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SECOND SPECIALIST MEETING ON OPERATOR AIDS FOR SEVERE ACCIDENT MANAGEMENT

SUMMARY AND CONCLUSIONS

Organised in collaboration
with EDF/SEPTEN

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SECOND OECD SPECIALIST MEETING

ON OPERATOR AIDS FOR

SEVERE ACCIDENT MANAGEMENT

(SAMOA-2)

SUMMARY AND CONCLUSIONS

I) - <u>INTRODUCTION</u>

The second OECD Specialist Meeting on Operator Aids for Severe Accident Management (SAMOA-2) was organized in Lyon, France from 8th to 10th September 1997 in collaboration with the Thermal and Nuclear Studies and Project Department (SEPTEN) of Electricité de France.

It was attended by thirty-three specialists representing ten OECD Member countries, the OECD Halden Reactor Project, the Commission of the European Communities, and the Russian Federation.

A number of operator aids (OA) had been presented during the first OECD Specialist Meeting on Operator Aids for Severe Accident Management and Training (SAMOA-1) held at the OECD Halden Reactor Project in June 1993. Some of them were already in operation, others were under development with a view to implementation within the next few years. SAMOA-1 had shown that the field was very active because of real needs and the possibilities offered by computer technology. It had therefore been concluded that another meeting should be organized in the not too distant future.

As for SAMOA-1, the scope of SAMOA-2 was limited to operator aids for accident management which were in operation or could be soon. The meeting concentrated on the management of accidents beyond the design basis, including tools which might be extended from the design basis range into the severe accident area. Relevant simulation tools for operator training were also part of the scope of the meeting.

Twenty papers were presented during the meeting. There were two demonstrations of computerized systems : the ATLAS analysis simulator developed by GRS, and EDF's "Simulateurs Post Accidentels" (SIPA). There was also a video demonstration of the Full Scope Simulator developed by a joint Russian-U.S. team for the

Leningrad nuclear power plant; this simulator is the first RBMK simulator to use real-time models for operating personnel training and, eventually, for management under conditions beyond design basis.

II) - CONCLUSIONS

2.1 - General

*It is clear that the development and implementation of operator aids for accident management is in progress in several countries.

*Both at the level of nuclear power plants and in national emergency centers (those of the utilities and those of the regulatory organisations), the current computer-based calculational tools are essentially the same as those already presented at the SAMOA-1 meeting. However, they have been enhanced to a considerable degree with respect to both calculational scope and performance (predictions are now frequently much faster than real-time). Moreover, they have been extensively validated against best-estimate codes. Computer-based calculational tools are successfully used during safety drills to assess the state of the plant and to predict the possible progression of the accident. However, there is still need for further work to improve some of these tools, in particular with respect to additional accident sequences and the development of more plant-specific models.

*Implementation of the more advanced computerized tools for accident management support like advanced predictive simulators in the Technical Support Center (TSC) has proceeded much slower than was expected at the SAMOA-1 meeting.

*Although opinions differ on the extent of operator training needs for severe accident scenarios, as discussed below, training for severe accident management (SAM) is generally considered beneficial. However, it is lagging behind SAM implementation programmes. The main purpose of training on OA systems is to enhance operator readiness for emergency situations, increase his mental flexibility and test his reactions . This is the reason why a number of specialists think that full scope simulators should include severe accident models : operators should be faced with and understand the consequences of improper action. OA systems used for operator training should also have application in normal situations, in order to familarize operators with their use.

*There is also debate on the need for advanced computerized tools in SAM. Some specialists feel that the use of such tools is too complex, that the operators would have too little time to wait for the results of simulations, and that it is not possible to guarantee computer availability. Other experts are of the opinion that computational aids may be useful during the mitigation phase of a severe accident as, in certain sequences, they can provide the operator with information which cannot be obtained from paper-based computational tools such as the computational aids of the Westinghouse Owners' Group (WOG) Severe Accident Management Guidelines (SAMGs) . More research and discussions are needed in this area.

