Unclassified **NEA/CSNI/R(97)13**

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

OLIS : 29-Jun-1998
Dist. : 03-Jul-1998

English text only

NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

NEA/CSNI/R(97)13
Unclassified

Principal Working Group No. 1 - Extended Task Force on Human Factors

TASK 5: ROLE OF SIMULATORS IN OPERATOR TRAINING

67121

Document complet disponible sur OLIS dans son format d'origine
Complete document available on OLIS in its original format

English text only

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article I of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (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 thus 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 original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and the Republic of Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of all OECD Member countries except New Zealand and Poland. The Commission of the European Communities takes part in the work of the Agency.

The primary objective of the NEA is to promote co-operation among the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source.

This is achieved by:

– encouraging harmonisation of national regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;
– assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;
– developing exchanges of scientific and technical information particularly through participation in common services;
– setting up international research and development programmes and joint undertakings.

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

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The Committee on the Safety of Nuclear Installations (CSNI) of the OECD Nuclear Energy Agency (NEA) is an international committee made up of senior scientists and engineers. It was set up in 1973 to develop, and co-ordinate the activities of the 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 among the OECD Member countries.

The CSNI constitutes a forum for the exchange of technical information and for collaboration between organisations which can contribute, from their respective backgrounds in research, development, engineering or regulation, to these activities and to the definition of the programme of work. It also reviews the state of knowledge on selected topics on nuclear safety technology and safety assessment, including operating experience. It initiates and conducts programmes identified by these reviews and assessments in order to overcome discrepancies, develop improvements and reach international consensus on technical issues of common interest. It promotes the co-ordination of work in different Member countries including the establishment of co-operative research projects and assists in the feedback of the results to participating organisations. Full use is also made of traditional methods of co-operation, such as information exchanges, establishment of working groups, and organisation of conferences and specialist meetings.

The greater part of the CSNI's current programme is concerned with the technology of water reactors. The principal areas covered are operating experience and the human factor, reactor coolant system behaviour, various aspects of reactor component integrity, the phenomenology of radioactive releases in reactor accidents and their confinement, containment performance, risk assessment, and severe accidents. The Committee also studies the safety of the nuclear fuel cycle, conducts periodic surveys of the reactor safety research programmes and operates an international mechanism for exchanging reports on safety related nuclear power plant accidents.

In implementing its programme, the CSNI establishes co-operative mechanisms with NEA's Committee on Nuclear Regulatory Activities (CNRA), responsible for the activities of the Agency concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also cooperates with NEA's Committee on Radiation Protection and Public Health and NEA's Radioactive Waste Management Committee on matters of common interest.

* * * * * * * * * * * *

Requests for additional copies of this report should be addressed to:

Nuclear Safety Division
OECD Nuclear Energy Agency
Le Seine St-Germain
12 blvd. des Iles
92130 Issy-les-Moulineaux
France

FOREWORD

This report has been prepared under the aegis of the Principal Working Group No. 1 on Operating Experience and Human Factors which is one of the groups set up by the Committee on the Safety of Nuclear Installations (CSNI). The purpose of the report is to present an analysis of the role of simulators in the training of NPP operators, from a human factors point of view.

The Working Group commissioned the Expanded Task Force on Human Factors (ETF-HF) to prepare this document on the basis of the currently available experience in some OECD member countries.

The ETF-HF members contributing to the report were:

Ms. G. Baumont (France, IPSN), ETF-HF Chairperson
Mr. L. Carlsson (PWG1 Secretary)
Mr. J. P. Clausner (former PWG1 Secretary)
Dr. K. Dahlgren (Sweden, SKI)
Mr. R. Eckenrode (United States of America, NRC)
Dr. A. Frischknecht (Switzerland, HSK)
Mr. T. Furuta (Japan, NUPEC)
Mr. B. Gil (Spain, CSN), Task Leader
Ms. F. Harrison (Canada, AECB)
Dr. K. Laakso (Finland, VTT)
Dr. M. Maqua (Germany, GRS)
Dr. C. Reiersen (United Kingdom, HSE-NII)
Mr. N. Sandor (Hungary, PAKS NPP)
Dr. B. Sim (South Korea, KAERI)
Mr. Y. Van den Berghe (Belgium, AVN)

The ETF-HF members desire to express their appreciation for the valuable participations, contributions and efforts of the personnel of all the organisations (regulatory bodies, utilities, research centres, training centres) which have collaborated to the successful realisation of this Task.

This report was finalised for CSNI review and approval in Autumn 1997.

PRESENTATION OF THE REPORT

VOLUME 1 (present report):

EXECUTIVE SUMMARY

PART 1: INTRODUCTION
PART 2: CURRENT PRACTICES IN OPERATOR TRAINING WITH SIMULATORS
PART 3: EXPERIENCES OR STUDIES ON SPECIFIC ISSUES
PART 4: CONCLUSIONS AND RECOMMENDATIONS

DEFINITION OF TERMS

To be issued together on a CD-ROM:

VOLUME 2:

APPENDIX A: RESPONSES TO THE SURVEY (PART 2)

VOLUME 3:

APPENDIX B: CONTRIBUTIONS TO PART 3

General Table of Contents

EXECUTIVE SUMMARY

During its meeting in September 1994, the Principal Working Group 1 (PWG-1) agreed on the proposal of the Expanded Task Force on Human Factors (ETF-HF) to deal with the topic of the role of simulators in operator training (defined as ETF-HF task 5). At the February 1995 meeting, ETF-HF members discussed in depth task 5 objectives, scope and agenda. These were approved by the PWG-1 during its meeting in September 1995. The task has been performed from then up to September 1997, as scheduled.

Task 5, and this report, consist of the following main Parts:

- Part 2: "Current practices in operator training with simulators". Its objective was to identify the role of simulators in the operator training programs, from a human factors point of view, in OECD countries.

  The selected strategy was to collect information by means of a questionnaire. The information requested with this tool was oriented towards the techniques and criteria used for establishing and evaluating that role in the different countries. Emphasis was done on those issues potentially more difficult or not completely solved yet and which had not been covered completely by previous Nuclear Energy Agency (NEA) studies.

- Part 3: "Experiences or studies on specific issues". Its objective was to discuss in-depth some of the issues more difficult or not completely solved yet, with the aim to draw lessons learned and current practices which are used to avoid incidents originated by operator errors due to inadequate training. The selected issues were: (1) Teamwork, Diagnosis and Decision-Making, (2) Stress, and (3) Simulator Fidelity, Issues and Concerns.

  The selected strategy was to collect information by means of contributions or reports prepared in the ETF-HF member countries.

- Part 4: "Conclusions and recommendations". Its objective was to gather, present and sum up the conclusions and recommendations reached all over the contributions reported by the ETF-HF members and during the discussions held at the ETF-HF meetings.

  The selected strategy was to discuss in depth potential conclusions and recommendations which had been raised taking into account the information gathered. This was done, basically, by means of an ad-hoc one-day meeting of ETF-HF volunteer members and one half-day meeting of ETF-HF members.

Regarding Part 2, the questionnaire was designed and reviewed by ETF-HF members. It consisted of seventy-eight questions, divided in five main sections. The questionnaire was distributed, through ETF-HF members, to all interested organisations of the different countries by the beginning of October 1995. Twenty-five different responses (some of them incorporating the point of view of various organisations), coming from eleven different countries, were received by the task leader before the end of the 1996 Spring. A summary of the answers to each question was prepared and presented to the ETF-HF members during the meeting of September 1996. The summary tries to highlight common problems, practices or issues of significance resulting from a comparative review of the responses. It does not intend to be an statistical comparison of the practices in each country.

Regarding Part 3, all ETF-HF members were invited to contribute with one or more reports to one or several of the selected issues. In order to make easier the preparation of the contributions, it was only requested that each report should include three different sections: definitions of issues, current practices and further developments. Eleven contributions coming from six different countries were received by the task leader before the end of October 1996. They were assigned in the following way: Teamwork, Diagnosis and Decision-Making (seven), Stress (two) and Simulator Fidelity, Issues and Concerns (two). A summary of all the contributions was prepared and presented to the ETF-HF members during the meeting of March 1997. The summary tries to remark, when possible, the definition of the issues, the evaluation methods, the applications of these methods, and the conclusions and further developments.

Regarding Part 4, the first draft report, identifying and describing conclusions and recommendations of the task, was prepared and distributed for comments to some PWG-1 volunteer members by February 1997. Later, this first draft was discussed in-depth during an ad-hoc one-day meeting of ETF-HF volunteer members and one half-day meeting of ETF-HF in March 1997. Taking into account the comments expressed during such meetings and some additional ones, the final version was prepared.

The generic conclusions identified are: a) there is an extensive and increasing use of simulators in the training programs of NPP control room operators in OECD countries; b) there are meaningful differences in current practices between countries and even between organisations; c) a Systematic Approach to Training (SAT) is commonly used; d) there is a limited use of Probabilistic Safety Assessment results as a tool of the SAT process; e) simulators are one part of the battery of training settings; f) various methods of testing are used for trainees assessment; g) there is a lack of objective indicator about training quality; h) currently main issues to be improved are related to human aspects; i) root causes included in real event data bases are not sufficiently detailed as to discriminate among different deficiencies in training; j) some important issues remain not completely solved; k) on-going projects are dealing with some unresolved issues; l) trainees attitude within simulator training.

Some recommendations have been derived from an assessment of the information gathered in this task. They denote significant and broad issues, where a lack of consensus or a lack of commonly accepted criteria or methodology have been observed across the current practices in different organisations. In this sense, they could be called "needs" which should be satisfied. Two types of generic recommendations have been proposed for those specific issues or topic areas: specialist meetings and research activities. In the first type, taking into account the significant differences identified in current practices (or ideas) on some topic areas, the ETF-HF also recommends member countries to compare their own practices on those areas with the practices of other organisations, in order to determine their usefulness for their own organisation. A final ETF-HF recommendation is to promote the integration of specialist in Human Behavioural Sciences into the training programs of operators. They could usefully collaborate with technical specialists. This would contribute towards the solution of those training issues related to human aspects and might simplify the assimilation of research project results.

Finally, the results of the task can be summarised as follows: the development of this task has allowed for a better understanding of the role played by simulators in operator training programs in OECD countries. Current practices and on-going research projects have been presented.

Several on-going research projects and activities, related to some specific issues (teamwork, stress and simulator fidelity) have been treated in more depth. The information gathered is very valuable but not as broad as for the topic of current practices.

Current practices are based on the responses to a survey from twenty-five different organisations (training centres, utilities and regulatory bodies) representing eleven countries. The large amount of oriented and graded information gathered (close to 2000 replies) reflects a real state of the art.

Thus, it could be claimed that the conclusions and recommendations described are not specific to any type of technology, organisation or country, and are likely to be pertinent to the majority of OECD countries. Additionally, the main value of the report does not lie only in the conclusions and recommendations, but principally in the structured information which is available to any organisation interested in comparing any aspect of their current simulator training practices with the ones of other organisations.

PART 1: INTRODUCTION

During its meeting in September 1994 the Principal Working Group 1 (PWG-1) agreed on the proposal of the Expanded Task Force on Human Factors (ETF-HF) to deal with the topic of the role of simulators in operator training (defined as ETF-HF task 5). At the February 1995 meeting, ETF-HF members discussed in depth task 5 objectives, scope and agenda. These were approved by the PWG-1 during its meeting in September 1995. The task has been performed from then up to September 1997, as scheduled.

Task 5, and this report, consist of the following main Parts:

- Part 2: "Current practices in operator training with simulators". Its objective was to identify the role of simulators in the operator training programs, from a human factors point of view, in OECD countries.

  The selected strategy was to collect information by means of a questionnaire. The information requested with this tool was oriented towards the techniques and criteria used for establishing and evaluating that role in the different countries. Emphasis was done on those issues potentially more difficult or not completely solved yet and which had not been covered completely by previous Nuclear Energy Agency (NEA) studies.

- Part 3: "Experiences or studies on specific issues". Its objective was to discuss in-depth some of the issues more difficult or not completely solved yet, with the aim to draw lessons learned and current practices which are used to avoid incidents originated by operator errors due to inadequate training. The selected issues were: (1) Teamwork, Diagnosis and Decision-Making, (2) Stress, and (3) Simulator Fidelity, Issues and Concerns.

  The selected strategy was to collect information by means of contributions or reports prepared in the ETF-HF member countries.

- Part 4: "Conclusions and recommendations". Its objective was to gather, present and sum up the conclusions and recommendations reached all over the contributions reported by the ETF-HF members and during the discussions held at the ETF-HF meetings.

  The selected strategy was to discuss in depth potential conclusions and recommendations, which had been raised taking into account the information gathered. This was done, basically, by means of an ad-hoc one-day meeting of ETF-HF volunteer members and a half-day meeting of ETF-HF members.

Finally, the vocabulary used in this report is based, mainly, on the terminology used in the following reports:

- CSNI Report nº 128/Task force related to HF nº 5: "Approaches to training programmes in NEA member countries" (1986).
- IAEA/TECDOC-525: "Guidebook on training to establish and maintain the qualification and competence of NPP operations personnel" (1989).

A glossary of terms can be found at the end of the report.

PART 2: CURRENT PRACTICES IN OPERATOR TRAINING WITH SIMULATORS

CHAPTER 1: INTRODUCTION

The objective of this Part 2: "Current practices in operator training with simulators" was to identify the role of simulators in the Operator training programs from a human factors point of view (human engineering, organisation and management, communications, etc.) for the various OECD countries.

The strategy was to collect information by means of a questionnaire. The information requested with this tool was oriented towards the techniques and criteria used for establishing and evaluating that role in the different countries. Emphasis was done on those issues potentially more difficult or not completely solved yet and which had not been covered completely by previous Nuclear Energy Agency (NEA) studies.

The questionnaire was designed and reviewed by the ETF-HF Members. A copy of the questionnaire final version is included in the Appendix A of the Task 5 Report.

The survey consisted of seventy-eight questions, distributed in five main sections:

- The first section was an introduction for obtaining a general view of the availability and main characteristics of simulation facilities in every country and their relation with the operating nuclear power plants. In other words, a context for a better understanding of the answers to the subsequent sections.
- The second section intended to gather information on the currently more frequent applications of training simulators.
- The third section was devoted to the design of the six phases of a Systematic Approach to Training from the point of view of the use of simulators.
- The fourth section was focused exclusively on the use of operating experience in Operator training with simulators.
- Finally, the fifth section solicited insights related to different aspects of the Operator training with simulators which could be considered more difficult or not completely solved yet.

The questionnaire was distributed through ETF-HF Members to all interested organisations of the different countries by the beginning of October-95.

Twenty-five different responses (some of them incorporating the point of view of various organisations) coming from eleven different countries were received by the task co-ordinator before the end of the 1996 Spring. A copy of all the gathered responses is included in the Appendix A of the Task 5 Report.

Chapter 2 of this Part 2 Report includes the summary of the responses. It consists of a summary of the answers to each question.

The summary has been prepared trying to highlight common problems, practices or issues of significance resulting from a comparative review of the responses. It does not intend to be an statistical comparison of the practices in each country. When possible, it has been oriented not only to answer how the training is done but to emphasise why the training is done in one way and not in other. It has been tried to remark the underlying knowledge, the reasons which support the ways in which the training with simulators is done.

CHAPTER 2: THE RESULTS OF THE SURVEY

2.1 Respondents to the Survey

Twenty-five (25) different responses (some of them incorporating the point of view of various organisations) coming from eleven (11) different countries were gathered. Different types of organisations (training centres, utilities, regulatory bodies, etc.) took part in these responses. .

