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SPECIALIST MEETING ON

INSTRUMENTATION TO MANAGE SEVERE ACCIDENTS

(16-17 March 1992)

SUMMARY AND RECOMMENDATIONS

Organised by
OECD Nuclear Energy Agency
in collaboration with
Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS
OECD NUCLEAR ENERGY AGENCY

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UND REAKTORSICHERHEIT (GRS)

SUMMARY AND RECOMMENDATIONS

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First CSNI Specialist Meeting on Instrumentation to Manage Severe Accidents

Summary and Recommendations

The First CSNI Specialist Meeting on Instrumentation to Manage Severe Accidents was held at Cologne, Germany on 16th and 17th March 1992. It was hosted by the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH. About seventy experts attended the Specialist Meeting from thirteen countries and two international organisations; they included an expert from the Czech and Slovak Federal Republic. Twenty-two papers were presented in four sessions. The proceedings will be published by GRS under separate cover.

The Specialist Meeting concentrated on existing instrumentation and its possible use under severe accident conditions; it also examined developments underway and planned. Desirable new instrumentation was discussed briefly. The interactions and discussions during the sessions were helpful to bring different perspectives to bear, thus sharpening the thinking of all. Questions were raised concerning the long-term viability of current (or added) instrumentation.

It must be realized that the subject of instrumentation to manage severe accidents is very new, and that no international meeting on this topic was held previously. One of the objectives was to bring this important issue to the attention of both safety authorities and experts. It could be seen from several of the presentations and from the discussions that this kind of work is still in a planning phase. The following conclusions and recommendations must therefore be seen as preliminary:

(1) To make decisions which are appropriate and effective to control and mitigate an accident, it is essential to have the clearest picture possible of the accident and its progress. This can be obtained by accumulating information from as many sources as is practical.

(2) It is important to use a systematic approach to evaluate accident sequences, information needs and instrument capabilities in severe accident conditions.

(3) It should be confirmed that instrument performance will be sufficient to give the information needed to manage a severe accident. In some cases the instruments may function beyond their specification range.

(4) Important lessons can be learned from the TMI-2 and LOFT-FP-2 measurements, in particular for instruments giving new information [e.g. Source Range Monitor (SRM) information about vessel water level].

(5) All participants agree on using the full instrumentation and accident management capacity of the plants. All are focusing on making full use of post-TMI-2 safety enhancements and instrumentation additions already in place.

(6) Most participants agree on the types of measurements which will prove useful. Various means are being pursued to think ahead and interpret plant status, such as computer codes and calculational tools.

(7) An important conclusion is that there is a need for additional work on unconventional use of existing instrumentation under severe accident conditions.

(8) This work will identify areas where existing instrumentation can indirectly contribute to the information needs in severe accident situations and areas where it cannot, thereby giving indications on desirable new developments.

(9) The question of new accident management instrumentation was raised. The current perspectives are based on national objectives, and depend on the optimism or pessimism of the participants over the longer term viability of instruments. It is clear that efforts to ensure the long-term viability of instruments are being pursued by all (with a reasonable "common sense" attitude). In fact, the pessimistic view is "conservative" and leads planners to make prudent provisions to manage the accident with any instruments that may be available.

(10) Some new instruments are being developed; their possible usefulness under severe accident conditions needs to be further qualified.

(11) In spite of differences in purpose, some instruments used in experiments can be evaluated and qualified also for current nuclear power plants.

(12) The papers presented at this meeting clearly showed that most approaches to expert systems are still in a conceptual phase. Some applications transferred from other fields are under development for use in the severe accident domain. Only those systems that offer a set of less sophisticated tools can be said to be readily available for limited purposes.

(13) Expert systems may be of help to plant staff and external experts, but cannot substitute for them.

(14) There will not be a single expert system for severe accidents (i.e. a general problem solver) but rather a set of simpler systems devoted to specific goals in situations that can be clearly identified.

(15) Expert systems should have the capability to verify plant conditions and assumptions made by the operating personnel.

(16) Expert systems used in this domain must be even more explanatory and transparent to permit verification of their conclusions by the personnel.

(17) Expert systems should, if possible, also be used during normal plant situations to increase operating personnel confidence.

