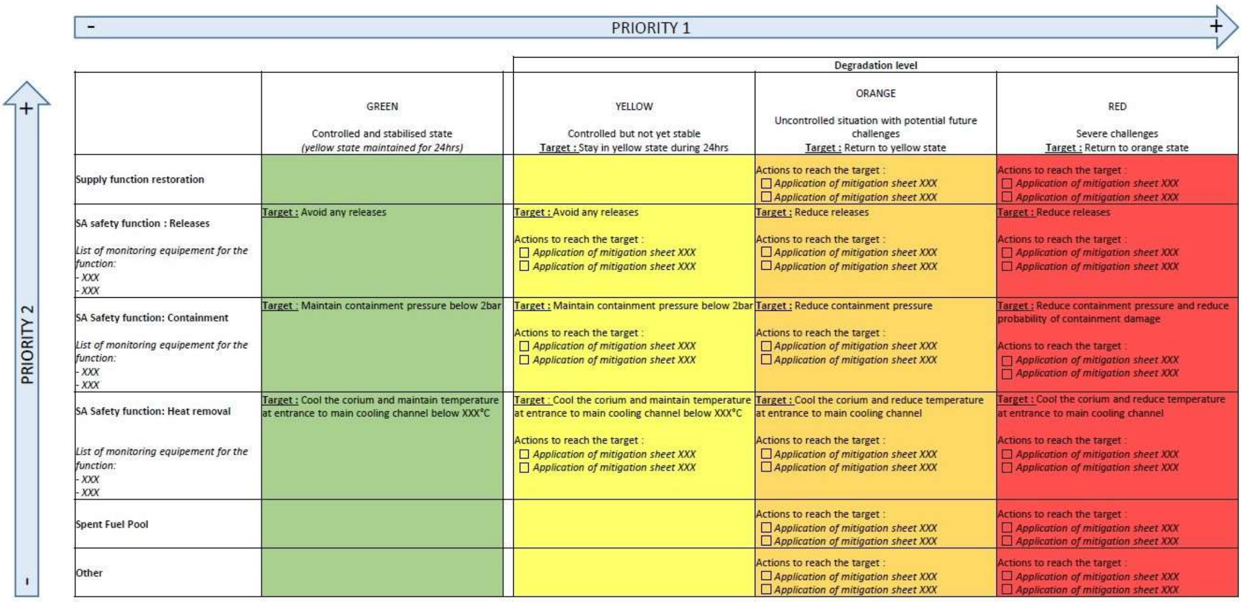
Mission Date; 17 Jun. - 4 Jul., 2019

Mitigation matrix

The mitigation matrix is a tool used to prioritize mitigation sheets and to provide a summary of plant conditions. This matrix can be accessed by members of the technical support group (ELC), ETC-N (corporate technical support team) and PCD1 (Emergency Director).

The matrix is composed of a dual input table: the severe accident safety functions (having the priority order: Release, Containment, Cooling) and the plant conditions. The colours designate the degradation levels:

- Green: conditions controlled and stabilized (post-accident phase)
- Yellow: conditions controlled but not stabilized (objective: remain in yellow status for 24 hours)
- Orange: potential hazard, anticipated risk (objective to return to yellow status)
- Red: confirmed hazard (objective: return to orange status)



	GREEN Controlled and stabilised state *(yellow state maintained for 24hrs)*	Degradation level YELLOW Controlled but not yet stable Target : Stay in yellow state during 24hrs	ORANGE Uncontrolled situation with potential future challenges Target : Return to yellow state	RED Severe challenges Target : Return to orange state
Supply function restoration			Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*	Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*
SA safety function : Releases *List of monitoring equipement for the function:* *- XXX* *- XXX*	Target : Avoid any releases	Target : Avoid any releases Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*	Target : Reduce releases Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*	Target : Reduce releases Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*
SA Safety function: Containment *List of monitoring equipement for the function:* *- XXX* *- XXX*	Target : Maintain containment pressure below 2bar	Target : Maintain containment pressure below 2bar Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*	Target : Reduce containment pressure Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*	Target : Reduce containment pressure and reduce probability of containment damage Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*
SA Safety function: Heat removal *List of monitoring equipement for the function:* *- XXX* *- XXX*	Target : Cool the corium and maintain temperature at entrance to main cooling channel below XXX°C	Target : Cool the corium and maintain temperature at entrance to main cooling channel below XXX°C Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*	Target : Cool the corium and reduce temperature at entrance to main cooling channel Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*	Target : Cool the corium and reduce temperature at entrance to main cooling channel Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*
Spent Fuel Pool			Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*	Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*
Other			Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*	Actions to reach the target : ☐ *Application of mitigation sheet XXX* ☐ *Application of mitigation sheet XXX*

XXX mean procedures already exist in the plant.

The matrix also targets priorities: priority 1 is assigned to the highest level of degradation and priority 2 to the 'Release' safety function. In addition, the matrix indicates the criteria for transition from one degraded level to another. For example, containment pressure is a criterion that is used to visualize any changes in the ‘containment’ safety function. Human and Organizational Factor testing showed that the matrix provided emergency response managers with a shared and synchronized representation of the severe accident management status, assisting with the objectives of controlling off-site release and of returning to a controlled state.

Benefit: The matrix enables emergency staff to visualize plant conditions more rapidly. It helps in selecting the appropriate mitigation sheet to be used once the diagnosis has been performed.

Tihange, Belgium

Mission Date; 17 Apr. - 4 May., 2023

Strategies for the stabilization of the reactor core following a severe accident resulting in a core melt have been designed and put in place by the plant and there were procedures for their implementation.

Purpose

The aim of the strategies for the stabilization of the reactor core was to facilitate actions during the phase following a severe accident. The strategies which have been developed can be applied after the plant has been returned to a controlled stable state and can continue for many years.

Description

The plant had evaluated the phase following a severe accident which resulted in a number of plant modifications to enable:

- Back flushing of the containment filtered ventilation system (CFVS) using a mobile pump.
- Refurbishing (refilling with water and appropriate chemicals) of the CFVS to support repeated use, using a mobile chemical supply unit.
- Chemical addition into the containment building via the spray system. The system consists of a mobile pump fed by a truck containing sodium hydroxide (NaOH).

These actions have been formally documented in the guidelines, procedures and Piping and Instrumentation Diagrams (P&IDs).

Figure 1: Injection points for Backflushing (or refilling the CFVS) and NaOH injection into Containment Building

Benefits

- Backflushing the CFVS transfers contaminants back into containment. The filtered vent is outside of the 3rd fission product barrier and so transferring this radioactivity back into containment is of benefit to longer term accident management.
- Following a severe accident, it is credible that repeated use of the CFVS may be required. Being able to backflush and then refurbish the filter with additional water and chemicals enables repeated use.
- Being able to inject NaOH enables the control of pH of the water inside containment which may be necessary because of the creation of various acids during a severe accident. This action minimizes corrosion and the spread of Iodine (I_2) from out of the containment sump.