IAEA-TECDOC-1411

Use of control room simulators for training of nuclear power plant personnel

IAEA
International Atomic Energy Agency

September 2004

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The originating Section of this publication in the IAEA was:

Nuclear Power Engineering Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

USE OF CONTROL ROOM SIMULATORS FOR TRAINING OF
NUCLEAR POWER PLANT PERSONNEL
IAEA, VIENNA, 2004
IAEA-TECDOC-1411
ISBN 92–0–110604–1
ISSN 1011–4289

Printed by the IAEA in Austria
September 2004

FOREWORD

In 1993, the IAEA published IAEA-TECDOC-685, Simulators for Training of Nuclear Power Plant Personnel, and in 1998, IAEA-TECDOC-995, Selection, Specification, Design and Use of Various Nuclear Power Plant Training Simulators. These publications, while providing some information on simulator training, focused primarily upon the characteristics of simulation devices used for training of NPP personnel. The IAEA Technical Working Group on Training and Qualification of Nuclear Power Plant Personnel recommended that an additional report be prepared that provided information on methods used for training of NPP personnel using control room simulators, including practical examples of current practices. This publication has been prepared in response to that recommendation.

Safety analysis and operational experience consistently indicate that human error is the greatest contributor to the risk of a severe accident in a nuclear power plant. Subsequent to the Three Mile Island accident, major changes were made internationally in reducing the potential for human error through improved procedures, information presentation, and training of operators. The use of full scope simulators in the training of operators is an essential element of these efforts to reduce human error. The operators today spend a large fraction of their time training and retraining on the simulator. In normal operation, the operators are not exposed to the accident environments that require the diagnosis of plant conditions, the use of operator aids like the safety parameter display system, and the use of emergency operating instructions. The ability of the simulator to closely represent the actual conditions and environment that would be experienced in a real accident is critical to the value of the training received. In cases where a full scope simulator is not available, it may be necessary for operators to receive their training with a computer simulation or to travel to another plant that has a simulator that is similar to their plant.

This publication provides information and examples based upon experience in a variety of Member States. The body of the report provides general information that represents a consensus among the individuals who contributed to the development of the report, while the annexes provide examples of specific control room simulator training approaches used in some IAEA Member States. In order to limit the size of this printed publication, only a few, relatively brief, examples are provided in the annexes; additional and more detailed examples are included on the CD-ROM that accompanies this publication.

Appreciation is expressed to all Member States for their valuable contributions and individuals who provided data on the subject. Particular thanks are due to C.R. Chapman of the Engineering Council, United Kingdom and J. Yoder of the US DOE for their editorial work. The IAEA officers responsible for this publication were T. Mazour and A. Kossilov of the Division of Nuclear Power.

CONTENTS

1. INTRODUCTION

1.1. OBJECTIVE

The objective of this report is to provide nuclear power plant (NPP) managers, training centre managers and personnel involved with control room simulator training with practical information they can use to improve the performance of their personnel.

While the emphasis in this publication is on simulator training of control room personnel using full scope simulators, information is also provided on how organizations have effectively used control room simulators for training of other NPP personnel, including simulators other than full-scope simulators.

1.2. HOW TO USE THIS PUBLICATION

This report provides information and examples based upon experience in a variety of Member States. The body of the report provides general information that represents a consensus among the individuals who contributed to the development of the publication, while the annexes provide examples of specific control room simulator training approaches used in some IAEA Member States. In order to limit the size of this printed report only a few, relatively brief, examples are provided in the annexes; additional and more detailed examples are included on the CD-ROM that accompanies this report.

The Appendix of this report offers a comprehensive directory of the Member States' examples that are included on the accompanying CD-ROM. For convenience of the reader, the Appendix is also included on the CD-ROM. The hyperlinks within this directory provide an efficient way to search the examples included on the CD-ROM.

Organizations should carefully consider implementation of the methods and ideas presented here in the context of their national and organizational cultures, status of their nuclear programme, and available training services and facilities. Where appropriate, IAEA workshops/seminars, advisory missions, and expert missions could assist in implementing such programmes.

In using this publication the reader should also be aware of other industry reports that have been developed on this topic and how they are related. Provided below is a listing of these publications and their characteristics. The principal difference between this report and the documents/reports referred to below is that this report provides specific examples of simulator training programmes and methods currently being used in IAEA Member States.

Publication/Report	Overall Publication/Report Characteristics
WANO WGP-ATL-97-001, *Guidelines for Simulator Training* (same as INPO ACAD 90-0222), 1990 [1]	Provides guidelines to assist in the development and implementation of simulator training.
IAEA-TECDOC-995, *Selection, Specification, Design and Use of Various Nuclear Power Plant Training Simulators*, 1998 [2]	Focuses primarily on the characteristics of NPP training simulators (not just full scope control room simulators). Provides general information about training using these simulators.

IAEA-TECDOC-685, *Simulators for Training of Nuclear Power Plant Personnel*, 1993 [3]	Focuses primarily on simulator hardware and software. Provides some overall information on simulator training for control room personnel.
NEA CSNI/R(97), The Role of Simulators in Operator Training, 1998 [4]	Provides summary information from an NEA survey on simulator training completed in 1997.

1.3. TERMINOLOGY

The following are terms used in this report in a specific way, but may not be familiar to all readers. Additional information regarding these terms, including examples of how they are used, is provided in Section 7.

This terminology is extracted from IAEA-TECDOC-1358, Means of Evaluating and Improving the Effectiveness of Training of Nuclear Power Plant Personnel [5].

Basic principles simulator
A simulator that illustrates general concepts, demonstrating and displaying the fundamental physical process of a plant. The main goals using of a basic principle simulator are to help trainees understand fundamental physical processes, basic operation of complex systems, and the overall operation of a plant.

Full-Scope Simulator
A simulator incorporating detailed modelling of those systems of the referenced plant with which the operator interfaces in the actual control room environment. Replica control room operating consoles are included.

Other-Than-Full-Scope Control Room Simulator (OTFSCRS)
A simulator that does not provide the same human-machine interface as does the plant to which it is referenced. The model of the plant thermo-hydraulic and neutronics characteristics may be the same as that of a full-scope control room simulator, or may be less comprehensive. Generally, for a simulator of this type, the human-machine interface is provided through computer driven displays and either touch-screens or mouse-control of on-screen buttons. These displays and controls may be similar to those of the referenced plant, or may be simplified. Examples: Analytical Simulators, Functional Simulators, Graphics Simulators and Multi-functional simulators.

Part-Task Simulator
A simulator that may incorporate detailed modelling of a referenced plant but of only some systems or portions of systems, thereby enabling a trainee to be trained specifically on only parts of a job or task.

2. TRENDS IN SIMULATOR TRAINING

2.1. HISTORICAL TRENDS/DEVELOPMENTS IN SIMULATOR TRAINING

In the 1970's, when the first computer-based control room simulators were put in service, the scope and fidelity of plant process models were severely constrained by limited computer capabilities. At the time of the Three Mile Island (TMI) accident, in 1979, there were few NPP control room simulators in operation in the worldwide nuclear industry. Those that did exist often had the following characteristics:

- their panel layouts and designs were not the same as the NPPs that they simulated;
- their thermodynamic models were not consistent with the NPPs that they simulated and the models (for PWRs) did not address two-phase flow conditions in the core, associated with accident conditions;
- they were located at vendor sites, often quite distant from the NPPs they simulated;
- for initial training, trainees generally had one or two weeks of training on a simulator as part of their training programmes;
- licensed/authorized operators might have one week per year of simulator training as part of their refresher training;
- simulator instructors often were not familiar with the operating experience of the NPPs for which they provided training;
- NPP procedures generally could not be used on these simulators, due to design differences, thus operators trained with procedures other than those at their own NPP;
- prior to authorization, control room operators' competences in responding to abnormal and emergency conditions were generally not formally assessed by either the operating organization or the nuclear safety regulator (rather, an assessment in these areas was made based upon written and/or oral examinations).

In the 1980's, detailed reviews of the lessons learned from operating experience caused a re-assessment of the adequacy of training of NPP personnel, particularly, for control room personnel. As a result of this review, operating organizations and nuclear safety regulators in a number of Member States established more stringent requirements for simulator training of control room personnel (as well as other aspects of these training programmes). Other changes were also initiated including: improved emergency operating procedures, improved display of safety parameters, greater reliance on simulator examinations in the qualification/authorization/licensing of control room personnel, and the use of the Systematic Approach to Training (SAT) as the basis for NPP personnel training programmes [6, 7].

2.2. CURRENT / EVOLVING TRENDS

The following are brief descriptions of what are considered to be the most significant current trends in simulator training for NPP personnel. Subsequent sections of this report provide more specific information, including examples, related to these trends.

2.2.1. Greater use of control room simulators

Control room personnel in virtually all countries with nuclear power plants now receive training on control room simulators for both initial and continuing training and more than 90% are being trained on plant specific simulators. New full-scope control room simulators are continuing to be built for existing plants, some for plants that don't already have a plant specific simulator and others because the existing simulators need improved models and computers in order to adequately simulate more complex accident scenarios. For example, since 1995 Germany has built 8 plant specific simulators. For new plants, a full-scope, plant specific control room simulator is now normally available even during the commissioning phase of a plant. Operations outside the control room are also often included in the scope of modeling and training programs (e.g. remote shutdown panels, emergency diesel generators). The following table contains information on the use of full-scope simulators. This data clearly shows the significant use of full-scope simulators. Note that training programs also include classroom, on the job training, and self-study.

USE OF FULL SCOPE CONTROL ROOM SIMULATORS*
U.S Statistics (1992 data): Hours of simulator operation: - 1 reactor site: 2,000 hours per year, usually on two shifts per training day - 2 reactor site: 3,500 hours per year, usually on three shifts per training day - 3 reactor site: 5,200 hours per year, on three shifts per training day - Simulator maintenance: 200– 300 hours per year - Pre-training simulator exercise validation: 300 hours per year Average use per shift: - Day shift: 45 weeks - Swing shift: 23 weeks - Midnight shift: 14 weeks Initial operator simulator training time: 20 % (10 weeks out of 52) ***Continuing operator simulator training time: 25% (2.4 weeks out of 6 per year (96 hours average))***
International Statistics (1995 data): Hours of simulator operation: - *Ranges from ~1000 hours to 24 hr, 7 day per week use. This wide range is due to the location of the simulator. If it is located at the plant site, its use is much higher than if travel to another location is necessary.* Initial operator simulator training time: - 10% to 30%. The range is influenced by the prior education and experience requirements for operators, the location of the simulator, and the availability of part task, desktop, or other types of simulators. The total length of all training varies widely. Continuing operator simulator training time: - *25 % to 50 %. At plants that need to send their operators to another country for simulator training, the training time is lower due to costs, logistics, and availability of simulators in another country. The total length of continuing training per year varies widely.*
*Sources: Institute of Nuclear Power Operations (INPO 92-007, Survey of Nuclear Training Activity in U.S. Electric Plants) and International Atomic Energy Agency (IAEA-TECDOC-1063, World Survey on Nuclear Power Plant Personnel Training)

Item 1 (CD-ROM) provides an example of recent changes in the use of control room simulators in one IAEA State.

2.2.2. More specific requirements by regulatory bodies concerning simulator training

Although national regulatory bodies have different requirements for simulators and simulator training, there are common trends in regulatory bodies establishing more specific requirements both for the simulator design and for the simulators use for the training of personnel and their licensing/authorization examinations. Because of the reduction in risk and the potential for negative training on a non-plant specific simulator, regulatory agencies generally require plant specific full scope simulators for all new nuclear power plants. For the same reasons, existing plants are continuing to develop plant specific simulators. Almost all plant sites now have at least one plant specific full-scope simulator. Training and examination on a plant specific simulator is almost always required to obtain an operator license.

Simulator training now must also consider multiple failures and include learning objectives with higher level cognitive skills and knowledge, such as analysis and synthesis. Annexes A, B, and C provide examples of these requirements in some Member States.

2.2.3. Greater emphasis on soft skills

While the technical aspects of NPPs continue to be emphasized during simulator training, increased attention in simulator training has been given to soft skills such as communications, decision making, and teamwork. Assessment methods have been developed for both independent assessment (by simulator instructors/line managers/regulators) and self-assessment by control room team members. Scenarios have been developed to include participants other than control room personnel to provide opportunities to practice soft skills with entire shift teams, and also with other organizational units, such as emergency response teams. Learning objectives have been added to simulator scenarios on higher level cognitive skills and knowledge, such as analysis and synthesis.

2.2.4. Considering simulator training as an integral part of overall training programmes for specific jobs

Through applying SAT to the process of training programme development, appropriate decisions are being made as to training settings to achieve needed learning objectives. Simulator training is used to reinforce learning objectives taught in other settings such as the classroom and vice versa. It has also been recognized that full-scope, plant-referenced control room simulators are not universally the best tool to achieve some training objectives assigned to simulator training. For example, for initial operator training, simplified, graphical simulators can be more effective in helping trainees to understand nuclear reactor and thermodynamic principles. Similarly, simulators that help operators and control room teams “see inside” the reactor vessel and steam generators have proven more effective than full-scope simulators in understanding thermo-hydraulic phenomena during accident conditions. Furthermore, analytical simulators with more robust thermodynamic models of the reactor core can provide better training tools for emergency response and engineering personnel than the more limited models used for full scope simulators. Item 2 (CD-ROM) provides an example of how one operating organization has integrated simulator training into the overall training programmes for licensed operators.

2.2.5. Better incorporation of operating experience into simulator training programmes and materials

Some of these improvements have been through better dissemination of NPP operating experience through international organizations such as WANO and the IAEA, and other regional, functional or national organizations. Other contributory factors have been closer links between trainers, operators, and operating experience analysts, more specific learning objectives, improvements in the modelling capabilities of full scope simulators and the addition of other analytical tools/simulators.

2.2.6. Use of simulators for training a variety of NPP jobs

Experience has shown that NPP control room simulators can effectively address training objectives for personnel other than control room operators, including: managers, emergency response personnel, technical support personnel, maintenance personnel, and field operators. Although instrument and control technicians, electrical and mechanical maintenance craft personnel, chemistry and health physics personnel and field operators do not perform operations from the control room, they can gain an appreciation of the impact that their work has on overall plant operation. Conversely, they can understand the impact that plant operations have on their activities. Training programmes for personnel other than control room operators have been enhanced by including demonstration training on the simulator as part of the curriculum.

2.2.7. Better methods to assess individual and group performance during simulator training

This has been achieved through a variety of means including: well designed assessment instruments, better assessment training for simulator instructors, greater involvement of operating teams in self assessment, more management participation in setting and enforcing control room standards, and more focus on indicators of simulator training effectiveness. There is certainly more work to be done in this regard, particularly with respect to the last item on measuring training effectiveness.

2.2.8. Decentralizing training facilities

In a number of countries there has been a trend to decentralize their training centers and place them at, or closer to, the plant sites. This is being done to improve the ownership and plant specific content of the training programs and avoid the logistical problems associated with sending people to other locations away from the plant site for training. France once used a highly centralized approach but has now established several training centers throughout the country that are strategically located close to plant sites. The Russian Federation also has changed from two centralized training centers to the establishment of training facilities at each plant. Even in the U.S. the Tennessee Valley Authority moved all of their simulators from one central location to the individual plant sites. Besides the problems and costs associated with logistics, most plants simply cannot afford to have their operators away from the plant for any extended period of time. This has resulted in fewer people being trained and the length of necessary training being shortened. For example, Brazil still sends their operators from Angra unit 1 to the U.S. or Spain for training on a simulator that is similar to, but not the same as, their plant. Their operators tend to spend most of their time trying to learn the differences between the simulator and their own plant as well as new operating procedures. Despite the costs of a simulator, Brazil is now in the process of procuring a plant specific full scope simulator for unit 1 (unit 2 obtained a simulator together with construction of the unit).

