Operator Training for SAM in the Netherlands

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Abstract

The Borssele NPP in the Netherlands, in operation since 1972, is a Siemens designed 2-loop PWR. The plant is using EOP’s and SAMG’s based on Westinghouse standards. In 1999 these SAMG’s were applied and implemented to the specifics of the plant. Determination of the present instrumentation capabilities was part of this work. The implementation phase was ended with a table-top exercise to test the functionality of the SAMG’s within the Alarm Response Organization.

Operator training for the SAMG’s consists of five phases:
- general introduction courses into the plant specific severe accident phenomena and the use of SAMG’s
- full scale emergency exercise focused on training the Alarm Response Organization for SAMG-implementation and -validation
- table-top exercises in the usage of the SAMG’s focussed on training the operator in understanding and application of the guidelines
- table-top exercises in the usage of the SAMG’s focussed on training the operator in application of the EOP’s and SAMG’s within the Alarm Response Organization
- full-scale emergency exercise focussed on training the Alarm Response Organization up to and including SAM.

Main purposes of these courses and table-top exercises are to give the operator insight in the structure of the SAMG’s, give insight in the strategies as proposed in the SAMG’s and give the operator experience in the usage. At the same time the exercises serve as a review of the SAMG’s and training in the different responsibilities within the Alarm Response Organization.

For the table-top exercises specific accident scenarios are defined which guide the operator through specific parts of the SAMG’s. An EXCEL tool was created to represent the information that the operator normally retrieves from the plant status computer.

Main information for the operator training is based on the next Borssele sources:
- safety evaluation and design base accident analyses
- plant simulator for design base accident analyses and training
- full-scope PSA level 3
Applying this information and this training the Borssele plant fulfills the objectives of improving operator knowledge, improving operator skills and testing the SAM organization efficiency.

1. Introduction

The Borssele NPP in the Netherlands, in operation since 1972, is a Siemens designed 2-loop PWR. The plant is using EOP’s and SAMG’s based on Westinghouse standards. Once conditions indicating a severe accident is in progress have been detected, use of the EOP’s is terminated, and a transition to the SAMG’s is made. In 1999 these SAMG’s were applied and implemented to the specifics of the plant. Determination of the present instrumentation capabilities was part of this work. The implementation phase was ended with a table-top exercise to test the functionality of the SAMG’s within the Alarm Response Organization. At present a training program is ongoing.

To aid in the diagnosis of the severe accident conditions and selection of the appropriate strategies for implementation graphical Computational Aids (CA’s) are developed. Each of the CA’s help the operator to assess the following phenomena or parameters:

- RCS injection to recover the core
- Injection rate for long term heat removal
- Volumetric release from vent
- Water level in the sump
- Gravity drain from RWST to containment
- Hydrogen flammability in the containment.

The Borssele specific CA’s are generally in the form of plots of two or three variables. They have been designed to be efficient and simple to use, requiring no computer capabilities.

2. Organisation of emergency response

An overview of the emergency-organisation is depicted in figure 1. The next responsibilities within the emergency-organisation are recognised:

- BOC “Bedrijfs Ondersteunings Coordinator”. This person is responsible for actions in the plant, e.g. restore a pump
- BT “Beleids Team”. This includes the Site Emergency Director, the MOB, the MOD and the MS
- MOB “Manager Ondersteuning Bedrijfsvoering”. This is the person to which the TAG reports
- MOD “Manager Ondersteunende Diensten”. This person is responsible for logistic support
- MS: “Manager Stralingsbescherming”. This is the person responsible for prediction of source terms
- S: Control room shift personnel
- SED: Site Emergency Director. This person is the head of the ERO and takes the decisions
- SM: Control room shift manager
- TAG “Technische Analyse Groep”. This is the group responsible for SAMG evaluations in the shelter

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The organizational aspects of the emergency response are specified in the Emergency Plan. The SAMG introduces new structured activities for emergency response personnel in a number of major areas. For each of these major areas it is necessary to define the members of the emergency response organisation who are responsible for:

- Evaluation; This is done by the people who perform the evaluation (using the SAMG’s) and recommending the appropriate recovery actions. These people need a detailed knowledge of the Severe Accident Management Guidelines
- Recommendation; This is done by the person who gives the recommendation of the to be applied strategy
- Decision making; This is done by the person who holds the authority to implement the recommendations. This person has a broader understanding of the status of other aspects of the emergency response
- Implementation; This is done by the persons who perform actions in the control room to implement the chosen strategy.

The new structured activities include:

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- The transition from EOP’s to SAMG
- The use of the SACRGs (Control Room Guidelines)
- Plant evaluations, development of recommended strategies and implementation of these
- Special cases (e.g. intentional fission product releases)
- SAMG termination and long-term recovery.

The matrix of the responsibilities for KCB is shown in table 1

<table>
<thead>
<tr>
<th>Task</th>
<th>Evaluation</th>
<th>Recommendation</th>
<th>Decision</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition from EOPs to SAMG</td>
<td>S/SM</td>
<td>MOB</td>
<td>SM</td>
<td>S/SM</td>
</tr>
<tr>
<td>Use of the SACRGs</td>
<td>-</td>
<td>-</td>
<td>SM</td>
<td>S/SM</td>
</tr>
<tr>
<td>SAMG evaluations, recommendations and implementation of strategy</td>
<td>TAG/MOB</td>
<td>MOB</td>
<td>SED</td>
<td>S/SM</td>
</tr>
<tr>
<td>Special cases</td>
<td>MS/MOB</td>
<td>MOB</td>
<td>SED</td>
<td>SM</td>
</tr>
<tr>
<td>Terminate use of SAMG</td>
<td>TAG/MOB</td>
<td>MOB</td>
<td>SED</td>
<td>S/SM/TAG</td>
</tr>
<tr>
<td>Long term recovery</td>
<td>BT</td>
<td>BT</td>
<td>SED</td>
<td>S/SM</td>
</tr>
</tbody>
</table>

3 Severe Accident Management Training

3.1 General

Severe accident management training has been provided to persons within the plant staff who have been designated for a decision making and support role in severe accident space. This training had sufficient depth and provided the staff with the ability to make independent judgements on severe accident conditions and appropriate response actions.

The operator training for the SAMG’s consists of five phases:
- general introduction courses into the plant specific severe accident phenomena and the use of SAMG’s
- full scale emergency exercise focused on training the Alarm Response Organization for SAMG-implementation and -validation
- table-top exercises in the usage of the SAMG’s focussed on training the operator in understanding and application of the guidelines
- table-top exercises in the usage of the SAMG’s focussed on training the operator in application of the EOP’s and SAMG’s within the Alarm Response Organization.
- full-scale emergency exercise focussed on training the Alarm Response Organization up to and including SAM.

Main purposes of these courses and table-top exercises are to give the operator insight in the structure of the SAMG’s, give insight in the strategies as proposed in the SAMG’s and give the operator
experience in the usage. At the same time the exercises serve as a review of the SAMG’s and training in the different responsibilities within the Alarm Response Organization.

The main information for the operator training is based on the next Borssele sources:
- safety evaluation and design base accident analyses. From this the behavior of the plant during design base accidents is determined
- plant simulator for design base accident analyses and training
- full-scope PSA level 3
- MAAP severe accident calculations
- MAAP-GRAAPH visualization of Borssele NPP.

3.2 Introduction Training ERO and shift personnel

The SAMG training can be divided for the different responsibilities. As first step in the implementation of the KCB SAMG’s, an initial one-week training program for EPZ ERO staff responsible for evaluation, recommendation and decision in SAM space was provided. The program included:
- an introduction and background to severe accident management, to SAMG and to the Borssele project
- an overview of the phenomenology of severe accidents (in-vessel phase and ex-vessel phase). This part is concentrated on those aspects of severe accident phenomenology of importance in SAMG
- a general SAMG overview. This includes the EOP interfaces and the control room guidelines
- an overview of the Emergency Plan and Interfaces
- an overview of the organisational responsibilities
- Borssele SAMG diagnostics. This includes the diagnostic flowchart and the severe challenge status tree
- an overview of the Borssele SAMG strategies which are applied in the guidelines
- an overview of the general SAG- and SCG-structure
- review of all Borssele guidelines (SAG’s, SCG’s and SAEG’s)
- an overview of the Computational Aids
- the Rules of Usage for the SAMG’s
- a practical exercise in using the SAMG’s
- wrap-up and summary of the course
- an individual test for each participant. This test gives an indication of the actual knowledge of participants and shows which items need further clarification.

After that the shift personnel (responsible for implementation) received similar overview training on the SAMG’s, except they were not involved in a detailed review of all Borssele guidelines (SAG’s, SCG’s and SAEG’s).

3.3 Full scale exercise for SAMG-implementation and -validation

A full-scale exercise focused on training the Alarm Response Organization and for SAMG-implementation and validation was developed by NRG with input from EPZ. The participants of these exercises were:
- a full Beleidsteam (SED, MOB, MOD and MSB)
- the shift personnel
- the TAG
- the BOC
The exercise participants are operating in the shelter (the normal work location for the ERO). During the use of the SAMG’s, information will be communicated both from the control room to the ERO and from the ERO to the control room. For example, the ERO will communicate the mitigative action required to the control room, and the control room will be updating the ERO on the availability of system alignment to restore diagnostic parameters to their acceptable range. Also during implementation of a severe accident management strategy, some dialogue will be held to complete implementation steps. Standard forms have been developed to communicate between control room and the shelter.

The SAMG contains strategies which may, under situations of extreme challenge to containment integrity, call for venting the containment via available paths – thereby causing a deliberate release. The person in the shelter who is responsible for predicting fission product releases is the “Manager. Stralingsbescherming”. This person is calculating the consequences of deliberate venting. He is also exercised during the full-scale exercises.

3.4 Table top exercises for the ERO

For the table-top exercises specific accident scenarios are defined which guide the operator through specific parts of the SAMG’s. The exercises are developed by NRG. There are two types of table-top exercises:
- exercises focussed on training the operator in understanding and application of the guidelines
- exercises focussed on TAG responsibilities and communication within the Alarm Response organisation

3.4.1 Determination of PPS parameters

An EXCEL tool was created to represent the information that the operator normally retrieves from the plant status computer. The information is based on safety evaluations, MAAP calculations and design base accident analyses. The presented information contains the following information:
- the plant parameters needed to perform the SAMG diagnostics and evaluations, these are the parameters included in the diagnostic flowchart and the severe challenge status tree
- the parameters which are needed for the availability of major equipment to perform the SAMG strategies

The information of the screens is updated automatically every 15 minutes.

3.4.2 First type of table-top exercises

The main purposes of the first type of exercise are:
- obtaining insight into the structure of the SAMG’s
- obtaining insight into the strategies of the SAMG’s
- obtaining experience in usage of the SAMG’s.