All the respondents are listed below according to Countries alphabetical order. For each respondent three data, separated by colon (:), are specified:

Country: Organisation replying to the questionnaire: Specific Organisation or Training Centre at which the answers are referred to:

1. Belgium: ELECTRABEL: Scaldis Training Centre.
2. Belgium: ELECTRABEL: Tihange Training Centre.
3. Canada: AECB: A summary response covering the major points made by three Canadian Training Centres (4,5,6).
4. Canada: NEW BRUNSWICK POWER: Point Lepreau Training Centre.
5. Canada: ONTARIO HYDRO: Eastern Nuclear Training Centre.
6. Canada: ONTARIO HYDRO: Western Nuclear Training Centre.
7. Finland: STUK: Generic.
8. France: EDF + IPSN: EDF Training Centres.
9. Germany: GRS + KSG/GfS: KSG/GfS Simulator Training Centre.
10. Japan: NUPEC: BTC (BWR Operator Training Centre Corporation) Fukushima Centre + BTC (BWR Operator Training Centre Corporation) Niigata Centre + NTC (Nuclear Power Training Centre).
11. South Korea: KAERI: Nuclear Training Centre at Kori Site + Uljin Site + KAERI Site.
12. Spain: TECNATOM: Tecnatom Training Centre.
13. Sweden: KSU + SKI: KSU Nuclear Training and Safety Centre.
14. Switzerland: HSK + BKW ENERGIE AG: Mühleberg NPP.
15. Switzerland: HSK + KERNKRAFTWERK GÖSGEN-DÄNIKEN AG: Gösgen NPP.
16. Switzerland: HSK + KERNKRAFTWERK LEIBSTADT AG: Leibstadt NPP.
17. Switzerland: HSK + NORDOSTSCHWEIZERISCHE KRAFTWERKE AG NOK: Beznau NPP.
18. United States of America: CAROLINA POWER & LIGHT COMPANY: Harris Simulation Facility.

19. United States of America: COM ED: LaSalle Simulator.
20. United States of America: CONSUMERS POWER COMPANY: Palisades Training Centre.
21. United States of America: DETROIT EDISON: Fermi 2 Simulator.
22. United States of America: ENTERGY OPERATIONS: Simulators of all 5 Entergy Operation Units (ANO 1&2, Grand Gulf, River Bend, Waterford-3).
23. United States of America: NRC: Not apply.
24. United States of America: TENNESSEE VALLEY AUTHORITY: Browns Ferry, Sequoyah and Watts Bar Simulators.
25. United States of America: UNION ELECTRIC COMPANY: Callaway Plant Simulator.

2.2 Summary of Responses

In the next pages it is included the summary of the responses. It consists of a summary of the answers to each question, with the exception of Section 1: "General Information (related to the whole country)" for which only a general view of the section is presented.

SECTION 1: ***General Information (related to the whole country)***

Simulators play an important role in the operators training programs all over the world. There are not meaningful differences on this point depending on countries, utilities, plant lifetime, plants automatization degree or any other factors.

The number of training simulators per nuclear power plants (stations) is significant, higher than one to one in some countries if simulators other than full-scope replica are also taken into account.

From the data collected, it could be stated that in all countries operators receive training in full-scope simulators. For most utilities this training is carried out on full-scope replica simulators. It could be said that in the majority of the countries, more than 80% of their Control Room Shift Teams receive training on full-scope replica simulators. In several countries this situation applies to the Crews of all their nuclear power plants. Also currently some countries as Germany has an intensive program on-going: ten new simulators are under construction.

However, it should not be forgotten that there is also an emerging use of specialised simulators. In some cases they are used as a complement for accomplishing the learning objectives covered with replica simulators, but in other cases they have different goals.

French utilities, for example, use specialised simulators for a variety of training activities. Part-task simulators are used for system specific training on chemical and volume control systems, turbine generator systems, and reactor control systems. A basic principles simulator is used as desk-top classroom training tool. A concept simulator is used for precise accident simulation. Finally, special purpose workstation simulators are used for operator refresher training on accident scenarios such as steam generator tube ruptures.

In Finland an special purpose simulator for boiling water reactor severe accident training is employed.

Japanese utilities use special purpose simulators for maintenance training (pumps and valves etc.) inside utility companies.

Korean utilities use a compact Pressurised Water Reactor simulator.

Spanish utilities are working with a Graphic Interface Simulator (SGI) for classroom training.

Swedish and Swiss utilities use basic principles simulators for training on new equipment and fundamentals training.

SECTION 2: ***Current practices with simulators closely related to operator training***

1. *Based on your experience, describe advantages and disadvantages of the location of the Simulation Centre with regard to the plant: on-site versus off-site. Specifically, describe those factors which have some influence on the operators' attitude towards the simulator training and in the quality of the simulator training.*

   Off-site training centre advantages and disadvantages:

The advantages of off-site training centres were identified by utilities that use them. The centres tend to have a high level of instructor teaching expertise with a centralised training staff. Operators from various sites receive consistent training and achieve standardised skills. Training at the centres is unaffected by day-to-day disturbances caused by site conditions. They also provide a venue to exchange experience with operators from other plants. Centralised training services are independent. This gives them a certain weight vis-à-vis site specific Operations Departments. Finally, the centres are less expensive for the individual utility than on-site simulators, because of an economy of scale.

Disadvantages of using off-site training centres were listed. Trainees get less access to the full-scope simulator than sites with their own simulator. Instructors are not current with the detailed problems of the trainee workplace. Because of distance from plant, instructors are less reactive to individual team requirements. Also, because of the distance from the plant, there is limited site management participation. Trainees are not available for problem solving. Finally, travel costs are high.

   On-site training centre advantages and disadvantages:

The advantages of on-site full-scope simulators were identified. Utilities feel that they contribute to greater proficiency during off-normal operations because the simulator can be used frequently. On-site location allows for `Just in time' training for upcoming plant evolutions such as reactor or turbine start-up. It facilitates easy local access for tours of in-plant emergency activities. On-site simulator training has little impact on operator's personal lives.

An on-site simulator facilitates review of modifications on prior to installation in the plant. It also facilitates ready comparison of plant data to simulator data to ensure fidelity to the actual plant.

Disadvantages of on-site simulators were identified. Some operators like to change their environment for simulator training. Also, on-site simulators are more expensive than centralised facilities because they do not operate on an economy of scale as off-site simulators.

Combinations of full-scope and specialised training simulators:

The emergence of part-task simulators, basic principles simulators, concept simulators and special purpose simulators reflects a change in the use of simulation in operator training. Specialised simulators are being used in classroom training and requalification. New simulation technologies even include expert systems to assess trainee performance. This has led to evolutionary combinations of full-scope and specialised simulation. This has also changed the concept of on-site versus off-site simulator training.

From a human factors perspective, it is important to understand the advantages and disadvantages of new specialised simulation combined with existing full-scope simulation technologies.

2.a) *During simulator training sessions, what factors (time, communications, etc.) influencing the interactions between Control Room Operators and other Plant Personnel (Operations Department outside of Control Room Personnel, Maintenance or Instrumentation and Control Departments, Technical Support Centre, etc.) are simulated?*

Communications and realistic time scale are the factors commonly simulated:

In most cases, instructors `simulate' in-plant personnel during exercises. Response times for plant support functions are built into scenarios (e.g. reporting of radiation dose measurement results during steam generator tube rupture). This provides realism in completion of support activities such as chemistry sampling, jumpering of relays as directed by the emergency operating procedures, etc.

Only one respondent, explicitly mentioned that through the training sessions, communications and disturbances from other people are not simulated.

b) *Do these other Plant Personnel participate in the training sessions?*

Describe the present training format pertaining to involvement of non Control Room Personnel in simulator training sessions and explain why this format is used.

The basic reason for including plant staff in simulator training would be to familiarise them with the needs of fellow crew members during emergency conditions.

In most cases, plant personnel (chemistry, health physics, maintenance) do not participate directly in simulator training.

However, there are some exceptions. For example, Assistant Operators simulate local equipment control. Director of Operations and Chief Reactor Technical Staff participate by telephone in specific scenarios.

Plant emergency response personnel participate in simulator exercises during Emergency Preparedness (EP) drills. Finally, some Plant Managers and Technical Staff receive training in Operator's role.

3. *What environmental conditions (normal and emergency lighting, humidity, noise, vibrations, sounds generated by equipments, etc.) that could be experienced by the reference plants, are usually simulated in the Simulator Rooms?*

   Describe the use of such effects at your simulator centre and explain why they are, or are not, incorporated into simulator training sessions.

A number of environmental conditions are simulated. Examples of simulated environmental conditions included: sounds associated with equipment running or trips of major equipment, safety relief valve lifting, audio count rate of nuclear instrumentation and fire alarms. Normal and emergency lighting is usually simulated. One Finnish utility is planning to include actual smoke to simulate fire in the control room.

Environmental factors are modelled because they directly effect the performance of the operators. They assure that operators receive the same cues for changing conditions as in the real plant. Finally, environmental factors are required to be modelled by ANSI 3.5.

4. *Do Control Room Operators receive simulator training for operations outside the Control Room, for example: operations from Remote Shutdown Panels?*

   Describe this type of training as it exists at your Simulator Centre and explain why it is, or is not, used in training sessions.

Simulated operations outside the control room were included at some, but not all, sites. Typical simulated activities included: remote shutdown panel operation, emergency diesel operation, transformer control panel, and evacuation panel.

In cases where simulated training outside the control room was not included, the reasons were due to the duplication of the functions in the control room simulator or to the training performance in the reference plant.

ANSI 3.5 Section 3.3.2 states that the systems that are operated outside the control room or provide some input to the simulation models described in normal plant evolutions and malfunctions shall be simulated. The trainee shall be able to interface with the remote activity in manner similar to the reference plant.

5.a) *How frequently are the changes taking place in plant (plant design changes, procedures changes, etc.) incorporated to the replica or full-scope simulator?*

   Describe any process or mechanism in place at your Simulator Centre to incorporate changes to the replica or full-scope simulator.

Simulator modifications are needed when: simulation faults are detected during training sessions, experience feedback from reference plant is provided, improvements or extension of simulation is needed, or to accommodate modifications to the reference plant.

In practice there are three basic types of modifications: large scale modifications, small scale modifications, and procedure changes. The planning depends on the type of change.

Large scale modifications generally require a high level of authorization along with discussion with committees and co-ordination with in-plant modifications. In some cases large modifications are carried out once a year in `batch' process to accommodate software quality assurance. In other cases major plant design changes are incorporated in the simulator in parallel with modifications to allow operator training prior to unit restart from refuelling.

Small scale modifications require less approval than major modifications, and can be implemented at any time. The approval is usually local within the training centres, and changes can be executed at any time.

Plant procedure changes are usually implemented immediately. Plant procedure changes almost never result in simulator changes, since simulator models already replicate accurately the plant response.

b) Do simulator model modifications require separate approval while the simulator is being used for training?

Simulator model changes require extensive testing and approval before implementation. As a result, modifications during training are minimised to avoid negative training impact.

Large scale simulator model changes require high levels of approval. Small changes are made and reported to the utilities or plant management. Procedure changes are incorporated when the changes are made in the reference plant.

6.a) Identify the members of the Control Room Shift Team (Reactor Operators, Turbine Operators, Shift Supervisors, etc.) and indicate the time (in hours) dedicated to simulator training by each member in their initial training program.

Specify, when applicable, the time spent with each type of simulator.

Control room staffing varies across the different organisations and technologies (vendors). Notwithstanding at least two main categories of Control Room Operators can be observed in the majority of the responses: Panel Operators (Reactor Operator, Turbine Operator,...) and Senior Operators (Shift Supervisor, Control Room Supervisor, Shift Engineer,...).

The time (in hours) dedicated to simulator training by each member of the first category in their initial training program varies greatly across the different organisations between a minimum of approximately 72 hours to a maximum of approximately 375 hours. Most of the organisations reported a number of hours in the middle zone of this interval. Usually this hours are spent along several weeks, with 20 hours a week at the simulator, during sessions no longer than 3 or 4 hours.

Regarding the second category, Senior Operators, in most of the organisations they receive several more weeks (1 to 6) of simulator training than Panel Operators.

Most of the organisations reported that the time of the initial training is spent completely using full-scope simulators. In some cases (Scaldis, Tihange, Beznau,...) Operators are trained using basic principles simulators prior to train on full-scope.

b) Indicate the time (in hours) dedicated to simulator training by each member of the Control Room Shift Team in their continuous training program.

Specify, when applicable, the time spent with each type of simulator.

All Control Room Shift Teams spend some time in yearly simulator training. However the time dedicated varies tremendously, oscillating between a minimum of approximately 20 hours a year to a maximum of approximately 160 hours a year.

The content of yearly retraining varies across the industry. Typical programs focus on normal, abnormal and emergency operations.

Most of the organisations reported that only full-scope simulators are used for continuous training. Compact simulators are used in conjunction with full-scope simulators for continuous training in some Belgian and Swiss utilities. Also, the French Control Room Shift Teams made an extensive use (in the order of 40 hours per team a year) of their special purpose simulators (SEPIA) in conjunction with full-scope simulators.

c) What is the minimum time, if any, required by the Regulatory Body?

Several utilities indicated that they have a minimum number of hours to be spent on simulators during yearly requalification. Their minimum number of simulator hours was greater than 20 hours.

However, the majority of the utilities indicated that no minimum simulator hours were required for yearly requalification by their Regulatory Body. The number of hours for yearly requalification is a function of the training program content rather than specified minimums. By design of the Systematic Approach to Training, there is a practicable minimum number of simulator hours in the requalification training program. A normal requalification day consists of four hours in the simulator.

7.a) Indicate the percentage of simulator training time by the different Members of the Control Room Shift Team devoted to i) normal, ii) abnormal and iii) emergency conditions in their initial training program.

All respondents indicated that simulator time for initial training included a combination of normal, abnormal, and emergency operations. Some of them explicitly mentioned that simulator sessions consist of integrated operations, so it is complicated to break down into normal, abnormal and emergency conditions.

Notwithstanding, and taking into account the above comment, a trend can be observed comparing the responses. Many utilities allotted approximately 1/3 of the time for each condition, with a generic tendency to higher percentages of normal conditions. The extreme situation for this tendency is represented by a distribution of 75% for normal conditions and 5% for emergency conditions. On the other hand, there are less utilities for which the percentage of time allotted to accident conditions is higher than the allotted to normal and abnormal. The most representatives examples implies percentages of 50% or even 60% dedicated to train on emergency situations only.

b) Indicate the percentage of simulator training time by the different Members of the Control Room Shift Team devoted to i) normal, ii) abnormal and iii) emergency conditions in their continuous training program.

All respondents indicated an emphasis on abnormal and emergency operations during retraining sessions in the simulator. Utilities spending 80% of the time only for emergency situations or even utilities which do not reserve any time for retraining on normal operations reflect such emphasis.

c) What are the minimum percentages, if any, required by the Regulatory Body?

Respondents indicated that there are no minimum percentages of simulator time required by their Regulatory Body as long as the required off-normal and emergency procedures are covered in the training process.

8. What is the role and the policy of the Regulatory Body regarding the use of simulators for Control Room Operators licensing and training?

Differences can be recognised in the policies of the Regulatory Bodies on this issue across the eleven countries.

Regarding the use of training simulators examinations for operators licensing, it is summarised in the question 3.e).6.a).

Regarding the use of training simulators examinations for operators licensing renewal, it is summarised in the question 3.e).6.b).

Regarding the minimum time of simulator training required to the members of the Control Room Shift Team in their initial and continuous training, it is summarised in the question 2.6.c).

Regarding the percentage of simulator training time devoted to normal, abnormal and emergency conditions which is required to the members of the Control Room Shift Team in their initial and continuous training, it is summarised in the question 2.7.c).

Regarding the use of licensing examinations applied to the whole Control Room Shift Team in addition to the individual ones, it is summarised in the question 5.a).6.

Finally, not so much information has been gathered about which are the requirements, if any, mandated by the Regulatory Bodies about simulator specifications. Notwithstanding a wide spectrum can already be observed. It ranges from countries where plant specific simulators are required to countries where none or very general specifications exist.

9.a) What standards (ANSI/ANS 3.5, IAEA, etc.) are simulators built to and maintained?

Basically, all the respondents mentioned ANSI/ANS-3.5 as a reference standard. In some cases it has served as a starting point for the development of in-house standards. Several respondents consider that their current standards exceed the ones included in ANSI/ANS 3.5 in many areas.

b) What exceptions are typically taken to the standard?

All the respondents indicated that no exceptions are typically taken to the standards.