2.2.9. Use of other than full scope control room simulators (OTFSCRS) for NPPs that already have full scope simulators

Real time physical phenomena models can be directly linked to the FSS computer models, or use the same models running on different computers in order to help NPP control room personnel to better understand what is going on inside the loops during the scenario. This can be done as either a stand-alone training activity, or during the debriefing period following a FSS scenario.

In recent years there has been a dramatic overall improvement in the operational and safety performance of NPPs worldwide. While it is not possible to determine the extent to which improved simulator training has contributed to these improvements (because many other changes have also been made in plant operations during this time), it is clear from anecdotal evidence that improved simulator training has contributed to fewer scrams and more effective responses to abnormal plant conditions.

2.2.10. Improved operational and safety performance

In recent years there has been a significant overall improvement in the operational and safety performance of plants worldwide. While it is not possible to determine the extent to which improved simulator training has contributed to these improvements (because many other changes have also been made in plant operations during this time), it is clear from anecdotal evidence that improved simulator training has contributed to fewer unplanned shutdowns and more effective responses to abnormal plant conditions.

Today, full-scope simulators are recognized worldwide as the only realistic method to provide real time and hands-on training of operators to correctly respond to, and mitigate potential accidents. The results of safety analysis conducted in the Ukraine and The Russian Federation have identified the biggest contributor to risk to be the high probability of operator error. The principal means of reducing this probability is through training on full scope, plant specific simulators.

Full scope simulators are also universally accepted as the best tool to support the development of, and dynamically validate the correctness of symptom based emergency operating procedures and are used to validate normal operating procedures, test proposed plant modifications, conduct engineering studies, and train other plant technical support personnel. Together, the provision of full-scope simulators, safety parameter display systems, and symptom-based emergency operating procedures are three of the most important factors in the improvement of safety and overall reduction of risk.

2.3. MANAGEMENT INVOLVEMENT AND RESPONSIBILITIES

As indicated in Section 4 of the IAEA Safety Guide on Recruitment, Qualification and Training of Personnel for Nuclear Power Plants, NS-G-2.8, 2002 [6], managers of operating organizations are responsible for the training and qualification of their personnel. Simulator training, particularly for control room personnel, has been found to be essential. Line management involvement in simulator training is of primary importance to its success. Experience has shown that simulator instructors alone are generally not effective in establishing and maintaining performance standards for control room operators, particularly for teams during refresher/continuing training. It is only when the crews know that the standards being used in the simulator are indeed the standards of line managers that these levels of performance will be consistently achieved. The way that many NPPs have achieved this objective is through line managers regularly observing simulator exercises, particularly those where team performance is being assessed; and then those line managers contributing to the post-exercise critiques where both exemplary performance is acknowledged and substandard performance is identified/corrected. Other effective ways of management involvement in simulator training include:

- Plant managers contributing to the identification of simulator training needs.
- Allocating the resources for simulator training.

- Establishing of and participating in the Training Review Committees (including a review of simulator aspects).
- Facilitating the rotation mechanism of plant personnel in the development, implementation and evaluation of simulator training.

2.4. QUALITY MANAGEMENT OF SIMULATOR TRAINING

Procedures for NPP and training organizations concerned in the development, implementation and evaluation of training programmes need to be governed by, and aim at achieving, the goals of the training policy. These procedures then serve as an agreement between the plant organization and the training organization and define the training that must be provided, and its quality. One strength of an SAT-based training programme is that quality management aspects are built into the process. This strength is particularly important for nuclear safety regulators.

3. ANALYSIS, DESIGN, AND DEVELOPMENT OF TRAINING PROGRAMMES

3.1. TRAINING OBJECTIVES

Training programmes for NPP control room personnel typically consist of a combination of classroom, on the job training, simulator training, and self-study. The objectives of the training are to develop control room operations personnel with the knowledge, skills, and abilities necessary to operate the plant in a manner that is safe, reliable, and professional. The specific learning objectives and content of the initial and continuing training programme and the selection of the training setting (e.g. classroom, simulator, etc.) are determined through the systematic approach to training (SAT) in accordance with reference [7]. The use of the SAT process (analysis, design, development, implementation and evaluation) for training of NPP personnel has become an accepted nuclear industry standard. For control room operators, most operating organizations use job and task analysis (or job competency analysis) to determine the content of simulator training. This analysis identifies tasks to be included in both initial and continuing simulator training. The analysis also ensures that performance standards are developed and used for critical tasks and critical task elements (steps). Operating experience is also an important source for identifying simulator training needs. Irrespective of the methods used to analyze training needs, the involvement of subject matter experts in the analysis process is essential. In addition, many countries have specific regulations or standards that specify the types of training to be conducted on a simulator [8–13].

A simulator provides the most realistic “hands-on” tool for the training of NPP control room personnel on the manipulation of plant controls during normal operation and in particular for postulated transient and accident conditions. Numerous documents are published that contain lists of the overall goals or objectives of simulator training. [8–13]. Collectively, these goals and objectives provide emphasis on training on:

- individual components, equipment, and systems;
- normal startup, operation, and shutdown;
- response to plant transient, abnormal, and emergencies;
- plant and industry operating experience;
- re-enforcement of theory and fundamentals;
- teamwork, communications, and diagnostics.

Reference [14] provides examples of analysis methods used by Member States' operating organizations to identify training needs.

3.2. SIMULATOR TRAINING ADMINISTRATIVE PROCEDURES

The design and maintenance of a simulator and the use of the simulator for training are normally governed by separate administrative procedures. The design and maintenance procedure addresses the process for modifying, periodic testing, and maintenance of the simulator hardware and software and is addressed in Reference [3]. The administrative procedure for simulator training governs the design, development, implementation and evaluation of all training conducted on the simulator. Table 1 contains a list of the typical content of an administrative procedure for the conduct of simulator training. Annex D provides the table of contents pages for the training administrative procedures of one operating organization (the complete text of these administrative procedures are provided on the attached CD-ROM, together with other administrative procedure examples).

Table 1. Typical Content of a Simulator Training Administrative Procedure

Purpose

Scope

Instructions:

- Type of simulator training
    - demonstration
    - training
    - evaluation
    - other (e.g. JPM's, training on modifications, etc.)
- Simulator session guidelines for instructors
- Use of Plant Procedures
    - formality/conduct of operations
    - procedure usage rules
    - exceptions to plant procedures
- Conducting and evaluating training
    - instructor requirements
    - preparing for simulator training/pre-exercise briefings
    - conducting simulator training
    - post-exercise critiques
- Evaluation of training
    - individual
    - team
- Crew Composition
- Required individual control manipulations/evolutions
- Use of Evaluation Guides
- Use of simulator features

- Maintaining simulator fidelity
- Videotaping procedures

Records
Definitions
References
Appendices:

- Simulator generic training objectives
- Form for recording and tracking individual required evolutions
    - annual requirements
    - biennial requirements
- Individual evaluation standard form
- Control room team/crew evaluation standard form
- Other checklists

3.3. TRAINING PROGRAMMES AND SCHEDULES

Training programme plans or procedures are typically written for each NPP control room job position and may include separate plans or procedures for initial training programmes versus continuing (sometimes referred to as re-qualification) training programmes. These plans address the total training programme for the position and address all training settings. Table 2 contains a typical outline for an initial training programme for a reactor operator.

Table 2. Example Outline of a Training Programme Plan/Procedure

Introduction
References
Definitions
Prerequisites for Assignment
Programme Sequence, Schedule, and Cycles
Trainee Attendance
Exemptions from Training/Equivalencies
Training Settings/Course Loading
Task or Competency to Training Matrix
Programme Evaluation
Trainee Evaluations and Examinations
Instructor Qualifications
Programme Content/Course Descriptions

- Theory and Fundamentals
- Systems and Component
- Simulator training

On-Shift Participation (on the job training)

Item 13 (CD-ROM) provides an example of a training programme plan for initial and continuing training for control room operators, including simulator training. Annex E provides an example of an initial training schedule showing how classroom and simulator training are integrated into the overall training programme.

3.4. INITIAL TRAINING PROGRAMMES

Initial training programmes are established for NPP control room personnel to develop their knowledge and skills to operate the plant safety and reliably. These programmes are structured according to each individual's specific control room operating or supervisory position. The initial training usually begins with classroom training on fundamentals and theoretical training followed by training on systems, components, and plant equipment. During this training the simulator is first used to familiarize the trainee with plant instrumentation and control locations in the control room, followed by demonstrations of the operation of systems and components. Simulator training exercises then usually begin with instructor demonstrated and coached exercises that involve normal reactor startup and shutdown, and the introduction of progressively more complex malfunctions to develop the skills and confidence of the trainees. These initial training exercises emphasize the importance of the use of plant procedures and provide practice in the diagnosis, as individuals, of problems. As operators gain experience, exercises are introduced involving integrated plant operations and incorporate multiple malfunctions with emphasis on teamwork and communications to diagnose problems, and for the team to safely operate the plant and mitigate abnormal and emergency events using plant procedures and operating limits. Annex F provides the table of contents from the training plan for an initial training programme for licensed operators (the complete training plan is provided on the accompanying CD-ROM).

3.5. CONTINUING TRAINING PROGRAMMES

Continuing training programmes are established to maintain and enhance the knowledge and skills of NPP control room personnel. These programmes are structured commensurate with the specific control room assignment and are typically conducted over a two-year period. Continuing training programmes for control room personnel typically consist of preplanned classroom training, on the job training, and simulator training on a regular and continuing basis throughout the two-year period. Continuing training programmes include simulator training on topics such as:

- Training on significant plant system and component changes.
- Procedure changes.
- Plant and industry operating experience.
- Normal, abnormal and emergency operating procedures with emphasis on the use of plant systems to control and mitigate accidents.
- Emphasis on selected fundamentals (e.g. seldom used knowledge and skills that are necessary to assure safety).
- Training as needed to correct identified performance problems at the plant.
- Emphasis on prioritized event scenarios based on the results of probabilistic risk assessments (PRAs).

Table 3 contains a list of typical plant normal operations, and abnormal and emergency operating evolutions performed on a simulator. Reference [15] and Item 14 (CD-ROM) provide examples of the use of probabilistic risk assessment in prioritizing event scenarios for training.

Table 3. Typical List of Scenarios Performed on a Simulator (for a pressurized or boiling water reactor; PWR, BWR)

1. Plant or reactor startups to include a range that reactivity feedback from nuclear heat addition is noticeable and heatup rate is established.
2. Plant shutdown.
3. Manual control of steam generators or feedwater or both during startup and shutdown.
4. Boration or dilution during power operation
5. Significant (more than10 percent) power changes in manual rod control or recirculation flow.
6. Reactor power change of 10 percent or greater.
7. Loss of coolant, including --
    - Significant PWR steam generator leaks
    - Inside and outside primary containment
    - Large and small, including leak-rate determination
    - Saturated reactor coolant response (PWR).
8. Loss of instrument air (if simulated plant specific).
9. Loss of electrical power (or degraded power sources).
10. Loss of core coolant flow/natural circulation.
11. Loss of feedwater (normal and emergency).
12. Loss of service water, if required for safety.
13. Loss of decay heat removal cooling.
14. Loss of component cooling system or cooling to an individual component.
15. Loss of normal feedwater or normal feedwater system failure.
16. Loss of condenser vacuum.
17. Loss of protective system channel.
18. Mis-positioned control rod or rods (or rod drops).
19. Inability to drive control rods.
20. Conditions requiring use of emergency boration or standby liquid control system.
21. Fuel cladding failure causing high activity in reactor coolant or offgas.
22. Turbine or generator trip.
23. Malfunction of an automatic control system that affects reactivity.
24. Malfunction of reactor coolant pressure/volume control system.
25. Reactor trip.
26. Main steam line break (inside or outside containment).
27. Instrument failures (e.g. nuclear instruments)
28. Anticipated Transient with Failure to Scram (ATWS)
29. Multiple safety system failures
30. Annunciator failures during both normal and emergency evolutions

3.6. SIMULATOR EXERCISE GUIDES

Simulator exercise guides are the "lesson plans" for conducting training on a simulator. They are the documents that govern the implementation of scenarios and contain an outline of the sequence of events as well as the training objectives for the scenario. Table 4 contains a typical outline of the contents of a Simulator Exercise Guide (SEG). The SEG may also serve as the lesson plan for pre-simulator briefings, otherwise a separate lesson plan may be used.

Table 4. Typical Simulator Exercise Guide Content Outline

Title Number Code Effective date Training Programme and Course Time required Approval List (typically the developer, reviewers, training manager, and operations manager) References Initial Conditions Malfunctions Scenario Summary Description Training Goals: • Generic or general objectives • Specific learning objectives Common Student Errors Table with: • Evolution or event steps • Instructor actions, activities, and information • Expected response of each control room position • Learning objectives

Simulator exercise guides (SEGs) are used in initial training for demonstrating the operation of controls, equipment and systems as well as for training exercises. At the conclusion of training SEGs are used as an evaluation tool for individual as well as team performance. SEGs can be classified in three categories:

- Demonstration scenarios,
- Training scenarios,
- Assessment scenarios (also referred to as performance or evaluation scenarios),

Table 5 describes each of the types of scenarios and contains an outline of the key instructional and pedagogical characteristics of the different types of scenarios. Reference [1] contains a description of the types of scenarios and their use in training and evaluation. Each type of scenario is applicable to individual trainees and to crews. Each of these types of scenarios has distinct characteristics in terms of instructor roles and intervention in the scenario process, pre- and post-simulator session training, control of the scenario, trainee awareness of scenario topic, and trainee activities. These distinctions have less to do with the technical content of the scenario (in fact the technical content may be exactly the same) than they have with the role of the instructor and the pedagogical aspects of the training. While the content of the scenarios may be the same, each type of scenario requires SEG development and implementation to be considered in a different way. For example, for a demonstration scenario, the instructor may want to plan where to freeze the demonstration and ask predefined questions or discussion points during the scenario. In these cases, there need to be specific instructions in the SEG (at what point to freeze, what questions to ask, is a backtrack or replay required, etc.) to the simulator instructors. These directions may be embedded in the scenario or placed in a designated section of the SEG. The selection of a specific type of scenario is a function of the training objectives and the trainees (new or previously qualified). The differences in the scenarios, in turn, dictate different instructional strategies and instructor activities to be planned. Item 13 (CD-ROM) provides an example of an SEG. Item 14 (CD-ROM) provides an example of a simulator scenario checklist used to check the quality of an SEG.

Table 5. Instructional and Pedagogical Characteristics of Scenarios

Demonstration Scenarios are used to implement simulator training designed to demonstrate unit, system, equipment or component operations. They may be used in initial or continuing training and be used for training individuals or teams. Demonstration scenarios have the following instructional characteristics:

- *Trainees observe operation of the FSS but do not participate in the manipulation of the controls unless specifically directed by the instructor.*
- There is a high level of interaction between instructor and trainees – questions and answers (from both instructors and trainees), discussions.
- Simulator features such as freeze, replay, fast and slow times are frequently used.
- There usually is a pre-simulator training session
- Trainees are aware of the content and purpose of the scenario
- There is generally a post-simulator session used to analyze system/equipment performance and review training goals.