SUMMARY OF THE SESSIONS

SESSION I - Information Needs for Managing Severe Accidents

Dr. Patricia Worthington (USDOE) presented the report titled "Instrumentation for Accident Management in Containment" prepared by CSNI-PWG4's Task Group on Containment Aspects of Severe Accident Management. The INEL and NUMARC/EPRI self-assessment methods for utility use were referred to. Each has instrumentation as one component of the assessment. It was suggested that creative information gathering includes portable instrumentation, system status (operational/failed), component failures, and unintended uses of instruments. It is the hope of the Task Group that this meeting facilitate creative approaches to accident management information/instrumentation. This paper provided an excellent kick-off to the meeting.

Mr. Erik Söderman (ES-KONSULT AB, Sweden) discussed the Swedish approach to information needs in Boiling Water Reactor (BWR) severe accident situations. Swedish Emergency Operating Procedures (EOPs) include mitigative steps. During a severe accident the operator would use EOPs even to the point of being allowed to release radioactive gases (through scrubbers) without requesting situation-specific state/regulatory permission. Normal operator responsibility is expected to a 800 °C core temperature. At that point the Technical Support Centre (TSC) should be available and assume lead responsibility. Accident management reactor instrumentation consists of pressure (reliable), water level (not so reliable below top of core), and power range monitor (complicated to interpret). For the late stages of accident management, it is judged that none of the Reactor Pressure Vessel (RPV) instruments will work. Containment instrumentation (for late severe accident stage) consists of pressure, water level, and temperature for wetwell and drywell, and radiation monitors.

Accident history information is considered important for interpreting current plant status. A system called SAS-II has been developed to perform oversight of the critical safety functions as an aid to the shift supervisors. A currently unfunded project concept, CAMS (Computerized Accident Management Support), is intended for the use of plant staff. It would eventually include an expert system judging validity of its plant signals. A great advantage of the concept is that the data base can be used for normal operation applications. The conclusion was that we can never make late-stage instrumentation sufficient, thus accident history is important for understanding especiallly for late stage plant status. Additionally, capturing early accident history for review by the TSC and crisis response team is important to they can correctly begin to deal with a severe accident.

Dr. Martin Sonnenkalb (GRS, Germany) presented "Information and Requirements Needed for Accident Management". The GRS approach was influenced by the USNRC/INEL approach but was independently arrived at. It starts with four safety objectives:

(1) prevention of core damage
(2) retention of core material in vessel
(3) prevention of containment failure
(4) mitigation of fission product release.

These are supported by safety functions which deal with various challenges. The challenges are caused by physical mechanisms and have various accident management strategies identified to deal with them. A detailed Pressurized Water Reactor (PWR) example was discussed. Filtered containment venting was discussed for PWRs. Requirements are that it should be operated from the control room, that the system has to be protected from effects of hydrogen combustion by additional countermeasures, and that instrumentation and control of the system include temperature and pressure variables together with an activity measurement, which is important.

Information sources for prevention of containment failure were outlined. RPV integrity and core melt process information would be useful to anticipate and respond in a timely manner. Requirements to limit hydrogen concentration were identified. Measurements of importance include pressure, temperature, radioactivity, and hydrogen/steam/oxygen concentrations.

In conclusion, the safety objective tree approach was successful. All relevant mechanisms were considered. A question during discussion raised the issue of determining hydrogen concentration based on observing if the ignitors are functioning, for those ignitors requiring electricity to function. Another question identified the potential information need for a carbon monoxide detector. Another question was how Direct Containment Heating (DCH) and steam explosion were eliminated from consideration for German plants. The answer was that the probability of high loads from steam explosion was very low because there would be no water in the cavity, and that DCH was eliminated because of primary bleed action and cavity design. Questions asked relative to the use of recombiners for severe accidents brought out the intent of Germany to look aggressively at catalytic (passive) hydrogen recombiners.