Notwithstanding, a number of exceptions can be found along the responses. Some examples are: simplification of testing requirements; no duplication of all divisional cabinets and of all control room backpanels, in cases where it can be shown that simulation is not required to effectively teach the desired objective; partly simulated systems and non simulated systems (redundancies) according to training analysis needs; differences in some equipments due to old control rooms.

Also one respondent has reported complete lack of physical fidelity among simulator and control room (different situation of the instrumentation).

c) What types of simulators are used that are not included in industry standards?

Most utilities use only full-scope simulators.

There were however, exceptions. Spanish utilities use also Interactive Graphic Simulators for some classroom training courses. Swiss and some USA utilities use also basic principles simulators for classroom fundamentals training.

10. a) Describe the role of part-task simulators in your current training programs

Most utilities do not use part-task simulators in their training programs.

Exception is France where an extensive use of such simulators is done. There are 22 part-task simulators, divided in three types: Reactor Chemical and Volume Control System; Turbine Generator and Reactor Control. They are used for precising the knowledge on the function simulated.

b) Describe the role of special-purpose (analytic) simulators in your current training programs.

As it happens with other types of simulators, different to full-scope, the use of special-purpose simulators for operator training is not very extended.

They are mainly plant analysers oriented toward training on thermohydraulic phenomena. Another uses are simulation of severe accident (Finland) or of behaviours of electrical plants on an electrical network (Belgium).

In Spain some utilities employ Interactive Graphic Simulators that use a graphic interface instead of the panels. They are used to help the knowledge fixing, once the systems have been studied. Additionally, they help to analyse in a deeper way the evolution of the critical parameters in accidents and malfunctions (specific courses completing initial training programmes).

11. Have the current operator training programs been conditioned by the availability and capabilities of the simulator(s) or, alternatively, has(ve) the simulator(s) been specified and acquired after analysing and designing the training programs?

Explain.

It seems, that this can be considered an iterative process for the majority of the utilities.

The general process could be described as follows:

The simulators were built from an estimate of what needs to be trained, taken into account the Standards. It could be considered for example that US Standard defines a specific set of simulator capabilities that are independent of the unique training program. In terms of the range of operations to be simulated, the Standard is inclusive. In terms of malfunction capability, the Standard specifies approximately one-third of a typical simulator scope. Unique training program requirements define the remaining capability. But this was experience based estimations.

The training was then based on what the simulators could do.

When a training need was discovered in a "new field" the need was valued against the cost and then maybe the simulators were upgraded. In this sense, operator feedback has led to improvements. Changes to control room procedures have driven to simulator changes. The operator training programs resulting from industry events have also led to simulator modifications. Many utilities consider that much of the feedback exceeds the requirements of the Standard.

In some cases the above explained process has led to the utilities to the conclusion that a new training simulator was needed. This seems to have been the situation of:

- Belgium: For both training centres (Scaldis and Tihange) their full-scope simulators were specified and acquired after a period of using non replica full scope simulators abroad.

- Finland: Some undesirable habits were received by the operators when the training had been given in another type of simulator (not replica) in another country. Nowadays there are replica simulators in use.

- Germany: New simulators (at least all of the nineties) have been specified and designed according to the requirements of the training program. Therefore, it can be stated that the current operator training program takes the leading role and simulators are designed or modified according to the needs.

- Switzerland: On site simulators (reduced replica and full scope replica) have been implemented recently in two NPPs. In the first case it is mentioned that it has been designed according to a deep analysis of training needs.

12. What extensions of simulator training are envisaged for the future?

In the future, simulators will be increasingly used for emergency preparedness training, engineering and procedural analysis. Modelling improvements will be made to accommodate beyond design basis severe accident training.

Modelling for shutdown events is already being implemented. For example of shutdown malfunction modelling that is already modelled is operation at mid-loop.

A number of utilities indicated that extensions of simulator training may be created in the future. The envisaged changes include use of personal computers and plant computer system to diagnose plant problems and isolating cause of plant problems.

In order to extend the range of simulation, some utilities are considering the purchase of new simulator technology.

13.a) Based on your experience, describe the uses of the simulators for activities other than training (plant drills, procedures validation, design changes validation, testing programs, acquisition of human data, licensing activities, reference plant systems "tuning", etc.).

Most utilities use simulators for activities in addition to operator training. Utilities use the simulators to: develop new procedures or change existing ones, verify plant equipment response, plan start-up and shutdown, review plant events, verify plant design changes, plan emergency response preparedness drills and conduct public relations.

An idea about the extensive use of the simulator could be gained from the response of one USA utility which states that simulator can be made available 24 hours a day and that all requests for use of the simulator are reviewed and scheduled based on a priority system.

b) What is the involvement of Control Room Operators for those applications?

Many of the respondents indicated the active participation of Control Room Operators in those applications directly related to their role in the Control Room, i.e.: plant drills and procedures validation mainly.

Although there are some examples about the relevance of their involvement in other applications, it is observed in many cases an intention of separating Control Room Operators training from other applications. In this sense, some opinions supporting this point of view are: the simulator is a training simulator, not a design tool; or the simulator is used for those applications as long as it does not interfere with availability for license training; or other applications could induce a negative training impact on the licensed operators. At least in two cases it is mentioned the important role which should play the Simulator Experts and Training Experts in the development of such applications not directly related to the role of the Control Room Operators.

14. What are the applications of simulator training for jobs other than Operations?

Full-scope simulators are used for training on jobs other than operations. Examples of the non-operator training includes:

- Radiological Emergency Response Preparedness drills.

- Engineering training.
- Plant systems training (control room components).
- Manager personnel training.
- Human factors research in BWR simulator experiments.
- Automation expert training.

<u>SECTION 3:</u> ***Systematic Approach to Training: considerations regarding the use of simulators***

a) Training analysis

1. *Are job and task analysis (or any other type of task identification technique) used for establishing a list of task, performance standards, learning objectives and training methods?*

   If yes, describe the technique used.

Most utilities that use job and task analysis depend on methodologies consistent with INPO accreditation criteria and documented in `Training System Development - TSD'. Initial training and requalification training tasks are used in scenario development to ensure that learning objectives cover the tasks and that performance standards address critical tasks. Job performance measures are performed on the simulator using plant procedures as part of the licensed operator program.

For those utilities that did not use a formal job and task analysis, alternative techniques were described. Some utilities use a Systematic Approach, but not job and task analysis in the INPO sense. The goal of the one approach was incorporation of all possible operational scenarios listed, inclusion of beyond design basis accident procedures, other operational requirements, and simulation malfunction list. Other utilities use a process that depends on subject matter experts to systematically define the operator's job and tasks.

2.a) *What are the criteria that determine the limits or scope of the job analysis for the Control Room Operators?.*

Job and task analysis is done by analysing the task performed in the particular job. The tasks are selected in accordance with the operating procedures and the opinion of the subject matter experts. Frequency, criticality and difficulty are reviewed and one or more of the multiple training settings are selected to provide the needed training.

Alternate approaches to job and task analysis are used by a number of respondents. Some utilities use operational procedures as the main basis for criteria to determine scope and limits of the job analysis. Some utilities use station expectations, safety reports and generic expectations defined by the regulator.

b) *From your point of view, what should the role of risk-based criteria be for determining such limits or scope?*

Explain your answers.

Almost a half of the respondents indicated that risk-based criteria are not used currently for this purpose in their training programs.

On the other hand, several opinions can be gathered through the responses to the questionnaire explaining which is, or should be, such role:

- In Finland one of the training centres has used PSA results to identify the incidents and accidents of importance for continuing simulator training. This classification determines how often the incident is repeated in simulator.
- In France, the operator actions which are identified as important for safety by the risk studies receive special emphasis during training sessions.
- In Switzerland, scenarios with high risk are trained routinely.
- It is suggested that the probability of events be used to limit the required scope of simulation.
- It is commented that risk-based criteria may offer efficiencies in training due to further limits on the scope of the training program, while a truly SAT allow the operator to optimise plant performance, which is essential in a competitive energy market.
- It is proposed that PSAs results be taken into account because they unveil major risks at the plants.

3. *Are there any special requirements for Job and Task Analysis which are imposed by the possibility of associated simulator training?*

No special requirements have been identified.

Some respondents indicated that they do not consider necessary to complete a formal job and task analysis for generating a training program, as it was mentioned in previous questions.

Other respondents, which have already performed a job and task analysis, mentioned that the analysis has not been influenced by the available simulator, because the simulator is just one of several means to accomplish the training.

SECTION 3: ***Systematic Approach to Training: considerations regarding the use of simulators.***

b) Training program design

1. What are the criteria for specifying simulator training rather than another training setting (classroom, laboratory, workshop, on-the-job, etc.)?

There were varied responses to question of criteria for selecting simulator training vs. classroom or on-the-job training.

At some utilities, simulator training is selected for tasks that are, complicated, stressful, sensitive or infrequent. Some utilities use the need for practical hands-on training to define whether simulator, plant training or class room training is the most suitable. In some cases simulation is selected when appreciation of the whole plant behaviour is necessary.

In one country, simulator training is used when there is a need for demonstration of mastery of skills required, performance based training or for the tasks that are impractical to train in plant. In another country, training needs are defined by level of accuracy concerning the task to be developed, possibility of potential problems in diagnosis of abnormal simulations, or teamwork.

At US utilities, learning objectives (ability or knowledge) dictate the use of performance based training. Is the item performed in the control room? Is the activity performed by a licensed operator? Frequency, criticality and difficulty are used to determine if the simulator is to be used to support the evolution. Typically a combination of classroom and simulator are used. The procedure or process is reviewed in the classroom and applied in the simulator.

2. What are the criteria for selecting different types of simulator (full-scope, replica, part-task, basic principles, concept, special-purpose)?

In the USA the criteria for selecting a replica simulator are listed in the requirements of Section 6 of the Waste Policy Act of 1982 as codified in 10 Code of Federal Regulations (CFR) 55.45, Operating Tests, and 10 CFR 55, Requalification.

Functional and physical fidelity requirements are defined in ANSI 3.5 Standard. Replica simulators are selected for the following reasons: replica precisely simulates the physical aspects reference plant control room and depicts various normal and emergency conditions. Fidelity specifications for full-scope simulators include:

- Knowledge-based objectives (plant specific response).
- Skill based objectives (control room design behaviour).
- The static simulator conditions meet expected or anticipated actual plant conditions.
- Normal operations can be performed on the simulator following plant procedures.
- Trend and direction are the same for changing simulator parameters.
- The design basis transients can be run on the simulator.

- Alarms match plant data.
- Pass all the safety related surveillance procedures.

The fidelity specifications for non full-scope simulators may include a subset of the items listed above.

Basic principle simulators are used as part of operational control technique learning:

- Give the operators basic understanding of reactor operating principals.
- Improve future operators mental representation of physical phenomena.

Part-task simulators are used when work requires extensive work on a given system:

- Give operators an understanding of the specific system functions.
- Give operators a chance to learn corresponding instructions.

French utilities use more specialised simulators than most of the utilities. They state that a full-scope simulator is not always needed. They estimate that 75% to 80% of the training needs can be satisfied by representing 25% to 30 % of the control room.

3. a) What are the criteria for selecting a replica simulator?

See previous comment 2.

b) What are the fidelity requirements?

See previous comment 2.

4. What are the specific pre-requisites for operators undertaking simulator training?

That is a facility program very specific question, difficult to answer and summarise in few words.

Notwithstanding of the responses gathered, the common point of view could be summarised as that the operators undertaking simulator training should have good basic science fundamentals and good knowledge of plant systems and operating procedures.

Two main remarks, representing the common feeling, can be selected from the responses:

- The operators need a strong foundation in theory and systems prior to the start of the simulator training so that they can concentrate on the whole "big picture" of what is happening during simulator operations vs. the specific details. Too much time would be lost on the simulator if systems and theory had to be tough in a "simulator" classroom.
- Simulator training sessions should be preceded by operational training. This allows the operators to see individually the various systems that the nuclear power plant consist of and

the plant's operating conditions to be analysed. Following this, the interactions between the various systems while the plant is actually running should be studied.

5. *Does the possibility of simulator training impose any constraints on the definition of learning objectives?*

Most utilities with on-site simulators indicated no major technical constraints imposed by simulator training. One utility did indicate that the cost of simulator training may dictate that a more cost effective training method be developed to accomplish the learning objective.

<u>SECTION 3:</u> ***Systematic Approach to Training: considerations regarding the use of simulators***

c) Training program development

1. *In the case of non-replica simulators, is it necessary to take parallel training actions, and if so, what kind?*

   Explain your answer.

The great majority of the respondents used replica simulators for giving training to their operators.

Notwithstanding the operators of some Units (reactors) from Japan (1), Germany (2, taken into account that ten new simulators are currently under construction), Sweden (1), Spain (8), Belgium (3) and Switzerland (4) use non-replica simulators. The actions commented in the responses are:

- In Germany a classroom preparation is performed before beginning of simulator training. These sessions last about 2 to 3 days.

- In Sweden, the Control Room Shift Teams from one reactor train in another reference plant simulator. Before the training starts, the specific software of that reactor is implemented (nuclear core and so on). As to the hardware some panels are replaced and there are also paper overlays to get the right system and component identification numbers.

- In Spain, regarding the Teams of those plants which receive training at Tecnatom, those tasks and knowledge/abilities identified without simulator training possibility (non-replica) are shown in their corresponding training plan, which have to be developed within the on- the-job training setting.

- In Belgium, adaptations were made to extend the replica full-scale to other non-replica units:

  - Some added replica hard panels.
  - Soft panels.
  - Panels masking existing synoptics.

- In Switzerland, one utility mentioned that Skill Based Behaviour can be supported by other means (Drills in the real Control Room, locating controls) or Plant Specific Compact Simulators, to support Rule Based Behaviour (Procedure Using). Other utility describes actions as training (orientation) on photographs of the real and the simulator control room, drawings and preparation classroom.

2. Do you use specific procedures for the training simulator, actual plant procedures or a combination of both?

Explain your answer and give reasons for the choice.

Actual plant procedures are used in all cases, with some minor exceptions.

Those exceptions are basically related to some simulators used for multiple units. Then some modifications must be done in certain procedures.

3. What are the criteria for selecting normal, abnormal and emergency scenarios to be trained with simulators? Are they risk-based criteria?

Explain your answer.

Most utilities use deterministic versus risk based criteria to select scenarios. The procedures must change something that is visible to the operators in the control room. The integrated operations then dictate which procedures can be combined for any particular simulator scenario.

Scenario selection criteria includes: degree of difficulty, complexity of upset, consequence of error, and how often the situation is encountered. In one case the task analysis data, specifically the task importance, difficulty and frequency, determine the need to train on a task.

Normal procedures to take the plant from cold shutdown to 100% power and back to cold shutdown are exercised. Abnormal scenarios covered by procedures are used. Scenarios covered by emergency procedures are also exercised.

Risk based criterion is used by some utilities to select normal, abnormal, and emergency scenarios. For example the training on SGTR at PWRs is a typical scenario derived from risk based criteria. Other plant specific scenarios are Station Blackout and ATWS. Other criteria include licensee event reports (LERs), plant modifications, and feedback from supervisors.

4. How are lesson plans and support documentation developed for simulator training?

Lesson plans and support documentation vary from country to country. Detailed descriptions are included in many of the responses.

In most of the cases, they are developed by Instructors based on technical plant documentation, in co-ordination with Operation Department.

***<u>SECTION 3:</u>* Systematic Approach to Training: considerations regarding the use of simulators**

d) Training program implementation

1. What selection, initial training, and continuing training is arranged for simulator instructors?

Most utilities reported that instructors are selected from licensed operators and supervisors. The key selection criteria are: personality, candidate ability and knowledge, communications and technical writing skills. Simulator instructors are provided with specific training on how to run the simulator equipment and develop simulator scenarios.

An interesting practice occurs in Japan. In Japan, licensed operator instructors are also supplemented by assignees from plant manufacturers.

2. What are the arrangements for instructor monitoring of, and feedback to, trainees during simulator sessions?

The arrangements for monitoring and feedback to trainees during full-scope simulator sessions were described. Both activities are done across the industry without meaningful differences.

Monitoring implies that instructors continuously observe trainees performance making use of some of the methods listed below and, in some cases, note trainee actions against predetermined criteria. Feedback includes: instructors provide verbal feedback during and at the end of each training session (simulator or classroom), formal trainees assessment and written reports.