Training Scenarios are used to implement simulator training designed to instruct individuals and team operation and control of unit systems and equipment during normal, abnormal and emergency conditions. Training scenarios have the following instructional characteristics:

- *Trainees assume role of operators and manipulate FSS controls as necessary.*
- The high level of interaction between instructor and trainees will range from moderately high (the instructor may be asking questions even as scenario unfolds or may freeze the simulator to take time to reinforce a specific point) to almost none (the instructor just observing trainee performance) depending on point in training, experience of trainees, prior performance, etc.
- Trainees may have some control of the training session in that they may be able to ask questions of the instructor or ask to terminate the scenario if they do not understand what is happening.
- Simulator features such as freeze, replay, fast and slow times may be used but not as frequently as in a demonstration scenario (depends on factors such as point in training process and trainee performance).
- There usually is a pre-simulator training session,
- Trainee is aware of the content and purpose of the scenario,
- There is generally a post-simulator session used to analyze system/equipment performance and to critique trainee performance and review training goals.

Assessment Scenarios are used in the assessment of trainee readiness to perform specified job functions and to operate the unit and associated systems and equipment during normal, abnormal and emergency conditions. Evaluation scenarios have the following instructional characteristics:

- *Trainees assume role of operators and manipulate FSS controls.*
- There is no interaction with the instructor except when the instructor provides technical information. Trainees may have some control of the training session in that they may be able to ask questions of the instructor or ask to terminate the scenario if they do not understand what is happening.
- Simulator features such as freeze, backtrack, replay, slow times are not used. Fast time may be used to accelerate time-consuming functions depending on capability of simulator
- There is NO pre-simulator training session.
- Trainee is NOT aware of the content and purpose of the scenario.
- The post-simulator session is used for further assessment of trainees (if required), for critique of performance, and for explanation of evaluation results.

3.7. JOB PERFORMANCE MEASURES

A job performance measure (JPM) is a test used to assess the level of performance of a job incumbent or trainee on a specific task or set of related tasks, against predetermined performance standards. Reference [7] contains detailed information concerning the development and uses of JPMs. Typically they are used to assess performance on the job at the NPP or by the use of a simulator. Items x and y (CD-ROM) provide examples of simulator JPMs.

3.8. SPECIALIZED TRAINING USING A SIMULATOR

3.8.1. Accident training

Almost all current full-scope simulators are capable of simulating design basis accidents (DBA) considered in the design and licensing of an NPP. In addition, almost all current simulators are capable of simulating beyond design basis accidents (BDBA) that do not include core melting. Both of these types of events are normally addressed by the plant event based or symptom based emergency operating procedures. References [13] and [16] contain example of scenarios covering these types of events.

More recently, full-scope simulators have been used to present training related to severe accidents (core melt) within the limits of simulation capability and the ability to validate any given scenario. Many NPPs have developed Severe Accident Management Guidelines (SAMG) for the management and mitigation strategies for severe accidents. References [15] and [17] also discuss DBA, BDBA, and SAMG, their definitions, and related training. The SAMG training for control room personnel generally includes classroom training on an NPP's PRA and severe accident management guidelines. The simulator training is primarily focused on the transition from event based or symptom based emergency operating procedures to the severe accident management guidelines due to the limitation of modelling and validation. SAMG training, utilizing engineering desktop simulators, is primarily provided for the technical support centre personnel and emergency response personnel training. References [15] and [17] are examples of SAMG training.

The third type of accident training is the use of the full-scope simulator to conduct periodic emergency exercises that involve the on-site technical support centre, on-site or off-site emergency crisis or operations centres, and the local community and government organizations. Item 17 (CD-ROM) provides an example of an emergency planning exercise.

3.8.2. Training of other NPP personnel

Simulators can be effectively used to support the training of managers, field operators and other support personnel (e.g. I&C technicians, electrical maintenance, radiation protection technicians) in selected portions of simulator training, to enhance team-building, reinforce crew communications, and improve their knowledge and skills of infrequently performed tasks. As the field operators or technicians are directed to perform simulated actions, they review and discuss the task with an instructor. Included in the discussion are reasons for the task to be performed, the length of time the task will take, the location of components, precautions associated with the task, and procedures and actions that are needed to complete the assigned task. By participating in training with the main control room personnel, field operators and technicians acquire an awareness of control room operator workload and a better understanding of their own roles in operating the plant. Simulator training can also be used in management development programmes to aid in helping managers to understand their roles and responsibilities. Item 18 (CD-ROM) provides an example of a management training course that utilizes simulator training.

3.8.3. Soft skills training

IAEA publications [18–20] address the content of soft skills training on topics such as teamwork, communications, and diagnostics. While this training is normally provided in a classroom setting, it is reinforced during simulator training. Learning objectives related to soft skills are typically identified in the generic or general learning objectives of the simulator exercise guides discussed in Section 3.6. Examples of these generic learning objectives are included in references [17, 18].

3.8.4. Preparation for NPP commissioning

Commissioning of recent NPPs has highlighted the considerable value in having a full-scope, plant-referenced simulator in operation well in advance of fuel loading. Not only does this provide the capability to train control room personnel on plant operations well in advance of fuel loading, it also provides a mechanism to develop and validate plant procedures, to dry-run commissioning activities, and to develop the standards of professional behaviour to be maintained once the fuel is loaded and the plant becomes an operational NPP.

3.8.5. Preparation for modifications

Plant modifications represent significant elements in the design and implementation of simulator training. For the purposes of this publication, only those modifications are considered that affect configuration of the simulator (software and/or hardware) and that have a considerable training impact. Various situations may occur, although the following are the most frequent:

- Plant modification completed, simulator modification will follow.
- Plant modification completed, simulator modification will not be done.
- Simulator modification completed before plant modification.

All the above listed situations have a specific impact on the implementation of training. Simulator configuration may not necessarily support modification training in a timely manner. It has to be understood also that certain modifications cannot be fully implemented on the simulator until, in addition to the design data, real operational data become available.

Modification training is typically “instructor intensive” as it usually requires up-front preparation and collection of material at the time when the as-built documentation is not yet available.

The modification(s) implemented on the simulator should be incorporated in the training programme as soon as possible. For the implemented modifications it is useful in some cases that demonstrations are performed prior to running the training scenario. Modifications should be individually addressed as this allows the whole control room team to focus on the subject.

4. IMPLEMENTATION OF SIMULATOR TRAINING

4.1. PRE-EXERCISE BRIEFINGS

Briefing of the control room team is typically conducted prior to demonstration, training or assessment scenarios. Such a briefing may be conducted in the classroom or at the simulator. In most cases the simulator exercise guide is used as the lesson plan by the instructor. These briefings usually cover team member assignments, plant initial conditions and, immediately prior to the exercise, a shift handover and control board walk down by the trainees. For demonstration or training scenarios the training will also include all information about a specific scenario and any refresher training regarding theory, systems, or components needed to support the exercise.

Reference [1] contains additional information about pre-exercise briefings.

4.2. CONDUCTING SIMULATOR TRAINING

Training should be conducted using the concept of a shift team or crew. On a routine basis, trainees should be assigned to the same control room team positions as those to which they are assigned at the plant. The plant administrative procedure describing NPP operational activities should be used to define areas of responsibility of individual team members. This method of training develops the trainees' proficiency in their normal job positions, provides an understanding of the roles of others in the team, and helps to develop the ability of the team to work cohesively in diagnosing and correcting operational problems. Depending on the plant organization, other personnel (such as a shift technical advisor) should be included periodically in this training (e.g. licensed operator continuing training in the simulator). Annex G provides an example of the method used in France in conduct simulator continuing training.

The attitude and professional demeanor of trainees and instructors should reflect the professionalism expected in the main control room. Plant operating philosophy should be stressed in the areas of:

- Control room formality
- Conservative thought processes and decision making
- Procedural use
- Reactivity management
- Crew (team) roles
- Communications
- Self checking, peer checking
- Emergency plan classification and implementation
- Technical specification implementation

Periodic observations and participation in operator simulator training sessions by Operations Department managers will reinforce the importance of these practices. Consideration should be given to involve operations management as classroom lecturers for the topics related to operations standards. This will ensure that operators receive first hand information regarding formal requirements.

During simulator training, every attempt should be made to make the simulator control room feel like the NPP main control room. Simulator problems should be treated as actual plant problems, with operators filling out the correct paperwork, making the necessary calls for assistance and notification, and troubleshooting problems where appropriate.

Operators should perform normal control room duties, especially the recording of information in the appropriate official records.

Controlled copies of plant documentation (flow diagrams, operating and administrative procedures, technical specifications, etc.) should also be used when conducting simulator training in order to assure consistency between the simulator training and control room work practices.

Prior to conducting simulator training or assessment scenarios, the scenarios should first be run on the simulator to verify and validate the desired performance of the simulator. This is necessary to ensure that the instructors are familiar with the expected plant responses and the correct simulator responses so that negative training does not occur.

The number of instructors needed to conduct simulator scenarios also needs to be considered. Typically, one instructor is assigned to the simulator instruction station and one or more instructors are on the simulator control room floor. For assessment scenarios, more instructors/assessors may be used to ensure effective observation and critique of each control room job position.

4.3. POST-EXERCISE CRITIQUES/DE-BRIEFINGS

Simulator training exercises serve for providing instruction, obtaining and enhancing operational skills, and for identification of good performance and shortfalls. Post-exercise critiques and de-briefings on trainee performance are an important form of instructor-trainee interaction at the end of an exercise. Such critiques may involve different activities including discussions based on the instructor and/or team observations, requiring the trainees to re-run portions of the exercise and use the monitored parameters' function of the simulator, and examination of videotapes to review what happened during the exercise.

The critique of the exercise should accomplish the following:

- reinforce skills and knowledge gained during training
- recognize progress and good performance
- reinforce a conservative approach to reactor safety
- identify trainee and team performance weaknesses and provide guidance or training to correct these weaknesses
- correct trainee misconceptions
- review the accomplishment of position specific learning objectives
- self-evaluation of performance by the trainees
- review of the exercise
- review of questions asked during the exercise
- solicitation of trainee questions and discussion of correct answers
- identification of procedure improvements needed
- identification of plant policy clarification needed
- identification of simulator improvements needed

To facilitate an effective critique, simulator instructors should use good monitoring techniques and accurate written notes of demonstrated performance strengths and weaknesses (e.g. effective use of 3-way communications, actions that are required by procedures not being taken, or inappropriate actions initiated that are not in the procedures). During complex or rapidly developing scenarios, consideration should be given to use more than one simulator instructor/assessor to provide adequate observation of trainees' actions.

Instructors are typically involved in training on the same subject with different groups, and their observations (and feedback) may be additionally "shaped" by practices/performance of other groups that can contribute to building harmonized common good practices.

Another helpful approach is to provide a team self-critique in which the shift manager serves as a facilitator, and the trainees identify good performance and shortfalls. Potential actions to be taken, resulting from such a critique, have very high value as this supports "ownership" of the corrective actions.

Formal and objective assessment is an indispensable part of simulator training. Individual and team performance should be evaluated regularly to identify performance deficiencies and to verify that the training was effective. Assessment of the operating crew's proficiency in operating the plant in a manner consistent with the philosophy and standards established by plant management is an essential element of their initial and continuing training programmes. Trainees should be aware of the evaluation process and standards, as their participation contributes to the objectivity of assessments.

During a simulator exercise, the evaluator identifies differences between expected performance and the actual performance of the trainee. These differences should then be analyzed to identify key performance problems that should be critiqued. The evaluator may supplement the observations by questioning the trainee to determine knowledge level. During simulator exercises that evaluate trainee performance, it may be appropriate to limit interaction. This minimizes interference with trainee actions, thus avoiding compromising the evaluation.

It is important that formal assessments are based on predetermined standards and that evaluators are thoroughly familiar with such standards. Table 6 contains examples of factors that could be used to conduct a structured assessment of individual or team performance. Evaluators should receive appropriate training on the evaluation process and procedures, and should acquire the necessary observation skills. Observation skills are best developed through participation in observations with skilled evaluators.

Well prepared assessment scenarios, containing information on expected individual and crew performance are essential in order to conduct objective evaluations. All identified weaknesses and suggested corrective actions should be documented and analyzed to determine individual or generic performance trends, and thus determine areas that need emphasis in future training.

During initial operator training, a formal assessment on the simulator should be a part of the final qualification process. Periodic "progress" evaluations should be conducted by operations management and qualified evaluators throughout the initial operator training programme to identify individual and potential programme weaknesses. Any such identified weaknesses would then be remediated during a subsequent training period.

The performance of control room personnel should be evaluated regularly. The abilities of each operator and crew to cope with normal, abnormal, and emergency operations should be formally evaluated during each continuing training segment. NPP line management should be involved in this evaluation by observing crew performance during selected scenarios.

Consideration should also be given to performing evaluations at the beginning of a training week (an “as found” evaluation) for the purpose of assessing existing crew proficiency. Such an approach allows for immediate corrective actions, if necessary.

Less formal but continuing evaluations should be conducted with the operating crews during normal simulator training scenarios. Any deficiencies noted during these informal training sessions should be addressed and remediated in subsequent simulator training sessions during that segment.

Assessment results should be treated as confidential but be available to appropriate training personnel and plant management on an as needed basis.

Table 6. Example of Individual or Team Assessment Factors

Understanding and Interpretation of Annunciators and Alarms
Diagnosis of the Event and Plant Conditions/Problem Solving
Understanding Plant and System Response
Use and Compliance with Plant Procedures
Operation of Control Boards
Communications and Interaction of the Control Room Team
Demonstration of Supervisory Abilities
Use and Compliance with Plant Technical Specifications

Annexes H, I and Item 56 (CD-ROM) provide examples of individual and team assessments using control room simulators: Reference [1] provides additional information regarding simulator assessments.

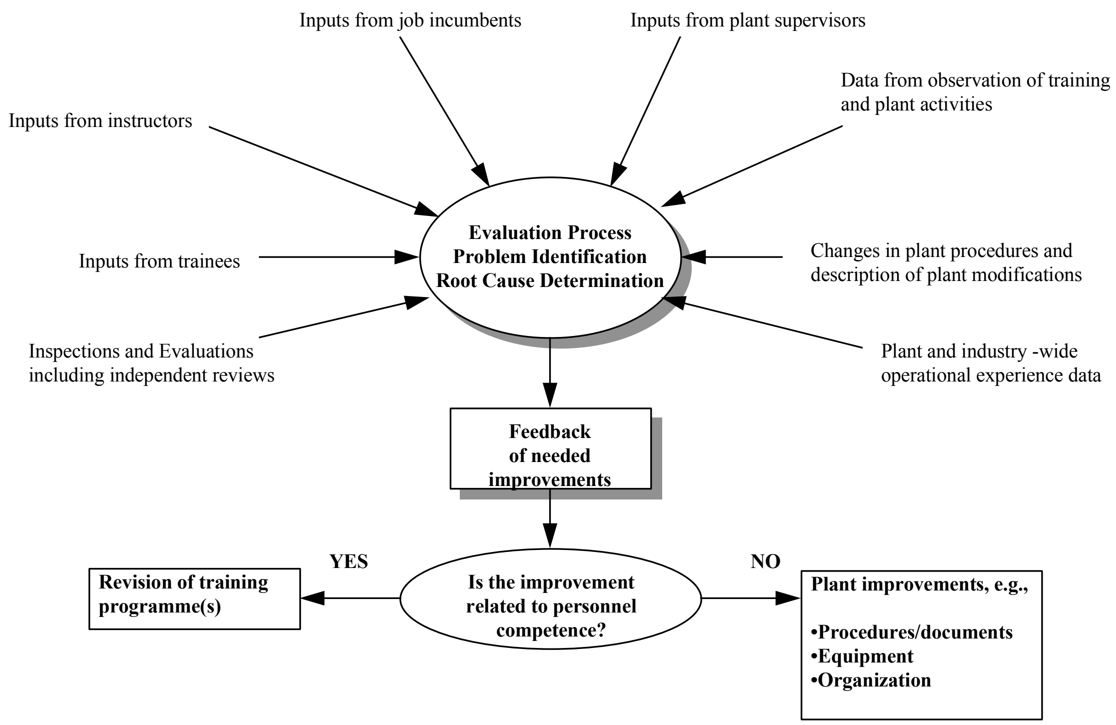

FIG. 1. Inputs and Outputs for Training Programme Evaluation.