Mr. Bruno Ragué (IPSN, France) presented instrumentation needs and data analysis for the diagnosis and prognosis of the source term by the French Institute for Protection and Nuclear Safety (IPSN) during an emergency in a PWR. Making such a prognosis at an early stage, in terms of time, duration and intensity of the potential release of fission products into the containment, will provide civilian authorities with sufficient advance warning for off-site emergency plan implementation. The French national emergency organisation was described. The IPSN crisis team which reports to the French Safety Authority, but also periodically compares its analyses with those of the utility emergency technical support team, basically uses an audioconference system and a computerised data acquisition system including plant parameters (safety panel, plant computer outputs) and radiation monitoring in the vicinity of the plant. The computer is backed up by telefax when appropriate. Necessary measurements for the diagnosis of the plant status include core exit temperature, containment pressure, saturation margin, primary circuit mass balance, and similar parameters in the auxiliary building in the event of a containment bypass. Additionally, activity and steam generator blowdown (level-related) measurements are also important. The status of containment isolation, generator and condensor steam dump valves, and steam generator pressure and mass balance are also useful. The various software tools used to help with accident prognosis are part of the SESAME project: they include BRECHEMETRE (assessment of primary break size and other parameters), SINBAD (various correlations including core degradation and containment leak size assessment), ALIBABA (expert system to identify containment leakage), HYDROMEL (containment temperature and pressure influenced by core melt progression, and hydrogen risk), PERSAN (diagnosis and prognosis of the release in the case of an accident without containment bypass) and RTGV (thermohydraulic and fission product transfer in case of steam generator tube rupture).

Data acquisition, organisation and control were discussed. Code qualification has been closely looked at. On-line data are available from the plant to the national crisis centre.

Dr. Jason Chao (EPRI, USA) presented "Instrumentation and Severe Accident Plant State Implementation". EPRI's current programme is aimed at getting the most out of current instrumentation/information to allow actions to be taken, and feedback on the impact of those actions. Instrument response does not need to be as accurate as during normal operation. Not all instrumentation loops will see a severe environment. Calculational aids to interpret instrument response and to predict conditions where there are no instruments will be developed. TMI-2 information was considered and studied. The six project steps to obtain the deliverables were described. Methods to interpret instrument response and survivability will be developed. The project will identify instruments of interest and select some for further study. The project identified conditions which instruments are likely to see. Interpretation of instrument response is the goal. Calculational aids will be developed to determine the relation of instrumentation readings to actual plant parameters. Additional aids will help interpret instrument errors. Deliverables include an instrumentation data base including failures and success under severe conditions, methods to assess validity of signals from instrument loops, and calculational aids.

Mr. Fausto Zambardi (ENEA/DISP, Italy) spoke about "Considerations on Monitoring Needs of Advanced Passive Safety Light Water Reactors for Severe Accident Management". A brief introduction to advanced passive reactor design was given. Information needs are influenced by the more robust (safer) design aspects of the advanced plants, such as operator error tolerance, reduced complexity, and the capability to easily detect abnormal conditions. Consideration in the design will be given to the design basis, severe accidents, and recovery after accidents. The concept of passive safety systems is to prevent accidents with limited human intervention. This potentially decreases the reliance on instruments and human intervention to ensure safety. Instruments are still important to monitor plant states. Functions to be monitored for EOPs include reactivity, Reactor Coolant System (RCS) pressure and temperature, residual heat removal, steam generation (PWRs), hydrogen/oxygen concentration in containment, and in-containment radioactivity.

Possible additional functions to be monitored include heat rejection to the environment, water level in containment, external energy and water inventories, and key systems availabilities. Instrument system requirements will include adequacy, completeness, performance, and reliability characteristics. A possible method to determine instrumentation needs for advanced reactors is embodied in the following five steps:

STEP 1: Using probabilistic risk analyses, considering foreseen accidents and potential evolutions characterising various plant states

STEP 2: Identifying strategies for the plant states

STEP 3: Defining information needed to perform these strategies

STEP 4: Identifying monitoring instrumentation requirements

STEP 5: Building in redundancy, diversification, and information correlation.

In discussion, it was suggested that these five steps could be applied to current plants also.

SESSION II - Capabilities and Limitations of Existing Instrumentation

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The importance of a systematic approach to understanding the capabilities and limitations of instruments was emphasized. A step-wise procedure was demonstrated by **Mr. William Arcieri** (INEL, USA). The different steps include:

STEP 1: Identify Severe Accident Sequences
STEP 2: Determine Expected Conditions
STEP 3: Assess Instrument Availability

From this information it can be found if needed instruments have the capabilities to give adequate information to find the best accident management strategy. Usually, the environmental challenge is temperature or pressure rather than radiation dose. It was pointed out in the discussion that many instruments may have an extended range beyond the specifications. Adequate instrumentation (extended range, environmental qualification) can also be found in non-nuclear applications.