2.2 - Operator training

Three objectives were developed and discussed to various extents:

*knowledge-oriented training, aiming at teaching the operators on severe accident phenomena and progression

*skill-oriented training, allowing to test operator behavior in case of severe accident-like situations

*efficiency-oriented training aiming at analyzing how all involved organizations would behave in case of emergency.

The first two objectives were more debated from the following standpoints:

*should training be knowledge-oriented or skill-oriented, and which conclusions could be drawn for simulators?

There was no definite answers as some participants thought emphasizing knowledge was sufficient , while others stressed that testing operator behavior in highly perturbed situations would provide valuable information on human factors and would be beneficial for safety. At the simulator level, only the second objective was considered relevant for real-time simulations.

*should operator aids be used for training?

Here also, there was no clear-cut answer as the need for such aids for SAM was still debated.However, for those considering operator aids, there seemed to be a consensus for recommending tool testing during training sessions.

*should training sessions be used for operator requalification for Severe Accident Management?

There was a consensus amongst participating regulatory bodies to consider that, though SAM training was considered to be very beneficial, and might even be required in some countries, there was no plan to consider SAM skills to be part of the formal operator licensing.

Efficiency of the organization put in place in case of emergency was not extensively debated, but specific problems were mentioned such as diagnostic discrepancies in the course of the accident and their impact when interfacing with the media.

Though agreement was not complete amongst participants, a majority thought that developing aids for non technically-oriented managers should be considered as future deregulation of the electricity market could lead to dramatic changes at the plant management level.

At last, as training for severe accidents could still be considered in infancy, there was general agreement that there was room for exchanges of information and (or) cooperation for defining objectives more precisely, together with associated requirements for an effective implementation.

2.3 - Operator aids

With respect to the use of operator aids in severe accident management, it is clear that such tools must be integrated with the Severe Accident Management Guidelines (SAMGs) in order to be of practical use.

At the meeting, no actual use of advanced computerized operational tools in the control room or TSC at the plant was reported. At the moment, there seems to be no consensus with respect to the usefulness of such tools for SAM at the plant. One viewpoint is that the use of SAMGs including simple, graphical , paper-based computational aids (CAs) is the most effective, and that use of more advanced, computer-based tools is too complicated and unpractical. Another viewpoint is that such tools would be useful in certain accident sequences, especially for the TSC at the plant, as it would provide additional useful information which the paper-based tools cannot provide. This is an unresolved question, and further research is needed, possibly through human factors experiments comparing operator performance when using different tools.

Another conclusion from the meeting was that if computerized tools are to be used for SAM at the plant, the tools or at least tools with the same man-machine interface must be used also during normal operation to make the operators familiar with the tools so that they will use them in accident situations.

2.4 - Areas for improvement

Signal validation and more generally information validation is recognized as being an important aspect of severe accident management. Indeed plant operators and emergency team experts need to rely on information given by the plant instrumentation. However, this information might come from failed sensors or from instrumentation working outside its validity range. Several methods and tools able to screen and validate the information presented to the operators were presented and discussed at the meeting. It can be concluded that this area of expertise is not yet mature. The use of advanced techniques such as fuzzy logic and artificial neural networks is being tested. Such techniques look very promising, but important problems remain to be solved like their qualification and the formal proof of their reliability.

Another important aspect related to the use of operator aids is the need for good communication and understanding between the different teams involved. It has been noted that in some countries, different tools are being developed for the control room operators, the on-site Technical Support Center and national emergency teams. There is a possibility to arrive at conflicting conclusions at different places. The way to resolve such conflicts has to be taken into account beforehand in the emergency organization. On the other hand, if the consistency of the tools used at different places has been verified, their use could facilitate communication, because people would essentially use the same language.

Finally, the use of Internet was proposed as a convenient way to share information between interested countries. There was no time at the meeting to discuss what concrete form this collaboration could take, but the Programme Committee is of the opinion that the Internet offers a complementary way to let information circulate and recommends that an appropriate forum be found to discuss the use of the Internet in the area of operator aids for severe accident management.

2.5 - International Collaboration

It was agreed unanimously that international collaboration and information exchange should be increased with respect to the development of computer-based operator aids and their applicability to operator training for severe accident management. In particular, there is a strong need to exchange views and experience related to the sort of training to be given to operators to cope with severe accident management situations and the most appropriate simulators.