5. EVALUATING SIMULATOR TRAINING PROGRAMMES

As indicated in Reference [7], the Evaluation Phase of SAT focuses on determining if the training was effective. As shown below, the SAT process then ensures that the results of the evaluation are fed back into the training programmes (and other areas if needed) in order to provide continuous improvement. As indicated in IAEA-TECDOC-1358, [5] training is effective if it provides significant added value to NPP operations by improved safety, quality and production.

Evaluation should be considered as an ongoing process, rather than as something that is done only at certain intervals. However, periodically, the results of the evaluation process should be assembled for a thorough review (both within the organization (internally) and externally). Examples of such external reviews include WANO peer reviews, IAEA OSART missions, and INPO training programme accreditation evaluations.

Evaluation of simulator training programmes should be integrated with overall evaluations of training programmes, rather than as a stand-alone process. In this way, the contribution of simulator training to meeting overall training programme objectives, and interactions of simulator training with other training activities will be evaluated. Lessons learned with respect to such evaluations are provided in References [5, 7, 20] and are not duplicated here. However, some particular aspects of simulator training evaluation are highlighted in the remainder of this section.

5.1. REGULAR OBSERVATION BY LINE MANAGERS

The collective performance of NPP personnel should be continually evaluated in order to identify areas for improvement. Simulator training provides a unique opportunity for NPP managers to observe performance of control room personnel in responding to infrequent, abnormal and emergency conditions, which is very important from safety, quality and production perspectives. Thus, NPP managers, particularly those responsible for control room operations, should establish schedules to periodically observe simulator training activities for all shift teams/crews. These observations should be collectively evaluated to identify overall strengths and opportunities for improvement in control room personnel performance. Similarly, this performance should be compared to performance observed in the plant control room to ensure that management expectations are being maintained in a consistent way in the simulator and control room. Simulator instructors should also participate in such evaluations.

5.2. METHODS OF EVALUATION

One of the most effective evaluation methods for simulator training is the cumulative analysis of post-training critiques/debriefs over time. Through this approach, trainee, simulator instructor and line manager observations can collectively be used to identify performance trends and issues. In order to obtain objective and factual information, it is important that this information is not used to punish individuals but rather to identify weaknesses in the system. Annex J provides an example of a training evaluation form used to solicit inputs from trainees regarding training programme improvements.

Identifying trends in performance indicators is potentially a powerful tool to indicate or predict degraded training programme effectiveness. Those indicators may also help managers to establish priorities in the scope of training programme (and other plant) improvement efforts. The principal challenge is to identify appropriate performance indicators. These indicators should be based upon and linked to the organization's current goals and objectives. Reference [21] provides several examples of performance indicators related to simulator training.

5.3. INTEGRATING TRAINING PROGRAMME IMPROVEMENTS AND OTHER PLANT IMPROVEMENTS

When a performance discrepancy/weakness is identified often the improvements identified to improve performance include both training and other plant improvements. These may include changes in procedures, responsibilities, organization, or plant equipment. In order to ensure that these improvements result in performance improvement it is important that these changes are coordinated and integrated. For example, procedure upgrades should be coordinated with training improvements to ensure that both are effectively implemented.

A good formal and informal communication system between plant departments and the training organization is important.

6. SIMULATOR INSTRUCTOR COMPETENCE

Effective simulator training depends strongly on competent simulator instructors. The following sections provide experience regarding simulator instructor selection, training and assessment.

6.1. SELECTION

It is important that simulator instructors be selected based upon a clear policy that defines human and technical competences needed for simulator instructors (e.g. oral and written communication skills, interpersonal skills, leadership potential, observation skills). After selection, appropriate training and familiarization with simulator operation should qualify simulator instructors and maintain their competence.

Consideration should be given to the importance of simulator instructor ability to evaluate soft skills. Communication, leadership, professionalism, adaptability, safety conscious focus, and problem resolution are some skills that should be evaluated during implementation of simulator training activities.

At some NPPs, rotational assignments between plant departments and the training centre, provide simulator instructors on a temporary basis for training purposes.

6.2. TRAINING

Initial training should be designed and developed to ensure that instructors possess the necessary competences to conduct training. Technical aspects related to possible operational scenarios and instructional skills should be the basis of initial training programmes of simulator instructors. The content of such a training programme will change depending on the qualification and previous experience of each candidate. Besides technical and instructional skills, skills related to other complementary aspects, such as communication, leadership and safety should be discussed and stressed in initial training programmes, of simulator instructors. Table 7 provides an outline of topics typically included in simulator instructor initial training programmes. Item 75 (CD-ROM) provides an example of a simulator instructor training programme.

Considering different designs and a variety of existing simulators, there are some areas, such as simulator controls, modelling characteristics/limitations, computer configuration, procedures, operational conditions and recording techniques that should be included in simulator instructor technical training. Additionally, on the job training should be provided for instructors who have no previous experience of plant operation.

Simulator instructor **continuing training** programmes maintain and improve competence and skills. Technical and instructional skills, together with some specific soft skills related to simulator instruction, are the basis for simulator instructor continuing training programmes. The scope of programmes should also include operational experience, design changes and any other subjects that potentially influence plant operation.

Feedback from simulator instructors should be considered as one of the main sources of information for the content of their continuing training programmes. Personnel who provide simulator training are expected to maintain routine communication with plant personnel and to participate regularly in some shift operations, in order to maintain operational expertise and familiarization with plant procedures.

Table 7. Topics Typically Included in a Simulator Instructor Training Programme

Initial Training
Role of the FSS in the NPP Personnel Training
Regulatory and utility documentation on simulators and simulator training
Familiarization with FSS: ▪ General Hardware and Software Configuration ▪ Simulation Scope and Limits ▪ Deviations from Reference Plant ▪ Use and Troubleshooting Procedures
FSS Instructor Station: ▪ Instructor Computer Interface ▪ Instructor Console ▪ Instructor Control Functions
Simulator Exercise Guides: ▪ Development ▪ Validation ▪ Correction and Modification
Simulator Use for Training: ▪ Demonstration Scenarios ▪ Training Scenarios ▪ Performance Evaluation Scenarios
Simulator Training Skills: ▪ Role of the Simulator Instructor ▪ SEG Instruction Methods ▪ Efficient Communication Principles ▪ Conflict Management ▪ Teamwork Training ▪ Guidance of and Feedback on Student Performance (coaching) ▪ Diagnostics Training ▪ Use of Simulator Training Features ▪ Student Control ▪ Observation and Evaluation Techniques, and Assessment skills ▪ Pre-exercise Briefings and Post-exercise Critiques ▪ Adult learning theory/pedagogy (specific to simulator training)

Administrative Procedures for Simulator Training
Continuing Training
FSS modifications and upgrading
Reference plant equipment and system modifications
Reference plant operating procedures modifications
Current status of FSS deviations from the reference plant and required compensation measures for the simulator training
Participation in shift operations through the rotation procedure
Modifications to the regulatory documentation
Industrial events
Instructional skills: ▪ New instructional methods ▪ Correction of performance deficiencies identified though feedback and evaluation ▪ Review of selected topics from the initial instructor training programme

6.3. SIMULATOR INSTRUCTOR ASSESSMENT

Instructor authorization/certification is achieved after initial training through the fulfillment of qualification requirements. A formal acknowledgment of instructor competence is generally provided, following established criteria that define procedures, renewal conditions and frequency of re-qualification. In some countries such formal acknowledgment takes the form of the instructor being granted an authorisation or certification or even a licence, stating the conditions of its validity.

Simulator instructor performance should be periodically assessed by both plant managers and training specialists/training managers based upon objective criteria. Feedback concerning simulator instructor performance should also be solicited from individuals who participate in simulator training, and periodically reviewed.

7. APPLICATION OF THE DIFFERENT TYPES OF SIMULATORS INCLUDING "OTHER-THAN-FULL-SCOPE CONTROL ROOM SIMULATORS" IN THE TRAINING

Experience has shown that different types of simulators, including basic principles simulators, full-scope simulators (FSS), other-than-full-scope control room simulators (OTFSCCS) and part-task simulators can be used in different ways to effectively train different groups of personnel during initial and continuing training.

FSSs include specific simulators such as main control room simulators, the emergency control room simulators and the local operation simulators.

OTFSCCS include specific simulators such as analytical simulators, compact simulators, functional simulators, graphics simulators and multi-functional simulators.

Examples of the use of different types of simulators are presented in Table 8. Included are:

- Different types of simulators.
- Main categories of personnel being trained using each type of simulator.
- Main uses or applications.
- Examples provided by the IAEA Member States relating to the types of simulators.

This table details the different types of simulators that may be used by the NPP training functions. According to the training needs and the financial aspects, some countries may use only one simulator or a number of different ones.

However, the table does not deal with the plant-referenced simulators: See the WANO document “Guidelines for Simulator Training”, 90-022, Section 9: “Development and implementation of a simulator training programme using a non plant-referenced simulator” for more information [22].

There may be some differences between the main control room at the NPP and the simulator used for training. It can be a non plant-referenced simulator or a plant-referenced simulator where the physical fidelity or the model accuracy is not so great.

The list is not intended to be all-inclusive nor definitive, but to illustrate the current state of the art of an evolving technology.

The three first examples in the table are actually of FSSs but are included for completeness.

Table 8. Examples of the use of different types of simulators [2, 24, 25]

Type of Simulator	Trainees	Application	Examples
Full-Scope Simulators			
1. Plant Replica with Main Control Room (MCR) Panels	MCR personnel, Technical Support Engineers, and Operations Management	To develop operational skills (whole plant & system interactions) in all modes (normal, abnormal, accident). To validate procedures, test modifications, and analyse incidents.	"Initial Training and Retraining of French Control Room Operators" (Ref. EDF/6608/56/NT/ PCT/221 – Poizat - May 2002), particularly the examples of FSS in Chapters 3 and 4. [France] (Item 13 on CD-ROM)
2. Emergency Control Room Simulator 3. Remote Shutdown Simulator	MCR Operators, Field Operators and Technical Support Engineers	When the MCR is unavailable: - to develop operational skills (whole plant & system interactions) in all modes (normal, abnormal, accident). - to validate procedures, test modifications, and analyse incidents.	"Initial Training and Retraining of French Control Room Operators" (Ref. EDF/6608/56/NT/ PCT/221 – Poizat - May 2002) particularly the example of the Emergency Control Room Simulator in chapter 3.3. [France] (Item 13 on CD-ROM)
Other Than Full Scope Control Room Simulators (OTFSCRS)			
Full Scope Models without MCR Panels			
4. Analytical Simulator	MCR personnel, Technical Support Engineers, Operations Management and Research Engineers	To analyze and understand plant dynamics, to develop skills, to validate procedures (if access to type 1 is not available or is not cost effective) and to increase access to type 1.	Russian practices in the development and implementation of analytical simulators. [The Russian Federation] (Item 78 on CD-ROM)
5. Plant Analyser: - for Reactor Control	MCR personnel, Technical Support Engineers, and Operations Management MCR personnel, Technical Support Engineers, Operations Management, and Regulatory Body	To study complicated plant transients or accidents in detail in order to conduct analysis. No real time simulation.	IAEA TECDOC 995 [2] – Appendix – Existing practices of using various types of simulators. [Germany]

- for Safety Relevant Systems.			See also Plant Analyser ASN at Konvoi NPP.
6. Graphical Simulator	MCR personnel, Technical Support Engineers, and Operations Management	To analyze and understand plant dynamics, to develop skills, to validate procedures, if access to type 1 is not available or is not cost effective, and to increase access to type 1.	Tecnatom paper to IAEA Specialist meeting on Training Centres for NPPs, at Connecticut. [Spain] See also IAEA TECDOC 995 [2] – Appendix – Existing Practices of Using Various Types of Simulators "Forsmark Graphical Simulator" [Sweden]
7. Compact Simulator *Full Scope Model with MCR panels*.	MCR personnel, Field Operators and Technicians (e.g. I&C Maintenance)	To develop knowledge/ understanding and individual operational skills of a specific or a part of the plant or process (normal/abnormal – not accidents)	"Systems and Technology" course examples including overview, timetable, aims and objectives and some lesson plans including SEGs. [United Kingdom] See also IAEA TECDOC 995 [2] – Appendix – Existing practices of using various types of simulators – "Compact Simulator at Paks NPP" [Hungary] See also "Result of LTFSS" - Rivne NPP – June 1999 including the example of the CORYS Compact Simulator. [Ukraine] (Item 80 on CD-ROM)

8. Multi-functional Simulator			
Compact Post Accidental Simulator	MCR personnel, Technical Support Engineers and Field Operators	To provide an understanding of physical phenomena (displays events in primary and secondary loops in real time). It complements FSS type 1 or 2.	“Initial Training and Retraining of French Control Room Operators” (Ref. EDF/6608/56/NT/ PCT/221 – Poizat - May 2002), particularly the example of SIPACT in Chapters 3.4. [France] (Item 11 on CD-ROM) See also “Information concerning the use of LTFSS” Ref. - EDF/D5110/NT/00016 – Roussel/Jaillet - February 2000. [France]
Multi-functional Simulator	MCR personnel, Technical Support Engineers, and Operations Management		IAEA TECDOC 995 [2] – Appendix – Existing practices of using various types of simulators – “WWER – 1000 Multifunctional Simulator”. [Ukraine]
9. Part-Task Simulator (for specific system or equipment). Examples: - *I&C Panels* - *Refuelling* - *Turbine Generator*	I &C Technicians, Refuelling crews, MCR personnel, Technical Support Engineers, and Operations Management	As for example 4 above but may be more specific and may be more in-depth.	IAEA TECDOC 995 [2] – Appendix – Existing practices of using various types of simulators – “Turbine part task simulator at Kursk NPP”. [The Russian Federation]
- *CVC circuits* - *Reactor control*	MCR personnel and Technical Support Engineers.	During initial training, to make it easier to understand the operation of specific circuits before being trained on a FSS type 1 or 2.	“Initial Training and Retraining of French Control Room Operators” (Ref. EDF/6608/56/NT/ PCT/221 – Poizat - May 2002), particularly the examples of Part-task Simulators (GTA, RCV, Pilotage) in Chapter 2.5. [France] (Item 11 on CD-ROM)

- *Electrical Switching Simulator*. - *Chemical simulator*	MCR personnel, Technical Support Engineers and Operational Management. - MCR operators.		See also “Result of LTFSS” - Rivne NPP – June 1999 particularly the example of Local Simulators “KLOTIK”. [Ukraine] (Item 77 on CD-ROM)

10. Basic Principles Simulator	MCR Operators and Field Operators. MCR Operators, Field Operators and Engineers. MCR personnel, Operational Management, Technical Support, and University students.	To identify the main thermohydraulic principles and physical phenomena. To provide self-study. To involve trainees in the learning process and theoretical concepts, to save valuable FSS time. To provide an overview of plant behaviour or a basic understanding of the main operating modes.	"Initial Training and Retraining of French Control Room Operators" (Ref. EDF/6608/56/NT/ PCT/221 – Poizat - May 2002), particularly the examples of MICROREP and Basic Principles simulators in Appendix 2. See also "Information concerning the use of LTFSS" Ref. EDF/D5110/NT/00016 – Roussel/Jaillet - February 2000. "US classroom simulator description". [United States] (Annex L) IAEA TECDOC 995 [2] – Appendix – Existing practices of using various types of simulators – "Magnox Electric plc. Portable Basic Principles Simulator". [United Kingdom] See also "Result of LTFSS" - Rivne NPP – June 1999 including the example of "General Principle Simulators". [Ukraine]
11. Severe Accident Simulator	MCR personnel, Technical Support Engineers, Emergency Response Teams and Accident management	To develop knowledge & understanding of physical phenomena and their impact on the plant. To perform practical emergency exercises	

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. CONCLUSIONS

Safety analysis and operational experience consistently indicate that human error is the greatest contributor to the risk of a severe accident in a nuclear power plant. Subsequent to the Three Mile Island accident, major changes were made internationally in reducing the potential for human error through improved procedures, information presentation, and training of operators. The use of full scope simulators in the training of operators is an essential element of these efforts to reduce human error. The operators today spend a large fraction of their time training and retraining on the simulator. As indicated in Section 4 of the IAEA Safety Guide on Recruitment, Qualification and Training of Personnel for Nuclear Power Plants, NS-G-2.8, 2002 [6], representative simulator facilities should be used for training of control room operators and shift supervisors. Simulator training should incorporate normal, abnormal and accident conditions. The ability of the simulator to closely represent the actual conditions and environment that would be experienced in a real situation is critical to the value of the training received.