The participants to these exercises are:
- two scenario-leaders
- 3 members of the TAG

The schedule of these exercises is:
- preliminary discussion of the scenarioleaders. During this discussion the scenario and the to be used SAMG’s are discussed
- briefing of the TAG. The TAG is informed about the initial sequence of the accident and from which procedure the SAM-space is entered
- exercise. The duration is approximately 2 hours. The information of the PPS-parameters is updated every 15 minutes. An example of screen with PPS-parameters is shown in table 2.
### Table 2: An example of a PPS-parameter screen

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SAMG DIAGNOSTIC PARAMETERS</th>
<th>EENHEID</th>
<th>WAARDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIVEAU SG1</td>
<td>SAG-1: &lt; 8,63 m</td>
<td>m</td>
<td>3,56</td>
</tr>
<tr>
<td>YB001L152</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIVEAU SG2</td>
<td>SAG-1: &lt; 8,63 m</td>
<td>m</td>
<td>8,63</td>
</tr>
<tr>
<td>YB002L152</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRIMAIRE DRUK</td>
<td>SAG-2: &gt; 6 bar eff</td>
<td>bar</td>
<td>10,20</td>
</tr>
<tr>
<td>YA001P064</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YA002P064</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YA000P152</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KERNUITREDE TEMPERATUUR</td>
<td>SAG-3: &gt; 370 gr. C</td>
<td>gr. C</td>
<td>185,77</td>
</tr>
<tr>
<td>YQ031T104</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YQ031T105</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YQ032T101</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YQ032T102</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YQ032T103</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YQ032T106</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIVEAU IN REACTORPUT</td>
<td>SAG-4: &lt; 3,25 m</td>
<td>m</td>
<td>4,23</td>
</tr>
<tr>
<td>TJ010L001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOZING</td>
<td>SAG-5: &gt; 1,3 E15 Bq/h</td>
<td>Bq/m3</td>
<td>2,85E+07</td>
</tr>
<tr>
<td>EDELGASSEN</td>
<td>SCG-1: &gt; 1,3 E16 Bq/h</td>
<td>Gy/h</td>
<td>3,17E-05</td>
</tr>
<tr>
<td>TL080R013</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TL080R023</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTAINMENT DRUK</td>
<td>SAG-6: &gt;0,3 bar eff; SCG-2: &gt; 6,3 bar eff; SCG-4: &lt; -0,17 bar eff</td>
<td>bar eff</td>
<td>0,17</td>
</tr>
<tr>
<td>TL004P005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WATERSTOF CONCENTRATIE</td>
<td>ZIE CA-6</td>
<td>%</td>
<td>0,40</td>
</tr>
<tr>
<td>TS090A001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS090A002</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Concerning the remaining information during the exercise (e.g. the response on proposed actions) the TAG communicates with the scenario leaders - debriefing and evaluation. The TAG is informed about the scenario and the exercise is discussed.

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3.4.3 Second type of table-top exercises

The main purposes of the second type of exercise are:
- exercise of the tasks for the TAG and allocation of work in SAM-space
- exercise of the communication and cooperation within the Alarm Response Organization
- acquaintance and exercising with the TAG-resources, a.o. for communication and the SAMG’s.

The participants to these exercises are:
- a scenario-leader
- one MOB-person
- the shift
- 3 members of the TAG

The schedule of these exercise is as in the first type, but more extensive and the duration of the exercise is 3 hours.

3.5 Full scale exercise for training the Alarm Response Organisation

Full-scale exercises focussed on training the Alarm Response Organization including SAM will be held as part of the normal Alarm exercises for the ERO. The participants and location of these exercises are:
- a full Beleidsteam (SED, MOB, MOD and MSB)
- the shift personnel
- the TAG
- the BOC

The exercise participants are operating in the shelter (the normal work location for the ERO).

4 Conclusions

At KCB severe accident management training has been provided to persons within the plant staff who have been designated for a decision making and support role in severe accident space. This training provides the staff with the ability to make independent judgements on severe accident conditions and appropriate response actions.

Applying the training program and information the Borssele plant fulfills the objectives of improving operator knowledge, improving operator skills and testing the SAM organization efficiency.
1. **Introduction**

The defence in depth concept requires not only provisions for coping with anticipated operational occurrences as well as design basis accidents but also provisions which allow appropriate reactions to beyond design basis accidents. In accordance with this concept the Nuclear Safety Convention, which was signed by many IAEA Member States, deals among others with emergency preparedness and the correlated provisions. The Safety Convention requires that on-site and off-site emergency plans are routinely tested for nuclear installations. The aim of these provisions is primarily the prevention of radiological consequences in the environment of nuclear installations but also the mitigation of such consequences, should they nevertheless occur.

Up to the eighties emergency preparedness concentrated on a few provisions by the operators and in particular on plant-external emergency planning. As a result of the accidents at Three Mile Island as well as Chernobyl and with the findings from many risk studies, accident management measures and emergency procedures were developed. This led to an increased plant internal emergency preparedness focussing on the prevention of severe core damage in case of beyond design basis accidents and on the reduction of external consequences in case of such hypothetical events.

2. **Provisions by the operator**

In the technical field various severe accidents have been analysed and based on these analyses additional technical measures have been added and special emergency procedures have been developed e. g. for the use of operational systems or special emergency systems in emergency cases.

With the increased plant-internal emergency preparedness the operator has received an additional role in order to comply with the above mentioned aims. For this reason, special organisational and technical measures have been implemented by operators and special training is performed to get and
keep the operator’s personnel familiar with the necessary knowledge and the individual tasks and responsibilities.

The Reactor Safety Commission (RSK) has essentially influenced the progress of the emergency provisions by issuing respective recommendations. In 1987 the RSK recommended the implementation of emergency measures for German npps. In 1993 the RSK recommended to lay down the pre-planned emergency procedures in an emergency manual and to drill them as far as possible. The RSK also dealt with the contents and scope of emergency manuals as well as with general requirements concerning emergency exercises.

3. Emergency exercises

According to the above mentioned general requirements concerning emergency exercises at least one comprehensive exercise has to take place annually at each unit. The crisis management as well as supporting teams necessary for the respective scenario take part in the exercise. Beside this annual exercise there are modular drills like fire fighting, rescue of injured persons or environmental surveillance. The shift personnel undergoes retraining with recurrent simulator training among others. In this context symptom-orientated procedures and to some extent beyond design basis scenarios are trained.

In the past the comprehensive emergency exercise was usually performed on the basis of so-called event-sheets. These event-sheets present the essential information and the relevant parameters of the pre-planned event sequence. The event-sheets are prepared on the basis of former accident analyses or with the help of simulator runs.

Beside this conventional exercise type with event-sheets presented by the exercise co-ordinator there is the simulator-assisted exercise type. A major prerequisite for a broader application of this type of exercise is the availability of plant-specific simulators with a capability to simulate preventive accident measures in the beyond design basis range.

3.1 Simulator-assisted emergency exercises

As quite a number of new plant-specific full-scope simulators is only available since about 3 years, (s. table 1), for German npps there have been very few simulator-assisted exercises in the past. In context with a project funded by the Federal government a few simulator-assisted exercises have been performed with various npps with the aim to derive recommendations for the planning, co-ordination and evaluation of plant internal emergency exercises. Some more generic findings are presented in the following.

Table 2 gives an overview of the boundary conditions related to the five exercises. This table clarifies that there is no standardised background for the exercises neither in the technical field nor in the organisational/administrative field. Columns 1 and 2 show that the reactor types were different, column 5 shows different kinds of crisis organisations. A factor which at first glance seems to be very important for the performance of simulator-assisted exercises is the site of the simulator in relation to
the npp site. Column 3 shows that only in one case the simulator was located at the npp site whereas the simulator usually is installed in the remote simulator centre.

The crisis organisation may consist of only one centralised control management with supporting personnel at its disposal or of several control teams in particular

- the main control team
- the operation control team
- the radiological control team
- the service control team

In both cases the necessary functions like

- overall crisis management
- plant status analysis and decision on countermeasures
- radiological/physical/chemical surveillance
- services for mechanical/electrical systems
- information of authorities and of the public
- other services (e.g. fire fighting, security)

have to be covered.

The co-operation between the participating groups is managed as shown in fig. 1. In the very beginning of the exercise the shift at the simulator contacts the npp control room e.g. for the initiation of internal alarms and informs the operation stand-by manager. After the establishment of the crisis team the main communication takes place between the simulator control room and the crisis team. At that time liaison persons in the simulator control room enter upon the communication and relieve the simulator shift. Necessary services are then requested by the crisis team.

The success of simulator-assisted exercises is usually not very dependent on the location of the simulator although generally the core of the crisis team convenes at first in the control room in order to get background information on the event. With an efficient data link between the simulator and an appropriate meeting place in the npp and with some additional information by phone from the shift or the liaison person, the crisis team has a proper basis for its work. Without real time data transfer of selected process parameters, however, the task is more difficult and the crisis team has to rely much more on the persons in the simulator control room.

### 3.2 Generic findings

Emergency exercises have already been performed for many years and many weaknesses have been eliminated. Nevertheless, there are a few generic findings resulting in most cases form the simulator-assisted type of exercise performance. There are three essential differences between simulator-assisted exercises and exercises based on event-sheets, namely:
- Every process information must be taken from the instrumentation and is not presented on paper (event-sheets) with already selected parameters.

- The reaction to the simulated scenario is time-consuming and needs good co-ordination. Declarations of intended actions are easier and faster.

- The event sequence is simulated in real time and wrong or untimely reactions show very soon their negative consequences.

The following topics which in many cases need attention have been noticed:

- Excessive charge of single persons
The association of tasks with special functions may be unbalanced. In particular the shift supervisor may be overburdened in the first phase of the event sequence. During the usual simulator retraining the shift supervisor concentrates only on the plant behaviour. During the exercise, however, the shift supervisor has to care additionally for internal and in case also external alarms as well as the first information of the operation stand-by manager and the head of the crisis team. Other tasks, like information of other npp units or filling in of plant-status reports should be properly distributed.

Real time exercises may also help to examine if other positions are overburdened.

- Support of the radiological control team
With simulator-assisted exercises there are no selected data listed on a sheet and the radiological control team is forced to get the relevant radiological data from the instrumentation. This task is usually done without any problem. In special event sequences there are, however, radioactive releases without radiological instrumentation indication. For an estimation of the potential radiological consequences the radiological control team needs for instance information on the amount of released coolant. The operation control team should make this information available to the radiological control team.

- Visualization of information to the crisis team
With exercises based on event-sheets selected data and in case also trend curves are handed over. So there is little need to document systematically the essential information. Simulator-assisted exercises have very often shown that the available information is not systematically documented which in some cases leads to a reduced overview. Three items are in particular helpful for the crisis team:

  • Plant status overview
  The hypothetical scenarios for emergency exercises are generally created by a combination of faults as well as system outages with some additional time dependent or event dependent failures and in case the repair of one or the other system.

  For a good and timely overview of such a complex situation to the members of the crisis team a rough plant scheme is helpful in which the not available systems can be indicated.

  • Trend curves
  In plants disposing of a process information system relevant parameters and trend curves can be presented on screen and can be printed. As the trend curves of the few crucial parameters give very valuable information on the event sequence trend curves should also be available in those plants without a process information system. A video-transmission of the respective recording strips may be one way for the presentation of such trend curves.
• Lists of measures
Due to the various assumed failures various repair measures may be initiated during the exercise. In addition some long lasting emergency measures may be performed. A systematic listing of the current measures with appropriate updating should give the crisis team the necessary overview on the status of these actions and the expected time of completion.

- Status reports
The responsible authorities are informed about the emergency event by phone as well as by faxed forms and status reports.

The operators have developed a harmonised frame for the plant and radiological status reports. The harmonised frame may plant-specifically be adapted.

The exercises have shown that the transmission of these status reports is on the average about half an hour or even more behind the timely situation. So on this way the authorities usually get outdated information. This disadvantage could be overcome by direct data links with a transmission of a number of relevant process data. This way is used in countries like France, the United States and Switzerland. The installation of such data links is in particular then worthwhile when the authorities regularly play an active role in the emergency exercises.

- Information sheets for control teams
During the preparation of the emergency exercise, a number of documents are prepared. Beside the exercise sequence plan there are in particular

• Exercise rules
• Exercise instructions for service teams and observers
• Sheets for on-site deposition (explaining the on-site situation e.g. for service teams)

In addition to these documents information sheets for the crisis team or the individual control teams should be prepared indicating for instance

• The procedure and extent to which repair measures or emergency measures are performed or only simulated
• The intended extent of environmental surveillance
• The intended involvement of external organisations, like Siemens-KWU crisis team
• The real or simulated mission of a liaison person to the emergency protection authority

- Evaluation of exercise results
For the evaluation of the exercise results principally a meeting is held immediately after the exercise. In some cases all participants in the exercise convene and comments are given concerning the preparation and boundary conditions of the exercise as well as the actual performance by the active participants. In some cases only (or additionally) the exercise co-ordinator(s) and observers meet and exchange their findings. Mostly these discussions are more detailed and frank.
4. Outlook

For emergency exercises based on event-sheets Volume 1 of the “Manual for the Planning, Coordination and Evaluation of Emergency Exercises” has been elaborated in 1997. This manual emphasizes the modular structure of emergency exercises.