SESSION SUMMARIES

SESSION I: OPERATOR AIDS FOR CONTROL ROOMS

Session Chairman: Benoît De Boeck (AVN, Belgium)

Session I dealt with calculational aids the mission of which is to assist the operator in the control room to prevent and mitigate severe accidents. Rather than to report on experience with implemented systems, all papers presented during the sessions described either systems under development, or related research activities. The R&D activities reported at the meeting covered theoretical studies (in Russia), signal validation (at the OECD Halden Project), and the activities sponsored by the European Commission. Actual systems developed in Russia, in Korea and at the Halden Project were also described. In all, seven papers were presented during the session. They are briefly summarized below.

A. Kramerov (RRC KI, Russia) presented "Some Problems on Operator Aids for Low Probable Severe Accident Management in Connection with RBMK Channel Reactors". Most of the problems that were faced during the development of operator aids for RBMK are however of a general nature. The first one concerns the need to build enough flexibility in the tools so that the operators are not lost if they encounter situations unforeseen in the symptom-oriented instructions. Connected with this is the problem of the identification and the classification of the severe accidents that are to be covered. To make sure that all essential cases are considered, the selection process was based on a combination of fission product barrier failure and the involved core part. It was then necessary to classify the great number of identified scenarios in a small number of groups that were felt to be most convenient for the operators. The severity of the event and the type of management strategy played an important role in this classification scheme. Finally, the need to evaluate and present to the operators parameters for which there exist no measurement was also felt by the author to be important for the diagnostic and the management of severe accidents.

I.D. Rakitin (RRC KI, Russia) presented "System of Dynamic Barriers Preventing the Development of Emergency Transients at Nuclear Power Plants as a Tool for Operators' Aid". The barriers here are the borders between the different plant conditions or states as defined in the INES scale. They have nothing to do with physical barriers like the ones that prevent radioactive releases. Because crossing such a barrier means increasing the severity level of the event, it is important that all features that can prevent this crossing are correctly identified. Such features include not only systems and components, but also procedures and communication means that can increase the reliability of the human intervention. Because these features can be different for the barriers between the different states, it is important to correctly identify the exact state of the plant and then to identify the means available to prevent the situation from worsening. A prototype of such an operator aid was described in the subsequent paper.

I.D. Rakitin (RRC KI, Russia) presented "Base Principles and Approach at Design of Generalized Operator Support System (GOSS)". This paper presents a computerized operator aid based on the approach presented in the previous paper. The goal of the system is to help operators manage incident and accident situations. The GOSS is being developed and tested on the Leningrad full scope simulator and is intended to be installed in the future in the main control room of the Leningrad power station. To increase the trust of the operators in the system and its applicability, the GOSS is designed to cover the full range of plant conditions from normal operation to incidents, design basis accidents and, at a later stage, severe accidents. The GOSS can identify and display the plant status, the critical safety functions and possible actions to control the situation. The feedback from the tests on the simulator has been very positive.

J. Ha (KAERI, ROK) presented "Operator Support System for Multistage Accident Management". This paper describes the development at KAERI of an integrated computer aided accident management system called KAMP that is intended to be installed in the Korean NPPs. KAMP will cover three stages: (1) before the severe accident takes place, (2) after the initiation of the severe accident, and (3) the radioactive release phase. Stage 1 corresponds to the use of the Emergency Operating Procedures (EOPs), stage 2 is linked with the use of the Severe Accident Management Guidelines, and stage 3 with the emergency plan. The tool for stage 1 is called KOSSN and provides the operator not only with a list of actions based on the EOPs but also additional information like the success paths of the safety systems and the event tree from the plant specific Probabilistic Safety Analysis (PSA). This allows to select the strategy with the highest success probability. The development of a tool for stage 2 has not started yet but the present plan is to base it on MELCOR. The tool for stage 3 is called KACAP and its purpose is to calculate the radiological and economic impact of severe accidents in the environment. This module can have a variety of applications from level 3 PSA to real time operator advice to reduce offsite consequences.