The following general conclusions are based on the content of this publication and the examples provided by Member States.

- Line managers are involved in the identification of simulator training needs and in observing simulator exercises.
- Administrative procedures are developed for simulator training that govern the design, development, implementation, and evaluation of all training conducted on the simulator.
- Simulator training is an integral part of initial and continuing training programs for control room operating personnel.
- Simulator exercise guides that serve as the “lesson plan” for the conduct of simulator training are developed for all demonstration, training, and evaluation scenarios.
- Training is conducted using a shift team concept.
- Individual and team assessments are based on predetermined standards of performance.
- Simulator instructors are selected based on both human and technical competencies and receive initial and continuing simulator instructor training.
- Simulator training is also provided to other plant personnel such as managers, field operators, and technical support personnel.

8.2. RECOMMENDATIONS

Configuration Management. A configuration control process for simulator hardware and software should be in place to ensure that the simulator continues to replicate the operating characteristics of the nuclear power plant. A formal program should be in place to track and evaluate plant changes for applicability to the simulator; all changes to the simulator should be verified and validated.

Validation of Simulator Scenarios. All simulator exercises should be validated on the simulator before use in the training or evaluation of control room operating personnel to ensure that specified learning objectives can be achieved and the simulator performs in accordance with design.

Simulator Exercise Guides. Administrative procedures should identify the required content of simulator exercise guides. In particular, guidelines for the number of malfunctions, abnormal events, major transients, entries into emergency operating procedures and recovery procedures, and critical steps to be included in assessment scenarios should be developed.

Conduct of Simulator Training. The conduct of training on the simulator should reinforce plant management's operating philosophy and the expected attitudes and professional behavior of control room operating personnel. Therefore, operations managers should regularly observe simulator training as a means to ensure that these standards are being maintained.

New NPPs. For new NPP projects a full scope, plant referenced control room simulator should be in operation in advance of initial fuel loading. It provides an invaluable tool for improving the efficiency and effectiveness of the commissioning process, not only for training or operations personnel, but also for validation of procedures.

ABBREVIATIONS

BDBA	Beyond Design Basis Accident
BWR	Boiling Water Reactor
DBA	Design Basis Accident
FSS	Full Scope Simulator
JPM	Job Performance Measure
NPP	Nuclear Power Plant
OTFSCRS	Other-Than-Full-Scope Control Room Simulator
PRA	Probabilistic Risk Assessment
PWR	Pressurised Water Reactor
RO	Reactor Operator
SAMG	Severe Accident Management Guidelines
SAT	Systematic Approach to Training
SEG	Simulator Exercise Guide
SRO	Senior Reactor Operator

CODE ELEMENTS FOR COUNTRY NAMES

Abstracted from ISO-3166 Part 1 (1997) (see Ref [26])

BR	-	Brazil
CA	-	Canada
CN	-	China
DE	-	Germany
ES	-	Spain
FR	-	France
GB	-	United Kingdom
HU	-	Hungary
LT	-	Lithuania
IN	-	India
JP		Japan
RO		Romania
RU	-	Russian Federation
SE	-	Sweden
SK	-	Slovakia
SI	-	Slovenia
UA	-	Ukraine
US	-	United States of America

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[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Simulators for Training Nuclear Power Plant Personnel, IAEA-TECDOC-685, Vienna (1993).
[4] OECD NUCLEAR ENERGY AGENCY, Principal Working Group No. 1 – Extended Task Force on Human Factors, Task 5: Role of Simulators in Operator Training, NEA/CSNI/R(97)13/3, Issy-les-Moulineaux (1998).
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[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Power Plant Personnel Training and its Evaluation: A Guidebook, Technical Reports Series No. 380, IAEA, Vienna (1996).
[8] Title 10 United States Code of Federal Regulations, Part 55, "Operator Licenses".
[9] UKRAINE STANDARD on Simulator Training….need number, title, and date.
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ANNEX A
US SIMULATOR TRAINING RELATED REGULATIONS AND STANDARDS

Title 10 United States Code of Federal Regulations, Part 55, “Operator Licenses” contains requirements for simulators and lists of operating evolutions that can be performed on a simulator.

Nuclear Regulatory Commission Report, NUREG 1021, Operator Licensing Examination Standards for Power Reactors contains requirements for initial and requalification written and operating tests, including the operating test on the simulator. It also includes requirements for simulator scenarios and criteria for the evaluation of individual and team performance.

Nuclear Regulatory Commission Regulatory Guide 1.149, Nuclear Power Plant Simulation Facilities for use in Operator Licensing Examinations endorses the ANS Standard 3.5-1998.

American Nuclear Society Standard, ANS 3.5-1998, Nuclear Power Plant Simulators for Use in Operator Training contains requirements for the design and maintenance of full-scope control room simulators.

ANNEX B

RUSSIAN FEDERATION SIMULATOR TRAINING RELATED REGULATIONS AND STANDARDS

1. General Provisions for Insurance of Nuclear Power Plant Safety. OPB-88/97, PNAE G-01-011-97, Russian Federation Commission for Nuclear and Radiation Safety (Gosatomnadzor of Russia), valid from July 01, 1998. (Общие положения обеспечения безопасности атомных станций. ОПБ-88/97 ПНАЭ Г-01-011-97. Федеральный надзор России по ядерной и радиационной безопасности (Госатомнадзор России), введен в действие с 01 июля 1998 г.)

Excerpts:

1.2.21 The design for each NPP shall include training department (center) with psycho-physiological research subdivision, necessary training-technical infrastructure, technical training tools, and staffing for organization of qualified training process.

For the typical nuclear power units the full scope simulator must be developed and must be ready for training before the first fuel loading.

5.3.5 Technical training tools must be used for the development of practical skills for NPP operation, including different types of simulators accepted for NPP personnel training in accordance to the established procedure.

2. Licensing Procedure of Russian Federation Commission for Nuclear and Radiation Safety for NPP Personnel for the Works in the Field of Use of Nuclear Energy. RD-04-29-99. Russian Federation Commission for Nuclear and Radiation Safety (Gosatomnadzor of Russia), valid from January 01, 2001 (Положение о выдаче разрешений федерального надзора России по ядерной и радиационной безопасности на право ведения работ в области использования атомной энергии работниками атомных станций. РД-04-29-99. Федеральный надзор России по ядерной и радиационной безопасности (Госатомнадзор России), введен в действие с 01 января 2001 г.)

Excerpts:

41.10 The verification of practical skills shall be conducted at full scope simulator designed for the particular NPP unit.

If full-scope simulator for the particular NPP unit is not available the verification of control skills can be conducted with approval of Gosatomnadzor of Russia in the job environment for specified job position or on similar NPP Unit by means of discussion of examination scenarios without real actions on control means or with using of simulators for different units or different types (local, functional, dialogical, and etc.).

41.11 The procedure of the simulator application or using of the job environment for control skills verification must be approved by the corresponding regional division of Gosatomnadzor RF for each particular simulator or NPP Unit. This procedure shall be defined in the separate guideline (instruction), which shall demonstrate, that application of this particular simulator (or using of work environment) will insure the full-scope and objective verification of skills, also the measures which compensates the simulator deviation from the modes of real unit operation condition shall be provided.

3. The Rules of Work Organization with ROSENERGOATOM NPP Personnel, RD EO 0176-2000. Government Enterprise Concern “Rosenergoatom”, Minatom RF, valid from December 01, 2001 (Правила организации работы с персоналом на атомных станциях концерна «Росэнергоатом», РД ЭО 0176-2000. Государственное предприятие концерн «Росэнергоатом», Минатом РФ, введен в действие с 01 декабря 2001 г.)

Excerpts:

13.3 …Continuous training of NPP personnel shall be conducted in the NPP departments, training department, training centers, special professional centers (for workers) in the forms of periodical training courses or individual training, technical courses, periodical training on technical tools (simulators, imitators, and mockups).

14. NPP shall include training departments, which shall have equipped training classes, laboratories, workshops, and shall be provided with methodological-training documentation, training technical tools, including simulators, and shall be staffed by highly qualified teachers and instructors, experienced in the training methodology.

4. Requirements to the Technical Means for training of NPP Operation personnel. РД ЭО 0278-01, Government Enterprise Concern “Rosenergoatom”, Minatom RF, valid from June 25, 2001 (Требования к техническим средствам обучения для подготовки персонала атомной станции, РД ЭО 0278-01. Государственное предприятие концерн «Росэнергоатом», Минатом РФ, введен в действие с 25 Июня 2001 г.)

The publication defines requirements for the technical tools for NPP personnel training (full scope simulators, analytical or functional simulator, part task simulators, and CBT systems).

5. Provisions for Commissioning and Issuing a Permit for the Use of the Technical Means of Training for Nuclear Power Plant Personnel Training. RD EO 0279-01, Government Enterprise Concern “Rosenergoatom”, Minatom RF, valid from June 25, 2001 (Положение о порядке ввода в эксплуатацию и допуска к применению технических средств обучения для подготовки персонала атомной станции, РД ЭО 0279-01. Государственное предприятие концерн «Росэнергоатом», Минатом РФ, введен в действие с 25 июня 2001 г.)

The publication defines the procedures of ready for training acceptance of technical training tools for NPP personnel training.

ANNEX C
UKRAINE SIMULATOR TRAINING RELATED REGULATIONS & STANDARDS

1. Ukraine National Law for Nuclear Energy Usage and Radiation Safety.

Article 32. License Applicant shall define the requirements for the personnel qualification depending on its responsibilities …(there are no direct references to FSS).

2. Ukraine National Law for Licensing Activities in the Field of Nuclear Energy Usage.

Article 9. The personnel responsible for the direct control of NPP reactor installation shall be subjected to licensing procedure. The list of such job positions shall be approved by Ministry Council of the Government. License conditions and procedures shall be defined by governmental body responsible for the regulation of nuclear energy usage and radiation safety.

3. Licensing Requirements for Ukraine NPP Personnel Training, ND 306.210-97. Normative Document of Ukraine Main Governmental Inspection for Nuclear Safety.

Section 2.6 General requirements for training technical means.

4. Licensing Requirements for Ukraine NPP Personnel ND 306.202-95. Normative Document of Ukraine Main Governmental Inspection for Nuclear Safety.

Section 2.7.3.7 requires to use FSS for continuous training and defines list of scenarios.

5. The Rules of Work Organization with NAEK ENERGOATOM NPP Personnel, 14.09.451.18.00. (NAEK – Ukraine NPP Operating Organization).

Section 4.6 Contains requirements for the simulator training.
Section 5.4.3: For the main control room personnel the pre-emergency training sessions on the FSS and another technical means shall be included in the plan of work with personnel.

6. System for Ukraine NPP Personnel Training. National Standard GSTU-95.1.07.04.047-2000.

5.4.1.7 Simulator Training. The initial and continuous training for the specified job positions, which are responsible for direct control of NPP systems from main control room, shall be conducted using the full scope simulator of NPP unit.

7. Requirements for the Training and Methodical Materials, STP 018.022-99. Ukraine NPP Operating Organization NAEK Standard.

Section 8.2 Requirements for the structure and content of the training documentation for the simulator training (includes the list of recommended SEGs for the FSS training).

8. Typical Training Program for the Reactor Operator (VIUR) Job Position, 14.09.464.18.00.

Section 4.5 Simulator Training: contains requirements for simulator training and the recommended SEG list for FSS training.

9. The Procedure of SAT Application for NPP Personnel Training. Simulator Training Documentation Development, 14.17.14.18.00.

10. Main Requirements for Training Technical Means, STP 018.023-99
Ukraine NPP Operating Organization NAEK Standard – drafted but has not been put in force yet:
Section 4.1 Full Scope Simulators

11. Typical Guideline for the FSS Commissioning Procedure. KND-95.1.06.08.002-97.
Prepared by Ukraine Main Governmental Inspection for Nuclear Safety but had not been put in force yet by NAEK (Ukraine NPP Operating Organization).

12. Full Scope Simulators for NPP Personnel Training KND 95.1.06.08.001-97.
Prepared by Ukraine Main Governmental Inspection for Nuclear Safety but had not been put in force yet by NAEK (Ukraine NPP Operating Organization).