The performed simulator-assisted exercises show that this type of exercises offers an extension of the spectrum of training measures. Explanations and findings related to this type of exercises are summarized in a second Volume of the above mentioned manual. In this volume the pros and cons of the two exercise types are discussed among others.

Using the gathered experience laid down in particular in the two volumes of the manual a basis for authority recommendations with regard to the planning, performance and evaluation of plant internal emergency exercises shall be developed.

Fundamental outcome: Simulator-assisted exercises are a very efficient kind of plant internal emergency exercises, in particular when the co-operation between the crisis team and shift shall be trained. If other training modules are the main exercise aim, the conventional exercise type (with event sheets) is suitable. Furthermore the conventional exercise type must be used when the chosen exercise scenario exceeds the simulation limits of the simulator.
### Simulators at KSG / GIS*

<table>
<thead>
<tr>
<th>Simulator</th>
<th>Reference Plant</th>
<th>Training Simulator for</th>
<th>I/O s</th>
<th>RFT</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Biblis, B</td>
<td>Biblis A/B, Stade</td>
<td>≈12.900</td>
<td>1977</td>
<td>Singer, USA</td>
</tr>
<tr>
<td>D2</td>
<td>Mülheim-Kärlich</td>
<td>Mülheim-Kärlich</td>
<td>≈23.400</td>
<td>1986</td>
<td>EAI/Singer, USA</td>
</tr>
<tr>
<td>D41</td>
<td>Emsland</td>
<td>Emsland, Neckarwestheim 2, Isar 2</td>
<td>≈23.000</td>
<td>1996</td>
<td>Siemens/S3T, Deutschland/USA</td>
</tr>
<tr>
<td>D42</td>
<td>Philippsburg 2</td>
<td>Philippsburg 2</td>
<td>≈25.000</td>
<td>1997</td>
<td>Siemens/S3T, Deutschland/USA</td>
</tr>
<tr>
<td>D43</td>
<td>Brokdorf</td>
<td>Brokdorf</td>
<td>≈28.700</td>
<td>1996</td>
<td>Siemens/S3T, Deutschland/USA</td>
</tr>
<tr>
<td>D51</td>
<td>Unterweser</td>
<td>Unterweser</td>
<td>≈16.000</td>
<td>1997</td>
<td>Thomson, Frankreich</td>
</tr>
<tr>
<td>D52</td>
<td>Neckarwestheim 1</td>
<td>Neckarwestheim 1</td>
<td>≈11.100</td>
<td>1997</td>
<td>Thomson, Frankreich</td>
</tr>
<tr>
<td>D56</td>
<td>Obrigheim</td>
<td>Obrigheim</td>
<td>≈10.600</td>
<td>1997</td>
<td>Thomson, Frankreich</td>
</tr>
<tr>
<td>S1</td>
<td>Brunsbüttel</td>
<td>Brunsbüttel</td>
<td>≈14.800</td>
<td>1978</td>
<td>Singer, USA</td>
</tr>
<tr>
<td>S2</td>
<td>Gundremmingen</td>
<td>Gundremmingen B/C</td>
<td>≈21.800</td>
<td>1993</td>
<td>Siemens, Deutschland</td>
</tr>
<tr>
<td>S31</td>
<td>Isar 1</td>
<td>Isar 1</td>
<td>≈18.000</td>
<td>1997</td>
<td>Atlas Elektronik, Deutschland</td>
</tr>
<tr>
<td>S32</td>
<td>Philippsburg 1</td>
<td>Philippsburg 1</td>
<td>≈16.300</td>
<td>1997</td>
<td>Atlas Elektronik, Deutschland</td>
</tr>
</tbody>
</table>

*There is furthermore the simulator D 53 (≈ 14200 I/Os) for the Dutch NPP Borssele

### Simulators at NPP site

<table>
<thead>
<tr>
<th>Reference Plant</th>
<th>Training Simulator for</th>
<th>I/O s</th>
<th>RFT</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Krümmel</td>
<td>Krümmel</td>
<td>27.600</td>
<td>1997</td>
<td>Siemens/S3T</td>
</tr>
<tr>
<td>Stade</td>
<td>Stade (operation via graphical interface)</td>
<td></td>
<td>1998</td>
<td>CAE/Kanada</td>
</tr>
</tbody>
</table>
Table 1: Available Simulators
<table>
<thead>
<tr>
<th>NPP</th>
<th>Reactor type</th>
<th>Simulator</th>
<th>PRISCA</th>
<th>Crisis-organisation</th>
<th>Scenario</th>
<th>External Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>KRB-II</td>
<td>BWR-72 (1984/85)</td>
<td>S2/KSG</td>
<td>no (Videotransmission)</td>
<td>decentralised</td>
<td>station blackout</td>
<td>(BStMLU)</td>
</tr>
<tr>
<td>GKN-1</td>
<td>PWR 3-Loop (1976)</td>
<td>D52/KSG</td>
<td>yes</td>
<td>centralised</td>
<td>small leak + impairment of RPV-feed</td>
<td>UVM-BW KS-KWU</td>
</tr>
<tr>
<td>KWB-B</td>
<td>PWR 4-Loop (1977)</td>
<td>D1/KSG</td>
<td>BuB-System</td>
<td>decentralised</td>
<td>Open MS safety valve + 3 SGTR</td>
<td>KHG, HMULF LA/PD-HP, KS-KWU</td>
</tr>
<tr>
<td>KKE</td>
<td>PWR – Konvoi (1988)</td>
<td>D41/KSG</td>
<td>Yes</td>
<td>centralised</td>
<td>total loss of SG feed</td>
<td>UM-Nds,TÜV</td>
</tr>
<tr>
<td>KKK</td>
<td>BWR-69 (1984)</td>
<td>KKK</td>
<td>no</td>
<td>decentralised (with centralised meetings)</td>
<td>loss of heat sink + impairment of RPV-feed</td>
<td>MFE</td>
</tr>
</tbody>
</table>

Table 2: Simulator-Assisted Exercises
The two J. M. Farley Nuclear Plant (FNP) units are of three loop, Westinghouse pressurized water reactor design. Commercial operation began for Unit 1 in 1977 and Unit 2 in 1981. The Control Room SAMG “Implementors” are on-shift in six crew rotation. Each crew compliment includes an Operations Shift Superintendent, two Unit Shift Supervisors and four Reactor Operators.

The Emergency Response Organization (ERO) SAMG “Decision Makers” and “Evaluators” are on-call in three crew rotation. Each crew compliment includes two Decision Maker trained individuals and six Evaluator trained individuals. During non-SAM events these personnel normally fill the position of Technical Support Center (TSC) Emergency Director, Technical Manager, Operations Manager, Systems Engineer, and Emergency Operations Facility (EOF) Recovery Manager, Recovery Manager Assistant, Dose Assessment Director, Reactor Engineer.

Severe Accident Management Guidance at FNP is based on the Westinghouse Owners Group (WOG) generic guidance. Implementation was conducted in accordance with the Nuclear Energy Institute NEI 91-04 Closure Process. This process which included the modification of generic guidance to be plant specific, interfacing the SAMG with the Emergency Plan, incorporating SAM material into training programs, and establishing a means to factor in new SAM information was completed in July of 1997. This paper provides a description of the pre and post implementation lessons learned to include plant specific SAMG enhancements and training challenges.

Implementation and Initial/Continuing Training Challenges

A twenty-seven step action plan was used to complete the closure process. A SAM Working Group was formed to administer the action plan and in doing so become the site experts for all aspects of implementation, to include training. The group was comprised of ten Senior Reactor Operator qualified personnel from Operator License Training, Technical Training, Emergency Planning, Operations, Probabilistic Safety Assessment (PSA), and Licensing. In order to gain SAM insights for incorporation into the FNP training plan, members of the FNP SAM Working Group actively participated as members at the WOG initial pilot exercises and in the WOG Core Training Group. The WOG Core Training Group was responsible to the WOG industry members for SAM training material scope, development and review. The insights gained from industry participation was shared with the members of the FNP SAM Working Group in “train-the-trainer” sessions in order to speed the learning process and enhance the action plan end product.

Members of the working group were tagged as “experts” for each SAM guideline and training lesson. As an expert, the member was responsible for research on all aspects of the SAM guideline and plant-specific conversion of the actual guideline and lesson material. These members attended the
initial classroom and performance based training sessions to provide the background knowledge base needed for meaningful classroom discussion.

Performance based training is the primary tool used to establish SAMG initial qualification and to maintain that qualification on a continuing basis. Objective based evaluation of team performance during interactive mini-drills is the training atmosphere that has been found most effective. The training objectives can easily be sorted into two categories: Can the team use the guidance to enhance the plant’s Emergency Plan response and can the team effectively communicate? (Table1) A point of interest is that SAMG job and task analysis identified no new jobs or tasks. The SAM team is simply prioritizing the performance of repair activities to allow normal design space jobs and tasks to be performed out of the normal sequence that would be directed by the plant’s Normal, Abnormal or Emergency Operating Procedures.

Adverse environmental effects required training on use of alternative instrumentation and a re-focus on trending rather than on instrument accuracy. Environmental qualification of specific instrumentation became less important than the ability for SAM users to identify if all instrumentation for a particular parameter was trending in a consistent manner. Proper instrument scaling was not much of an issue because scaling was checked and calculated setpoints were rounded conservatively so that setpoint values were actually readable on the designated instruments. Harsh environment effects on referenced instruments and the potential usefulness of that instrument during a severe accident were placed in table format (Table 2) for easy reference and notes were added to direct users to the tables. The fact that the forty-one setpoints referenced by the SAM guidelines/computational aides do not contain the instrument errors and uncertainties required for the same setpoints within the Emergency Operating Procedures was also a source of many training discussions.

The seven Computational Aides were found by SAM users to be very easy to use after minimal training. Subsequent usage has resulted in several user requested changes. The changes include revision to or addition of notes to ensure that these graphical aides are clear and of sufficient detail to stand alone. Users have been found to be reluctant to reference WOG background documents because of the perceived or actual time constraints of simulated events.

Several guideline strategies introduced the concept of weighing the positive and negative consequences of actions prior to deciding to take a particular directed course of action. From the normal operating, verbatim compliance world of the EOP step usage, this concept was difficult for trainers to convey and considerable time was spent building teamwork skills in this area. Directed classroom table-top skill building sessions were used as the primary training medium to enhance the needed skills.

Training in use of Severe Accident and Severe Challenge Guideline usage appeared to be extremely difficult. Worksheet and table design within each guideline was determined to be a human factoring problem. The worksheets within the guideline continuously referred to the tables located at the end of the guideline. The swapping back and forth resulted in the users getting lost in the process of completing the worksheets instead of remaining focused on the guideline strategy. Combining the information in the tables with the information in the worksheets simplified the guideline usage and trainee strategy understanding was observed to markedly improve.

The converse was true concerning the use of out-of-guideline reference to procedural usage steps. Because of user familiarity with the design space procedures, trainees recommended that the SAM guidelines reference steps in existing procedures when ever possible. System Operating Procedures were found to provide all needed component/system support and initial condition references. Normal, Abnormal, and Emergency Operating Procedures were found to provide all
needed system alignment requirements. Although many referenced steps in the SAM guidelines are out of the normal sequence that would be expected for normal design space operation, users preferred using the existing procedure steps despite the need to constantly reference steps outside the written SAM guidelines. Use of existing design space procedural steps also had the added benefit of not having to duplicate and maintain existing steps in the SAM guidelines thus greatly easing the administrative burden for keeping the SAM guidelines current.