P.F. Fantoni (IFE, Norway-OECD HRP) presented "A Neuro-Fuzzy Model Applied to Full Range Signal Validation of PWR Nuclear Power Plant Data". To be able to manage an accident, operators need to know what is happening in the plant, and for this they have to rely on the information given by the plant instrumentation. But the question arises of the validity of this information: sensors or connections might fail, especially under severe accident conditions, or data processing might be operating outside its validity domain. It is therefore important for the operator to have some means to assess the reliability of available information. The Halden Reactor Project is studying the use of artificial neural networks and of fuzzy logic to this aim. Such models can be combined to exploit the learning and generalization capability of the first technique with the approximate ("possibilistic") reasoning embedded in the second approach. The system under development at Halden has been tested in a simulated environment on a French PWR, to monitor safety-related reactor variables over the entire power-flow operating map. Sensor failures were successfully detected. In the presence of unknown scenarios, the model correctly alerted the user about the impossibility to provide a reasonable diagnosis. The capability of the model to operate under accident conditions will be tested in the near future.

P.F. Fantoni (IFE, Norway-OECD HRP) presented "CAMS: A Computerized Accident Management System for Operator Support during Normal and Abnormal

Conditions in Nuclear Power Plants". CAMS is a system that is intended to provide assistance to the staff in a nuclear power plant control room, in the Technical Support Center and in the national emergency center. Support is offered in identification of the current plant state, in assessment of the future development of the accident and in planning prevention and mitigation strategies. CAMS consists of a data acquisition module, a signal validation module, a tracking simulator, a predictive simulator, a state identification module, a probabilistic safety assessment module and a man-machine interface module. In addition, the possibility exists to include a strategy generator and a critical function monitor. The signal validation module is based on the system described in the previous paper. The PSA module contains plant specific PSA data like event trees and failure probabilities. It calculates the core damage frequency based on the plant states and the component failures. It can also feed the strategy generator with information about the critical systems. The CAMS is designed to operate in all plant conditions, from normal operation to severe accidents (the development of the severe accident part has just started), giving continuity in its interaction with the user.

J. Martin Bermejo (CEC/DGXII-F-5) presented "EC-Sponsored Research Activities on Accident Management Measures". This paper discusses the objectives and achievements of a completed project of the 1992-1995 R&D Framework Programme known as "Accident Management Support" (AMS), and also presents the current status of an on-going project of the 1994-1998 programme called "Algorithm support for accident identification and critical safety functions signal validation" (ASIA). The objectives of AMS were (1) to define, investigate and develop means and methods to provide reliable information and diagnostics, as well as support tools for accident management, and (2) to investigate the different signal validation methodologies with emphasis on the existing instrumentation rather than on new instrumentation needs. The research activities of ASIA will extend and build on the work of AMS. In particular, it will further develop operator aids based on physical models in order to validate critical safety functions measurements and understanding accident progression by using search algorithms.

From these presentations, the first observation is that often the same tool is designed to be used by the main control room operators and the Technical Support Center team. The impression from the SAMOA-1 meeting that the needs of control room operators were very different from those of the emergency team does not seem to have materialized.

A second observation is that some of the tools presented include (or will include) a PSA module. The main goal of incorporating probabilistic capabilities into operator aids is to make a ranking of the proposed strategies according to their success probability. The merit of such an approach, and in particular the question of the added value compared to the added complexity, and the question of the validation, were not discussed in detail at the meeting. This is certainly an area in need of further research.

During the discussion period, participants agreed that signal validation was an important aspect of operator aids, but that signal validation tools are difficult to develop and qualify, especially if one wants to go further than simple cross-checks between redundant sensors. In particular, as artificial neural networks have the capability to recognize patterns, they are very attractive for this kind of activity. However, because they act as a black box, their reliability is hard to prove. More work is needed in the area of signal validation.

Finally, the merit of having the same tool or at least tools with the same man-machine interface giving advice to the operators in all plant conditions, from normal operations to severe accident conditions, compared to dedicated tools for each case was debated. To increase the probability that the operators will use and trust their tool, some advocate that the interface should be the same for all uses. Others are of the opinion that dedicated tools can be more easily optimized. No conclusion as to the best approach was reached at the meeting.