ANNEX D
TABLE OF CONTENTS FOR TVA'S SIMULATOR TRAINING PROCEDURES, USA

SOURCE NOTES

ANNEX E
TRAINING PLAN OUTLINE FOR KRSKO NPP LICENSED OPERATOR INITIAL TRAINING PROGRAMME, SLOVENIA

Program phase	*Topic Area*		Duration
Phase A	**Science and Engineering Fundamentals**		**~80 days**
	Theoretical topics /classroom/		
	Introduction to Nuclear Technology	6 h	
	Nuclear Physics	36 h	
	Reactor Physics	75 h	
	Radiation Protection	30 h	
	Chemistry	8 h	
	Thermodynamics	26 h	
	Design and Operational Limits	12 h	
	Hydrodynamics	7 h	
	Valves, Pumps, Turbine	9 h	
	Heat Processes in NPP	23 h	
	Electricity	35 h	
	Instrumentation and Control	26 h	
	Bases of Nuclear Safety	40 h	
	Material Science	29 h	
	Review of selected topics (scheduled)	45 h	
	Exercises /laboratory, TRIGA reactor, Basic Principle Simulator/		
	Nuclear Physics	6 h	
	Reactor Physics	20 h	
Phase B	**Plant Systems and Operation**		**~160 days**
Phase B1	Introduction to Plant Systems /classroom/		20d

Phase B2	On the job Training on the Field Operator (FO) Positions /self study of training material and plant documentation; familiarization with plant layout, systems and equipment locations; follow operations activities with operations personnel; follow-up by operations and training personnel/	70d
	FO - Primary Systems — 17 d	
	FO - Condensate System and Diesel Generator — 12 d	
	FO - Main Turbine and Steam Systems — 19 d	
	FO - External Cooling Systems — 8 d	
	FO - Electrical Equipment — 9 d	
	FO - Water Treatment Systems — 5 d	
Phase B3	Detailed Plant Systems and Operation /classroom, simulator demonstrations/	70d
	Plant Systems – 13 weeks • Classroom lessons (~81) • Simulator demonstrations – 3 to 6 hours per week • Walk-downs of Plant Systems – 2 to 4 hours per week • Self study	

Phase C	**Plant Operation Simulator Training** /classroom 4 h/day, simulator 4 h/day/		**~85 days**
	Special Introductory Topics: • Plant Design Basis Documentation • Human Performance and Reactor Operator Skills • Introduction to Procedure Usage and Standards of Operation • Work Safety	5d	
	Normal operations AOP's introduction Abnormal operations Emergency operations Abnormal & Emergency operations Rx start up certification & audit Exam preparation & Final exam	12 d 3 d 15 d 25 d 10 d 5 d 10 d	

Phase D	**On the job Training in Main Control Room** /self study of training material and plant documentation; familiarization with MCR control boards; follow operations activities with MCR personnel; follow-up by operations and training personnel/	**~70 days**
	Positions: • Reactor Operator • Balance of Plant Operator • Electrical Equipment Operator	
Final examination for RO license administered by a Panel of experts, appointed by Slovenian Nuclear Safety Administration.		**3 days**

ANNEX F
TABLE OF CONTENTS FOR A LICENSED OPERATOR INITIAL TRAINING PROGRAMME [1]

[1] Provided by the North Atlantic Energy Service Corporation, USA.

10.1.1 Classroom
10.1.2 Simulator
10.1.3 On The Job Training
10.1.4 Independent Study
10.2 Course Loading

11.0 TASK-TRAINING MATRIX

12.0 PROGRAM EVALUATION
12.1 Trainee Evaluation of Training Presentation
12.2 Training Program Effectiveness Evaluation
12.3 Training Program Content Evaluation
12.4 Training Modification

13.0 TRAINEE EVALUATION/PERFORMANCE
13.1 Program Examinations
13.1.1 Detailed Systems Phase
13.1.2 Simulator Phase Examinations
13.1.3 On The Job Training
13.2 Academic Performance Review

14.0 INSTRUCTOR QUALIFICATION/INITIAL
14.1 Participation in Instructor Training
14.2 Participation in Licensed Requalification Training

15.0 SUPPORT SERVICES/FACILITIES

16.0 PROGRAM ORGANIZATION
16.1 Program Cycle
16.2 Initial Training
16.3 Issues Clarification

17.0 PROGRAM CONTENT/COURSE DESCRIPTIONS
17.1 Detailed Systems
17.1.1 Purpose
17.1.2 Goals
17.1.3 Objectives
17.1.4 Course Schedule
17.1.5 Training Content and Structure
17.2 Simulator
17.2.1 Purpose
17.2.2 Goals
17.2.3Objectives
17.2.4 Course Schedule
17.2.5 Training Content and Structure

ANNEX G
EDF FULL SCOPE SIMULATOR RETRAINING COURSE DESCRIPTIONS[2]

The EDF Training and Development Division has developped two kinds of retraining courses in order to improve the competencies of the operation personnel. They are performed on full-scope simulator.

The first course is called «Recyclage». It is a technical retraining. During this 5 days course, the instructor observes the trainees and at the end of the course, each trainee is provided a balance sheet.

See example of Paluel Training Center «Balance sheet for simulator continuing training session». It is based on technical criterias. (Pages 2 and 3)

The second course is called «Mise en Situation» (MS). It is a soft-skills retraining. At the end of this course, each trainee is provided a balance sheet. It is based on soft-skills criterias. The main concern of this course is the self-assessment of the shift.

See example of Paluel Training Center «Real-life training weekly balance sheet». It is based on soft-skills criterias. (Pages 4 to 6).

For more information about these two retrainings, see the publication «Initial training and retraining of French control-room operators – Use of the simulators» — ref. 6608/56/NT/PCT/221 – June 2002 — Chapter 5 «Retraining scheme for French PWR operators».

[2] Provided by the EDF Training and Development Division (SFP/PCT – PZTC)

BALANCE SHEET FOR SIMULATOR CONTINUING TRAINING SESSION

SESSION n°:............ from ....to	Training Centre: PALUEL	Trainer:....................

THEMES		Class	Simulator	Strengths of Difficulties Encountered during the Scenarios
Technical Common	1 : SGTR			
Depts Topics MCP	2 : LOCA(RHR disconnected)			
(National Level)	3 : Reactivity Function (dilutions, Overcooling, Abnormal Position or over inserted Control Rods, Reactivity Monitoring)			
	1 : N I5 F			
	2 : Loss of Reactor Control System Power Supply D (Train B)			
NPP TOPICS	3 : Criticality			
(Local Level)	4 : Reactivity Accident			
TRAINER OR TEAM TOPICS	Inst / Equipe			
	Inst / Equipe			
	Inst / Equipe			

AREAS	N.O = No Observation, N.G = No Gap, G = Gap		NO	NG	G	OBSERVATIONS IN CASE OF GAPS
RIGOUR IN OPERATION	Quality of Usual Actions (analysis, organisation...)					
	Respect of Procedures Steps					
	Operational Communication exists	Formulate a message				
		Understand a message				
	Call of Supervisors (Shift Manager, Technical Supervisor)					
	Respect of Tecs Specs					
RISK ANALYSIS ON SIMULATOR ACTIONS	Diagnosis implementation (team, information means management)					
	Problem analysis (infrequent and difficult actions or actions not taken into account in procedures)					
	Decision making					
	Decided actions co-ordination					
	Verification of actions consequences					
USE OF PROCEDURES	Systematic use of operation documentation (Alarm sheets, procedures)					
	Normal Operations	Everyone's job knowledge				
		Everyone's job respect				
		Difficulties in doing their job				
	Abnormal and Emergeny	Everyone's job knowledge				

This sheet is a team sheet; one sheet will be filled by the trainer for the training session, and sent back to the NPP Experience Feedback Correspondent of the training centre . It will be used by the Technical Common Departments to feedback the training centres on generic problems . The annual balance per NPP can be used by the operation manager to determine the topics for the next year.

		Everyone’s job knowledge				
	Operations	Difficulties in doing their job				

	Classroom or Simulator	GIVEN KNOWLEDGE
PRACTICAL	Knowledge in depth of equipment	
	Improvement of physical phenomena understanding	
	Implementation of procedures training	
	Systems knowledge improvement	
EXPERIENCE	Knowledge of the Normal Operations Rules (from RCS dynamic venting to 100% of Power)	
	Improvement of the safety functions knowledge (mainly dilution problems, abnormal position or over inserted control rods, overcooling...)	

Flamanville ☐ Paluel ☐ Belleville ☐ Penly ☐ Session :

MS WEEKLY BALANCE SHEET

Area : Procedure Compliance :

Area : Methodology – Problem Solving

Area : Communication

Area: Team Building

Observations

Flamanville ☐ Paluel ☐ Belleville ☐ Penly ☐ Session :

Date :	Session Themes	

AREAS			Y	N	NA
PROCEDURES COMPLIANCE	Time between alarm and procedure in progress < 10 minutes				
	Use of SPE (Shift Supervisor Procedure) when criteria are reached				
	Independence between Shift Supervisor and STA compare to operation crew				
	Use of right procedures				
	Procedures steps respect				
	Tecs Specs respect				
METHODOLOGY PROBLEM SOLVING	Taking into account the problem and its consequences				
	Diagnosis implementation (behaviour, team, information means management)				
	Decision making				
	Strategy Choice				
	Decided actions co-ordination				
	Verification of actions consequences				
Communication	Construction du message				
	Accuracy, pertinence [message is appropriate to the addressee (vocabulary), simple, clear, structured, complete]				
	Withhold Information				
	Relay in information transmission (information goes directly to the addressee)				
	Addressee name is accurate				
	Expressing a message				
	Intonation is in accordance with the situation				
	Body language				
	Preference relationships between trainees (sympathy, antipathy)				
	Reception of a message				
	Confirmation of good message reception				
	Evaluation of the importance of the message				
	Normal Operations	Everyone's job knowledge			
		Everyone's job respect			
		Difficulties in doing their job			

TEAM BUILDING	Abnormal or Emergency Operations	Everyone's job knowledge			
		Everyone's job respect			
		Difficulties in doing their job			
	Use of other than shift operation personnel or external departments				
	Interaction between trainees				
	If yes describe the type of interaction (influence, redondancy...) :				
	Call of Supervisors (Shift Manager, TechnicalSupervisor)				

GENERAL OBSERVATIONS	

NAME : SURNAME :	Job Position:	Trainer:

	SIMULATOR SCENARIOS and PROCEDURES USED	R OP	T OP	TEC SUP	SM SPE
AYEAR: ...... CODE: ...... SESSION :	Day 1: Day 2: Day 3:				

ANNEX H
ASSESSMENT FORM FOR RO LICENSING EXAM ON FULL-SCOPE SIMULATOR[3]

LICENCING RO/FULL SCOPE SIMULATOR
Normal & Incidental & Accidental Operation

Rev. 8 2/2001

INIT: S 24	Power 100%Pn xenon at equilibrium
EXERCISE No.1	M1/ Load change from 100%Pn to 70%Pn
	M2/ Drift down GRE 23 MP (-2%)/ Drift down of gray group position RGL 9 GD/ Loss of 2 CEX pumps
	M3 / Loss of Main grid and LHP unavailable
TIME:	M1+M2+M3=3Hours
INITIAL STATUS:	
STANDARD MODE:	Power 100%Pn
POWER LEVEL:	100%Pn
PRESSURE:	155 B
T_{AVG}:	310 °C
BORON CONCENTRATION	812 PPM
XENON	3700 PCM
BURN UP	MOL
SCENARIO:	
T0	S24/ 100% Pn xenon at equilibrium
T1=t0+05MN	Ask to decrease load from 100% Pn to 70% Pn (Grid demand for 3 Hours)
T2=t0+10MN	Drift down GRE 23MP (-2%)(Ma1function analog sensors)
T3=t0+30MN(or Power stable)	Drift down of G bank position RGL 9GD (-10%) (RGL 3D) & restore
T4=t0+60MN	Loss of 2 CEX pumps (first block one already stopped than an other one)
T5=t0+95MN	Active malfunction LHP 01 start fail LHP
T6= t5+ 2MN	Loss of main grid (I 2.1) active RES 05
T7=t0+180Mn	End of the exercise

[3] Provided by Daya Bay NPP, China.

DAYA BAY **TRAINING CENTER**	**LICENSING RO** **ON FULLSCOPE SIMULATOR**			Drafted	LAMEYSE/ LI GUI FU	
				Visa		
EXERCISE NO. 1 Part 1				Approved	Xu Ping Sheng	
DATE: 2001/02				Visa		
REV: 8	NORMAL AND INCIDENTAL OPERATION			ACCIDENTAL OPERATION		
INIT: S 24	Load change from 100% to 70%Pn (Grid demand for 3h)			I2.1 -		
TIME: 3H	- Drift down gray bank position RGL 9GD			LHP unavailable		
	REACTOR OPERATOR	PTS	PTS	REACTOR OPERATOR	PTS	PTS
Technical spec	Operating region monitoring LSS	3		DEC procedure then I 2.1	2	
Alarms	R banks in maneuvering band	4		Warning STA and personnel	2	
Diagnosis	Xenon monitoring and BC control	3		Confirmation of diagnosis	2	
Procedure Utilization	Normal operating procedure application	3		Periodic monitoring(during I2.1)	2	
Operating skill	Temperature average control	4		Confirmation of automatic actions	2	
	Attention to the alarms and good actions	4		Opening of 6.6kv and 380v	2	
	Calling I&C section	2		Control of power sources	2	
	Using the good documents	3		Control of PZR level	2	
	Monitoring the main parameters during load decrease	5		Control of diesels (call maintenance)	2	
	Parameters stabilization	4		F RCP 2 using to start pump &T RIC check	3	
				Re-energized LGB by auxiliary	2	
				In I2.1 go to RRA connected (I 0)	3	
				Control of PZR parameters	2	

				Transition to intermediate shut down	2	
Supervision	TEAM WORK AND COORDINATION ABILITY	5				
Management	COMMUNICATION	10				
Communication	TAKING INTO ACCOUNT INFORMATION:AA KIT KPS	5				
	KNOWLEDGE OF CONTROL ROOM	5				
	GENERAL COMPREHENSION	10				
TOTAL		70			30	
FINAL SCORE						
TRAINEE	NAME:			Examiner1:		
				Examiner2:		
EXAM DATE	INSTRUCTORS:			Examiner3:		

DAYA BAY TRAINING CENTER	**LICENSING RO** **ON FULLSCOPE SIMULATOR**	Drafted	LAMEYSE/ LI GUI FU	
		Visa		
EXERCISE NO. 1 PART 2		Approved	Xu PingSheng	
DATE: 2001/02		Visa		

REV: 8	NORMAL AND INCIDENTAL OPERATION			ACCIDENTAL OPERATION		
INIT: S 24	- Load change from 100% to 80% Pn			I2.1		
TIME: 3H	- Drift down GRE 23MP - loss of 2 CEX pumps			LHP unavailable		
KEY POINTS	FEEDWATER OPERATOR	PTS	PTS	FEEDWATER OPERATOR	PTS	PTS
Technical spec	Micro-governor using	2		Verification the unit when operator use DEC	2	

Alarms	Secondary parameters monitoring	2		Confirmation of automatic actions	3	
Diagnosis	Turbine, feed-water, GSS/AHP/ABP controls	2		Isolation of VVP steam lines	2	
Procedure Utilization	Normal operating procedure application	2		Periodic monitoring(during I2.1)	2	
Operating skill	Temperature and gradient monitoring	2		Control of SG levels	3	
	Attention to the alarms	4		Control of T_{RIC}	3	
	Using the good documents	3		Control of TG set	3	
	Parameters stabilization and analyze with RO	4		After coordinator's decision go to RRA	3	
	Information checking (SG, RGL, GRE24MP)	2		Change over systems to train B (RRI)	2	
	Change-over to GRE 24MP (402CC)	3		Control of SG level when RCP pump start	2	
	Monitoring the main parameters	3		Control temperature gradient	3	
	Decrease the load on loss of CEX & adjust load to ≅ 60 %	4		Transition to intermediate shutdown	2	
	Calling the maintenance section	2				
Supervision	TEAM WORK AND COORDINATION ABILITY	5				
Management	COMMUNICATION	10				
Communication	TAKING INTO ACCOUNT INFORMATION:AA KIT KPS	5				
	KNOWLEDGE OF CONTROL ROOM	5				

	GENERAL COMPREHENSION	10				
TOTAL		70			30	
FINAL SCORE						
TRAINEE	NAME:			Examiner1:		
				Examiner2:		
EXAM DATE	INSTRUCTORS:			Examiner3:		

INSTRUCTOR SHEET 1

REV: 8

DATE: 09 01

DAYA BAY TRAINING CENTRE	SRO FULL SCOPE SIMULATOR EXAMINATION

INCIDENTAL & ACCIDENTAL OPERATION

TIME	3 hours
INITIAL STATUS	INIT: S 6
POWER LEVEL	100% NP
PRESSURE	155B.
TºAVERAGE	310ºC
BORON CONCENTRATION	812PPM
XENON	2800PCM
BURN UP	BOL