One respondent mentions that instructors must complete INPO Advanced Simulators Instructors Course, which deals with monitoring and feedback skills. This typically entails 1-3 instructors observing with subsequent feedback.

Another respondent explains that the type of session dictates the monitoring and feedback arrangements and timing. In this sense three different types of simulator sessions are distinguished: evaluation, practice and training sessions.

3.a) What specific training modes such as simulator freeze, playback, running at higher speed than real time, activity recording, video recording, etc. is made use of during initial training?

The training modes such as simulator freeze, play back, running higher speed than real time, activity recording, video recording (in less degree) and other like operation history/trend graphics are the common techniques reported by most of the respondents. The decision of which mode to use is based basically on instructor needs.

b) What specific training modes such as simulator freeze, playback, running at higher speed than real time, activity recording, video recording, etc. is made use of during continuous training?

In requalification training, most of the respondents indicated that the same modes are used. Notwithstanding in some companies there is an inclination to do not use some of these modes during continuous training, i.e: fast time, backtrack or even all of them if possible.

The responses stated that in requalification training there is more emphasis on crew performance than in initial training. In this sense, some respondents specify that video recording is a helpful tool for supporting team work and communication training. One respondent explicitly alludes to the use of video recording only for continuous training. On the other hand two respondents indicate the use of such tool only for initial training.

4. What limits of simulation impede planned training sessions or examination scenarios?

Specific limits of simulation that would impede the training sessions or examination scenarios were listed. Simulator hardware or software failures (computers, etc.) produce occasional incidents. However, these problems are usually avoided if the scenarios are reviewed in advance and corrected.

Modelling deficiencies include limited reactor regulating/ flux, xenon transient events modelling and lack of parameter fidelity in some events.

Examination scenarios are usually not impeded by limits of simulation. The typical limits include fuel temperature >2000 degrees F., bulk boiling of containment pressure suppression systems, loss of coolable geometry, and physical damage to structures and components.

Beyond design basis events are not usually modelled at the current simulators. For example there is little modelling of severe accidents when the nuclear steam supply system is beginning to change the fuel/core geometry, detected by an `internal variable' that represents the fuel temperature. In a second example, Boiling Water Reactor simulation does not have a good `reduced inventory' simulation that reduces flexibility in choosing success paths for certain shutdown scenarios.

SECTION 3: ***Systematic Approach to Training: considerations regarding the use of simulators***

e) Trainee Assessment

1.a) What methods and procedures are used for initial trainee assessment during and after simulator sessions?

Methods and procedures used for initial trainee assessment during and after simulator sessions were documented. This primarily involved subjective assessment by instructors during dynamic evaluations.

Some utilities use evaluation guides modelled after regulatory examination guides. Other utilities used guides based on overall assessment of objectives, detailed training goals connected to assessment objectives, instructor consensus based on assessment objectives, and results discussed with trainees.

Some utilities use a checklist grid for evaluating all scenarios. This grid is broken down into elementary actions, corresponding to six abilities which are to be tested in the operator. Fifteen to twenty actions characterise each ability (collecting information, assessing plant conditions, checking information, communications, and achieving the desired results).

Two instructors compare the results at the end of the scenarios.

b) What methods and procedures are used for continuous trainee assessment during and after simulator sessions?

There are not meaningful differences compared with the methods and procedures used for initial training.

2. List and describe the main areas or groups of skills and knowledge of the trainee assessed in training simulators (for example: "control board awareness, event diagnosis, immediate actions /entry-level actions, subsequent actions, control board manipulations, use of procedures/technical specifications/reference data, communications, supervisory ability, team skills" (IAEA-TECDOC-525)).

Identify, when applicable, the types of simulator used for assessing each one.

The main knowledge and abilities assessed in simulator training included:

- Ability to prioritise, interpret, and verify alarms/enunciators.
- Ability to diagnose event.
- Ability to interpret system response and predict effect on plant.
- Ability to select and use plant procedures.
- Ability to locate and manipulate controls, verify response, and take control of automatic systems when required.
- Ability to give and receive information.
- Ability to supervise and direct licensed operators.
- Ability to recognise and ensure compliance with technical specifications and limiting conditions for operations.
- Knowledge of integrated plant response.
- Knowledge of general operating procedures.
- Knowledge of emergency operating procedures.
- Knowledge of emergency plan.
- Knowledge of technical specifications.
- Attitude of operational crew member.

3. Describe the ranking of importance, if any, given to the main areas or groups of skills and knowledge taken into account for a trainee assessment.

Most utilities use no importance ranking scheme for knowledge and abilities. Trainees must pass all competency areas regardless of relative importance rankings.

Notwithstanding some utilities reported the use of importance rankings for Knowledge and Abilities provided in NUREG-1122 (PWRs) and NUREG-1123 (BWRs).

Finally, Examination Standard NUREG-1021 (Rev. 7) ES-303 suggests that knowledge and abilities catalogue importance ratings be considered in operating tests.

4.a) Based on your experience, describe difficulties you have had for assessing the individual skills and knowledge of a trainee while operating within a whole Control Room Shift Team during simulator sessions.

The difficulty in assessing individual knowledge or ability comes when another crew member covers more than his panel or station, overlapping the other crew member's area. Individual questioning following the scenario is sometimes required to assess the knowledge levels of individuals versus team as a whole. Strong team members tend to compensate for the shortcomings of the weak members.

In most cases, the assessment is done by the instructor. Some utilities use team test checklists to highlight individual contributions. However, there is no standard formula or test to highlight individual contributions (good or bad).

b) Describe the measures adopted to overcome these difficulties.

There are techniques for assessing individual skills and knowledge in team context. The in-the-booth instructor can place multiple malfunctions in the system so that the booth operators are occupied at the same time. Follow up questions can be used after the scenario to clarify `fuzzy' areas.

Another technique is use of role players in key areas and restriction on duties and scripting action to force candidates to perform activities so that they can be judged individually.

5.a) Based on your experience, describe influences on trainees performance during simulator sessions resulting from the attendance of personnel such as utility managers, regulatory body inspectors, etc.

The impact of regulatory inspectors or plant managers on trainees vary. The full range of impact has been reported. The most stressful personnel on trainees seems to be internal plant management and regulatory examiners during final examination.

b) Based on your experience, describe current practices and influences on trainees performance resulting from the instructors involvement in training sessions (location in the Simulator Room, communications with trainees, participation, etc.).

During the first phase of initial training, for example, familiarisation with the control room with normal operation, the instructor is in the simulator helping. Some instructors tend to provide coaching and guidance versus allowing the student to learn and experience on their own. This is normally acceptable in the early stages of training. However, during evaluation sessions for abnormal and emergency operations coaching is not allowed.

Instructors who act as trainee evaluators are considered a normal part of simulator operations. Instructors normally do not intervene in the performance of the trainees unless they are in a dead-lock. Therefore, they induce little stress on the trainees.

6.a) Are training simulator examinations used in order to grant initial license to operators?

Explain.

Formal simulator examinations are required by the Regulatory Bodies of some countries in order to grant initial license to operators. That is the case of Finland, Japan (only for Operation Supervisors), USA, South Korea, Canada and Spain.

In other countries there is a regulation requiring the licensee to verify the competence of the operators. One part of this should be an evaluation of their performance in the simulator training.

Finally, in some countries simulator training is not used for the licensing of operators.

b) Are training simulator examinations used for requalification?

Explain.

In most of the countries formal training simulator examinations are not used for requalification.

In two countries, Finland and USA, they are formally required following the criteria stated in "Regulatory YVL Guide 1.6" and in "10.CFR.55" respectively.

In Japan, simulator examinations are used for training to renew the Operations' Supervisor qualification.

In Canada, exams are done by utilities on annual basis. Process is audited by regulator.

In all countries simulator training is mandatory for periodical licensing renewal, independently of such period (1 year, 2, 3, 5 or any other period).

7. How is examination integrity preserved during the examination/scenario preparation period?

In several utilities, personnel involved in examination preparation sign a confidentiality agreement. They are removed from the training environment during the examination. In addition, the examination is coded with password protection.

In some cases, an inspector's panel has a set of approved scenarios prior to the examination. One of these is selected just before the examination starts. Trainees and the instructors do not know the content of the examination until just before the examination. Therefore, integrity is maintained.

In the USA in order to preserve examination integrity, instructors and staff sign a security agreement. Examiner Standard, NUREG-1021, Rev. 7, provides guidance to examiners.

8. *What performance monitoring or data acquisition features of the simulator are used during simulator examinations?*

A great diversity could be appreciated across the different countries which require regulator examinations to the operators.

It varies from the minimum of some US utilities to the maximum of the some Canadian ones. In the first case, none other features than direct observation are mentioned. In this sense one utility argues that as little information as possible is recorded in order to protect exam security, because in other case this would allow anyone to rebuild the scenario at a latter time. In the case of most Canadian utilities the features used are: direct observation, Training Action Monitor (TAM), history trends and examiner notes. Also audio and video recordings are used in the initial license.

Direct observations and operational history records seems to be the features used most frequently in most countries.

SECTION 3: ***Systematic Approach to Training: considerations regarding the use of simulators***

f) Training program evaluation

1. *Describe the approach used for evaluating the simulator training program and main results.*

Very different approaches could be observed across the responses, ranging from countries were the evaluation is mostly performed by the instructors involved on an Ad Hoc basis, to countries were internal (utility) and external evaluations are done regularly.

Most of these approaches make use of several practices. These allow to obtain feedback about the quality of the simulator training program. Some of the specified practices are:

- Trainees informal opinions.
- Trainees questionnaire responses.
- Evaluation meetings among instructors and trainees at the end of each simulator session. The remarks made by them are recorded and reviewed annually.
- Regular meetings between Training Centre personnel and plant Operating Department personnel.
- Evaluations done by National Organisations involved in training issues.

- Evaluations done by Regulatory Bodies during licensing examinations and specific training program inspections.

- Evaluations done by international organisations (OSART).

Some other reported means for evaluating simulator training programs are:

- Success rate on in-house and regulatory simulator based examination.

- Performance of trainees on the job after completion of training.

- Plant events attributed to simulator training deficiencies.

Finally, it is necessary to mention that one response states that it does not exist any objective nor calculated indicators about the good quality of training.

2. What program is in place for validation and continuous verification of the simulator performance?

A number of different techniques are used for validation and continuous verification of simulator performance.

In some cases, 25% of the Acceptance Test Procedures are performed annually. In addition, every new simulation load has to pass a set of tests including normal, abnormal and emergency evolutions as well as steady state conditions. These tests, frequency, and validation criteria are specified in the Simulator Configuration Management Procedure

In other cases, non-regression tests are performed to evaluate the simulator response under steady state, abnormal and emergency conditions at the end of modifications. Responses are compared to previous years.

In some cases, software modifications are made twice per year to reflect plant changes, and correct deficiencies. Modifications are tested against a number of standard transients.

In Japan, the Thermal and Nuclear Power Plant Engineering Society are given the assignment of simulator evaluation.

In the US the yearly test program is performed to meet the requirements of ANS 3.5.

3. What types of performance discrepancies are most frequently identified by operators during training sessions?

Some respondents indicated that there are not specific patterns of faults identified, and they are often minor details.

Nevertheless, some examples of simulator discrepancies were reported. The most frequent one is the behaviour of steam generators levels during specific transients.

Additionally, several respondents manifest that in some scenarios the operators have the feeling that the timing is not correct (the simulator process is often considered as too slow). One respondent indicate that this is not usually the case (based on real plant data), but may result from a difference in the way the operators operate the simulator vs. the plant.

Procedure discrepancies (ergonomical or logical) seems to be another typical matter detected.

Finally, some examples of operator mistakes found by themselves were also reported: operation of a wrong switch adjacent to the correct one, wrong judgement of operations.

4. What types of performance discrepancies are most frequently identified by examiners or inspectors?

Several respondents manifested that the majority of the detected discrepancies are of lower significance (minor details), due to the long experience and the improved models. So there are not "frequent" discrepancies.

Nevertheless, examples of simulator discrepancies has been reported, mainly revealing that the simulator does not match the expected plant response. Some of them are related to: the containment response, the NSSS dynamic response in EOPs and in normal operation, the NSSS logic response, the physical fidelity, the lack of satisfactory models for some "Loss os services" scenarios (Loss of Instrument Air, Loss of Class III Electrical Power), the amount of after shutdown decay heat, etc.

Additionally, other respondents provided examples of discrepancies observed in the operators performance during simulator sessions. Some of them are related to: diagnostic failures, non following of the operating procedures, late judgement because of lack of information on the situation, lack of information exchanges because of inadequacy of the transferred information or because of transmission of information when the receiver is not in a suitable condition to receive the information, etc.

<u>SECTION 4:</u> ***Use of operating experience for operator training with simulators***

1. How is operational experience feedback incorporated into the design of simulator training programs (experience reviewed, schedule, people involved)?

The provided responses show a considerable diversity in the practices employed for incorporating operational experience into the design of simulator training programs. It ranges from one example in which it is explicitly mentioned that there are nothing specifically oriented to ensure operating experience be incorporated in simulator training to other examples having a very strict control of the process.

Most of the respondents indicated that own, domestic and overseas NPP events are reviewed on a continuous cycle in order to include the relevant ones, if any, in the simulator training program and to adapt, if necessary, the simulator models. Domestic Event Reports, Nuclear Power Experiences (NPEs), Significant Operating Experience Reports (SOERs), INPO, WANO and UNIPEDE are mentioned as some of the sources where seeking for meaningful events.

Regarding the schedule, there are differences which depend, mainly, on the approach (timing for the revision of the training programs and rules) utilised for designing the content of the training programs. So farthest situations are illustrated by the incorporation of the operational experience feedback into the training programs almost immediately or after periods of six years.

Finally, different organisations, divisions or people have the responsibility of screening reports on operational events across the industry. In some cases events are screened by training staff or instructors. In other cases the process is much more complex, involving for example a group which are responsible for ensuring that lessons learned from events are forwarded to the appropriate plant groups (including training as appropriate), another groups which forward information to various training disciplines (i.e Operation) and finally the group in charge of the operators training.

2. *Has your organisation developed any kind of program by which simulator operator training is correlated with real operating events?*

   Explain.

No organisation has mentioned the development of an specific program for correlating operators performance (as impacted by training) with plant performance (i.e. with a reduction in the number of events reports).

Anyway, it is usual for the majority of the organisations the review of plant operating events in order to determine if the lack of or appropriateness of training was a contributing factor (root cause of the event). In such cases, the training programs are revised and the proper training setting, which could be the simulator, selected.

<u>SECTION 5:</u> ***Specific topics on Operator training with simulators***

a) Team training techniques

1. a) *Are job and task analyses used for defining the role and responsibilities of the Members of the Control Room Shift Teams and, in general, of the various levels of staff who are charged with operation of the plant? Explain your answer.*

Job and task analysis was used, in a number of cases, to determine training requirements, identify performance standards, define learning objectives, and establish training methods. In most cases the job and task analysis was confined to control room operators.

In some cases, job and task analysis was used to define the roles of the Shift Supervisor and Shift Supervisor Assistant. In one case a task analysis was performed for all shift workers including auxiliary operators.

A number of the respondents did not use job and task analysis in the INPO sense. Alternatives included the use of operator job descriptions or allocation of tasks by plant management.

b) *Are job and task analyses used for establishing performance standards, learning objectives and training methods for Team skills training?*

Explain your answer.

Where INPO type job and task analysis was used, it was used to determine training requirements and systematically identify performance standards, learning objectives, and training methods.

In cases where job-and-task (JTA) analysis was not used, performance standards were established in alternative ways. For example, training was developed and maintained by operation manual. Roles and responsibilities were defined and improved over time, but not based on formal JTA.