SESSION II : Operator Aids for Technical Support Centres

Session Chairman: Thorbjørn Bjørlo (IFE, Norway - OECD HRP)

The eight papers presented in this session covered a broad range of methodologies, computational tools and guidelines for use in the TSCs and by emergency teams in different countries. The presentations and discussions covered approaches and practices in the following countries : France, Belgium, US, Spain and Japan; utilities, designers (reactor vendors) and safety authorities points of view were presented.

From the presentations it became clear that development and implementation of Severe Accident Management Guidelines are in progress in several OECD Member countries. As an example, all plants in the US are committed to implementation of SAMGs, and it is expected that by the end of 1998 plant specific SAMGs will be implemented at all US plants.

One paper presented by M.F. Van Haesendonck, described the Westinghouse Owners' Group SAMGs, in particular the graphical computational aids (CAs) incorporated in these guidelines. These are simple, paper-based tools which are used to fulfill the need for information that is not directly available from plant instrumentation.

Several papers addressed tools and simplified computational models to be used by national emergency evaluation teams, both those of the safety organizations and those of the utility. Three papers presented by H. Cappon (Framatome), D.Winter (IPSN) and B. de Magondeaux (EDF-SEPTEN), described the French efforts in this field as well as the latest development of tools used to support the 3D/3P (triple diagnosis / triple prognosis) methodology used to assess the state of the installation and to forecast the possible development of the accident.

In essence these tools are the same as those already presented at the SAMOA-1 meeting in Halden. However, they have been enhanced to a considerable degree with respect to both calculational scope and performance (predictions much faster than real time). Further, they have been extensively validated against best estimate codes like e.g. CATHARE. These tools are successfully used in emergency drills in France.

Also, CSN Spain (J.R. Alonso Escós) reported ongoing development to extend the use of computer-based aids at their Emergency Room. In particular, work is in progress to utilise MARS (MAAP Accident Response System) as a diagnosis and predictive tool based on the set of safety parameters transmitted from the plant in real time. Currently validation of the system towards thermal hydraulic and severe accident codes is taking place. The use of this tool in yearly drills and internal training exercizes will improve the capabilities of the Operational Analysis Group of the Emergency Room.

Information Validation is an important issue in Severe Accident Management. In France, a signal validation tool for TSCs is under development (by IPSN/EDF-SEPTEN/Framatome) which aims at assessing the confidence in information based on an analysis of both sensor quality and other factors like redundancy, coherence with other measurements, and state of plant. This is ongoing development; testing and validation of this tool have to be performed before it becomes an important element among the tools used in French TSCs.

The Spanish utility Iberdrola reported a comprehensive programme for implementation of tools and guidelines in their TSC for coping with severe accidents (paper presented by L. Borondo). This includes implementation of SAMGs at the Cofrentes NPP through implementation of extensive Technical Support Guidelines (TSGs) for the TSC. At Cofrentes they are also developing a severe accident management tool based on the MAAP code and the CAMS system of the Halden Project but this system is in its early development phase.

Two papers presented tools of the expert system type to be used for supporting the assessment of plant safety state by the TSC. The US NRC has developed the Reactor Safety Assessment System (RSAS) which will be used in their operations center (paper presented by J.B. O'Brien). Plant specific models have been made for all the PWRs; work on the BWR version is under way. The RSAS has potential for being very useful for assisting NRC in monitoring emergency response

The Japanese BWR group (paper presented by T. Fujiwara, Hitachi) has developed a prototype of an Emergency Response Support System (ERSS). The prototype has undergone verification testing which shows that it can be useful and effective in accident management training, especially in improving communication between the control room, the TSC and the head office in emergency cases if all these locations have access to the ERSS.

One observation from the session was that the implementation of the more advanced computerized tools for accident management support like advanced predictive simulators in the TSC has proceeded much slower than expected at the SAMOA-1 meeting held in Halden in 1993. This is especially true for the TSC at the local level, i.e. the TSCs of the specific NPPs. In the discussion, the views from several participants were that at this level, at the plant, advanced computerized tools are <u>not</u> needed in SAM, that is in the mitigation phase, after core damage has occurred. Actually, the use of such tools is too complicated, operators cannot wait for the results of the simulations and one cannot rely on the computers being available, according to the view of these participants.