Emergency Operating Procedure transitions to the SAM guidelines were found to be straightforward but concerns were raised by trainees during initial training. Two of the three transitions, Loss of all AC Electrical Power and Anticipated Transient without Trip (ATWT), were clearly beyond design basis accidents. For the third transition, Loss of Core Cooling, it was not as clear as to when the loss of coolant accident operating condition exceeded normal design basis space. At trainee request, notes were added to the appropriate Emergency Operating Procedures and SAM guidelines to ensure that normal design space actions were completed and that time was allowed for these actions to effect core heatup rate prior to transition into beyond design basis space.

Within the WOG SAM guideline structure, the Control Room Implementors have only two guidelines. One of these guidelines provides active strategy implementation guidance prior to the Technical Support Center (TSC) being staffed. This guidance allows the Implementors to continue trying to establish actions directed by the Emergency Operating Procedures while providing SAM guidance to limit actions that might jeopardize the Containment barrier integrity. The second guideline, which is entered when the TSC is staffed, directs the Implementors to enter a monitoring only mode. In this monitoring only mode, the Implementors are expressly prohibited from taking actions that would change component/system configurations without prior direction from the TSC Decision Maker. During initial training scenarios, Implementors were eager to follow the guidance provided by the TSC, and transition to the monitoring mode guideline typically took place as soon as the TSC had sufficient staff to be operational. This premature transition resulted in much frustration within the SAM team because the TSC had not yet determined what guidance to recommend and the Implementors were no longer able to implement a strategy without TSC concurrence even if equipment was subsequently returned to service. Notes were added to the appropriate guidelines to prevent the Control Room from transitioning to the monitoring mode guideline until the TSC evaluators have had time to enter the SAM guidelines and develop a strategy for the Control Room to implement. Evaluation of training performance subsequent to adding these notes has been very positive.

When the Technical Support Center staff members transitioned to their SAM staff positions during fast breaking events, key Emergency Planning issues were found to be overlooked. Scenario evaluations were routinely showing that upgrade declarations of the emergency classification level to General Emergency (most severe) were not being performed nor where the notifications to the State agencies that conditions were significantly deteriorated. Additionally, the Technical Support staff was failing to notify the Nuclear Regulatory Commission (NRC) when actions were being taken that departed from the license condition in accordance with Title 10 of the Code of Federal Regulations, Part 50, Section 54(x). Based on trainee requests, steps were added to the applicable guidelines. These steps have been shown to be effective based on subsequent mini-drill performance evaluation.

During initial SAM scenario training evolutions manpower needed to monitor Diagnostic Flowchart (DFC) and Severe Challenge Status Tree (SCST) usage was observed very closely. The evaluation indicated that a single Evaluator’s time would be totally consumed simply updating information provided by the Implementors. A second Evaluator was determined to be needed if the goal of being able to trend data and confirm occurrences of positive and negative consequences following strategy implementation was to be fulfilled. Trainee recommendations led to the development of a Status Board that reduced the burden so that one Evaluator was able to meet all DFC
and SCST monitoring goals (Table 3). The Status Board allows the user to see all guideline priorities on a single page, identify guideline implementation needs based on comparison of setpoint and current parameter value, show which guideline strategies have been implemented, and trend parameters to determine strategy worth and impacts. The Status Board is in the process of being automated which is hoped to free up additional Evaluator time so that more focus can be on evaluation of strategies and observance of instrumentation failure trends.

Initial severe accident phenomena training lessons used at Farley Nuclear Plant in 1995 were created by the Institute of Nuclear Power Operations (INPO). The generic INPO two hour lesson provided a high level overview in multimedia format. The Westinghouse Owner’s Group (WOG) SAM Training Group found that the INPO material lacked needed depth. The group was chartered to develop an expanded phenomena lesson that could be made plant specific and that had the depth needed by the SAM Evaluators. The resultant four-hour lesson was built to expand on the INPO lesson and was first taught to all SAM users at FNP in 1996. The two courses are still used for initial training. A two hour continuing training lesson has subsequently been developed by FNP and is presented to all SAM users annually to maintain needed phenomena awareness. Evaluation of the continuing training course effectiveness indicates that two hours is sufficient to maintain the needed phenomena awareness given that the SAM guidelines contain many phenomena references to ensure the SAM users understand the cause and effect phenomena relationships of implemented strategies.

The WOG also funded development of SAM guideline specific lessons. The lessons were developed so that they could easily be made plant specific. Only the nine lessons developed to provide training on SAM overview, instrumentation usage, Diagnostic Flow Chart usage, and Severe Accident Control Room Guideline usage were designed to be presented in a classroom format. The WOG recommended 15 hours of classroom time be allowed for presentation of these lessons. The remaining twenty-one lessons developed to provide training on each SAM Guideline were designed for repetitive self-study application. The self-study modules include self-assessment questions so that a student can evaluate their understanding prior to advancing to subsequent guideline modules. The WOG recommended 45 hours of self-study time be allowed to complete these self-study lessons. Several trainees evaluated the self-study modules and determined that the modules were a good training tool but that initial training using the self-study approach could take significantly longer than a classroom approach. The trainees went on to recommend that Farley conduct all initial training in a classroom format. Their recommendation was accepted and in 1996, three twenty-eight hour classroom training weeks were conducted for all SAM guideline users. Even though not required, all Farley Implementors attended each of the seven, four hour lessons based on their desire to understand the strategies to be utilized. Post evaluation quizzes indicated that the initial training was adequate.

Performance based training was facilitated through the use of SAMG mini-drill scenarios. Farley Nuclear Plant’s Individual Plant Evaluation (IPE) results were used to choose the most probable core damage sequences that could lead to SAMG entry. The sequences were then provided to the probabilistic safety assessment (PSA) staff so that data sets could be created using MAAP-3B. MAAP results were converted to spreadsheet format to allow manipulation of suspect data points, timeline compression, and unit conversion necessary to make data more useful for drill purposes. To enhance scenario realism and increase the worth of the training time for Control Room Implementors, the Simulator was used to drive the scenario through an Abnormal/Emergency Operating Procedure front end that led into each core damage scenario.

Initial performance based training was conducted in 1996 with a fully integrated Control Room Implementor staff and TSC/EOF Evaluator/Decision Maker staff. Integration with other Emergency Response Organization facility locations, such as the Operations Support Center (OSC) and Corporate Emergency Operations Center (EOC) were simulated through use of control cells. Each
of the six Implementor crews participated in eight hours of mini-drill scenario training while each of
the three Evaluator/Decision Maker crews participated in sixteen hours of mini-drill scenarios.

A matrix was constructed that verified that the selected scenarios exercised all SAM
guidelines and EOP transitions. The following scenario commonalities existed:

- All scenarios went well beyond the design basis of the plant
- All scenarios started on a live simulator in Abnormal/Emergency Operating space
- Timeline dependent data was provided via overhead transparency projection when simulator
  modeling was exceeded
- “Time-outs” were used to re-focus/discuss strategy positive/negative implementation concerns
- Crews were directed to make real-time emergency classifications and notifications
- Crews were forced to prioritize needed tasks based on simulated real staffing
- Each scenario allowed the crew to exercise an EOP to SAMG transition
- Success paths were allowed even though data may not have shown that strategy
  implementation was a success

During the implementation phase, all mini-drill performance was evaluated by the SAM
Working Group and management. Guideline usage was considered effective and reasons for strategy
implementation or non-implementation defendable. Initially inter-facility communication appeared to
be a major barrier. Operations and Emergency Response Organization crews learned to communicate
more effectively from scenario to scenario. All crews determined that effective communication
methods varied based on the scenario.

In 1997, each of the SAM Evaluator/Decision Maker teams were offered three additional four-
hour mini-drill scenarios to validate enhancements in the guidelines and to evaluate implementation
readiness. As was done during initial performance training sessions, the scenarios used were designed
to force multiple strategy usage and test communication objectives. These scenarios did differ
however in that they were not time dependent. Instructor/facilitators had the option of allowing the
SAM teams to explore guideline paths to whatever detail that was warranted. At the completion of
these sessions each of the crew Decision Makers were convinced that their crew could successfully
implement the SAM guidance.

SAM mini-drill continuing training requirements at Farley were established based on the
industries desire to effectively manage training resources by ensuring that the need for training on low
probability SAM events was maintained in perspective with the need for continuing training on the
more probable design space events. The decision was made to conduct one SAM mini-drill per
calendar year and to rotate crew annual participation so that each of the three Emergency Response
Organization crews participates in a SAM type drill every three years. Decisions were also made that
Implementor as well as Operations Support Center (OSC) and EOF participation would be simulated
by control cells for continuing training mini-drills. MAAP (version 4 now) remains the tool of choice
to develop needed data to drive scenario play.

The following is a summary of the major training challenges that have been identified during
Plant Farley continuing training:

1) In order to build a beyond design basis SAMG knowledge base that was as in-depth and as
well understood as the design basis accident Emergency Response procedure knowledge
base, it was determined that SAMG continuing training would have to be melded with
normal design basis simulator training for Implementors. This was done by allowing
simulator scenario progressions into SAMG space on a more frequent basis with inter-
facility play being simulated or discussed.
2) Implementors (Control Room staff) needed to be trained initially to a greater depth on SAMG than was previously believed. This was necessary so that directed actions to protect the Containment Barrier in beyond design basis space were understood and followed even though they might fundamentally contradict actions that might have been provided in design basis space.

3) In 1998 Evaluator/Decision Maker continuing training, FNP found that the crews had not had sufficient repetitive training and that additional continuing training sessions would be necessary to allow SAM guidance to be implemented at the same level of proficiency that exists with the Emergency Operating Procedures. For years 1998 and 1999 the continuing training was expanded such that each crew participated in a one-hour guideline usage refresher training session just prior to participating in a three-hour mini-drill. Evaluation in year 2000 indicated that the added exposure to the SAM usage had been effective in raising the crews performance to the desired standard.

4) The use of guidance, which does not require strict procedural compliance, continues to surface as an issue during training. The problem revolves around two issues: the Control Room Implementor’s need for assurance that actions being implemented by them are the correct directed actions and assurance that the TSC is responsible for the consequences of the directed actions being performed. A SAM User’s Guide which clearly explains the responsibility chain was created to provide a readily available reference for the SAM users in both the TSC and the Control Room. In addition a SAMG Strategy Implementation Instruction Sheet was incorporated into the Farley SAMGs so that the Control Room would have written documentation regarding the TSC’s directed actions. During guideline usage refresher training, TSC Evaluators and Decision Makers are also reminded of the importance of communication with the Implementors. This communication goes beyond the need to provide directed actions; the communication must include explanations of why strategies are being implemented and the positive and negative consequences associated with the strategy implementation.

5) Time compression of scenarios can result in negative training from the aspect that SAM users may lose perspective of resources that might otherwise be available to them if the timeline was more near real time. Examples of this problem include hydrogen control actions for the large dry containment designs, effluent release calculations associated with the need to vent containment, and availability of personnel to perform needed corrective maintenance. When developing a scenario timeline, it is important to make these resources appear available to the SAM users via controller interjects or other means of facilitation so that the end result of the training is representative of the actual predicted response.

Summary

As was discussed at the beginning of this paper, one of the key items of the SAMG implementation closure process involved the incorporation of methods to establish a means to factor in new SAM information. Based on the industries self-evaluation of SAM implementation and continuing training, many potential enhancements to the SAM generic guidelines have been identified. Many of these enhancements have been determined to have generic application and are in the process of being folded back into Revision 1 of the WOG generic guidance. In some cases, as was the case at Plant Farley, some of the changes have already been incorporated into plant specific SAM guidance in an effort to improve user performance. It is an industry imperative that change be managed to ensure user performance actually is enhanced and to ensure that severe accident management strategies being implemented actually do improve the capability to protect employees and members of the public. As enhancements are made to SAM programs, the continued self-assessment of Severe Accident Management training activities remains an integral part of an effective change management process.
Table 1. Mini-Drill Scenario Objectives

1. Given access to the SAMG documentation and given the information and data specified in this scenario, the EVALUATOR shall be able to use the guidance provided in the SAMG to perform the evaluations required by that process so that the DECISION MAKER will be able to make process based decisions.