SIMULATOR SCENARIO FOR N°

T0	
t1=T0+05mn	ASK TO BLOCK APA BY DSS WITH WORK PERMIT
t2=T0+10mn	DECREASE THE LOAD TO 500 MW
t3=T0+15mn	
t4=T0+20mn	TRIP APP2 (when load is< 750 MW)
t5=T0+25mn	RECOVERED APA
t6=T0+30mn	
t7=T0+40mn	DISPATCHING ASK TO INCREASE TO 750MW
t8=T0+50mn	FAILURE LOW RCV 12MN
t9=T0+60mn	
t10=T0+90nm	BREAK ON PZR STEAM PHASE AT 1%
t11=T0+120mn	INCREASE THE RATE TO 10% WHEN I 3.1
t12=T0+150mn	
t13=T0+180mn	END

DAYA BAY TRAINING CENTER	*LICENSING SNPPO* **ON FULLSCOPE SIMULATOR**			Drafted	GAUCHER CHEN GUAN FU	
				Visa		
Date: 07/2001				Checked	XU PINGSHENG	Approved ZHANG MING
Rev: 8				Visa		Visa
Init: S6	**NORMAL AND INCIDENTAL OPERATION**			**ACCIDENTAL OPERATION**		
EXERCISE N° 1	LOAD DECREASING WITH APA PUMP BLOCKING, ONE APP PUMP TRIP AND RCV 012 MN FAILURE LOW			BREAK ON PZR STEAM PHASE: A 1.1.		
Time: 3h						
Key points		Pts	Pts		Pts	Pts
	STUDIES SCHEDULE OF THE SHIFT ACTIVITIES		3	DEC → I RCP 4		2
	CALL DISPATCHING TO DECREASE LOAD TO 750 MW		1	WARNING PERSONNEL		1
	DILUTION AND R BANK POSITION CONTROL		2	CALCULATING THE LEAKAGE RATE		3
	CHECK UNLOADING		2	AO USE		2
	RESTORE ALL THE DISCREPANCIES		2	WARNING PERSONNEL		1
	FOLLOW THE XENON		2	PERIODIC MONITORING		2
	SG LEVELS CONTROL (AVOID TRIP)		4	CHECK CONFIRMATION OF AUTOMATIC ACTIONS		3
	UNBLOCKING APA		2	DIAGNOSIS WITH A0 → I 3.1. → A 1.1.		3
	CALL THE DISPATCHING		1	CONFIRM EMERGENCY WITH STA		2
	CHANGE THE LOAD IN GOOD CONDITIONS		2	SI CONTROL VERIFICATION		5
	DEC ALARM SHEETS		3	COLD DOWN CONTROL		3
	IDENTIFICATIONOF RCV 12 MN FAILURE		2	SG LEVEL CONTROL		2
	MAKE ACTION QUICKLY		3	PERIODIC MONITOTING : CONTAINMENT & PTR		3

Alarms *Diagnosis* *Procedure utilization* *Operating skill*	CALL I&C STA AND DISPATCHING		1	Δ T sat - P RCP CONTROL		3
Management *General communication*	TEAM WORK AND COORDINATION ABILITY		6	TRANSITION TO CHARGING CONFIGURATION		3
	COMMUNICATION		3	TRANSITION TOWARDS FALL BACK MODE		2
	TAKING INTO ACCOUNT INFORMATIONS / AA KIT KPS		3			
	KNOWLEDGE OF CONTROL ROOM		3			
	GENERAL COMPREHENSION		5			
COORDINATOR TOTAL			**50**			**40**
Operator's ability	REACTOR OPERATOR DURING EXERCICE N°		5	FEED-WATER OPERATOR DURING EXERCICE N°		5
FINAL	**Coordinator /90 + OPE1 /5 + OPE2 /5 = /100**					
TRAINEE'S NAME				Examiner 1:		
				Examiner 2:		
Exam date:	Instructors:			Examiner 3:		

Full Scope Simulator Training Follow Up Evaluation Sheet

Name:		MODULE REFRESHER (505) OR REINFORCED MODULE 4 (509)	
Date:	GRADE:	Score	NOTE
WORKING METHODS	Information management	7	
	Priority for the actions	3	
	Choice of outside members	2	
	Decisions	5	
	Methodology of problem resolution	7	
	Confirmation of orders	3	
COMMUNICATION	Message Formulation for all actions	5	
	Information cross checking	5	
	Information taking into account	5	
MANAGEMENT OF PERSONAL BEHAVIOUR	Knowledge of every one's role	2	
	Interaction between team members	5	
	General coordination	7	
	Transmission of orders	5	
	Standing back	6	
	"STAR"	5	
TECHNICAL ASPECTS	Procedure applications	6	
	Use of all the documentation	4	
	Use of KIT KPS AA	2	
	Decision to adapt procedures	6	
	Safety function aspects	10	
FINAL SCORE		100	
INSTRUCTOR IN CHARGE			

ANNEX I

SRO SIMULATOR ASSESSMENT FORM[4]

Shift

SRO Evaluation

Customer:		**Team:**
Trainee:	**Cargo:**	
	Date:	
Instructor:		
Job position :		**Module:**
Course:		**Grade:**
Scenario:		

SRO – Simulator Evaluation Criteria

1. Understanding and Interpretation of Alarms	**Grade:**	
A) Trainee RECOGNIZES and ANSWERS alarms in accordance with their importance **1. Precision (3x0,30)** **2. Answering with minor delays (2x0,30)** **3. Trainee fails or change priorities (1x0,30)**		
B) Trainee UNDERSTANDS clearly alarms and uses the correct procedures **1. Yes(3x0,35)** **2. Minor mistakes and delays (2x0,35)** **3. Trainee hardly do it (1x0,35)**		
C) Trainee check the relationship between alarms and plant conditions **1. Yes(3x0,35)** **2. Minor mistakes with no significant consequences (2x0,35)** **3. Checking is not well performed (1x0,35)**		

[4] Provided by Angra NPP, Brazil.

2. Event Diagnosis	Grade:	
A)Trainee RECOGNIZES abnormal conditions 1. Fast and accurately (3x0,25) 2. Some delays (2x0,25) 3. Lack of precision (1x0,25)		
B) Trainee takes precise and complete data from the panels 1. Yes (3x0,25) 2. Minor mistakes (2x0,25) 3. Incorrect use of relevant information (1x0,25)		
C) DIAGNOSIS of plant conditions 1. Correct diagnosis (3x0,25) 2. Minor mistakes or difficulties(2x0,25) 3. relevant mistakes(1x0,25)		
D)Shift personnel reacts promptly and correctly to abnormal situations 1. Yes(3x0,25) 2. Minor mistakes(2x0,25) 3. relevant mistakes(1x0,25)		

3. Understanding of plant behavior	Grade:	
A) Trainee UNDERSTANDS indicators 1 Yes (3x0,35) 2. Minor mistakes(2x0,35) 3.Relevant mistakes, delays (1x0,35)		
B)Trainee is CONCENTRATED on panel indications 1. He checks indications periodically and anticipates changes in plant conditions (3x0,20) 2. He checks indications but does not anticipate changes (2x0,20) 3. He does not check indications properly(1x0,20)		
C)Trainee demonstrates, through actions, that he understands the interaction between plant systems, reference values, interlocks, and automatic actions 1. Yes(3x0,45) 2. Minor mistakes (2x0,45) 3. Mistakes related to lack of understanding(1x0,45)		

4. Use of procedures	Grade:	
A)Trainee selects correctly the adequate procedures and follows steps adequately 1. Yes(3x0,25) 2. minor mistakes(2x0,25) 3. Relevant mistakes(1x0,25)		
B)Trainee uses procedures correctly, follows sequence of steps and makes appropriate decisions 1. Yes(3x0,50) 2. Minor mistakes(2x0,50) 3. Relevant mistakes leading to risk for plant operation(1x0,50)		
C)Trainee follows effectively procedure implementation 1. He keeps shift personnel informed of the fulfillment of procedures(3x0,25) 2. Shift personnel should ask him questions to get information (2x0,25) 3. He reads procedures just for himself(1x0,25)		

5. Operation and Monitoring of control room panels	Grade:	
A)TRAINEE LOCALIZE CONTROLS PRECISELY 1. Yes(3x0,50) 2. Minor mistakes(2x0,50) 3. He needs assistance to do it(1x0,25)		
B)Trainee operates controls rightly 1. He does it consistently(3x0,25) 2. Minor mistakes with no relevant consequences(2x0,25) 3. Mistakes causing relevant system effects(1x0,25)		
C)Trainee answers correctly instrumentation readings 1. Yes(3x0,50) 2. Minor mistakes(2x0,50) 3. Relevant mistakes(1x0,25)		
D)Trainee changes from automatic to manual operation when necessary 1. Yes(3x0,25) 2. Some delays(2x0,25) 3.He hardly does it properly (1x0,25)		

6. Communications	Grade:	
A)Trainee communicates clearly with shift personnel 1. Clear and easy to understand(3x0,45) 2. Confusing and difficult to understand, sometimes(2x0,45) 3. Bad communication abilities(1x0,45)		
B)Trainee keeps technical personnel informed about plant status 1. Yes(3x0,35) 2. He needs assistance in some situations(2x0,35) 3. He does not do it properly (1x0,35)		
C) Trainee always check if shift personnel understands what he says 1. Yes(3x0,20) 2. Not always(2x0,20) 3. He is not concerned about shift personnel understanding (1x0,20)		

7. Direction of Shift Operations	Grade:	
A) Trainee make decisions in time 1. Yes(3x0,20) 2. Sometimes (2 X 0,20) 3. Seldom (1x0,20)		
B)Trainee gives direct, correct and fast instructions to shift personnel and shows high commitment with safety culture 1. Yes(3x0,40) 2. Sometimes(2x0,40) 3. Shift personnel often question his instructions(1x0,40)		
C) Trainee is concentrated in plant operation and gives appropriate instructions to shift personnel 1. Yes(3x0,20) 2. Most of the time(2x0,20) 3. He does not keep total control of plant operation (1x0,20)		
D) Trainee asks for feedback from shift personnel 1. He keeps shift personnel involved with the decision making process(3x0,20) 2. Not always (2x0,20) 3. (1x0,20)		

8. Use and fulfillment of Tech. Specs.	**Grade:**	
A) Trainee knows ever if plant conditions are within the limits of Tech. Specs. **1. Yes(3x0,40)** **2. Minor mistakes (2x0,40)** **3. Significant mistakes (1x0,40)**		
B) Trainee uses Tech Specs. correctly **1. Yes(3x0,20)** **2. He demonstrates some minor difficulties(2x0,20)** **3. Hardly(1x0,20)**		
C) Trainee follows Tech Specs strictly **1. Yes(3x0,40)** **2. He always need some help from shift crew(2x0,40)** **3. Mistakes leading to violations sometimes (1x0,40)**		

ANNEX J
ANGRA NPP TRAINING PROGRAMME EVALUATION PROFILE, BRAZIL

Period:	No of Participants: No of Evaluations	Training Location:

The chart below represents the average grades established by trainees for each question of the Training Evaluation Form.

PLOTTING OF RESULTS *PARTICIPANTS OPINION*	WEEK		UNSUFFICIENT		REGULAR		GOOD		EXCELENT	
	0 1		2 3		4 5		6 7		8 9 10	
1 - TRAINING ORGANIZATION AND COURSE CONTENT	0 1 2 3 4 5 6 7 8 9 10									
2 - TRAINING ADEQUACY RELATED TO YOUR ACTIVITY	0 1 2 3 4 5 6 7 8 9 10									
3 - TIME PERIOD ESTABLISHED FOR TEACHING SUBJECTS	0 1 2 3 4 5 6 7 8 9 10									
4 - TIME PERIOD ESTABLISHED FOR TEACHING SUBJECTS	0 1 2 3 4 5 6 7 8 9 10									
5 - USE OF MATERIAL RESOURCES (audiovisual, documenation, etc...)	0 1 2 3 4 5 6 7 8 9 10									
6 - AVAILABLE FACILITIES (classroom, chair, blackboard, temperature, light, etc...)	0 1 2 3 4 5 6 7 8 9 10									
7- DIFFICULTY DEGREE, SPEACH READABLITY, AND TIME AVAILABILITY TO SOLVE WRITTEN EXAMINATION QUESTIONS	0 1 2 3 4 5 6 7 8 9 10									
8 - PERFORMANCE OF TECHNICAL COORDINATION OF COURSE	0 1 2 3 4 5 6 7 8 9 10									
9 - PERFORMANCE OF ADMINISTRATING COORDINATION OF COURSE	0 1 2 3 4 5 6 7 8 9 10									
10 - INSTRUCTOR EFFICIENCY (knowledge of given subject, easyness and sharpness of presentation, sequence of subjects, clarifying of doubts	0 1 2 3 4 5 6 7 8 9 10									

Date:	Technical Coordinator of	Training Management

ANNEX K
RUSSIAN PRACTICES IN THE DEVELOPMENT AND IMPLEMENTATION OF ANALYTICAL SIMULATORS

As it is shown in Attachment there are 10 Analytical Simulators (AS) in Russia, which are used for NPP and regulatory personnel training. Attachment # 1 includes only AS with NPP full scope models and admitted for use (licensed) by Russian “Gosatomnadzor”. There are additional part-task functional or analytical simulators and compact simulators that have been developed over previous years, some of them are still in use for some special local training tasks.

In general, Russia develops an approach based on the implementing of FSS as main training tools for operator’s training. AS shall serve as means for extending use of full-scope models, developed for FSS, for the following purposes:

- Operator’s initial training;
- Operator’s individual training;
- Engineering support and regulatory personnel training;
- Engineering tasks for NPP operation support (operating procedures development and modifications, NPP equipment and control system modifications, abnormal/emergency event analysis, and etc).

For these applications AS has substantial advantages over FSS because it allows to avoid the substantial expenses related to FSS operation and also problems with FSS availability from operator’s crew training. AS also presents wide spectrum of capabilities to demonstrate the physical processes in the NPP equipment. Expenses related to the development of AS based on the FSS model are limited only by graphic control-information interface development, which will replace MCR panels and consoles with associated I&C.

Nevertheless, at some Russian NPPs AS are being used as a main training tool for operator training:

- Bilibino NPP with EGP-6 reactors, located on the arctic north – the price of the facility for FSS is very high and units are close to being taken out of operation.
- Novovoronezh NPP – for units 3&4 (oldest WWER-440), because of age of units and considering the availability of old FSS with limited simulation capabilities.
- Kola NPP for unit 1&2 (WWER-440, V-230) – due to the age of units and availability of FSS for Units 3&4 (WWER-440, V-213).
- Beloyarsk NPP with BN-600 reactor, which is unique.

So, the main reasons for deviation from FSS concept, for above mentioned sites, are financial constrains in combination with NPP age. The above mentioned AS are using the simulation scope which is very close to FSS and proved its efficiency for operator’s training with a combination of OJT at real MCR. Need also to consider that these old NPPs already had experienced personnel in place with extensive knowledge and skills for work at MCR, and AS were mainly intended to close the gap for training in operating at transient and emergency conditions.

Attachment

Status of simulator use for Russian NPP operators training.