Other specialists were of the opinion that computerized aids may be useful also in the mitigation phase as they can provide for certain sequences information the operator needs and which he cannot get by paper-based computational tools like the CAs of the WOG SAMGs.

This is an unresolved issue, and more research is needed. Some participants suggested that human factors experiments should be carried out comparing the performance of TSC staff using different tools in simulations of accident scenarios.

With respect to use of tools at the national emergency centers, there has been progress since SAMOA-1, but few new tools were reported. The progress has more been enhancement of tools presented at SAMOA-1 and implementation of such tools in modern PC environments.

An issue brought up in the discussion was the use of different computational tools by the different national emergency centers and by the different emergency evaluation teams, e.g. those of the safety organizations and those of the utility. Could the use of different tools cause communication problems and potential conflicts? Even though the different emergency organizations have different, clearly defined responsibilities, some specialists felt that the use of different tools could be confusing and that some consistency might be called for. Some participants were even of the opinion that computerized tools for Accident Diagnosis and Management were not needed at National Authority Emergency Centers because the responsibility to manage the accident should remain with the utility.

SESSION III : Simulation Tools for Operator Training

Session Chaiman: Michel Vidard (EDF-SEPTEN)

Five papers were presented in Session III devoted to Simulation Tools for Operator Training.

The paper presented by M. Vidard of EDF discussed some issues related to operator training for Severe Accident situations.

After recalling the main conclusions of the report issued by the SESAM group (Senior Group of Experts on Severe Accident Management), he noticed that training for Severe Accident Scenarios was considered beneficial but lagging behind implementation of SAM programs.

To explain this, he commented on some differences between accident management and severe accident management and concluded the first part of his presentation saying that, as the problem was complex and cost issues could not be neglected, training could be contemplated only after clear definition of utility objectives.

Three objectives were discussed, one stressing improvement of knowledge, the second operator behavior in case of severe accidents, the third one organization efficiency in case of emergencies.

His conclusion was that there was a potential for cooperation between OECD Member countries in this domain, at least to define what was needed.

The second paper, presented by S.D. Malkin, from the RRC Kurchatov Institute (Russia) described the main features of a full-scope simulator devoted to operator training on RBMK type reactors. After outlining the most significant characteristics of this type of reactors, he stressed that operator error was a non-negligible factor of risk and that the full-scope simulator had been designed to address this kind of problem.

After detailing options and possibilities offered to the user, he stressed the most significant capabilities of the simulator, in particular the adoption of 3-D neutron kinetics (STEPAN-SIM) and advanced thermal hydraulics (KOBRA-SIM) softwares. As mechanical behavior of the fuel plays a role in plant response, the need for implementing the STALACTITE software was also justified.

Finally, the full-scale simulator was tested on the Chernobyl accident scenario, and simulation showed that :

*the simulator had the capability to correctly simulate the accident.
*design upgrades (Safety Systems and fuel loading patterns) had the potential for preventing degradation into a severe accident.
*a skilled operator could prevent massive reactivity injection a few seconds before the neutron power burst.

The ODES on-line diagnosis code was also described, together with the GOSS (operator support system); the author's conclusion was that this type of simulation could be used to improve NPP safety.

The third paper, presented by M. Garcés from the University of Cantabria in Santander - Spain, described an Integrated Simulator and Real Time Information System. Based on the MAAP3 computer code, the simulator allows several operators to interact simultaneously on the process. It includes an anomaly-generating capability both before and during the accident, and operators can interact with the model at any time into the accident. Special attention was paid to visualization; the SCADA graphics software allows to display plant data in real time.

Applications and benefits of the system, already used at the Maria de Garoña Nuclear Plant was also detailed :

*periodic retraining of plant operators, emphasizing human reliability aspects,
*advantages resulting from the SPDS graphics system,
*the capability to feed the plant Technical Support Center, and the Emergency Response Center situated at Utility Headquarters, with simulator data,
*the possible use for training on severe accident scenarios.