A specific example of implemented procedures for Core Damage Assessment (CDA) was given by **Mr. Staffan Hennigor** (Vattenfall, Sweden). Methods to judge the core damage include

- dose rate readings in the containment
- post-accident sampling system
- process parameter
- hydrogen concentration.

The first two methods are quantitative, in particular the post-accident sampling system. The process parameters can be used as a source of information if the core has been uncovered. The hydrogen measurements can only be used as a supportive argument confirming that zircaloy oxidation has occurred. It was pointed out in the discussion that the uncertainty on the amount of hydrogen generated was important, but that an equally important uncertainty was the possibility of hydrogen stratification in the containment. Thus, the importance of having a sufficient number of hydrogen sensors was stressed.

The instrument readings from the TMI accident and LOFT-FP-2 were described by **Dr. Wahba** (GRS, Germany). The history of important phenomena was reconstructed from data available for pressure, pressure difference, temperature and neutronic measurements. A thorough examination of the instrument information from the TMI accident shows that water level in the primary system and core relocation can be deduced. The difficulty is, of course, to interpret instrument readings outside normal operation, in particular in a severe accident situation. In the first place there is a lesson learned that some instruments may have a different interpretation, e.g. the source range detectors normally indicate an increase in power if the count rate increases. In the case of TMI-2, the increased count rate was due to a water level decrease in the core.

In the case of the severe accident experiment conducted at the end of the OECD-LOFT programme (LP-FP-2), careful interpretation of instrument readings was important in identifying the following phenomena:

- water level degradation in the pressure vessel
- metal-water interaction and hydrogen generation
- time of clad rupture
- exothermal reactions during reflood
- natural circulation during long term cooling.

The locally harsh environmental conditions during severe accidents can influence the instrument readings as observed in the behaviour of some thermocouples in LP-FP-2. Some thermocouple cables were routed through the high power region of the core. These thermocouples showed a steeper increase in measured temperatures than adjacent thermocouples where the cables were routed through colder core regions (cable shunting effect).

From the examined measurements it is concluded that:

- pressure sensors, thermocouples and radiation monitors are able to withstand the consequences of severe accidents
- these three types of sensors can be utilized in combination with advanced information technology to manage severe accidents
- several methods are now available to monitor the water level in the pressure vessel
- reliable methods to monitor core melt progression and hydrogen generation are needed.

Three papers dealt with instruments used in experiments: LOFT-FP-2, PHEBUS, HDR, and the Battelle Model Containment. It should be emphasized that the purpose of instrumentation in experiments and nuclear power plants is different. Experiments usually have elaborate equipment to get as much information as possible from various phenomena and for code validation. The purpose of instruments for accident management is to understand reactor accident status and to select the best accident management strategy.

Mr. Roland Zeyen (CEC/JRC Ispra) presented the PHEBUS FP project, in particular the instrumentation and methods used to extract experimental data. Several sophisticated instruments will be used to measure the steam flow rate, hydrogen rate, oxygen potential, as well as an aerosol light extinction photometer, etc. to get a full understanding of the experiments being performed. Some of the containment instruments could be of interest for current reactors, such as Maypacks (iodine measurements) and sequential sedimentation coupons.

Another presentation from experimental facilities, HDR and Battelle Model Containment, was given by **Dr. Teja Kanzleiter** (Battelle, Germany). His experience with temperature, pressure, steam content, hydrogen and aerosol measurements from these experimental facilities, and the possibility to use these instruments in commercial facilities, were discussed.

In particular a sampling system using a long stalk could be used if it is possible to provide it with the necessary safety features.

It was also pointed out that not only instrument qualification could be achieved but also better understanding of the system response to different phenomena.

The discussion at the end of the session brought up interesting information needs, for example, how can the plant staff understand where the core is located: in place, in the lower plenum, in the cavity, or somewhere else in the containment. This also implies the difficulty to judge if vessel melt-through has occurred.

SESSION III - Unconventional Use and Further Development of Existing Instrumentation

This Session discussed the unconventional use and further development of plant instrumentation, which can contribute to increase the diversity and flexibility of accident data available.