2. Apply the entry criterion and exit conditions for applicable guidelines.
   a. Recognize the criteria for entering applicable guidelines.
   b. Prior to exiting a guideline, ensure that any applicable exit conditions are met and that a process to follow long term concerns is implemented.

3. Determine which strategies are available and applicable under current plant conditions.

4. Identify any negative impacts potentially associated with the available strategies and evaluate action to mitigate negative impacts.

5. Decide whether to implement a strategy and which mitigative action, if any, to take.

6. Specify instructions for the control room pertaining to strategy implementation and mitigative action.
   a. Preferred lineup
   b. Limitations

7. Verify implementation of instructions pertaining to strategies and mitigative actions.

8. Monitor negative impacts and decide whether to take additional mitigative action.

9. Check the effectiveness of an implemented strategy and determine whether additional strategies should be attempted.

10. Evaluate data and interpret instrumentation readings given that severe accident conditions exist.

11. Use computational aids as needed.

12. Actively participate in the scenario critique process.

13. Utilize effective communication techniques to coordinate emergency information/actions with the Control Room IMPLEMENTORS and other ERO staff.
Table 2. Instrumentation Usefulness During a Severe Accident

<table>
<thead>
<tr>
<th>INSTRUMENT</th>
<th>RANGE</th>
<th>USEFULNESS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG Water Level</td>
<td>Narrow Range</td>
<td>0-100% of SG</td>
<td>Likely to be useful during all phases of core damage.</td>
</tr>
<tr>
<td></td>
<td>Wide Range</td>
<td>0-100% above tubes</td>
<td>May also be useful to track large containment pressure transients. Under conditions of high CTMT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>pressure, indicated SGWL may be higher than actual level. SGWL error is also a function of SG</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>pressure, temperature and actual level but all errors are expected to have minimal impact on the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SAMG span of interest.</td>
</tr>
<tr>
<td></td>
<td>(SGWL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG Pressure</td>
<td>0-1300 psig</td>
<td>Likely to be useful during all phases of core</td>
<td>Limited usefulness in diagnosing and monitoring severe accident sequences. Increased CTMT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>damage.</td>
<td>pressure and temperature has minimal effect but does cause indicated pressure to be less than</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>actual pressure.</td>
</tr>
<tr>
<td>RCS Pressure</td>
<td>0-3000 psig</td>
<td>Likely to be useful throughout a core damage</td>
<td>Normal instrument errors may double under high CTMT pressure conditions. Indicated RCS pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>event.</td>
<td>will be lower than the actual pressure if CTMT pressure is elevated. At low RCS pressures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>indications at low end of the scale cannot be considered accurate but are reliable for trending.</td>
</tr>
<tr>
<td>Pressurizer Pressure</td>
<td>1700-2500 psig</td>
<td>Limited in usefulness during core damage.</td>
<td>Lower indication range (1700 psig) limits usefulness during severe accidents. CTMT heating</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>may cause the indicated pressure to be higher than actual pressure. Indicated RCS pressure will be</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>lower than the actual pressure if CTMT pressure is elevated.</td>
</tr>
<tr>
<td>Accumulator Pressure</td>
<td>0-600 psig</td>
<td>Limited usefulness during core damage.</td>
<td>Accumulators may not mimic RCS pressure due to isolation (intentional or due to RCS pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>increases.)</td>
</tr>
<tr>
<td>Core Exit Thermocouples (CETC)</td>
<td>0-2300°F</td>
<td>CETCs not accurate after significant core relocation. Error increases as temperature increases.</td>
<td>Errors can occur from formation of virtual junctions at temperatures &gt;2200°F. Permanent errors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>can occur from formation of new permanent junctions at temperatures &gt;2500°F. Peripheral CETCs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>may be useful longer than center region CETCs.</td>
</tr>
<tr>
<td>Hot Leg RTDs</td>
<td>Wide Range</td>
<td>0-700°F</td>
<td>RTDs may not be accurate after core damage. Cold leg RTD’s is likely to be more reliable and</td>
</tr>
<tr>
<td></td>
<td>Narrow Range</td>
<td>530-650°F</td>
<td>accurate than hot leg measurement. RTDs may indicate trends during core uncovery. Permanent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>damage can occur from exposure to high temperatures. Accurate measurement at the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>instrumentation cabinets available to 1100°F. Above 1100°F trendable accuracy should exist to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>about 1900°F. Instrument will fail above 2300°F due to shunts and shorts of the leads.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold Leg RTDs</td>
<td>Wide Range</td>
<td>0-700°F</td>
<td>RTDs may not be useful during core uncovery. RTDs should be useful when RPV is refilled.</td>
</tr>
<tr>
<td></td>
<td>Narrow Range</td>
<td>510-630°F</td>
<td>See comments under hot leg wide range RTDs.</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>INSTRUMENT</th>
<th>RANGE</th>
<th>USEFULNESS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subcooling Margin Monitor</td>
<td>200°F subcooling to 35°F superheat</td>
<td>Not accurate after significant core damage</td>
<td>The subcooling margin monitor relies upon CETCs and Hot Leg RTDs for its computed indication. Error can increase significantly at low RCS pressures.</td>
</tr>
<tr>
<td>Reactor Vessel Level</td>
<td>0 -100% of RPV above upper core plate</td>
<td>Not useful after core damage.</td>
<td>High temperature in upper plenum is likely to cause thermocouple failures.</td>
</tr>
<tr>
<td>Source Range/Intermediate</td>
<td>1 to 10^6 cps</td>
<td>Instrument trends may detect RPV water refill after core damage.</td>
<td>Instrument indication can only provide information on gross water level and should be interpreted with caution. Source range changes in gamma flux may indicate changes in core geometry or in RPV water level. If RPV fails then instruments will probably be damaged by environment.</td>
</tr>
<tr>
<td>Range Monitors</td>
<td>10^{-4}-10^{-2} R/hr</td>
<td>Instrument trends may detect RPV water refill after core damage.</td>
<td>Instrument indication can only provide information on gross water level and should be interpreted with caution. Source range changes in gamma flux may indicate changes in core geometry or in RPV water level. If RPV fails then instruments will probably be damaged by environment.</td>
</tr>
<tr>
<td>Power Range Monitor</td>
<td>0-120% Power</td>
<td>Likely to be useful until RPV failure.</td>
<td>May be used for recriticality diagnosis.</td>
</tr>
<tr>
<td>Containment Water Level</td>
<td>Wide Range 0-10 ft</td>
<td>Likely to be useful prior to vessel failure. After vessel failure, usefulness may be limited by disposition of core debris.</td>
<td>Usefulness is limited if more than 1 RWST volume is injected given the limited range. Boiling water in containment after RPV failure may result in unstable instrument indication.</td>
</tr>
<tr>
<td>Seal Table Radiation</td>
<td>10^{-4}-10^{-1} R/hr</td>
<td>Likely to be useful until RPV failure.</td>
<td>Useful for detection of incore instrument tube failure in RPV. Not a significant input for SAMG diagnosis.</td>
</tr>
<tr>
<td>Containment Radiation</td>
<td>1-10^8 R/hr</td>
<td>Likely to be useful throughout severe accident.</td>
<td>Not a primary indication for severe accident diagnosis.</td>
</tr>
<tr>
<td>Containment Pressure</td>
<td>-5 psig to 65 psig</td>
<td>Likely to be useful throughout a core damage event.</td>
<td>Accuracy at lower end of range may limit usefulness for diagnosing a controlled stable state. Upper range may limit usefulness for some accident sequences and for detecting the occurrence of some severe accident phenomena.</td>
</tr>
<tr>
<td>Containment Temperature</td>
<td>0-300°F</td>
<td>Likely to be useful throughout a core damage event.</td>
<td>Limited range of temperature indication may hamper some diagnostics.</td>
</tr>
<tr>
<td>Containment Hydrogen</td>
<td>0-10 %</td>
<td>Likely to not be useful after reactor vessel failure.</td>
<td>Accuracy prior to vessel failure is based on installation of sample lines. Sample lines likely to become plugged after vessel failure. Also, cannot measure carbon monoxide (a flammable gas).</td>
</tr>
</tbody>
</table>
Table 3. SAMG Status Board

<table>
<thead>
<tr>
<th>UNIT</th>
<th>SEVERE CHALLENGE / ACCIDENT GUIDELINE</th>
<th>DFC/SCST SETPOINT</th>
<th>CURRENT VALUE Date/Time</th>
<th>STRATEGY REQ’D?</th>
<th>IN USE?</th>
<th>TREND IMPROVING?</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCG1</td>
<td>Mitigate Fission Product Releases</td>
<td>TEDE &gt; 1 R or CDE_{THY} &gt; 5 R</td>
<td>_______ R _______ R</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SCG2</td>
<td>Depressurize CTMT</td>
<td>CTMT Pressure &gt; 92 psig</td>
<td>_______ psig</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SCG3</td>
<td>Control H² Flammability</td>
<td>CTMT Hydrogen &gt; 6% AND &gt; CA3 setpoint</td>
<td>_______ %</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SCG4</td>
<td>Control CTMT Vacuum</td>
<td>CTMT Pressure more negative than -5 psig</td>
<td>_______ psig</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SAG1</td>
<td>Inject Into SGs</td>
<td>SG Narrow Range Level &lt; 58%</td>
<td>_______%NR</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SAG2</td>
<td>Depressuize RCS</td>
<td>RCS Pressure &gt; 400 psig</td>
<td>_______ psig</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SAG3</td>
<td>Inject Into RCS</td>
<td>Core Exit Temperature &gt; 700°F</td>
<td>_______ ⁰F</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SAG4</td>
<td>Inject Into CTMT</td>
<td>CTMT Sump Level &lt; 4.8 ft</td>
<td>_______ ft</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SAG5</td>
<td>Reduce Fission Product Releases</td>
<td>TEDE &gt;100 mr or CDE_{THY} &gt;500 mr</td>
<td>_______ mr _______ mr</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SAG6</td>
<td>Control CTMT Conditions</td>
<td>CTMT Pressure &gt; 4 psig</td>
<td>_______ psig</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SAG7</td>
<td>Reduce CTMT Hydrogen</td>
<td>CTMT Hydrogen &gt; 4%</td>
<td>_______ %</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
</tr>
<tr>
<td>SAG8</td>
<td>Flood CTMT</td>
<td>CTMT Sump Level &lt; 14.5 ft</td>
<td>_______ ft</td>
<td>(Yes/No)</td>
<td>(Yes/No)</td>
<td>(Yes/No/Stable)</td>
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Training for Severe Accident Management at Tihange NPP: 
Program Development and Experience Feedback

Introduction.

Tihange Nuclear Power Plant is composed of three 1000Mwe PWR units, operated by ELECTRABEL. These units have been successively started up in 1975, in 1983 and the third one in 1985.

History of the "Severe Accident Management Guidelines" Development.

In 1989 already, the plant operator and the architect engineer TRACTEBEL, in cooperation with the Regulatory body, initiated a safety project with the aim of keeping up with the international development in the severe accident management field and of analyzing the efficiency and feasibility of measures taken in Belgian units (hydrogen control, containment pressure control, etc.).

In 1991, this project was added to the list of topics to be reviewed within the framework of Unit 2’s ten-yearly overhaul and it was decided to analyze the feasibility of adapting SAMG’s (Severe Accident Management Guidelines), edited by the Westinghouse Owner's Group, to this Unit.

So, studies were carried out in the following fields:

- Ultimate resistance of containments.
  This study concluded that containments could resist pressure of about 0.6 Mpa. It was decided that no containment venting system would be installed;
- Risks pertaining to hydrogen release after a severe accident.
  The conclusions of this study resulted in the installation of passive catalytic recombiners in reactor buildings.