At last, possible future developments, i.e. implementation of the MAAP4 code, and the connection of an Expert System allowing tracking of Emergency Operating Procedures, were also described.

The fourth paper, presented by M. Sonnenkalb from GRS Germany complemented the demonstration performed in session I. Responding to the interest of German Utilities, GRS had developed a special training course on the Phenomenology and Progression of Severe Accidents in PWRs.

After analysis of what was required to take full advantage of such a course, it had been decided to develop a numerical tool using off the shelf state-of-the-art Severe Accident modules (MELCOR, ATHLET, RALOC and WECHSEL).
As knowledge-based training was the objective, real-time was not the main concern in developing the numerical tool.
From a sequence (or scenario) standpoint, rather than offering the capability for simulating different types of accidents, emphasis was put on a very specific scenario, considered less improbable than the others in the German context, i.e. total loss of secondary feedwater and total loss of heat sink.
Emphasis is put on the most significant phenomena encountered during accident progression, and on problems specific to Severe Accident scenarios, e.g. instrumentation response or availability, or the consequences of Severe Accident Management Actions. For the latter case, guidance is provided and further justified.
Amongst the conclusion, it can be noted that this tool has the potential for adaptation to BWR scenarios. At the time being, GRS doesn't consider that there is an urgent need to go beyond what is currently done (no need to evaluate other scenarios or test operator behavior).

The last paper, presented by J. Hortal from the Nuclear Safety Council (CSN) of Spain, Madrid, dealt with the Integration of Operator Actions in Accident Sequence Simulation Tools for a BWR Plant.
Starting from an analysis of some differences between normal operation and accident situations at the system level on one side, on the complexity of physical phenomena on the other side, he stressed that plant behavior during accident was dominated by phenomenology and manual or automatic protective actions. Also, operator actions play a very important role as nobody would expect an operator doing nothing in a perturbed situation.
It was therefore decided to develop a multi-purpose simulator combining simulation capabilities under normal and accident conditions and integrating operator actions. Potential uses could be for PSAs and Individual Plant Examinations (IPEs), design and verification of procedures, including severe accident guidelines, and simulation of scenarios to derive criteria for operator training or evaluation activities.
The accident simulation package includes three softwares, TIZONA, COPMA II and MAAP. TIZONA simulates plant evolution and communicates with COPMA II, the latter feeding TIZONA with operator actions resulting from Emergency Operating Procedures. Once TIZONA detects that plant parameters are near the range of validity of the model, most simulation work is transferred to the MAAP code . System architecture is such that COPMA II does not make any difference between TIZONA and MAAP, thus simplifying software interface.
After a description of the detailed capabilities of the code, e.g. taking care of operator burden or synchronizing plant and procedure simulation, it was stressed, as a conclusion, that :

*the simulator has already been tested on a Station Blackout Scenario in a BWR, using real plant operating procedures,
*the TIZONA - MAAP software was being completed with manual control inputs needed for the implementation of some procedures,
*a complete set of EOPs for a BWR/6 plant had been edited.

Presentations were followed by a discussion on operator training allowing to stress the following :

*There was a consensus to say that operator training was beneficial.

*Opinions largely differed on what was needed. Some participants, considering that if there were a severe accident, it would anyway never look like scenarios chosen for training sessions, thought that only knowledge-based training was needed to make operators more familiar with physical phenomena and accident progression. Other participants, though agreeing that, if there were a real coremelt situation, plant evolution would likely deviate from that seen in scenarios used for training, stressed the interest of analyzing operator behavior under perturbed situations, with the help of real-time simulators.

*Even for those agreeing on the latter, there was no agreement on the kind of simulator which would provide a reasonable approach to operator training.

*The need to provide operator aids and test them during training sessions was also debated, and the specific problem of providing plant managers with adequate tools for making decisions was evoked, in the perspective of more finance-oriented managers in a deregulated electricity market.

Annex

PROGRAMME COMMITTEE

Michel Vidard (EDF-SEPTEN, France) - Chairman

Benoît De Boeck (AVN, Belgium)

Thorbjørn Bjørlo (IFE Norway, OECD HRP)

Jacques Royen (OECD-NEA) - Secretary