Enterprise	Type of Simulator	Year of commis-sioning
Balakovo NPP	FSS VVER-1000 (V-320) AT VVER-1000 (V-320) Shutdown Control Room for FSS	1993 1999 1999
Kalinin NPP	FSS VVER-1000 (V-320) FSS VVER-1000 (V-338)	2001** 2003
Kola NPP	FSS VVER-440 (V-213) MFT VVER-440 (V-230)	2000 1998
Novovoronezh NPP	AT VVER -440 (V-179) AT VVER -1000 (V-187)	1998 1990*
Novovoronezh Training Center	FSS VVER-440 (V-230) FSS VVER -1000 (V-187) FSS VVER-1000 (V-320) MFT VVER-440 (V-179)	1979* 1990* 1996 1999
Smolensk NPP	FSS RBMK-1000	1999
Smolensk Training Center	FSS RBMK-1000	1991*
Kursk NPP	FSS RBMK-1000 AT RBMK-1000	1998 1997
Leningrad NPP	FSS RBMK-1000 FSS RBMK-1000	1999 2003
Bilibino NPP	AT EGP-6	2002
Beloyarsk NPP	AT BN-600	2002
Gosatomnadzor (Russian Nuclear Regulatory Body)	AT VVER-1000 AT RBMK-1000 AT VVER -440	1998 1999 2000
Rostov (Volgodonsk) NPP	AT VVER -1000 FSS VVER-1000	2001 2004

FSS - Full Scope Simulator;
AT - Analytical Simulator;
MFT - Multi Functional Simulator;
*) - old type of simulators with limited scope of simulation
**) - planned simulator modernization in 2004 due to NPP control room modernization

ANNEX L
USA NPP CLASSROOM SIMULATOR EXAMPLE

A large, computer driven, touch screen projection video system is used to display integrated system operation in classroom training. The video system is used to display plant parameters during transient conditions and provide student interaction with graphics replicating main control board instruments and switches. The classroom simulator uses the full-scope simulator model so that full fidelity is maintained. When running scenarios students can touch the screen to “manipulate” control switches. In addition, a full 360 degree photo of the control room is available and by touching the screen, individual panels and components can be “zoomed in” for detailed viewing. Transient studies are enhanced by a feature that allows the instructor to assign parameters to up to four graphing pens. Students then take an electronic marker and draw their prediction of how these parameters will change once the transient begins on the screen. The instructor then starts the simulated plant transient and the actual plots are drawn by the classroom simulator and then compared with the students predications. This training actively involves the students in the learning process, theoretical concepts are reinforced, and valuable FSS time is saved. The classroom simulator is also used for training on industry operating experience to provide a clear understanding of the sequence of events and system response.(Source: D.C. Cook NPP)

ANNEX M
CONTENTS OF THE ACCOMPANYING CD-ROM
DOCUMENTS & PROCEDURES PROVIDED BY MEMBER STATES

No	Country	Title	Description	Reference Chapter
1	HU	Simulator Training of NPP Personnel	Article on experience of PAKS NPP	2
2	CN	Simulator Licensing Training for Daya Bay NPP	Article on simulator licensing training courses; includes methods for staff to obtain RO and SRO licenses [Daya Bay NPP]	2
3	DE	Training of Nuclear Power Plant Personnel in the German Simulator Centre	Article on simulator training provided at Essen Training Center	2
4	RU	Russia's experience in BDBA training	Brief description, including list of topics	2
5	UA	Full Scope Simulators for Training of Personnel for NPPs with WWER reactors.	Ukrainian National Standard KHD 95.1.06.08.001-97 (in Russian)	2
6	UA	Licensing Requirements for Ukraine NPP Personnel Training.	Ukrainian National Standard HD 306.210-97 (in Russian)	2
7	UA	Licensing Requirements for Ukrainian NPP Personnel	Ukrainian National Standard HD 306.202-95 (in Russian)	2
8	LT	Response to the IAEA request for data for this TECDOC	IAEA Questionnaire with Ignalina NPP responses (in English and Russian)	2
9	JP	Introduction of Japan Electric Association Guide 4802-2002 [Guideline for the Operator Training]	Viewgraphs on Guideline for the Operator Training [BWR Operator Training Center Corp.]	2
10	JP	BTC Training Courses	Viewgraphs on BTC Training Courses [BWR Operator Training Center Corp.]	2, 3
11	IN	Full Scope Simulator Training: India	Detail on practices used to conduct simulator training	2, 3, 4
12	US	TVA Nuclear Training Procedure: Conduct of Simulator Training	Detailed procedure for conducting simulator training [Tennessee Valley Authority]	3

13	FR	Initial Training and Retraining of French Control Room Operators	Detail of training schemes using for a 900 MW PWR	3
14	USA	Incorporating PRA into Training	Example Showing How PRA Information is Used to Prioritize Simulator Training [Prairie Island Training Center]	3
15	SI	Simulator Training Exercise Guide	SEG: used on a course for Licensed Operator Continuing Training [NPP Krsko]	3
16	US	Simulator Scenario Review Checklist	Excerpt from the US NRC Inspection Procedure 711111, USA	3
17	US	Job Performance Measure AOP-3B-1	Example of Simulator JPM: Reactor Coolant System [Calvert Clifts]	3
18	US	Combined Functional Drill	Example Emergency Planning Exercise Using a CR Simulator	3
19	SI	Training Plan Outline for Licensed Operator Initial Training Programme	List of topics for an initial training programme [Krsko NPP]	3
20	US	Licensed Operator Initial Training (LOIT) Program Description 2002–2003	Detail of a training programme, including sections on simulator training [North Atlantic Energy Service Corporation]	3
21	US	Preparing Initial Operating Tests [ES-301]	Procedure for developing operating tests using simulators [abstract from NUREG-1021]	3
22	BR	Compact Introductory Course to Simulator (for Managers) [A110]	Course for managers on requalification for emergency tasks; includes use of a simulator [Trillo NPP]	3
23	IAEA	Full Scope Simulator Scenarios Development	Generic SAT Procedures (IAEA TC Project SLR/0/003), 1998	3
24	DE	Emergency Exercises assisted by Simulators	Article on advantages of using simulators in emergency exercises [GRS]	3
25	CN	Course Progress Chart	Curriculum and objectives of a 2-week simulator training course	3

			[Daya Bay NPP]	
26	UA	Training Methodology Support for Full-Scope Simulator	Detailed statement that procedures, training materials and topics should be developed for use in FSS training [ENERGOATOM]	3
27	DE	Overview of Simulator Training in Germany	32 viewgraphs detailing simulator training with examples of courses and assessment materials [KSG/GfS]	3
28	US	Seabrook Nuclear Training Group Instruction	Simulator Training Procedures	2, 3, 4, 5
29	SI	NPP Krsko – 2 year Licensed Operator retraining plan	List of Classroom and Simulator Topics [Krsko NPP]	3
30	UA	Положение о лицензировании персонала ОП ЗАЭС, ОО.ЭП.ПЛ.04	Guidelines for Licensing of personnel at Zap NPP (in Russian)	3
31	UA	Методическое пособие по разработке учебно-тренировочных занятий на полномасштабном тренажере	SEG: development of training scenarios for Zaparozhe NPP FSS (in Russian)	3
32	UA	Положение о порядке подготовки и поддержания квалификации оперативного персонала Запорожской АЭС в учебно-тренировочном центре	General Requirements for Operating Personnel Initial and Continuing Training at ZNPP Training Center. [Zaparozhe NPP] (in Russian)	3
33	SI	Simulator Training Exercise Guide	SEG: scenario of a main steam line break and steam generator tube rupture after reactor trip [Krsko NPP]	3
34	ES	Experiencia de entrenamiento en Factores Humanos del personal de Operación con Licencia utilizando el Simulador de Alcance Total	Experience of soft skills training for operating personnel using a FSS [Tecnatom] (in Spanish with brief English summary)	3
35	US	2002 Licensed Operator Requalification Training Program Schedule	Training schedule [Seabrook NPP]	3

36	US	Three Mile Island Licensed Operator Requalification Training Schedule	Training schedule [Three Mile Island NPP]	3
37	US	Three Mile Island LORT Five Year Plan	5-year training plan [Three Mile Island NPP]	3
38	US	Three Mile Island SRO Group 21 Training Schedule	Training Schedule [Three Mile Island NPP]	3
39	US	Licensed Operator Training – Team and Diagnostic Training	Lesson plan for 3-day course	3
40	US	Shift Supervisor Initial Training Program – Recognition of Human Performance Problems And Contributing Factors	Sample programme	3
41	US	Shift Supervisor Initial Training Program – SLM06T Shift Team Management	Sample programme	3
42	US	Licensed Operator Training – Supervisory Skills	Lesson Plan for 3 day course	3
43	US	Annual Licensed Requal Schedule 2001, Program Year 1	Sample schedule [Susquehanna NPP]	3
44	US	Annual Licensed Operator Requal Schedule 2002, Program Year 2	Sample schedule [Susquehanna NPP]	3
45	LT	Сценарий учебно-тренажерного занятия «Снижение частоты в энергосистеме и останов обоих блоков ИАЭС»	SEG: Grid Frequency Decreasing and Shutdown of Both Units [Ignalina NPP] (in Russian)	3
46	LT	Сценарий тренажерного занятия «Течь ТК в пределах РП»	SEG: Fuel Channel Leak within RP [Ignalina NPP] (in Russian)	3
47	UA	Руководство инструктора по проведению учебно-тренировочного занятия КУРС «Режимы нарушения условий нормальной эксплуатации» ТЕМА «Отказ системы	SEG: Neutron Flux Measurement System Failure [Zaporozhe NPP] (in Russian)	3

		ядерных измерений» ЗАНЯТИЕ "Отказы аппаратуры контроля нейтронного потока"		
48	UA	Учебно-методическое обеспечение ПМТ Противоаварийная тренировка Тема: Ложная посадка пневмоарматуры	SEG: False Closing of Air Operated Valve [Zaporozhe NPP] (in Russian)	3
49	IAEA	Implementation and Evaluation of Full Scope Simulator Training	Generic SAT Procedures (IAEA TC Project SLR/0/003), 1998	4,5
50	CN	Instructor Sheet. Licensing RO/Full Scope Simulator	Assessment forms for RO and SRO licensing exam on full-scope simulator [Daya Bay NPP]	4
51	CN	Full Scope Simulator Training Follow Up Evaluation Sheet	Evaluation form [Daya Bay NPP] (in English and Chinese)	4
52	GB	Conduct of Training – Simulator	Procedure for conducting simulator training [British Energy]	4
53	FR	Weekly Balance Sheet Collected Data for MS Session	Simulator: soft skills (communication, team building etc) evaluation form [EDF]	4
54	FR	Balance Sheet For Simulator Continuing Training Session	Simulator: technical skills evaluation form [Paluel NPP]	4
55	BR	SRO Evaluation	SRO simulator assessment form [Angra NPP]	4
56	US	Dynamic Simulator Requalification Examinations [ES-604]	Abstract from NUREG-1021, USA	4
57	CN	The Organization and Performance of MS-TERRAIN Training Course	Outline of course to improve Main Control Room operators’ communication skills and field operators’ responses using the NPP and a simulated control room [Daya Bay NPP]	4

58	HU	Evaluation of simulator training – the status in Hungary	Brief account of FSS usage at Paks NPP	4
59	GB	Conduct of Simulator Assessments	Procedure with assessment guides and record forms [British Energy]	4
60	CA	Simulator-Based Assessment of Authorized Staff	Detailed procedure for planning and implementing simulator-based assessments [Ontario Power Generation]	4
61	BR	Angra 2 Plant Courses Trainee Individual Report	Simulator performance evaluation form [Angra NPP]	4
62	ES	Manual de Usario Sistema Automático de Evaluación de Alumnos en Simulador (SADEAS)	Description of computerized assessment system of performance on a simulator by trainee Ros and SROs [Tecnatom] (in Spanish, brief summary in English)	4
63	ES	Evaluation Form – Simulator	Feedback form used to evaluate a simulator training session [Tecnatom]	4
64	US	2002 Operations Combined Training Schedule	Sample schedule	4
65	US	Cycle 02-01 Shift A Requal Schedule	Sample weekly schedule [Susquehanna NPP]	4
66	LT	Программа поддержания квалификации персонала БЩУ с 2001 10 08 по 2002 03 29	Continuing training programme for Control Room Personnel (in Russian) [Ignalina NPP]	4
67	UA	Индивидуальная программа подготовки на должность ВИУР	Self-study training programme for Reactor Operator (in Russian) [Zaporozhe NPP]	4
68	SE	Using full scale Simulator in Human performance training	Short article on using a FSS to reduce human errors, emphasizing communications [Forsmark NPP]	4
69	DE	Assessment of NPP-Personnel in Simulator Training	Short article on assessment methodology at Essen [KSG/GfS]	4

70	JP	Performance Evaluation for Operations Shift Teams	Viewgraphs on Performance Evaluation for Operations Shift Teams [BWR Operator Training Center Corp.]	4, 5
71	BR	Training Evaluation Average Profile [by] Trainees	Training course evaluation form [Electronuclear]	5
72	BR	Training Evaluation by Trainee	Course feedback form [Electronuclear]	5
73	LT	Оценка качества поддержания квалификации персонала БЩУ	Evaluation form for Control Room Personnel Continuing Training (in Russian) [Ignalina NPP]	5
74	Roma nia	Individual Performance Evaluation	Sample Individual Performance Evaluation – Test for Shift Supervisor Candidate [Chernavoda NPP]	5
75	RU	Russian Experience in Simulator Instructor Training.	Article on Russian experience of initial and continuing training of simulator instructors, including competences and curricula	6
76	UA	Положение по поддержанию квалификации инструкторского персонала. 00.УЦ.ПЛ.06А	Guideline for Instructor Continuing Training (in Russian) [Zaparozhe NPP]	6
77	ES	Guide to the Preparation of Training Materials for Use with Simulators	17 viewgraphs on preparing an instructor's guide and developing a simulator training session [Tecnatom]	6
78	RU	Russian practices in the development and implementation of Analytical Simulators	Brief overview of simulator use for Russian NPP operator training	7
79	FR	Information Concerning the use of Less Than Full-Scope Simulators	Article on various LTFSSs in use [Bugey NPP]	7
80	UA	Results of Less Than Full Scope Simulator Survey	Materials of the Seminar on Less Than Full-Scope Simulators held 20-22 June 1999 at Rivne NPP, Ukraine	7
81	ES	Prácticas en simulador gráfico interactivo	SEG for use on Interactive Graphic Simulator (IGS) course,	7

		tecnología de c.n. asco	describing plant systems (in Spanish, summary in English) [Tecnatom]	
82	LT	Использование тренажеров, отличных от полномасштабного, в подготовке персонала БЩУ	The use of OTFSS for Control Room Personnel Training (in Russian) [Ignalina NPP]	7
83	ES	Use of a full scope (replica) simulator availability study and a use of an interactive graphic simulator (SGI) availability study	Two surveys of training identifying activities, hours and remarks [Tecnatom]	7
84	FR	EVEREST: WWER-440 extended scope multifunctional simulators	Brief description of EVEREST simulators supplied to Bulgaria, Czech Republic, the Russian Federation, Slovakia and Ukraine [Corys T.E.S.S.]	7
85	NEA	Role of Simulators in Operator Training	OECD/NEA Survey prepared by the Principal Working Group No. 1 –Extended Task Force on Human Factors, NEA/CSNI/R(97)13	7
86	GB	Less than Full Scope Simulators	Paper on the use of Less than Full Scope Simulators [British Energy]	7

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Technical Meetings

Vienna, Austria: 9–11 October 2001; 3–7 June 2002