On the other hand, the adaptation of the SAMG’s documents was carried out by TRACTEBEL in cooperation with the plant operator. These severe accident management guidelines aim at limiting fission product release in the environment, and at restoring the unit in a stable and controlled condition.

The aims of these guidelines are as follows:

- Management of the reactor coolant system integrity degradation;
- Management of the containment integrity;
- Control over the fission product release.
Organization of the Crisis Team using the SAMG’s.

The SAMG’s are mainly used by the crisis team at the OTSC (Outside Technical Support Center). They consist in two diagnosis guidelines, the "Severe Challenge Status Tree" and the "Diagnosis Flow Chart", to which two strategy preparation guidelines are related, the "Severe Challenge Guidelines", and the "Severe Accident Guidelines". These guidelines are available at the OTSC and used by the Safety Engineer. The control room operators have two specific guidelines at their disposal, the "Severe Accident Control Room Guidelines" designed, on the one hand, to manage the accident before the crisis team intervenes and, on the other hand, to communicate with the crisis team members once they are ready for action.

At the crisis center, the Safety Engineer is responsible for the implementation of the SAMG’s in cooperation with the crisis center head and his/her assistant. He/she gets the help of an Engineer from an undamaged production unit, himself/herself in contact with a Production Engineer located in the control room of the damaged unit. All these support crews are trained to use the guidelines.

The guidelines are developed and implemented at Unit 2. They are developed and under implementation at Unit 3. They are under adaptation at Unit 1.

Crisis Teams' Training Plan.

The crisis teams’ training plan includes a theoretical training and a practical training to the use of these guidelines.

The three-day theoretical training is about:

- Explaining the physical phenomena involved in severe accidents;
- Studying the strategy to draw up these guidelines;
- Reviewing the detailed instructions of these guidelines.

It was considered that a practical training to the use of the guidelines was necessary to complement the theoretical training. It deals with the aspects related to the crisis team's organization and with the use of the guides. Real-time simulated accident scenarios set up on the basis of the MAAP4-GRAAPH code are used to that effect. As an example of these scenarios: Total loss of internal power busses combined with a total loss of feedwater to the SG’s and no injection to the RCP’s seals. The operator can have access in real time to values such as elapsed time, levels of primary and secondary water, mass ratio's of hydrogen in the core, interaction corium-concrete in the cavity, vessel integrity indicator. He can experience in realistic conditions and in real or accelerated time the use of the Diagnostic Flowchart and the Severe Challenge Status Tree. The real time is indeed accelerated in some transient conditions, when the phenomenon evolution is too slow, so as to focus training on transient conditions and on phenomena which are considered to be important. After each transient, the crisis team has the opportunity to have comments on the selected decisions from an SAMG expert and to experience alternative actions.
The experience feedback from this training is highly positive and proves that the crisis team members have digested the guidelines' principles as well as their practical implementation.

At this stage, the crisis team is ready to use their SAMG knowledge in fully integrated emergency plan exercises. Tihange NPP organizes yearly emergency plan exercises based on pre-simulated scenarios set up by means of a Tractebel severe accident calculation code (MELCORE). The use of these scenarios and their multiple choices of decision trees enable the crisis team to make realistic decisions and so control the progress of the emergency state.

Conclusions

Tihange NPP developed a consistent and comprehensive severe accident management strategy, combining the installation of complementary engineered safety systems, the development of the severe accident guidelines and a training program for the crisis teams, resulting in an optimized control of accidents.
In Collaboration with EdF/SEPTEN Lyon, France,
12-14 March, 2001

RESEARCH REACTOR OPERATORS TRAINING
FOR EMERGENCY ACCIDENTS MANAGEMENT
USING SIMULATORS AND NUCLEAR POWER ANALYZER

Makin R.S., Ochrimenko A.I., Demidov L.I.

State Scientific Centre of Russian Federation
Research Institute of Atomic Reactors
(SSC RF RIAR)

Dimitrovgrad, Russia
2001
At present according to the official data of Gosatomnadzor RF there are 26 research reactors under operation in Russia (see Table 1). Most of them are located at the State Scientific Centre of RF Research Institute of Atomic Reactors (SSC RF RIAR). SSC RF RIAR is situated in Dimitrovgrad, Volga region, 1000 km southeast from Moscow, Russian Federation.

SSC RF RIAR is the largest center in CIS that deals with the experimental research of fundamental nuclear power engineering problems and development of design decisions and issues of safe operation of nuclear plants.

At present there are 5 types of reactor facilities under operation at SSC RF RIAR. Among them there are 2 pilot NPPs generating electricity and heat for local consumers (Table 2):

- The SM-3 reactor, 100MW (thermal power), high-flux, vessel-type;
- The MIR reactor, up to 100MW (thermal power), multiple-loop, testing;
- 3 pool-type reactors RBT, up to 10MW (thermal power);
- The pilot NPP VK-50, 50MW (electrical power), vessel-type boiling water reactor;
- The pilot NPP BOR-60, 12MW (electrical power), fast breeder reactor with liquid sodium coolant.

The SSC RF RIAR main experimental base also involves a complex of “hot” material science laboratories, radiochemical complex, and a complex for utilization and disposal of radioactive waste. This allows the fulfillment of research programmes on a comprehensive basis.

All the activity of SSC RF RIAR included in MINATOM RF is supervised by Gosatomnadzor RF which controls the work of nuclear and radiation-hazardous facilities and plants including personnel training, their qualification and competence level.

Two above SSC RIAR NPPs and research reactors operate round-the-clock. Their personnel works on the preparation and performance of the experimental programs along with functions typical of a NPP. This determines some peculiar features of their operation [1].

One of the main peculiar features of the research reactor (RR) operation is its operation efficiency criterion in comparison with the similar criterion for NPP. It should be born in mind that according to General Safety Regulations (GSR) the safety criterion is the
Based on the brief analysis the following conclusion may be drawn that regarding a RR it is necessary to take into account the achievement of final results in the course of an experiment while for a NPP the criterion of electricity generation remains unchanged in any case. From this point of view the main difference may be defined as follows: for a NPP it is production of energy (electrical and/or thermal); for research reactor – generation of “knowledge” and only afterwards production of products.

Another peculiar feature is that alternative requirements may arise during the RR operation to provide these or those conditions and operation parameters of different in-reactor experimental devices. There is no doubt that all the experimental conditions should be provided in strict correspondence with safety regulations. Nevertheless simultaneous observance of these requirements, particularly in transient and abnormal conditions, is a very difficult task.

The above operation peculiar features that require operating personnel is always ready to make guiding decisions under constantly changing operational conditions and especially under transient, abnormal and emergency situations.

It should be noted that at present in the SSC RIAR Training Center (TC) a training procedure of personnel from research and testing reactors has been developed ensuring the required personnel qualification level and also acquisition, analysis, generalization and distribution of operation experience of Russian RR among the personnel. The RR personnel training system, upgraded on the basis of modern computer information technologies, is the part of the branch system of personnel training for hazardous facilities of nuclear fuel complex. It closely interacts with its other elements (higher educational institutions, technical schools, qualification institutions and so on) [1, 2].

The RR operators’ training Programme of SSC RIAR TC “ Theoretical background of nuclear technology ” is presented in Table 3 as an example. Section 4 of the Programme is devoted, in particular, to the issues of accidents and incidents at a RR.

Current practice of emergency readiness training for personnel of research and testing reactors is useful but it doesn’t cover all the problems.

Forecasting such a situation at SSC RIAR TC during the last several years the steps have been taken to create technical means in order to solve all problems of operator’s training (in broad sense of the word) on the control over abnormal and emergency conditions. These are the following means:
- Functional – Analytical Simulator (FAS) of pilot NPP VK-50;
- Functional – Analytical Simulator of pilot NPP BOR-60;
- Research Reactors Nuclear Analyzer on the basis of the main host-computer (cluster) with specialized application software;
- Functional Simulator for electrical part of pilot NPP VK-50;
- Functional Simulator for electrical part of pilot NPP BOR-60.

The above technical means are integrated into a system the main components and structure of which are presented in Fig. 1:

- The main computer and operational software;
- Research reactors nuclear analyzer (RRNA);
- “Flexible” Simulator Systems (FAS and functional simulators) and applied software;
- Users’ workstations and reactor units personnel support system;
- Network and data exchange.

Main objectives and purposes are achieved using the above technical means are:

- Analysis of transient and emergency modes of reactor units and SSC RF RIAR electric power production facilities, including the real time mode;
- Provision of support for reactor facilities operating personnel while taking the guiding decisions including emergency situations and severe accidents;
- Training and continuous training (in a broad sense of this word) of operators of reactor units and electric power production facilities;
- Development, support, analysis and testing of project decisions and systems;
- Support of experimental research aimed at validation of project decisions of VVER reactors in emergency situations.

Let us dwell on the main technical decisions taken during creation of technical means for research reactors personnel training.

Fast upgrading of technology development of processors for personal computers (PC) created a unique situation in the last decade. It became possible to perform massive parallel calculations using such PCs with parallel calculation of complicate problems using several
simultaneously operating processors (clusters). Moreover such cluster productivity achieves and often exceeds the expensive supercomputers productivity. This tendency remains and it is impossible to define the number of clusters being in operation from USA to Australia and Japan. The described cluster is evidently the second in Russia.

The cluster includes 12 two-processor workstations with following specifications:

- Processor P III/600-2; SRAM-256 MB; hard disk-20 GB;
- Motherboard Super Micro P6 DBE;
- Video card; sound and network cards;

The workstations are integrated into cluster using a switchboard 3 COM SSII 3900/24 and server with following specifications:

- Processor P III/600-2; SRAM-1024 MB;
- Motherboard Super Micro P6 DBS;
- 4 hard disks – 27 GB
- Video card, sound card and 2 network cards.

On the basis of the host-computer (cluster) a class RRNA is developed that allows:

- To implement the simulation of technological processes in real time mode and modes, exceeding it;
- To conduct visualization of massive parallel calculations;
- To simulate, in certain limits, and analyze abnormal and emergency situations as well as their forecasting and prevention;
- To provide operators training (in a broad sense of this word).

Multimedia equipment is included into the hardware because the cluster belongs to RRNA class that is also meant for operator training (in broad sense of this word).

At the first stage batch processing is used and further parallel processing is used. User registration is performed at the cluster main server, which is used for interactive work (program editing and compilation and initial program load). This server is accessible through RSB from any SSC RIAR network computer. Experts-researchers computers can be included into the cluster through the server that is directly switched on to the cluster subnet.

RRNA (ASIR) class – cluster software (SW).
System SW of workstations is based on the usage of Linux Operation System (OS) of VALinux V 6.2 Company. Windows NT application is possible as a temporary alternative. For RRNA server – Linux (OS).

**System SW** – program packages and libraries for paralleling and calculations management.

Mainly MPICH package developed in ANL USA is used. Within the VALinux V 6.2 distributive a PVM package, developed by ORNL jointly with Tennessee University, USA, is used. Programs initial load and management is performed with the help of batch system PBS.

**Applied SW.** Program development and debugging environment means are widely presented in the VALinux Company distributive and are installed in the cluster main server.

At present the library of programs is being filled for reactor systems calculations and simulation using work paralleling. Particularly the programs Monte-Carlo NCN, LANL, USA and QVAZAR SSC RIAR for boiling water reactors calculations and also some others are considered.

Cluster testing was made using ScaLAPAC v.1.6. package and high-performance algebraic subprograms for computers with distributed memory and workstation clusters.

Well-known advantages of mathematical simulation in combination with high research and simulation capabilities of transient and emergency conditions supported by increased performance of modern computers provide the conditions for the use of full-scope models of research and pilot reactors in order to solve a wide scope of actual and practical problems. These problems include:

- Safety evaluation (design and beyond designed accidents calculation including severe accidents);
- Man-machine interface optimization;
- Operator training (in broad sense of this word) including team-work training;
- Data flow analysis;
- Development of algorithm and procedures of emergency center;
- Development and revision of emergency regulations and procedures.