The first paper was presented by **Dr. Richard Oehlberg** (EPRI, USA) and **Mr. Revis James** (ERIN Engineering and Research, USA). It highlighted that other information sources can help to augment and confirm data available from dedicated accident instrumentation such as Reg. Guide 1.97 Instrumentation: inferences of plant status are possible from measurements and measurement trends obtained from instruments not expected to function, observations of system or component operability/inoperability, and observations of locally harsh environmental conditions. Detailed plant-specific examples were given, e.g. regarding the reactor pressure and level indication in BWRs, or the reactor cavity temperature indication in Westinghouse-type PWRs which the authors speculate may yield information related to vessel and core temperature. The authors advocate that others look at their information sources in a creative way.

The second paper was presented by **Mr. Jörg Pauls** (T.H. Zittau, Germany). It described a new water level measuring method in vessels, based on the utilisation of a combination of exterior gamma detectors, which measure the internal activity of N^{16}, generated by a (n,p) reaction on the O^{16} in the primary water. Two applications were given, one on the water level indication in a steam generator with U-tubes, the other on the water level indication in BWRs, with the corresponding calculation methods. Such a method, which appears to be valid during power operation or shortly after reactor shut-down, will be further qualified on a test reactor before being proposed for power reactors.

The third paper, presented by **Mr. Bernd Eckardt** (Siemens/UB KWU, Germany), discussed methods developed in Germany for measurements of hydrogen concentration and airborne nuclide concentration in the containment atmosphere, which are due to provide additional information on the accident history, plant status and effects of countermeasures to reduce hydrogen concentration, and also to help assessing the potential hazard in the vicinity of the plant. In-site hydrogen measurements as well as measurement through extractive sampling were discussed, the former system, using sensors in the containment, providing continuous and simultaneous information displayed in the control room without radiation exposure. Regarding containment atmosphere activity monitoring, the difficulties of extraction pipe systems were described and some preference was given to in-containment sampling and to pool sampling system.

The fourth paper, presented by **Dr. Horst-Michael Prasser** (Z.K. Rossendorf, Germany), described the use of needle-shaped conductivity probes for two-phase flow pattern determination during simulated emergency core cooling hot leg injection experiments at the COCO facility in the HDR containment. The first results appear promising and the use of such probes as additional instrumentation can be envisaged in the future in power reactors, e.g. for the control of water level, once some improvements have been achieved, in particular regarding the stability of the probe.

The fifth paper, presented by **Dr. Harri Tuomisto** (IVO, Finland), focused on plant-specific severe accident management instrumentation that has been or will be added to the Finnish NPPs TVO I and II, Loviisa I and II, as a consequence of the severe accident management policy adopted, and of the resulting safety functions to be ensured.

A distinction is made between the instrumentation that is of crucial importance for performing a correct management measure and the instrumentation needed for monitoring the success. New instrumentation is strictly limited to those ensuring the safety functions.

The sixth paper, presented by **Professor Kurt Becker** (RIT, Sweden), described the performance studies of a new core cooling monitor for BWRs. Such a detector has been successfully tested at various elevations, including in the lower plenum, in the Barsebäck nuclear power plant under normal operating conditions, and also in various environments in a 160 bar loop (with sudden uncoveries) and in the laboratory (up to 1265 °C). It can be operated in two modes: the core cooling mode and the temperature mode, where it actually acts as a thermometer. It currently appears ready for implementation in BWR installations.

SESSION IV - Operational Aids and Artificial Intelligence

The session focused on the applicability of techniques in the domain of severe accidents. The subject treated can be split into three main categories:

- semantical* concepts
- integrated applications
- operational tools.

These categories will be defined and discussed below.

The success of expert systems in other fields (like medicine, etc.) is largely due to the fact that large amounts of data have been gathered and represented as a homogenous sets of "rules" that can be stored and retrieved in and by

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* Semantics is the branch of linguistic research concerned with studying changes in meaning of words.

using modern computers. However, the intelligent selection, i.e. the systemsanalysis that has to be performed implicitly or explicitly, determines the structure of the resulting expert system. Thus, this structure varies from domain to domain, from one application to another; with regard to nuclear power: from one plant over to another.