2. *List and describe Team skills (communication, management of resources, team co-operation, team leadership, feedback, conflict resolution, team decision-making, etc.) which are trained using simulators. Identify, when applicable, the types of simulator used for training each one.*

All the organisations reported that several or even almost all the Team skills listed below are trained on simulators. The simulators used for this purpose are full-scope in all the cases:

- Teamwork behaviour styles.
- Personality of the crew.
- Roles and responsibilities assumption.
- Leadership of shift supervisor (direction and supervision).
- Assertive behaviour.
- Personal growth commitment.
- Teamwork in diagnostics.
- Team decision making.
- Conflict resolution.
- Use of resources.
- Understanding yourself and each other.
- Communication within the team.
- Communication with external parties.
- Feedback.
- Co-operation.
- Influencing.
- Performance under stress.
- Shift turnover.

The highest emphasis seems to be on communication issues (feedbacks, stress influence, etc.).

3. Are any guides used for conducting and evaluating Team skills training simulations?

Explain your answer.

Several organisations reported that no guides are used, neither for conducting nor for evaluating Team skills training simulations.

Some organisations from US and Canada mentioned the "Control Room Teamwork Development" course develop by INPO. AN US utility commented the use of games as "Artic survival" to develop some of these skills in the initial training courses.

The remainders expressed the utilisation of some guides, mainly checklists for evaluation purposes. In several cases these checklists are embedded within evaluation guides which comprise individual skills also. These checklists are employed by observers during selected events.

Differences can be recognised in the team skills assessed by different organisations and in their level of detail. One utility mentioned that Job Performance Measures are used to assess key skill requirements, but on an individual basis.

Also different approaches are observed regarding the simulator training modes employed for this purpose. Meanwhile one utility indicate that team skills requirements are reviewed with the team using the audio/video tapes from the events, another utility does not employ video because it was observed that the behaviour changes during its use.

At the end it seems that, in many cases, the level of subjectivity in the assessment of team skills is higher than for individual ones.

4. Based on your experience, describe advantages and disadvantages of Team training with the participation of the same (usual) Members every time or with changes in the Shift Team compositions.

Crews that work together on a daily basis often do well. The advantages of same team training are great. First, communications role for each operator is clearly understood. Second, shift supervisor becomes aware of individual crew capabilities. Third, there is less conflict between Team members.

The disadvantage of same Team training is the crew develops its own paradigms (decision making techniques). Over time that may tend to limit knowledge based behaviour because operators always perform the same job.

In some utilities, both techniques (normal Shifts and different Shifts) are used.

In Team training with change of composition the advantage is that operators learn to appreciate the role of others (suited for young operators). The disadvantage of changing crew composition is that the capability of individual crew member is not confirmed.

5. *Are simulator sessions used for the optimisation of Control Room Team Shifts taking into account the characteristics (aptitudes, attitudes, ...) of each Operator? In other words, are simulator sessions used for deciding which Members are going to constitute each Shift Team?*

   Explain your answer.

Simulator training is not used for determining shift composition. Crew makeup is determined by unions or plant management, etc.

6. *Are there any licensing examinations applied to the whole Control Room Shift Team in addition to the individual licensing examinations?*

   Explain.

There are not licensing examinations applied to the whole Control Room Shift Teams in any of the countries which have participated in the survey with the exceptions of Finland and USA. In both countries there are requalification exams for licensing renewal. Regarding the use of simulator, initial license is concentrated on individual performance, whereas renewed licenses are retained by means of the participation in shift team exams, where individual and crew performances are assessed.

SECTION 5: ***Specific topics on Operator training with simulators***

b) Training for stress

1. *Is any part of the simulator training programme specifically devoted to train Control Room Operators to operate under stress?*

   Explain your answer.

Most of the respondents specify that their simulator training programmes do not include a specific part devoted to train Control Room Operators to operate under stress.

In the answer from Japan, some examples of stress situations provoked regularly are mentioned, like time stress, lighting stress or event combining stress.

In the answer from Spain, it is alluded to specific stress management training courses, implemented in a classroom setting using lectures and practices. These courses are delivered before simulator training. Also some "unofficial" talks about stress and generic stress handling training are given in two Canadian and Swiss utilities.

Notwithstanding, a really common idea expressed in the replies is that realistic job conditions (also stress) are induced by the very nature of appropriate scenarios. They are for example scenarios with multiple malfunctions, scenarios with a lot to do and very little time and complex scenarios.

Finally a Swiss utility specifies that reaction to stress is a qualification criteria employed.

2. Are stress levels induced and measured during simulator training sessions?

If yes, describe the methods and results.

Stress is inherent to some simulator scenarios because they are simulated as close to reality as possible. In this sense all the respondents manifest that stress levels are induced, although not in a controlled manner.

Stress levels are not formally measured by any respondent.

In some cases it is mentioned that trainees' stress is observed by instructors as part of the regular monitorization of their behaviour.

3. Based on your experience describe any measures adopted during simulator training to counter stress.

A number of countermeasures for preventing stress during abnormal situations in the control room were identified by the respondents. Some of them are:

- Make trainees to be as prepared as possible for the tasks that have to be performed under the influence of stress. All the training allows them to develop improve response to stressful situations. After simulator training, diagnosis is both better and faster. Stress is managed better because the operator is assured of making faster and well-founded diagnosis. They move quickly from an unknown situation perceived as dangerous.

- Make trainees to put priority on grasping the plant situations rather than quick actions under accident conditions.

- Make trainees to point out and announce each operation for calm and assured implementation of the actions.

- Make trainees to look at problems as a team, not individually. Encourage teamwork: good communication and positive participation.

- Make trainees to avoid concentrate work loads on them.

- Prepare good, easy to use, operating procedures in order to limit stressful situations as for example the "flood of information".

- Make trainees to follow procedures because, among other advantages, this tend to overcome stress.

Also a number of countermeasures for preventing stress during simulator sessions were identified by the respondents. Some of them are:

- Make trainees understand that the purpose of simulator evaluations is to enhance their ability to cope with plant events - not to fail people.

- Establish non-adversarial instructor/trainee relationship.

- Structure the scenarios with a minor operational evolution or abnormal condition to let the operators get familiar with the board and plant status before initiating a major emergency event. This helps build confidence, and add realism.

- Encourage post event simulator discussions which deal with in a facilitative manner. To openly discuss the issue of stress with constructive suggestions being put foreword. This approach has been observed to be effective for most in-house training.

SECTION 5: ***Specific topics on Operator training with simulators***

c) The theoretical basis underlying training

1. Are any models of human behaviour being used in designing and implementing training programs?

If yes:

i) refer to or describe the models,

ii) indicate the areas in which these models are being applied (for example: signal detections, decision-making, etc.),

iii) give the main results.

For the majority of the respondents, human behaviour models are not being used in designing and implementing training programs. Confidence is placed on already developed methodologies, common sense and experience.

Rasmussen's human action model (skill, rule, knowledge) is referred in the Japanese response.

The French response mentioned the subsequent models:

- Error typology of Reason.
- "Human reliability in PSH" model, Rasmussen and Swain.
- Model linked to Piaget's "Scheme Theory"

There are currently some research work between NPP and research centre in Finland to develop practices from human point of view. The work is still going on.

***<u>SECTION 5:</u>* Specific topics on Operator training with simulators**

d) Habits acquired during training sessions with simulators

1. *Describe, based on your experience, undesirable habits which could be acquired by trainees during training sessions with simulators (for example: due to limited number of simulated scenarios, due to lack of physical or functional fidelity, due to the use of conservative codes for simulation instead of best estimate codes, etc.) and discuss their potential consequences on safety.*

Almost half of the respondents indicate that undesirable habits have not been detected, or at least sufficiently important bad habits, in such way that they could impact negatively on safety. Many of these respondents have based this statement in the utilisation of replica simulators.

Some respondents comment that undesirable habits could appear due to the use of non-replica simulators or, even using replica simulators, due to some discrepancies (some of them very common all over the world) in their physical or functional fidelity. Some of the examples reported are:

- Bad habits were received by the Operators of one country when the training was given in a non replica simulator in a foreign country.
- When a new simulator recently was taken into use, it was discovered that operators had acquired undesired habits when during lots of years being trained on other simulator. They were looking at wrong instruments and going to wrong panels. This has been dealt with, but it shows the problems with training in non replica simulators.
- In one real event during the steam bubble formation in the pressuriser, the operator was waiting a small peak in the flat temperature signal. He learnt during his simulator training that a small peak appear and it is correlated to the end of the bubble formation. But this is true for the type of reactors/simulators where the operator was receiving training, but not for the reactor where operator was operating. The pressuriser levels were false (first main cause), this small waited peak never came during operating, so the operator never understood that pressuriser was empty and did not stop pressuriser heaters. They were destroyed.
- Fidelity in terms of parameter direction, magnitude of parameter deviation, and timing of the parameter deviation. This could result in the trainee acquiring a false sense of security. For example, in a real life event the event could be misdiagnosed.
- The use of a very small number of core and containment model nodes which would cause drastic changes in the response to significant events such as the ATWS for a BWR. This response had the effect of amplifying the simulator response to operator input and in some cases made the simulator much more responsive than best estimate models would predict. The effect on operator training was that any given operator response could produce widely varying plant effects due to timing differences.
- Response of containment model and absence of containment isolation malfunctions could decrease attention to potential radioactivity release paths.
- A temporary simulator deficiency may cause the operator to become complacent and ignore a warning indication when, in the plant, ignoring the same thing would be bad.

Finally some respondents also comment other types of undesirable habits which could appear during simulator training. They could be due to very miscellaneous causes, independently of the degree of simulator fidelity to the plant. Some of the examples reported are:

- A small number of scenarios can condition the operator to always expect a certain type of transient.
- Trainees develop a "mind set" resulting in misdiagnosis.
- Trainees respond too quickly, missing indications and procedural steps.
- All paths of a procedure may not be exercised sufficiently. Sometimes there is the argument that "this will never happen".
- Over focus on use of proceduralized events could not condition the crew to think about what they are doing.
- Training based solely on the use of procedures which are assumed to work in all cases. The trainee may become totally frustrated if a procedure fails to work in real life.
- Support staff assumed to perform error free actions. If the support staff makes an error in real life, this may lead to total confusion.
- The need to demonstrate individual skills sometimes forces application of skills in inappropriate situations.
- Newly authorised staff not participating as fully as they should in the team.

At the end, two respondents mention a habit which could be widespread. That is the different behaviour of the operators in the simulator versus the real control room. During simulator sessions, some usual comments could be: "Just turn the switch it does not really matter here" or "It is probably a simulator problem, just ignore it".

2. *Describe, based on your experience, any measures adopted to avoid acquisition of those undesirable habits or to prevent use of them.*

Regarding the undesirable habits which could appear due to the use of non-replica simulators, most of the respondents indicate that the use of replica simulators would avoid such problems.

Regarding the discrepancies in the physical or functional fidelity of replica simulators, some actions taken against the bad habits mentioned in the previous comment are:

- Instructors should make efforts to get the trainees understand the meaning of the differences, making use of pre-scenario briefings and post-scenario discussions.
- The advent of core and containment multipoint models is leading to much more realistic simulator response and has allowed a better review of the operator response and comparison of the expected effects.

Regarding those possible undesirable habits which are independent of the simulator fidelity degree, some measures adopted are:

- To prevent guessing about the scenario by varying the initial conditions and minor normal or abnormal events that are used at the beginning of the scenario.
- Give trainees a variety of events, specially new/unseen events.
- To start to use more non proceduralized events.
- More focus on the rationale of procedures so that crews recognise when the procedure is not appropriate.
- Insert failures that occasionally take the candidate down different procedural paths.
- Insert failures that require confirmation of more than one indication.
- To ensure individual skills are demonstrated but done in a situation where proper priorities are maintained.
- Greater feedback in this area by instructor during continuous training.

Finally, the proposed measure for fighting against the different behaviour of the operators in the simulator versus the real control room is that instructors, operation staff and management should criticise this behaviour and encourage the operators to respond as if they were real plant events.

SECTION 5: ***Specific topics on Operator training with simulators***

e) Simulator training on normal and emergency conditions during shutdown and low power operation

1. *What use is made of simulators for Control Room Operator training in normal, abnormal and emergency conditions during shutdown and low power operation (simulated scenarios, trained skills, training techniques, etc.)?*

Several respondents indicated that simulator training about shutdown conditions is not included in their training programs. The rest reported that a part of the time dedicated to simulator training is devoted to such conditions. Notwithstanding most of them explicitly mentioned that this time is substantially less than the part allotted to at power operation.

It seems also that simulated conditions varies meaningfully throughout the industry, although mid-loop operation in PWRs is recurrent in many responses.

More extended (although not used by all the respondents) is the simulation of low power operations. Specially focused to normal start-up and shutdown tasks.

2. *What are the criteria (risk-based criteria, deterministic criteria, results of need analyses, simulation availability, etc.) supporting the above mentioned use of simulators?*

Criteria supporting both options (use and not use of simulators) can be found in the responses.

Among the criteria which justify not to use simulators for these conditions (mainly for shutdown), or at least a minor use of them, there are:

- Usually, difficulties during shutdowns are related to communication and organisation issues. These things are not very effectively dealt with in simulators.
- Events are too slow-moving, so rapid response of operators is less likely required.
- Relatively complex operations involving a lot of intervention with a number of systems.
- Limited modelling capabilities.

Among the criteria which justify the use of simulators for these conditions, we can found:

- Usually, there is only one annual start-up and one annual shutdown in a well performing NPP. So these normal routines should be trained at simulators, although with small deviations (abnormal scenarios).
- Actual plant operating manuals contain some operation items whose implementation should need for some skills training.
- Needs analysis.
- Risk based criteria.
- Frequent industry events, specially during mid-loop operation condition in PWR reactors and high xenon startups in BWR reactors.
- Same reasons that the ones used for giving simulator training at power.
- Regulatory body requirement.

3. *Are job and task analysis (or any other type of task identification technique) used for establishing a list of task, performance standards, learning objectives and training methods on shutdown and low power operation?*

   Explain.

Most of the organisations which impart simulator training on such operational conditions reported that some type of Job and Task Analyses are done (not all according to INPO standard).

For most of them the basis for such Job and Task Analyses comes from the plant operating procedures.

Other techniques or sources mentioned for identifying important scenarios and tasks are:

- List of PSA incidents.
- Observed operational difficulties.
- Errors that are known to have occurred in the industry.

Finally, one organisation reported that Job and Task Analyses has been done and simulator has not been selected as the most appropriate training setting for such conditions.

4. What are your plans for the future in this area?

Many utilities will continue with the improvement of shutdown and low power simulator capabilities, although obviously depending on their current situations. This improvement will depend on the review of industry event data and risk analyses.

Almost all the PWR respondents which has not implemented mid-loop operation yet are planning to do it in the near future. The ones which have it are planning to improve their models. This seems to be the common objective.

In one case, additionally, it is said that simulator capabilities will be extended in order to incorporate refuelling operations.

SECTION 5: ***Specific topics on Operator training with simulators***

f) Simulator training on severe accidents

1. What use is made of simulators for Control Room Operator training in severe accidents (simulated scenarios, trained skills, training techniques, ...)?

The majority of the respondents comment that, nowadays, severe accident is not part of their simulator training programs.

Four respondents manifested some use of simulators for this purpose:

- One Finnish Training Centre has a severe accident PC-simulator for e.g. core melt accident, which has been used in operator training.
- Some of the Swedish simulators are equipped with the possibility to run meltdown scenarios.
- In South Korea, full-scope simulators, which simulate various severe incidents/accidents, are used for training.
- In France, crisis teams are trained on SIPA (concept simulator) in the understanding of these accidents and test decision-making procedures currently being developed. Crisis exercises test the means available to the teams. Events proposed are coherent with physical codes used and with PSA scenarios. Each site carries out an exercise such as this every two years.

Finally, several respondents indicated that although operators are not trained on severe accidents by the strict definition of the term, the use of symptom based emergency operating procedures allows them to response to a wide range of conditions, including some aspects of severe accident.

2. *What are the criteria (risk-based criteria, deterministic criteria, result of need analyses, simulation availability, etc.) supporting the above mentioned use of simulators?*

Many respondents indicated that the necessity of such training is being discussed nowadays. So the criteria are still under development.