Full-scope research reactors maths models availability allows the existing model to be taken as a basis and developed according to particular requirements. This enables adequate
decisions-making concerning reactor facilities that are different in design as well as in physics, thermalhydraulics, control and safety systems. This essentially reduces labor expenses and decreases performance period.

The training class of flexible FAS operates now at SSC RIAR on the basis of Training Center where set up, test and trial operation of functional simulators are carried out for NPP VK-50 and BOR-60 operating personnel training [3].

Let’s consider the pilot NPP VK-50 FAS, which is on the stage of trial operation and development of training scenario.

The calculation programs complex KASSETA-RAGU-QVAZAR is used as application software. Non-stationary neutron transfer process is simulated by three-dimensional space kinetics in small-group diffusion approximation. Coolant conditions are simulated by solving nonstationary one-dimensional equations of motion, energy and mass balance in steam generating and other types of in-vessel channels. Closure proportions for steam slip in subcooled liquid are used for two-phase flow simulation in the core steam generating channels.

It was shown that neutron transfer processes simulation with the usage of space kinetics equations in accidents with large reactivity change describes real processes more accurately and correctly than point kinetics simulation. The complex is verified using “benchmark” tests and according to experimental data.

The pilot NPP VK-50 electrical part (EP) simulator has been developed and its trial operation is being carried out training for chief engineers, electrical engineers and electricians.

The simulator has been developed on the basis of advanced computer controlled three-phase analog-physical table mock-up (hybrid model) [4].

The hybrid model allows the analysis of operation modes of the multimachine electrical power system in the real time mode. It is very important to solve this problem for NPP simulators particularly concerning the reliability of local consumption supply and work safety.

The model consists of a unit of electrical models of analog machines that regulates the Park-Gorev equation and motion equation considering automatic speed regulator and automatic excitation regulator. It also includes switch gear (SG) of the physical mock-ups unit. The three-phase electrical machine mock-up is the model primary element. The model adequacy evaluation by full-scale experiment showed that steady conditions reproduction accuracy was 5% and transient conditions reproduction accuracy was 10-15%. These data satisfy the requirements for simulators.
The hybrid model of the given simulator may also include all types of electrical machines available at the plant (turbogenerators, dieselgenerators, asynchronous motors) as well as SG, control boards, control panels and also model of relay protection and automatic system.

The simulator program complex fulfills the following tasks:

- Soft hardware adaptation to the plant operation mode setting;
- Initial data and control actions loading;
- Reception processing of information on simulator processes;
- Reflection of received and processed information;
- Simulation of relay and automatic protection system;
- Support of training and methodological activities.

Training tasks scenarios were designed simultaneously with the simulator development. The following modes were chosen for training tasks scenarios: 1-normal modes (synchronization); 2-special modes (asynchronous mode, generator rundown); 3-accident modes (short circuit in switch gears and boards).

The EP simulator of the pilot NPP BOR-60 was developed and created according to the similar design.

The accepted FAS structure provides obtaining rather deep knowledge and also gives the possibility to master practical skills of control processes.

The job positions of expert-researchers and specialists in the software support are provided in the FAS class.

**Conclusion**

SSC RIAR pays great attention to the problems of provision of safe operation of operating reactor facilities also including guarantied achievement of personnel qualification level and its supporting.

The complex of technical training tools has been created recently with this purpose. It permits the provision of purposeful training of the pilot NPP VK-50 and BOR-60 operating personnel. Technical tools that operate on RRNA and FAS basis along with the removed workstations at the reactor facilities represent a distributed and integrated network. This allows
organization of access of the operating personnel (operators in the broad sense of this word) to the final results obtained at FAS and RRNA.

All this provides:

- Integrated support of operating personnel including their actions for control over abnormal and emergency modes;

- Training of operators using above mentioned technical tools with consideration of adequate information about reactor conditions including accidents management.
References


<table>
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<tr>
<th>N</th>
<th>Name of reactor</th>
<th>Location</th>
</tr>
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<tbody>
<tr>
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</tr>
<tr>
<td>2</td>
<td>Gidra</td>
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<tr>
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<td>TIBR-1M</td>
<td>Moscow</td>
</tr>
<tr>
<td>23</td>
<td>BARS-2</td>
<td>Moscow</td>
</tr>
<tr>
<td>24</td>
<td>BARS-3M</td>
<td>Moscow</td>
</tr>
<tr>
<td>25</td>
<td>BARS-4M</td>
<td>Moscow</td>
</tr>
<tr>
<td>26</td>
<td>PIK (under construction)</td>
<td>Gatchina</td>
</tr>
</tbody>
</table>
### Table 2: MAIN SPECIFICATIONS OF SSC RF RIAR REACTORS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SM-3</th>
<th>MIR</th>
<th>RBT-6</th>
<th>RBT-10/1</th>
<th>RBT-10/2</th>
<th>BOR-60</th>
<th>VK-50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal power, MW</td>
<td>100</td>
<td>To 100</td>
<td>6</td>
<td>10</td>
<td>55</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Electric power, MW</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Max. density of thermal neutron flux, cm$^{-2}$ s$^{-1}$:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>thermal</td>
<td>5.10$^{15}$</td>
<td>5.10$^{14}$</td>
<td>1.1-10$^{14}$</td>
<td>1.5-10$^{14}$</td>
<td>-</td>
<td>1.0-10$^{1}$</td>
<td></td>
</tr>
<tr>
<td>fast(E$&gt;$0.1MeV)</td>
<td>2-10$^{15}$</td>
<td>2-10$^{14}$</td>
<td>5.6-10$^{13}$</td>
<td>6.9-10$^{13}$</td>
<td>2.5-10$^{15}$</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Operation time, h</td>
<td>6700</td>
<td>6600</td>
<td>8000</td>
<td>8000</td>
<td>5800</td>
<td>6500</td>
<td></td>
</tr>
<tr>
<td>annually</td>
<td>-</td>
<td>continuous</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>operation</td>
<td>300</td>
<td>2400</td>
<td>4800</td>
<td>4800</td>
<td>3000</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Number of irradiation channels:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>neutron trap</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>core</td>
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<td>11</td>
<td>8</td>
<td>10</td>
<td>25</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>reflector</td>
<td>30</td>
<td>-</td>
<td>Stand</td>
<td>-</td>
<td>To 100</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&quot;Korpus&quot;</td>
</tr>
</tbody>
</table>
PROGRAM OF COURSE
"THEORETICAL FOUNDATIONS OF NUCLEAR TECHNIQUE"

Scope: 320 h

Topic 1 Nuclear Physics Foundations
Topic 2 Reactor Physics Foundations
Topic 4 Review, Construction, Outlook of Development and Accidents at Research Reactors
Topic 5 Research Reactor Coolant Chemistry
Topic 6 Sodium Coolant Technology
Topic 7 Radiation Safety of Research Reactor Facilities
  • General concepts about radiation safety bases at reactor facilities
  • Provision of reactor radiation safety
  • Research reactors - ionizing radiation sources
  • Main principles of reactor facilities radiation protection
Topic 8 Foundations of Measuring Theory
Topic 9 Research Reactor Electric Power and Equipment
Topic 10 Labour Protection
Topic 11 Fire Safety
Topic 12 Russian Federation Legislative Foundations in the Field of Atomic Energy Using
  • Government bodies and structure of legislative, regulatory-legal and regulatory-technical documents regulating activity in the field of atomic energy using
  • Legislative statement of Russian Federation in the field of atomic energy using
  • Legislative regulation of international obligations of Russian Federation in the field of atomic energy using
  • Social defence of personnel and populations
Topic 13 Technical Principles of Safety Provision at Research Reactor Facilities
Topic 14 Emergency Measures of Reactor Facilities
Topic 15 Provision of State Regulation and Supervision for Nuclear and Radiation Safety of Reactor Facilities
Topic 16 Technical Tours of SSC RF RIAR Reactor Facilities
Topic 17 Psychophysiological Inspection and Questionairing
SSC RF RIIAR TRAINING CENTRE
Technical Means of Personnel Training System

Main Structure

Fig. 1
Severe Accident Management
as Applied by EDF

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Abstract
The general approach adopted in France to address Severe Accident Management is presented, together with some of its specifics. In a second step, the context in which national drills are made is described, and specifics of the drills seen from the utility side are commented.

1. Introduction
Severe accidents would lead to the release of significant quantities of radioactive material to the Containment. Depending on the gravity of the sequence, containment integrity could be threatened, either in the short-term or in a longer term, thus leading to releases to the environment which could be harmful to populations if no countermeasure was implemented.

To allow categorization of incurred risks, a very simple approach was adopted in France, based on the definition of three Source Terms allowing to characterize radioactive releases to the environment:
- S1, which characterizes releases in case of accident accidents leading to early containment failure. Such accidents would generally involve very energetic phenomena such as Direct Containment Heating or Hydrogen detonation. Such accidents are practically ruled out for French plants, due to the large containment volume on one side, which allows to mitigate the loads resulting from some of these sequences, or because preventive provisions have been implement to decrease the likelihood of such sequences and thus their credibility.
- S2, which characterizes sequences leading to direct radioactive releases to the environment after approximately one day into the accident,
- S3 which is representative of accidents with indirect releases to the environment due to the existence of leak paths after approximately 24 hours into the accident.

As sequences leading to releases which could be considered bounded by S3 seemed the most credible for French plants, Emergency Planning was organized for the above mentioned time frame for S3.

Accordingly, the Emergency Organization has been structured, and procedures and tools developed for achieving consistence with S3.

2. Emergency organization
2.1 Structure of emergency procedures
In case of abnormal situation, incident or accident management is made based on the redundancy between the operating shift and the Safety Engineer. Implementation of Emergency Operating Procedures, either event-oriented or physical state-oriented depending on the plant series, allows the operating shift to adequately cope with the situation. The safety Engineer monitors the Nuclear Steam Supply System evolution using a specific procedure, and thus assesses the adequacy of actions performed by the operating shift.

As original event-oriented EOPS were developed to address Design Basis Accidents only, and more complex sequences involving multiple failures or loss of redundant systems couldn't be ruled out, specific beyond design procedures were developed to address the most important challenges. These procedures are known as H procedures and address:

- loss of heat sink (H1)
- Total Loss of Feedwater to the Steam Generators (H2)
- Station Blackout (H3)

As success cannot be guaranteed in case of Beyond Design Basis event, and there could be progress towards core-melt U procedures were developed to:

- delay or limit core damage (U1),
- address potential containment bypass or failure(U2, U4, U5)

At last, in case of core melt, Severe Accident Management Guidelines, the Crisis Team Action Guide and the Triple Diagnosis/Triple Prognosis (3D/3P) approach are used to limit the consequences of accidents below S3.

2.2-Activation of the Emergency Organization

As stopping or limiting accident progression is the main objective in case of accident, emergency response plans are activated as soon as one of the following EOPs are implemented:

- break on the primary or the secondary side,
- steam generator tube rupture
- H procedures
- U1 procedure
- fuel handling accident
- Reactor Coolant System activity high

The local and national emergency teams are operational within respectively one and two hours after activation of the Emergency Organization.

The EDF National Emergency Team includes specialists with expertise in components, instrumentation, transients analysis, emergency procedures, containment, radioactive releases evaluations.

Diagnosis of the situation, and prognosis on its evolution are carried out by the local and national teams, and, independently, by the Safety Authorities. Ultimately, decisions belong to the site manager.

The EDF Management, Plant manager and Safety Authorities Manager remain in permanent contact during the whole duration of the emergency.

3. Methods for emergency teams

3.1 Ultimate procedures U2, U4, U5

3.1.1 Containment isolation (U2)

The U2 procedure has been developed to address containment bypass resulting from random failure of containment penetration or of systems circulating highly contaminated water outside containment. Objectives of the procedure are rapid location and isolation of the leak, and re-injection of the leaked fluid into the containment. Activity thresholds used in the procedure are consistent with acceptable personnel exposure in case local intervention is needed.