Nevertheless, these structures are essentially semantical concepts, i.e. the attempt to describe implications in the problem domain.

Once such a semantical concept exists, it can be used to implement a special case (application). The way is to put the data for the application together and write a program to execute the concepts based on the data. However, as many changes, experiments, tests and further enhancements must be envisaged, so-called "shells" that represent the semantical concepts are programmed in which the data can be "fitted in". Such an approach is called an integrated application. One drawback, however, of today's integrated applications is that they require general concepts such as rules of the form "IF turbine is tripped THEN reactor will be tripped", which restrict the expressive power of such systems [you can only model (describe) what the concept yields !]. This implies that integrated applications can only be successfully used when the concepts already match the requirements completely.

Many problems in many domains do not require very sophisticated inferences as the integrating element is the human being. Therefore conclusions are being drawn by the human and not by some concept. Here, the human must be supported by an array of tools (the sophistication of which may vary). Even though in the eyes of the "artificial intelligentsia" these tools are not fully accepted, they can be of great help especially in situations where the domain tends to break apart and can no longer be reviewed as a single entity with the conclusion that truly artificial intelligence strategies do not apply any more and become useless.

The presentation made by Dr. Sergio Guarro (Advanced System Concepts Associates, USA) clearly falls into the semantical concepts category. He described the outline of AMAS (Accident Management Advisor System). The system is intended to have three levels: Parameter State Identification Filter, Plant State Identification Module, and the Management Action Decision Support Module.

Each of these levels uses specific concepts. While level one strongly relies on the so-called Logic Flow Graph Methodology (LFM) to track key parameter interaction and consistency, level two refers to Accident Progression Trees (APT) and Bayesian Belief Networks (BBN). The top level associates plant conditions with accident consequence minimization schemes. The system is in the conceptual phase. A working prototype is to be developed in the second phase.

Also in this category was the paper presented by Mr. Paul Millar (AEA Technology, UK) about a system called TOPS (TOtal Plant Surveillance). The TOPS concept is also hierarchical and roughly divided into two sections at the second level, monitoring and diagnosis. Diagnosis provides on level three incipient fault detection, full fault detection and identification, post-fault status, and post-fault behaviour prediction. The plant monitor uses an observer based on a mathematical model of the process. In essence, measured data are compared to computed (model-inferred) data. Diagnostics are performed on several plant levels and plant areas such that the computation-intensive parts are preferred on the lower level in a distributed environment (i.e. in parallel). In this way it is also claimed that real time operation of TOPS can be achieved. The system is currently under development.

The paper presented by **Professor Rainer Hampel** (T.H. Zittau, Germany), titled "Model-Based Correction Algorithms", described model-based measuring methods, which could be used for the reconstruction of non-directly measurable variables and therefore may contribute to the diagnosis of the complete system state, the realization of state controllers, or fault detection. The results of the methods and algorithms developed for the case of the hydrostatic level measurement on horizontal steam generators have been compared with experiment data on pilot plants and **ATHLET** calculations. Such methods are expected to be used in the future, after further qualification, on power reactors.

A more general paper on the use of Artificial Intelligence (AI) for operator support systems was presented by **Dr. Michel De Vlaminck** (Tractebel, Belgium). It described OPA (Operator Advisor), which is an expert system of the category "integrated applications". OPA's main advantages are: on-line access to a flexible and adaptable knowledge base, post-accident monitoring of operator actions, priority listing of all needed actions, and the availability of background information. The system heavily relies on rules in the classical sense. However, the system has capability to react to events and has elements to treat time-dependent actions. Presently, the system is implemented on a Symbolics LISP-machine, though chances are, the system will be available on regular workstations in the near future. The system is used in the reactor operator training centre.

To satisfy the third category listed in the beginning **Mr. James Raines** (Fauske & Associates, USA) gave a presentation on MARS (MAAP Accident Response System). This system uses the Modular Accident Analysis Program (MAAP) code to calculate the nuclear plant thermal-hydraulics and fission product response under accident conditions. MARS uses on-line data from plant instrumentation to initialize MAAP any time during the accident. MARS then is able to perform a variety of functions. Among them are: diagnosis of event and evolution of accident sequence, tracking plant behaviour and operator actions as well as their impact, ensuring consistency of simulation, performing root cause analysis and near-term predictions. MARS operates much faster than real-time. A typical set of computation times was given for a forty-hour scenario ranging from about one hour (on a 486 PC) to seven minutes on an optimized HP workstation.