Notwithstanding several reasons have already been provided by the respondents in order to justify the current lack of simulator training on severe accidents:

- Much of the response to severe accidents is in the area of technical support to operation. Simulator training is probably not the appropriate method for training for this technical support role.
- The training benefit from this kind of scenarios must be considered low since the concept itself states that there is little left to do.
- Risk based criteria are the basis for not using such scenarios.
- There is not analytically derived plant response for these beyond design events. So simulators cannot be realistically expected to model them.
- There are not available procedures for coping with this situations.
- Current simulator training only cover events analysed in the Station Safety Report.

On the other hand, severe accident management is an essential part of emergency management in Finland, required to be taken into account in old units and specially in NPPs of new construction.

3. *Are job and task analysis (or any other type of task identification technique) used for establishing a list of task, performance standards, learning objectives and training methods on severe accidents?*

   Explain.

Various respondents mentioned that severe accident tasks have been or will be treated (depending on the current situation) not differentially than any other task in the job and task analysis or whatever task identification technique employed usually.

It is stated by one respondent that job and task analysis are not yet appropriate until the industry defines the general responsibilities of each group which would be called upon to deal with the results of a severe accident.

Related to the above comment, another respondent manifests that from the job and task analysis already performed by INPO following the US approach represented by NEI, it seems that it is not obtained the necessity of training operators in the operation to introduce strategies on severe accident management. However, it would be convenient to have some simulators which provide training for the evaluators and responsibles in decision making personnel.

4. *What are your plans for the future in this area?*

It seems that in the near future most of the organisations do not plan to modify meaningfully their training programs in this area. Some of them are waiting for the results of industry initiatives to develop a position on general responsibilities and, consequently, the necessity of simulator severe accident training.

***<u>SECTION 5:</u>* Specific topics on Operator training with simulators**

g) Simulator training on accidents caused by fires, floods, earthquakes, etc.

1. *What use is made of simulators for Control Room Operator training in accidents cause by fires, floods, earthquakes, etc. (simulated scenarios, trained skills, training techniques, ...)?*

Almost a half of the respondents mentioned that fires, floods and earthquakes scenarios are not trained making use of simulators. Some of them reported that another training settings as classroom or field training are used.

Some organisations explained that these external events are the basis for simulator training on the available abnormal procedures for abandoning the main control room and for operating from the "bunker" or remote shutdown control room or backup panels.

The rest of the organisations mentioned some specific simulator training on this issues, specially regarding fires. Mainly they are considered as initiating causes for multiple equipment failures, conducting to loss of plant functions. Some examples provided of training scenarios are:

- Fire events in actual plants (Japanese organisation)
- Loss of plant buses due to fires (US organisation)
- Artificial smoke is used to train shutdown in fire case (Finnish organisation).
- Flooding due to Service Water pipe break (Canadian organisation).
- Safety functions are lost due to earthquakes (Japanese organisation).

Regarding this kind of events a Canadian organisation mentioned that the training is based in the Common Mode Event Procedure and a US organisation mentioned the use of specific procedures for response to the natural events.

2. *What are the criteria (risk-based criteria, deterministic criteria, result of need analyses, simulation availability, etc.) supporting the above mentioned use of simulators?*

In some responses it is commented that, from the point of view of the control room operation, there are not meaningful differences between equipments failures initiated by external events or by other causes. Notwithstanding some differences are noted, such as: the higher complexity of the transients because of many systems could be affected at the same time, the use of specific procedures for response to the natural events, the activation of the emergency plan based on the event.

In those cases where specific simulator training is implemented for such external events, some of the provided reasons are:

- Training under various conditions is necessary.
- All the scenarios covered by some operation procedures should be trained. It is assumed that the analysis for determining what risks should be covered, where done during the development of the abnormal and emergency procedures.
- Needs analysis.
- Regulatory body requirement.

3. Are job and task analysis (or any other type of task identification technique) used for establishing a list of task, performance standards, learning objectives and training methods on accidents cause by fires, floods, earthquakes, etc.?

Explain.

In some cases Systematic Approach to Training is applied, although almost all the respondents indicate that formal job and task analyses are not used.

4. What are your plans for the future in this area?

No special changes are planned for the future in this area in any organisation.

PART 3: EXPERIENCES OR STUDIES ON SPECIFIC ISSUES

CHAPTER 1: INTRODUCTION

The objective of this Part 3: "Experiences or Studies on Specific Issues" was to discuss in-depth some of the issues more difficult or not completely solved yet, with the aim to draw lessons learned and current practices which are used to avoid incidents originated by operator errors due to inadequate training.

The strategy was to collect information by means of contributions or reports prepared in the different Member Countries.

In September-94 this Task "Role of Simulators in Operator Training" was beginning to be designed. In those days, it was thought that, in addition to the Survey, some of the relevant issues related to simulator training could be discussed in more detail. This proposal was supported by PWG-1. It was decided that these issues should be selected taking into account, not only the interests of the ETF-HF Members, but also the interests of the rest of PWG-1 Members. So it was decided that, from then up to February-95, any Member could communicate to the task co-ordinator his/her main issues of interest. Taking into account the opinions received, during the ETF-HF meeting it was decided to deal with three of them. This was supported by PWG-1 in September-95 meeting. The selected issues were: (1) Teamwork, Diagnosis and Decision-Making, (2) Stress, and (3) Simulator Fidelity, Issues and Concerns.

All Member Countries were invited to contribute with one or more reports to one or several of the selected issues.

In order to make easier the preparation of the contributions, it was only requested that each report should include three different sections: definitions of issues, current practices and further developments.

Eleven contributions coming from six different countries were received by the task co-ordinator before the end of October-96. They are distributed in the following way: Teamwork, Diagnosis and Decision-Making (seven), Stress (two) and Simulator Fidelity, Issues and Concerns (two). A copy of all the gathered contributions is included in the Appendix B of the Task 5 Report.

Chapter 2 of this Part 3 Report includes a list of all these contributions and a summary of them.

The summary has been prepared trying to remark, when possible, the definition of the issues, the evaluation methods, the applications of these methods, and the conclusions and further developments.

CHAPTER 2: CONTRIBUTIONS

2.1 List of Contributions

Eleven (11) contributions coming from six (6) different countries were gathered. They are distributed in the following way: Teamwork, Diagnosis and Decision-Making (7), Stress (2) and Simulator Fidelity, Issues and Concerns (2). Different types of organisations (Training Centres, Research Centres, Regulatory Bodies, etc.) prepared these contributions.

All the contributions are listed below within their corresponding Section and according to Countries alphabetical order.

***SECTION 1*: Teamwork, Diagnosis and Decision-Making**

- Finland (VTT): "A method for analysis of nuclear power plant Operators' Decision Making in simulated disturbance simulations". (1994). Authors: Kristiina Hukki and Leena Norros.
- Finland (VTT): "Contextual analysis of the Operators' on-line interpretations of process dynamics". (1995). Authors: Leena Norros and Kristiina Hukki.
- Finland (VTT): "A contextual approach to systems safety analysis of decision making in an accident situation". (1996). Authors: Jan Holmberg, Kristiina Hukki, Leena Norros, Urho Pulkkinen and Pekka Pyy.
- Hungary (Paks NPP): "Development and usage of a computer based assessment technique for simulator training". (1997).
- Japan (CRIEPI, Kurume University, Tohoku University): "Modeling and Simulation of Operator Team Behaviour in Nuclear Power Plants". (1996). Authors: K. Sasou, K. Takano, S. Yoshimura, K. Haraoka and M. Kitamura.
- Japan (NUPEC): "Development of Team Performance Evaluation Method and its Application for Team Performance Improvement". (1996). Authors: Tomihiko Furuta and Kunio Akutagawa.
- Spain (TECNATOM): "Teamwork, diagnostic and decision-making". (1996).

<u>SECTION 2</u>: Stress

- Spain (TECNATOM): "Stress". (1996).
- United States of America (NRC): "Stress". (1996).

<u>SECTION 3</u>: Simulator Fidelity, Issues and Concerns

- France (IPSN): "Comparison methods of simulator fidelity models and impact on operation". (1995).
- United States of America (NRC): "Simulator fidelity issues". (1996).

2.2 Summary of Contributions

In the next pages it is included a summary of the contributions.

<u>SECTION 1</u>: Teamwork, Diagnosis and Decision-Making

Finland (VTT): "A method for analysis of nuclear power plant Operators' Decision Making in simulated disturbance simulations"

<u>Objectives</u>

This paper describes an analysis method which is a conceptual tool for systematical evaluation of nuclear power plant operators' decision making in simulated disturbance situations.

The aim of the analysis is to investigate "Operators' Orientation" which is expected to manifest itself as "Collective Strategies" in utilisation of "Resources of Decision-Making".

Resources analysed are different "Information Sources" and, in addition, "Collaborative Resources" like Communication and Participation.

<u>The Model</u>

The Model used is a conceptual description of Operators' collective diagnostic and operative decision making in a particular disturbance situation.

It is supposed that there are two different aspects of "Orientation" controlling construction of decision making: tendencies to "Coherence" and "Reflectivity". Coherence as comprehension of the plant process. Reflectivity as consideration of the context of the decision making activity.

Dynamical, contextual (operative and social) and even historical aspect of decision-making are considered in the Model.

The Analysis Method

The Analysis Method consists of two main parts: (A) Creation of "Operative Reference" for analysis of decision making, and (B) Analysis of decision-making with respect to this "Operative Reference".

(A) It is necessary to develop an "Operative Context". This is made with help of "Conceptualisation of the Disturbance Situation from the Decision Making" point of view and by construction of "Operative Reference" for activity. The latter means "Conceptualisation of the Situation from the Safety" point of view and also "from Other Boundary Constraints" of decision making, i.e. economical and technical aspects.

(B) For the analysis of decision-making with respect to this "Operative Reference", that means for the analysis of "Operators' Orientation", the analysis method offers two different mutually supportive means: (1) evaluation on the basis of Operators' verbalised comprehension concerning process control, with help of interviews, and (2) evaluation on the basis of differences in their utilisation of resources of decision-making (Information Sources and Collaborative Resources), during a simulator run and after it during a debriefing session.

Applications

The Analysis Method is aimed to be used in routine simulator training in nuclear power plants:

- By virtue of its dynamical, contextual, and historical approach it makes the developing nature of activity visible.
- It is expected that trainees become more conscious of their strategies in decision making and in co-operation.
- It is expected that trainers become more conscious of their criteria and strategies in their training activity.
- Learning can be improved also by deliberately developing Operators' orientation during simulator training.
- Cumulation and distribution of knowledge of decision making as developing activity, controlled by orientation and boundary constraints of process control, is expected to improve operational culture of a plant organisation.

Further Developments

The operative context will be extended to comprise not only decision making in disturbance situations but also normal routine work in process control.

Finland (VTT): "Contextual analysis of the Operators' on-line interpretations of process dynamics"

Objectives

The aim of the study described on this paper was to reveal differences among the NPP crews' regarding their modes of making on-line interpretations of difficult disturbance situations. That is, to identify qualitatively different modes of interpretation of process situation based on an analysis of the operators' ways of utilising available information and co-operative resources of activity.

The assumption was that differences in the crews' orientation become manifest in action as differences in the crews' ways of utilising information and co-operative resources, within which the authors expected to reveal variations in expressions of two basic subject-environment relationship: the tendency to coherent explanation of the situation and taking account of the specificity of the situation.

The Method

The study was carried out in a nuclear power plant full-scope training simulator and an analysis method was developed during the study (the basis of the analysis method are mentioned in the preceding summarised contribution).

The experiments comprised of 11 crews' performance in a complicated disturbance situation. The research material included pre-interviews with the operators, detailed registrations of process data, observations and videotaped recordings of the operators' performance, and debriefing discussions with each crew.

As a result of the analysis of the operators' task performance, structured descriptions of each crew's conceptions of the disturbance and choice of operative methods were prepared.

Based on these, behavioural anchors were defined for ratings regarding the models of the crews' interpretations. As it was mentioned previously, the dimensions of evaluation were derived assuming that the dynamics of construction of an interpretation of the situation is related to typical features of a person's relationship with the environment: tendency to coherent explanation and account for the specificity of the situation.

The Results

As a result of the analysis three different modes of interpretation of process situation were identified: (a) constructive, (b) schematic and (c) implicit.

These modes could be distinguished from each other regarding the use of information and co-operative resources; criteria being: (1) attention to process situation, (2) basis of interpretation of the situation and (3) explication of interpretation.

Due to the aims of the study no direct evaluations of the adequacy of the crews' performance or the efficiency of the different modes were carried out. Authors consider that it will be an interesting future research problem to try to find a relevant way to acquire such evaluations. Authors' hypotheses is that clear differences in the efficiency of the modes manifest themselves only in extreme situations, the strengths and weaknesses of the modes being qualitative signs of efficiency in less critical or routine situations.

The results of the study suggest the possibility to teach the crews efficient utilisation of resources.

Further Developments

Analysis of the relationship of these modes with the operators' conceptions of the plant process is currently going on in order to make inferences concerning the crews' orientations.

Based on the described evaluation method the authors are currently developing a tool to be used in normal simulator training. The work is carried out in co-operation with the instructors of the power plant. The experiences have been promising thus far. It seems that this kind of a contextual analysis of the crews' activities may create insights within the operators regarding their own decision-making, and increase interest among the crews to reconsider current orientations for opening new possibilities of action.

Finland (VTT): "A contextual approach to systems safety analysis of decision making in an accident situation"

Objectives

This paper discusses integration of two complementary approaches for analysing Operators' decision making and human reliability in accident sequences: (A) Probabilistic Modelling, and (B) Contextual Psychology.

A Probabilistic Model represents decision making as a part in the event sequence depending causally on the situational factors. The uncertainties in the evolution of the events are expressed by probabilities.

Contextual Psychology analyses decision making with respect to its context, the actual state of the process to be controlled.

The combination of the two approaches is based on common descriptions of the decision making context, i.e. the reference models. The truly integrating aspect of the analysis is the process beginning from descriptions of the situation and ending with the common formalization of the context. Decision Analytic Thinking forms the framework for developing the reference models, which represent the flow of decisions and random events and the boundary conditions and objectives of the decision making. In this way the intentional aspect of decision making is reflected properly in reliability models.

The Analysis Process

The outline of the integrated analysis is threefold:

(1) The decision context is identified and described by creating descriptions of the investigated situation. They provide a basis for both reliability and psychological analyses. The main idea is not to describe the ideal solution of the task but represent the identified relevant possibilities of activity from the diagnostic and operational point of view.

(2) The accident situation is modelled from the risk and reliability point of view using the descriptions as reference. The modelling technique is based on a marked point process framework, in which not only stochastic events but also decisions are seen as marked points.

(3) The operators' decision making is analysed with respect to the reference models, by means of a psychological analysis. The way in which they utilise available process information and co-

operational possibilities manifests the coherency of their interpretation of the situation and their ability to take into account the situational demands.

Simulators runs provide useful information for both probabilistic and psychological analyses. This information is mainly qualitative and can be used for: (i) validating the description of the situation, (ii) by observing the operator crew's behaviour during the run the analysts may obtain information on the way which the operators use the information from various sources, (iii) operators' decision rationale may be identified by analysing the simulator run.

This integrated analysis framework was applied (mainly phases 1 and 2) to the analysis of specific operator actions in BWR plant environment during shut down for refuelling.

Further Developments

The integration of two complementary disciplines, Probability Analysis and Contextual Psychology, as a new paradigm for human reliability analysis provides promising opportunities to comprehend human decision making at risky situations.

The current stage of the analysis is seen by the authors as a promising intermediate phase in the integration of the two approaches. In the continuation, it is important to carry out the integration in a way that considers decisions as intentional actions influencing risk, not as components of the risk assessment of the situation. Such an approach would make visible how operators' different ways of decision making contribute to safety.

The integrated safety analysis approach was applied to an accident scenario during refuelling outage. The scenario was analysed through a simulator experiment. As a formalised and comprehensive description of decision making the integrated approach gives possibilities to analyse and interpret the simulator experiments. There are not, however, any obstacles to apply it also to the analysis of other types of operational experience and to maintenance activities.