Though it is obvious that leakage must be detected as soon as possible, priorities for action may vary in the course of an accident. The following principles have thus been adopted...
monitoring of adequate operation of automatic isolating devices. This increases detection capabilities and makes repairs easier.

- Core cooling must remain the priority if core degradation has not started. If the situation starts to degrade inside containment, the procedure requires isolation of some penetrations. These should not be re-opened later.

- In case containment bypass is detected by the control room staff, the local crisis team must be informed to fix the problem. The control room staff must retain focus on comprehensive management of NSSS systems.

Monitoring of radiological situations is implemented as soon as any accident with radiological risk happens, up to severe accident situation.

3.1.2 Containment basemat melt-through (U4)

This procedure has been implemented for the Cruas site only, due to the use of anti-seismic devices. It requires flooding of the cavity under the reactor building to avoid direct leak path to the environment, soda injection inside containment, and containment venting to ensure low containment pressure in case of basemat melt-through.

For all other sites, it appears that basemat melt-through should be consistent with emergency planning implementation.

3.1.3 Containment Venting (U5)

The venting system has been installed to address delayed containment failure due to slow pressure buildup inside containment. System actuation is not contemplated prior to 24 hours into the accident and until the pressure inside containment reaches 5 bars, which is compatible with containment mechanical integrity. System actuation is decided by the Plant Manager after advice from Emergency teams.

3.2 Triple diagnosis - Triple prognosis

The objective of this approach is to carry out a diagnosis of the situation and make a prognosis for release on fission product release to the environment, and feed site teams with recommendations for optimal plant management.

In the Diagnosis phase, integrity of the three barriers between the fuel and the environment is assessed. and characterization of NSSS is made based on:

- The status of systems allowing to maintain barrier integrity (control rods, boron injection systems, ECCS and RCS make up, Refueling water storage tank, steam generators, RHR system, containment spray and isolation)
- Estimation of fission product release from the fuel, airborne activity inside containment, release pathways and amount of activity released to the environment.

Evaluation of environmental consequences.

Prognosis is then made based on the evolution of the situation, operator actions as defined in EOPs or SAMGs and availability of systems designed to maintain safety functions.

Evaluations are carried out by experts in National and Local Crisis teams. The end products are the definition of revised barrier state and release pathway. To allow on-line comparison of evaluations between the different experts (EDF, Safety Authorities), summary reports are written using the same format (plant behavior, evaluation of releases, information for decision makers).

3.3 Crisis team action guide

The Crisis Team Action Guide aims at providing guidance for SAM to Crisis Team. Four levels are considered:

- **Instrumentation** guidance on how to use measurements is provided. This guidance is deals with the treatment of rough information used for performing the diagnosis.
- re-alignments allowing to restore of system availability This section gathers a set of means and methods usable to restore or maintain RCS coolant inventory, and heat removal from the reactor building through restoration of support systems (e.g. power supply or cooling systems) or non conventional use of available auxiliary systems (e.g. systems from other site units). To illustrate this, it can be noted that 280 re-alignment allowing to manage RCS loss of coolant. have been identified.

- Containment bypass to detect Containment failures and mitigate their consequences,
- Long term operating strategies allowing evolution to a controlled and stable state.

3.4 Severe accident management guidelines
In case of severe accident, actions required in the EOPs procedures need to be reconsidered, to take into account new and complex phenomena which occur during the course of the accident and the difficulty to assess NSSS status due to loss of instrumentation. Furthermore, experience shows that reaching an agreement among specialists to timely advise operators is not an easy task.

This guide was created to structure knowledge gathered through severe accident research programs in a form adequate for operational purposes. The SAMG objective is therefore to define actions allowing to minimize radioactive releases to the environment and keep the situation under control.

As further studies are needed to consider that in-containment instrumentation can be relied upon under very degraded conditions, recommended actions essentially result from an evaluation of system availability. This has led to the definition of a matrix (system-actions), simple to use and should not increase operator stress even in highly perturbed conditions. All systems are considered (safeguard systems and some auxiliary systems) even if actuation results in potential drawbacks. Priorities are as follow:

- maintain containment integrity: use the spray system in all cases. If containment pressure cannot be controlled, implement the U5 procedure.
- limit releases to the environment : through use of the spray system, supply of water to the Steam Generators, and the U2 procedure.
- remove decay heat through intact generators
- inject water into the RCS to prevent or delay vessel melt-through.
- limit risks of energetic events through keeping the RCS at low pressure (keep relief valves open) use borated water when possible and stop Reactor Coolant Pumps.

4 Operator training
Operator training for normal operation and the management of accidents has always been emphasized by EDF. Basically, such training is based on lectures on physical phenomena, plant system architecture and system performance on one side, on management of normal transients or accident situations on simulators. For the latter, full scale simulators allowing the operator to work in a familiar context have been used, as well as more focused tools such as the SEPIA simulator(SGTRs) or SIPA, which has extended physical capabilities compared to more standard simulators but a simplified control room instead of a replica of a unit control room. Looking at event capabilities, the major commonality between all these simulators is that the validity of their softwares is limited to the onset of coremelt.

Strictly speaking, so, knowledge-based training for severe accidents is not possible as adequate simulation tools are not part of the training arsenal.

Also, as was shown in paragraph 3.4 above, SAMGs are based on the use of a system-action matrix emphasizing system availability rather than identification of physical plant status. Operator skill-based training, or evaluation of the effectiveness of the accident management structure in case of Severe Accident is by far more important to the utility than knowledge-based training.

4.1 The origins
On the regulatory side, French Safety Authorities (DSIN) started to organize, in 1982, drills allowing to test the organization to be activated in case of nuclear accident. Originally, these drills involved DSIN and their local representatives, and the utility: included in these drills were also the technical supports of both DSIN and the utility. The main objectives of these drills were to assess the adequacy of resources needed to bring the plants back to a controlled situation, and test the efficiency of involved teams to handle accident situations.

In 1989, guidance on the coordination of government resources in case of nuclear accidents was issued. This guidance contemplates drills for testing issues such as information procedures for the public, intervention procedures, at both local and national levels. For the latter, identified as inter-ministry drills, activation of Emergency plans triggering real actions possibly involving surrounding populations are also contemplated.

At the beginning of the nineties, DSIN started to involve local representatives of civil authorities in drills. However, drills triggering local actions involving the public started in the mid-nineties only. Examples of such actions are the intervention of local emergency teams (Dampierre, March 1995), or installation of decontamination centers (Blayais, October 1995). The first drill in which protective actions were implemented was that on October 1995 in Fessenheim: people in some geographical areas were confined, iodine pills were distributed, and messages were broadcast on local channels.

Since 1996, most drills involve the public, and emergency provisions like confinement of whole quarters or administrations are tested on a case by case basis.

4.2 Drills seen from the utility

For EDF, adequate reaction in case of accident relies on personnel professionalism maintained or enhanced through regular training sessions and drills. Beyond involvement in national drills as mentioned above (more than 10 per year), EDF also organize local drills on all nuclear sites.

4.2.1- Local drills

Though not directly relevant for Severe Accident Management, these drills are aiming at testing new organizational provisions, improve reaction in case of emergency, or test personnel behavior in case of technical incident. Two types of tests are contemplated:

- unanticipated tests: they happen without notice and are aiming at evaluating delays needed for implementation of the on-site emergency organization as well as for performing actions such as personnel gathering. They can be of limited extent, involving headquarters only, or more important like site evacuation as was done in Saint-Laurent des Eaux in 1995.

- anticipated technical incident: they are aiming at testing the behavior of part or all the emergency organization in case of simulated scenario. Some are limited in order to assess the efficiency of implemented measures at headquarter level (e.g. evaluation off-site consequences of a postulated accident by the control headquarters, in charge of radiological measurements) or involve more teams. Others are of greater extent and sometimes involve the national emergency organization.

4.2.2 National drills

National drill frequency is such that at least one site is involved every two years. In the average, so, one such drill is organized every month.

The initiative of the drill is on the Safety Authorities side, who delineate drill requirements. For example it could be decided that the drill should address an accident leading to short-term core melt, with radioactive releases beyond site boundary to test population warning systems and assess the efficiency of provisions adopted for sheltering people.

The second step is to create an accident scenario (at power or at shutdown) allowing compliance with the above mentioned requirements. This is done by an integrated team involving the technical support of the Safety Authorities and utility people. After defining the basic scenario (i.e. which kind of failure need to be assumed to result in anticipated consequences within a timeframe compatible with that anticipated for the drill), they evaluate possible Accident Management actions including some possible
operator errors to identify possible bifurcations. Based on these evaluations, sensitivity studies are made to have a more extended view of possible plant evolution if alternate strategies are chosen.

The first part of the drill is made on a simulator, and only addresses the period before the onset of core-melt. This part is variable depending on the type of simulator, full-scope simulators generally having narrower domains of validity than SIPA for example.

In a second step, accident progression is monitored based on the preliminary evaluations previously mentioned. Operators and crisis teams receive information on plant status from drill supervisors, and evaluate which actions are appropriate and should be implemented. After reaching an agreement on the strategy to be adopted, actions are confirmed to the drill supervisors which derive a new plant status and provide it to the other participants for further investigation on what should be done.

4.2.3 Communication

Seen from the utility, communication is an essential factor in case of emergency, especially in the case of nuclear. Beyond providing fast, coherent and understandable information to the public on the situation on-site, which in itself is already a real challenge, the major problem to deal with is often the contradictory conclusions made by different organisms, or explaining actions which seem inconsistent with technical predictions. For example, based on very similar evaluations of plant status in terms of core degradation, the Utility and the Safety Authorities could well come to very different conclusions on releases to the environment and which measure should reasonably be taken. These information being released to the local civil authorities (prefect) for advice only, implementation of countermeasures which don’t seem proportionate with risks as perceived by the utility are thus possible. In such cases, EDF is generally "summoned" to provide explanations which puts additional pressure on technical teams when they have to explain differences in prognosis, or on utility spokespersons when they have to put into perspective technical prognosis and protective measures taken by local authorities.

4.2.4 Some comments

Currently, knowledge-oriented training, aiming at familiarizing utility personnel with physical phenomena is not the priority of the utility. During mandatory national drills, the major objectives are testing operator skills and the capability of crisis teams for providing valuable input for SAM on one side, assessing the effectiveness of the emergency organization and interference from outsiders through communication with the public and the media.

From a technical standpoint, though limitations in simulation tools could seem a handicap for SAM training, it can easily be overcome through careful drill preparation. Something which is worth mentioning however, is the gap existing between the general approach adopted for real-life situations and that prevailing in case of drill.

To address real-life situation, the utility has implemented preventive and mitigative measures allowing to decrease the likelihood of sequences leading to short-term problems either on-site or beyond. As described before, this is consistent with implementation of emergency planning at 24 hours into the accident. For drills, on the contrary, it doesn’t appear reasonable to freeze all activity in one area for more than a few hours, and scenarios must be built accordingly. This sometimes lead to retaining scenarios with multiple independent failures whose credibility in terms of risk is difficult to confirm. This results in additional burden for operators and crisis teams, which seems manageable, but also in a potentially biased understanding of plant risk by outsiders. For the latter, there could be the impression that currently implemented countermeasures are not well adapted to credible accident situations. This problem is currently evaluated.

From a communication standpoint at last, drills have allowed to improve the efficiency of the internal organization, through coordinating the information available to and could be used by utility spokespersons at site and national levels. The major field for further improvement is probably dealing with divergences of opinions between involved organisms and intervention of outsiders as both seem inevitable whatever the future.
5 Conclusion
The approach adopted by EDF for Severe Accident Management emphasizes system availability rather than detailed assessment of core degradation. As drills where operator and crisis team skills can be tested are made on a monthly basis in the average, there is no urgent need to modify the current approach. These drills also allow testing the effectiveness of communication with the public and the media in case of emergency. Addressing concerns raised by potential bias on real risk evaluation resulting from the limited timeframe in which these drills need to be performed is underway.