A very lively discussion was going on at the end of the session, focusing on subjects like: "What is necessary for the operator to infer the plant status during a severe accident ?", "Is no information better than incomplete or erroneous information ?", "How can such artificially intelligent systems be validated ?", and "Is it not most important to avoid information overload ?". Whilst most of these issues were discussed rather controversially, the opinion was rather unanimous that if a severe accident happened at all, it would not quite match any of the predicted scenarios.

Validation of AI Systems is important. Bad information is worse than no information. With bad information, plant staff may try to do something based on it, and could make things worse. If the plant staff know that they have no good information they can make attempts to remedy that. Thus, AI systems should produce validated "good" information or indicate that no good deductions can be made. A participant suggested that the further the accident proceeds, the more general the analytical attempts should be to analyze and understand it. This appears very consistent with the validation limitations for severe accidents.

Some participants were extremely worried about the use of computers in carrying out high-complexity inferences during a severe accident as the impression prevailed that this may eventually discard the operator. However, the general consensus was that the last decision-making will always be human responsibility; only the degree of support (and its necessary complexity) that such approaches may yield was divisive.

Appendix

Members of the Programme Committee and/or Session Chairmen

Mr. Jacques Duco (CEA/IPSN, France)
Mr. Lothar Felkel (GRS, Germany)
Dr. Gustaf Löwenhielm (Vattenfall, Sweden)
Mr. Walter F. Pasedag (USDOE)
  [replaced at the meeting by
  Dr. Richard N. Oehlberg (EPRI, USA]
Mr. Jürgen Rohde (GRS, Germany) - Chairman

Mr. Jacques Royen [OECD(NEA)] - Secretary

Annex

OECD

The Convention establishing the Organisation for Economic Co-operation and Development (OECD) was signed on 14th December 1960.

Pursuant to article 1 of the Convention, the OECD shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and this to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The current Signatories of the Convention are Australia, Austria, Belgium, Canada, Denmark, Finland, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

NEA

The OECD Nuclear Energy Agency (NEA) now groups all the European Member countries of OECD and Australia, Canada, Japan and the United States. The Commission of the European Communities takes part in the work of the Agency.

The primary objectives of NEA are to promote co-operation between its Member governments on the safety and regulatory aspects of nuclear development, and on assessing the future role of nuclear energy as a contributor to economic progress.

NEA works in close collaboration with the International Atomic Energy Agency, with which it has concluded a Co-operation Agreement, as well as with other international organisations in the nuclear field.

CSNI

The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of scientists and engineers. It was set up in 1973 to develop and coordinate the activities of the OECD Nuclear Energy Agency concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations. The Committee's purpose is to foster international co-operation in nuclear safety amongst the OECD Member countries.

CSNI is sponsoring several Senior Groups of Experts and Principal Working Groups (PWG's). PWG4 is dealing with the confinement of accidental radioactive releases.

ABBREVIATIONS

CEA	Commissariat à l'Energie Atomique
CEC/JRC	Commission of the European Communities/Joint Research Centre
CSNI	Committee on the Safety of Nuclear Installations
ENEA/DISP	Ente per le Nuove Tecnologie/Direzione Centrale Sicurezza Nucleare e Protezione Sanitaria
EPRI	Electric Power Research Institute
HDR	Heissdampf Reaktor
INEL	Idaho National Engineering Laboratory
IPSN	Institut de Protection et de Sûreté Nucléaire
IVO	Imatran Voima Oy
LOFT-FP-2	Loss-of-Fluid Test-Fission Products-2
NEA	Nuclear Energy Agency
NPP	Nuclear Power Plant
NUMARC	Nuclear Management and Resources Council
OECD	Organisation for Economic Co-operation and Development
PWG4	Principal Working Group on Confinement of Accidental Radioactive Releases
RIT	Royal Institute of Technology
T.H.	Technische Hochschule
TMI-2	Three-Mile Island 2
TVO	Teollisunden Voima Oy
USDOE	United States Department of Energy
USNRC	United States Nuclear Regulatory Commission
Z.K.	Zentralinstitut für Kernforschung