Hungary (Paks NPP): "Development and usage of a computer based assessment technique for simulator training"

Objectives

The aim of the system is to provide an objective computerised assessment method for the operational crew performance on the simulator session, called C(computerised) OP(erator) A(ssessment) S(ystem). During the training session the last step is to experience a malfunction, and to perform the required trouble shooting. There are 25 different transients have been developed from the EOPs, varied from anticipated operational occurrences to incidents such as control rod drop or turbine trip up to steam generator tube rupture. Each shift are trained with 5-6 events at every simulator training. By means of the COPAS the instructor is able in real time mode to follow the prescribed actions and interventions and finally using the printout the team performance can be evaluated as a whole. The printout with the plant shift supervisor written evaluation is used as a documentation for the session.

The method

The method is based on the emergency operating procedures. An EOP is handled like a logical network of the status and events. The system in real-time mode follows the event-flow on the simulator during the transient, and compares it with the pre-defined events. If the sequence of execution of the operators is not correct the time appears in different colour on the logical diagram. There is a warning label in case of omitted action when the session is over. The system also present the most important parameter changes and compares to the prescribed ones. When a parameter exceeds the limits there is also an indication of it.

Japan (CRIEPI, Kurume University, Tohoku University): "Modeling and Simulation of Operator Team Behaviour in Nuclear Power Plants"

Objectives

This paper depicts the technique of simulation for plant operators facing abnormal events within the plant called SYBORG "Simulation System for the Behaviour of an Operating Group". SYBORG simulates decision making processes via communication among operators.

The Operator Model

SYBORG accounts for 3 operators - one is the leader of the team and the others are followers with different roles. It is assumed that the leader does not observe or touch the control panel. The leader model accumulates information of the plant via communication.

The operator model consists of the attention, thinking, action and utterance micro models. The thinking micro models introduces the "mental model mechanism", that describes and illustrates how operators predict plant behaviour and make decisions to prevent the deterioration of its conditions. It was developed based on cognitive science, group dynamics and also on interviews with nuclear power plant operators. Each operator model has some knowledge bases (KBs). They store knowledge pertaining to the relations between (1) events and parameters, (2) events and causes, (3) change of parameters and interlock, (4) change of parameter and carrying out countermeasures, etc.

The Team Model

The above operator model is not enough for simulating the complete behaviour of the operator. So, some other characteristics related to the team behaviour have been incorporated. Thus, authors introduced the HHI (Human Human Interface) model that has the task assignment, disagreement and utterance management micro models which consider personality, credibility, position, etc.

The task assignment micro model incorporates the characteristics of team behaviour related to the co-operation with each other to deal with a work that is divided among operators. It is assumed that each task is undertaken by 2 operator models (the leader and one of the follower models). The leader model can deal with 2 tasks that are dealt with by the follower models. This task assignment micro model consider several types of the task assignment such as types a follower model follows the leader's instruction for task assignment. However a task assignment type is predetermined as one of the team characteristics.

The disagreement solution micro model simulates the characteristics of team behaviour related to the fact that real operators communicate to exchange plant information and their thoughts on plant conditions, and then they decide on countermeasures that are thought to be the best ones for the plant. It is assumed in the micro model that the team's decision making is carried out between 2 operator models and that the team's decision is an alternative to the countermeasures the operator models decided on. The disagreement solution micro model considers 30 kinds of predetermined communication processes. This micro model considers several dynamic parameters (arousal level, confidence) and static parameters (expertness, reliability) to describe a variety of communication processes.

Applications

SYBORG is implemented using computers. It has 2 workstations and 3 personal computers interconnected through a Local Area Network. Basically a workstation calculates the behaviour of the team and the other one calculates the plant behaviour.

This paper also describes an example of the simulation results, indicating that SYBORG can expectedly simulate the behaviour of the operating team faced abnormal events happening in a simplified plant.

Further Developments

The authors will improve on SYBORG through verification experiments with subjects. Learning mechanisms and error mechanism will be added to SYBORG in the future.

Japan (NUPEC): "Development of Team Performance Evaluation Method and its Application for Team Performance Improvement"

Objectives

The purpose of this study is to evaluate the performance of the co-operative tasks in nuclear power plants and to develop measures to improve the performance of the operating team.

The performance of an operating team in the control room of a nuclear power plant depends on the abilities of its members and their circumstances.

Team reliability is defined as each member giving and receiving information without error and acting as a team member correctly. This definition is adopted in this study as an index to evaluate the performance of the operating team.

The Evaluation Method

Team Performance Evaluation Model consists of Man System Model and Man-Machine System Model. Applying those models, factors affecting team reliability are taken into account.

Regarding the Man System Model, the evaluation factors chosen are: (1) information among team members, (2) ability of team members and (3) external information. Based on this factors and on the model of the group decision, the probability that each member makes his decisions correctly and the probability that the team makes correct decisions are derived.

Regarding the Man-Machine System Model, two additional factors are taken into account: (4) probability that machine system transmits correct information and (5) probability that member corrects wrong information transmitted from machine system. Based on this factors and in the probability estimated in the Man System Model, the probability that each member makes the correct decision in the Man-Machine System is derived.

Applying these models, contributions of each factor to the team decision reliability are examined parametrically. This examination considers several types of potential team performance improvements. The advisable improvement measures are derived from among these improvement types applying the Analytical Hierarchy Process (AHP) which is one of the quantitative decision making methods.

Applications

In the paper it is described how this evaluation method has been used with the operating team in the central control room of a nuclear power plant in order to investigate several improvement measures for team reliability.

The conditions established in this application are:

- Control Room Operating Team consists of 5 members.
- There are 4 possible combinations of utilities' surrounding management conditions: utility potentiality for implementing improvements on the human side (easy or not) and on the hardware side (easy or not).
- The evaluation factors used are the five mentioned above plus another one for the Man-Machine System Model: (6) compensational factor among team members.
- Improvement measures or types investigated are several combinations of improvements on some of the six evaluation factors.

So, based on the evaluation model and the established conditions, each evaluation factor is parametrically examined.

The advisable improvement measures corresponding to each possible surrounding management conditions of the utility are derived.

The derived improvement measures common to each surrounding condition are:

- Concentrate information to a shift supervisor with strong leadership.
- Improve ability to correct wrong information by training of emergency correspondence on mock-ups.
- Improve display systems by installing a large display screen or individual display terminals for operators to obtain common occasional plant information.

Spain (TECNATOM): "Teamwork, diagnostic and decision-making"

Definitions

In this paper Teamwork is defined as the work being accomplished by a group of people with assigned individual roles and responsibilities whose priority is accomplishing a common goal. For it, several rules should be taken into account.

Diagnosis and Decision-Making is defined as a logical mental process developed in three stages:

- Supervision: to know the state of the plant at all times, differentiating between normal and problematic situations, being able to forecast abnormal evolution.
- Interpretation: to be able to analyse problems, and to assign priorities, identify the causes of problems and to define the most probable cause.
- Intervention: to determine whether or not any action should be taken, the action to be taken, the priorities and to analyse the possible consequences.

Current practices

TECNATOM is a Training Centre where, nowadays, most of the Spanish NPP Operating Teams receive training. A Human Factors Course, previous to simulator training, has been developed. Teamwork, Diagnosis and Decision-Making issues are included in this course. Its objective is to transfer to the trainees the bases required to understand efficient teamwork and previous diagnostic techniques, necessary for decision making in the operation of a NPP.

The course is delivered in classroom setting using lectures and practices. The skills acquired are practised during simulator training programme. The course is held during four days (24 hours), making use of formal instruction, discussions and case studies, role playing, diagnostic practical exercises and quizzes.

The main areas treated are leadership (leadership styles, effective supervision), teamwork (shift roles and responsibilities, task assignment, co-ordination, assertive behaviour), motivation, communication (verbal communication, written communications, shift turnover) and diagnosis (attention to details, logical process of diagnosis).

Further developments

It is planned to implement the Human Factor Course on CD-ROM using multimedia techniques, text, graphics, sound and video images, for self study and retraining.

SECTION 2: ***Stress***

Spain (TECNATOM): "Stress"

Definitions

In this paper the difficulties for defining stress are highlighted. Taking advantage of the stress definition in Physics, stress is defined for human beings as any internal or external force which generates physical or mental tension.

In this sense stress control means the psycho-motor ability to control our physiological activation in response to endless stress producing factors found in daily life.

Current practices

TECNATOM is a Training Centre where, nowadays, most of the Spanish NPP Operating Teams receive training. An specific Stress Management Training Course, previous to simulator training, has been developed. Its objective is to teach trainees to identify stress-related behaviour and stress inducing conditions and implement techniques that minimise the impact of stress on people performance.

The course is delivered in classroom setting using lectures and practices. It is held during three days (18 hours), making use of formal instruction, discussions, relaxation practices and quizzes.

The main areas treated are stress definition, stressors, effects of stress and symptoms and coping strategies.

In the paper some strategies used to manage stress during simulator training are mentioned: prior to or at the beginning of an event to reduce the level of stress, and when the stress is felt in order to diminish its effects.

Further developments

It is planned to include relaxation exercises into retraining programmes in order to develop performance patterns, advanced instructors training on stress symptoms identification, and other practices to avoid trainees' stress during training sessions.

United States of America (NRC): "Stress"

Definitions

In this paper it is defined that a stressful situation occurs when a substantial imbalance exits between the demands imposed on an individual and the individual's ability to successfully handle those demands. Stress can also occur if an individual simply perceives a mismatch between the demands of the situation and his or her abilities to cope with those demands.

The causes of stress that have been identified in the research literature are numerous and include environmental factors (e.g., extremes in temperature, noise, and crowding), workload, competing goals, and conditions that are novel or cause uncertainty.

Stress can significantly influence human performance and stress effects can range from facilitation to severe impairment. Interest in the U.S. concerning the effects of stress on the performance of nuclear reactor operators has largely been focused in two areas: the effect of stress on performance during plant operations (e.g., abnormal or emergency operations and plant outages) and the effect of stress on performance during the license examination process.

In 1994, NRC published NUREG/CR-6127: "The Effects of Stress on Nuclear Power Plant Operational Decision Making and Training Approaches to Reduce Stress Effects". The report documented a review of research literature concerning stress and presented an analysis of the effects stress can have on decision making and performance in the context of nuclear power plant operations. Four general types of impairments in cognitive performance were identified:

- Narrowing and shift in attentional focus.

- Reduced working memory capacity.
- Time pressure effects.
- Impaired crew communications patterns.

Current Practices

The paper states that the emphasis is on eliminating stress or minimising its effects in both of the above mentioned areas.

In the area of human performance during plant operations two practices are highlighted.

- The first one is Simulator Training. It is considered that this is perhaps the most effective tool available to address stress in the context of nuclear plant operations. It eliminates or reduces two potential sources of stress: novelty of inexperienced events and uncertainty in the prediction of outcomes. Regarding mitigation of stress effects, repeated training in plant emergency simulations is an important means by causing effective accident mitigation behaviours to become well-learned, routine behaviours that tend to be less susceptible to, if not facilitated by, stress.
- The second practice is Communications and Team-Building Training. This training can mitigate the effect of stress: impaired exchange of information among crew members.

In the area of human performance during the license examination process, several actions has been taken by the NRC. They intend to mitigate the specific sources of the undue stress derived from the process itself. This undue stress is additional to the one inherent to real emergency conditions. These actions are:

- To make changes to the examination process more predictable.
- To improve consistency in the administration of examinations
- To emphasise the performance of the crew versus individual performance.
- To train examiners in order to avoid they inadvertently cause stress and to put operators at ease during examinations.

In this second area, many US utilities have also implemented different programs to assist operator in coping with text anxiety.

Further Developments

The digital technologies that are currently being developed and introduced into nuclear plant control rooms have the potential, depending on the design and implementation details, of reducing stress by reducing cognitive workload.

Regarding severe accident management, several training approaches for mitigating the effects of stress on the operator's cognitive skills have been identified in NUREG/CR-6127. One of them would be training using realistic (although at that moment non-real-time) severe accident simulations to reduce the novelty of such conditions.

***SECTION 3*: Simulator Fidelity, Issues and Concerns**

France (IPSN): "Comparison methods of simulator fidelity models and impact on operation"

Objectives

This report deals with a specific type of simulators fidelity: the representativeness of the simulation codes. It includes a description and an example of a proposed simulator evaluation methodology which can be used directly and which is based on control concerns.

The question of the representativeness of simulators has been coming increasingly to the fore, in view of their increased use in France over the last ten years.

The consistency of the simulator responses with those observed at the plant real events is considered the best way for evaluating simulator codes fidelity. But for those transients more serious than the ones happened in plant real events, the preferred evaluation method is currently the comparison with the results of reference, best estimate, codes. And, as long as computer limitations prohibit real-time calculations which make direct use of the reference codes, this latter evaluation method will have to be used.

Notwithstanding the comparison of simulator responses with the results of the reference codes could be done in different ways and this is the main point of this report.

The Evaluation Method

The conventional method is based on the design of a matrix, where the rows represent different "system states" and the columns different "transient families". Typically system states consist of 67 physical phenomena listed for the reference code. Some of them are specific of a particular "component" of the plant (e.g. natural convection on reactor coolant system). There are usually five or six columns of broad transients families which include the fifty or so transients selected. Crosses are entered in the corresponding column/line intersection when the simulator provides a response with an acceptable deviation from the baseline code.

The conventional method evaluates simulator fidelity with respect to the evolution of the physical process. But the Operators do not observe the phenomenology in such detail. The actions taken by them are based only on the signals (indicators) observed in the Control Room in accordance with their Operating Procedures. These are the reasons for the new evaluation method proposed in this report.

The new method replaces "system states" by "parameters observed by the Operators" and "transient families" by "transients covered by procedures" in the evaluation matrix. Amplitude of the response and action of automatic control devices and timing of the simulated response are compared with the ones of the reference code. Based on this it is possible to perform sensitivity studies on the methodology used to evaluate the simulators and to observe the consequences this has on the effect of the Operating Procedures. This is specially important when simulators used to draw up Operating Rules are not the same used for Operators Training.

Applications

This report includes an example which compare the evolution of several parameters using three different simulators and the reference code. The consequences derived in the example for operators training are:

- If the state parameter serves as reference to change of Procedure, the Procedures will not be used in the same way during the simulation and during a real situation.
- The timing of the different parameters learnt with the simulator training could be wrong.

In the report it is concluded that this new simulator evaluation methodology, which address the issue of simulation codes fidelity, is one means of directly determining simulators degree of representativeness according to concerns which are akin to those used in operations. The effects of a maximum permissible difference between the simulated response and the baseline code can be measured in terms of difference of orientation in the Operating Procedures.

United States of America (NRC): "Simulator fidelity issues"

Definitions

The 1993 revision of ANSI/ANS 3.5 defines "Physical Fidelity" as a measure of the degree of similarity between the simulator and the reference unit with respect to the replica hardware.

Other type of fidelity is also the goal of the software simulator development process. Many efforts are done to assure fidelity to actual plant response or best estimate performance.

Simulator fidelity is perhaps the most abstract "component" in the matrix of simulator requirements. But fidelity is essential for effective and valid simulator training and examination programs.

Current Practices

In the US nuclear industry the simulation facility has been considered to be the traditional "full-scope" control room, although other devices may be incorporated in the simulation facility. A detailed regulatory environment surrounding simulators exists. The regulations assume simulator fidelity and encompass simulator design, testing, and usage for initial and requalification examinations and on-the-job requalification training.

The simulator scope and design and the verification and validation processes are closely related to the acceptability of the simulation facility for training and examination. NRC has two significant concerns in this area: (1) to validate features initially and (2) to periodically test features that are used in the training and examination program.

Multi-discipline evaluations of simulations facilities are done by NRC staff in order to verify the adequacy of the simulation facility to meet and support the requirements included in the Code of Federal Regulations.

Four areas are evaluated: Performance Testing; Physical Fidelity/Human Factors; Control Capabilities; and Design, Updating, Modification, and Testing.

Additionally examiners routinely observe simulator performance as part of the operator licensing program and record discrepancies.

Simulator performance discrepancies persist in the areas of the Nuclear Steam Supply System and major Balance-Of-Plant design. More importantly, the rate of occurrence of these discrepancies has remained constant over the monitored period in spite of substantial improvements in simulator computing capacity, software development tools, and model sophistication.

The NRC staff does not quantitatively assess discrepancy counts as a measure of simulator fidelity or of the ability to meet CFR requirements, although persistently high discrepancy counts do sometimes attract attention. In such cases, the staff usually contacts the facility simulator supervisor and reviews the nature of the outstanding discrepancies or, in some cases, visits simulation facility to evaluate specific concerns in more depth.

If fidelity discrepancies exist that would greatly hinder or limit the ability of the licensee to conduct an examination on the simulation facility, operating examinations shall not be conducted until the facility licensee has corrected the discrepancies and recertified the simulator.

Simulators must also avoid misleading or negative training, which could result from the use of a simulation facility that does not correctly portray plant response to malfunctions.

Further Developments

A simulation facility is not limited to the control room replica. The regulatory definition provides for other simulation devices, like part-task or limited-scope simulators, although they are excluded from the scope of ANSI/ANS 3.5. NRC does not consider this to be a problem but does expect fidelity to be comparable to that addressed by such document.

PART 4: CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 1: INTRODUCTION

The development of this task has allowed for a better understanding of the role played by simulators in operator training programs in OECD countries. Current practices and on-going research projects have been presented. Based on these, some conclusions and recommendations have been developed.

Current practices in operator training with simulators have been summarised in Part 2 of this report. They are based on the responses to a survey from twenty-five different organisations (training centres, utilities and regulatory bodies) representing eleven countries. The large amount of oriented and graded information gathered (close to 2000 replies) reflects a real state of the art. Thus, it could be claimed that the conclusions and recommendations described below are not specific to any type of technology, organisation or country, and are likely to be pertinent to the majority of OECD countries. Additionally, the main value of this report does not lie only in the conclusions and recommendations, but principally in the structured information which is available to any organisation interested in comparing any aspect of their current simulator training practices with the ones of other organisations.

Some specific issues (team work, stress and simulator fidelity) have been treated in more depth in Part 3 of the report. Several on-going research projects and activities, related to those issues which have not yet been completely solved, have been summarised. The information gathered for Part 3 is very valuable but not as broad as for Part 2.

CHAPTER 2: CONCLUSIONS

The following paragraphs summarise the main generic conclusions derived from the task.

a) Extensive and increasing use of simulators

It is clear that simulators currently play an important role in the training programs of NPP control room operators in OECD countries. There are no meaningful differences on this point, independent of countries, utilities, level of plant automation or any other factor:

- 100% of the operators receive training on full-scope simulators.
- More than 80% of the operators train on replica simulators.
- Important activities are on-going, like the construction of new replica simulators. At the same time, taking advantage of developments in computer technology, there is an emerging use of specialised (compact) simulators, installed in workstations. The latter are being used in combination with full-scope ones.

b) Meaningful differences in current practices

There are meaningful differences in current practices with the use of simulators between countries and even between organisations. Trends or correlations between such practices and specific factors (e.g. the degree of plant automation) have not been found. Differences include:

- Differences in the policies of the regulatory bodies.
  - Simulator use (devoted time, type of scenarios or conditions, etc.).
  - Licensing exams.
  - Simulator specifications (types, fidelity criteria).

- Differences in the practices of the training centres.
  - Simulator use (devoted time, type of scenarios or conditions).
  - Operations outside control room (remote shutdown panel, emergency diesel, etc.)
  - Involvement of non control room operators in the simulator sessions.
  - Procedures followed to incorporate operating experience into the training programs (nothing versus strict control of the process; current versus several years later; instructors versus several expert teams).

c) SAT is a common framework

A Systematic Approach to Training (SAT) is commonly used in all the OECD countries. Nevertheless there are many differences in the way SAT is implemented.

d) Limited use of Probabilistic Safety Assessments (PSA) results

Up to now, risk-based criteria have not been frequently used as a tool of the SAT process, although sometimes their plausible use is recognised. For example PSA might be used to select important scenarios, or to limit the required scope of the training, or to determine the frequency with which some actions should be trained.

Symptom-based procedures are used in many plants. They are based on generic PSA studies and results. In this way, it could be considered that PSA results are taken into account in simulator training.

However, it seems that the insights and results derived from the significant specific PSA programs undertaken in many countries have not begun to be systematically and formally used. Perhaps, up to now, there has not been a great deal of liaison between the groups of people involved in both types of activities (training and PSA).

e) Simulators are one part of the battery of training settings

Typically, the training programs combine training on simulators and classroom and, to a lesser degree, other training settings. But in no cases are training programs based exclusively on simulators. Simulator training is designed within the framework of a whole training program.

f) Various methods of testing are used for trainees assessment

The survey indicated that it is extremely difficult to objectively assess trainees. Skills and knowledge of the trainees are assessed in many different ways, but in cases reported it was very difficult to suppress subjectivity in assessment (although several levels of subjectivity can be found). Individual assessment is even more complicated when operating within a whole control room shift team.

g) Lack of objective indicator about training quality

The same problem of subjectivity, similar to trainees assessment, appears with respect to the evaluation of the simulator training programs.

h) Main issues to be improved are now related to human aspects

It seems that, currently, the main difficulties in the development and implementation of training with simulators, or of SAT in general, are related to human aspects (e.g. stress, team work, training frequency, etc.). No meaningful problems have been reported regarding simulator hardware or software.

Historically, when simulators were first used for operator training, the main efforts were concentrated on the development and acquisition of simulation tools (computers, codes, etc.). There were important activities in this area, as shown in the documents in the bibliography. But, nowadays, although there is a continuous work in the improvement of such tools (for example compact simulators), the main points of interest have moved to the human aspects of the training.

i) Root causes included in real event data bases are not sufficiently detailed as to discriminate among different deficiencies in training

Inadequate training is an important contributor to real events. This should draw our attention to the continuing importance of training. Notwithstanding, root causes included in real event data bases are not so detailed as to discriminate among deficiencies in different aspects of training. Thus, it may not be possible to identify in a data base which incidents have been caused by deficiencies in simulator training. Perhaps this is one reason why there are not formal analyses correlating simulator operator training and real plant operating events.

j) Some important issues remain not completely solved

Some specific simulator training issues seem not to have evolved so much as it might be expected in recent years. These are the issues of team work, stress, severe accidents, shutdown and low power conditions and external events. Several reasons were identified.

In the case of team work, it seems that the intrinsic difficulties associated with the issue itself are delaying improvements in this area, although important research activities have been done or are on-going.

- High levels of subjectivity occur in the conduct and evaluation of simulator team training. Opera-ting teams are still treated as an aggregate of individuals, not as crews. No initial licensing examinations apply to whole control room shift teams in any country. This is also true for requa-lification in most countries.

In other cases, like simulator training on low power and shutdown operation or on severe accident conditions, the reasons for the delay in implementing training seems to be based on a lack of consensus about the importance of the issues or about the effectiveness of simulator training for such conditions.

In further cases, like simulator training to prevent stress and simulator training in external events (fires, floods, etc.), current practices appear to be viewed as being good enough, sufficient; and additional efforts have low priority.

- Stress levels are neither induced in a controlled manner nor measured. A common idea is that realistic job conditions (also stress) are induced by the very nature of appropriate scenarios. So intensive training is a measure adopted to counter stress.
- Simulators are not frequently used for training on accidents caused by fires, floods, etc. Sometimes it is thought that there are no meaningful differences between equipment failures initiated by external events than by other causes.

Finally, simulator training, and training in general, is being applied in a systematic and technically-based way, but sometimes without questioning or investigating the human factors associated with training.

- Human behaviour models are not usually used.

k) On-going projects are dealing with some unresolved issues

Currently, there are activities and research and development projects on some of those unresolved issues. They reflect the priority levels and the importance assigned to them by some organisations. Examples can be seen on Part 3 of this report.

l) Trainee attitude within simulator training

Finally, it is necessary to conclude with a problem inherent to any simulation: the trainee attitude within simulator sessions. Some difficulties have been reported with respect to the behaviour of operators in the simulator versus the real control room. The need to encourage operators to respond as if they were dealing with real plant events has been raised.

CHAPTER 3: RECOMMENDATIONS

In the subsequent paragraphs, some recommendations are described. They have been derived from an assessment of the information gathered in this task. They denote significant and broad issues, where a lack of consensus or a lack of commonly accepted criteria or methodology have been observed across the current practices in different organisations. In this sense, they could be called "needs" which should be satisfied.

Two types of recommendations have been identified for those issues or topic areas: specialist meetings and research activities.

a) Specialists’ Meetings

Taking into account the significant differences identified in current practices (or ideas) on some topic areas, the ETF-HF recommends member countries to compare their own practices on those areas with the practices of other organisations, in order to determine their usefulness for the own organisation.

Additionally, it is the opinion of the ETF-HF that Specialist Meetings, specially arranged for this purpose, might provide a useful forum to continue to exchange practices on specific topic areas. But, in order to increase the meetings' efficiency, their scope should not be too broad, and their objectives must be clearly and precisely defined. The meetings should promote discussions among specialists, and avoid being simply a collection of individual contributions.

Some of the important topic areas for which significant differences in practices or ideas exist are:

1. Use of simulators to train operators on emergency conditions during shutdown and low power operation.
2. Use of simulators to train operators on severe accident scenarios.
3. Role that PSA criteria could or should have in a SAT.
4. Time devoted to simulator training, type of scenarios or conditions to be trained and time percentages.
5. Simulation of operations outside control room.

b) Research Activities

Some recommended issues where research is needed are:

1. Trainee assessment: continuing efforts should be put on the development of objective methods for trainee assessment.

2. Evaluation of simulator training programs: efforts should be put on the development of objective methods for the evaluation of simulator training programs.

   It would be important to consider whether real event databases (e.g. IRS) should seek to discriminate among deficiencies in different aspects of training. And, based on this, to assess whether formal analyses could be done in order to correlate simulator operator training with real plant operating events.

3. Team work: more emphasis should be put on the resolution of the important-for-safety issue of team work. This issue has not evolved much in recent years nor have there been many research results related to training of the operating shift teams.

4. Stress: it is important to assess whether intensive training (and to what extent) might be enough to reduce the stress influence on operator errors during emergency conditions, or whether additional methods should be investigated.

5. External events: it is advisable to assess the current situation of simulator training in external events (fires, floods, etc.). The risk associated with these events is not negligible in many plants. Additionally the conditions that the operators might encounter in the control rooms to manage these events are completely different from the ones encountered during normal transients (multiple failures of equipment, instrumentation failures or uncertainties in the values, smoke effects, etc.).

Finally, it seems, taking into account some conclusions of this task, that the flow of information and results on specific issues from research centres to training centres, utilities and regulatory bodies is sometimes too slow or less than adequate. Research results are not always transferred and put into practice easily or in a timely manner. Therefore, it could be recommended to promote the integration of specialists in Human Behaviourial Sciences into the training programs of operators. They could usefully collaborate with technical specialists. This would contribute towards the solution of those training issues related to human aspects and might simplify the assimilation of research project results.

DEFINITION OF TERMS

Operator: Any Member of the Control Room Shift Team (Reactor Operator, Shift Supervisor, etc.).

Full-scope training simulators: A full-scope simulator represents in real time the most range of operations which can be performed from the main control room. It consists of a control room which simulates the nuclear steam supply system and the balance of plant systems, including all major nuclear, conventional, service and safety systems.

Replica training simulators (or Plant-specific simulators): Replica simulators are those full-scope simulators based on a reference plant, which incorporate detailed models of the reference plant and its systems, including a replica of the control room design. These simulators respond as the plant would to normal and off-normal conditions in real time.

Part-task simulators: A part task simulator is designed for training on a specific part of plant operations or for training in special phenomena. Specific systems and phenomena may be simulated more accurately than in a full-scope simulator and they are used to provide training in a particular Control Room activity, usually including replica controls and instruments.

The system activities to be simulated are usually chosen based on the need of frequent retraining in very important or difficult tasks.

Basic principles simulators (or Compact simulators): Basic principles simulators are used to provide plant system overview training with less detail than a full-scope simulation.

The plant system model is usually generic and somewhat simplified and the emphasis is on training to understand plant dynamics.

Simulation scope may be limited to major systems, components and functions or may be essentially the complete plant. The control room or panels very often have a fundamentally different design in comparison with conventional control room design; keyboards are used to enter some control actions and CRT's are used to display much of the simulated plant responses.

Concept simulators: Concept simulators are used to train in particularly difficult concepts by isolating them from other considerations, being specially useful in reinforcing theoretical training in concepts. For the purpose of this training neither replica controls and instruments nor real time response is needed.

Special-purpose simulators: Several types of special-purpose simulators are in use, most notably thermohydraulic simulators (glass model). This simulator is used primarily to demonstrate basic thermohydraulic principles and plant phenomena. There is also a combination of simulation and expert system to maintain the skills of its control room staff in the SGTR event, where the trainee interfaces the package through keyboard and screens.

IGD (Interactive Graphic Simulator): Is a computer system that allows the behaviour of a given industrial process to be reproduced, providing the capacity for real time display and interaction with the systems and components involved via graphic interface.

The main objective of the system is to serve as a powerful and flexible didactic medium for the acquisition of concepts related to the operation of the different systems, providing a high capacity for the analysis and diagnosis of the associated-phenomena.

On-site Simulation Facility: In this questionnaire, a Simulation Facility is considered on-site when it is located close to the plant site (not necessarily inside the security fence), in such way that Operators' daily life outside the plant does not result disturbed during training days.

Off-site Simulation Facility: In this questionnaire, a Simulation Facility is considered off-site when it is located far from the plant site, in such way that Operators need to make special arrangements (trip, accommodation, ...) for attending training sessions.

Systematic Approach to Training: A logical progression from the identification of the competencies required to perform a job to the development and implementation of training to achieve these competencies, and subsequent evaluation of this training.

Systematic Approach to Training, Training Analysis: The gathering of information necessary to design the entire training program. This consists of a needs analysis which looks at the tasks being done, the people doing them, and the organisational context in which the job takes place.

Systematic Approach to Training, Training Program Design: When training programs reach the design stage, measures of job performance are established and learning objectives are designed based on the tasks selected for training. The training settings are selected and, at this stage, tests are usually chosen based on the learning objectives.

Systematic Approach to Training, Training Program Development: The activities of both instructors and trainees are defined during the development stage of training programs. In addition, the most appropriate method/s are chosen for instruction. Training materials are selected and/or developed. The technical content of each part of the training program is reviewed by an appropriate subject matter expert. The training program is validated by trying it out on a group of trainees. Revisions are made as necessary.

Systematic Approach to Training, Training Program Implementation: Implementation involves instructors' training, trainees' selection and training delivering.

Systematic Approach to Training, Trainee Assessment: Evaluation of the trainees during the whole training period.

Systematic Approach to Training, Training Program Evaluation: Evaluation is a continuous monitoring tool throughout the entire training process. It is used to measure, control, and improve the training program. Evaluation can also be considered a final step of review, specially when a new or improved training program has been implemented. Evaluation provides information about training program areas that need improvement.

Skill: The ability to perform a job-related activity that contributes to the effective performance of a task.

Knowledge: Understanding of facts, principles, or concepts. Knowledge includes cognitive (mental) processes necessary for applying information.

Needs Analysis: A process of identifying potential or existing training needs by examining gaps between performance requirements and existing performance.

Job Analysis: The analysis process used to determine the duty areas and tasks comprising a particular job. The results are typically presented as task inventories together with associated data describing task performance (e.g. frequency of task performance, importance) and the job position.

Performance Standards: The measurable requirements for personnel performance.

Training Setting: The environment in which training is conducted and learning occurs, such as classroom, laboratory, workshop, on-the-job training, simulator.

Learning Objective: A statement that specifies measurable behaviour that a trainee should exhibit after instruction. This statement includes the conditions and standards for performance.

Job Performance Measure: Tests used to evaluate a trainee's proficiency on a specific job task.

Training Method: The method by which a trainee is provided with the means and the opportunity for achieving learning objectives, e.g. lectures, demonstrations/practices with models and mock ups, discussions, walk-throughs, self-study.

Training Materials: Written materials, audio-visual media, models and mock ups, etc.

Lesson Plan: A document that presents an overview of the purpose and an outline of the instruction covered in a lesson, including such items as the learning objectives, training methods and materials, trainee activities, and resources.

Severe Accidents: Core damage accidents.