EXECUTIVE SUMMARY
OF THE GUIDEBOOK ON TRAINING
TO ESTABLISH AND MAINTAIN
THE QUALIFICATION AND COMPETENCE OF
NUCLEAR POWER PLANT OPERATIONS PERSONNEL

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1989
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EXECUTIVE SUMMARY
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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 1989
FOREWORD

Since the IAEA published its Guidebook on the Qualification of Nuclear Power Plant Operations Personnel in 1984 (Technical Reports Series No. 242) there have been important developments in the approach to training adopted by many operating organizations in different countries. It is now accepted that to develop training programmes on the basis of experience alone is inappropriate for the nuclear power industry and a systematic approach to training is necessary. It has been recognized that the development and implementation of initial and continuing training programmes must be reviewed. The Guidebook described here proposes an approach which is comprehensive and systematic in its methodology and cost effective in its implementation.
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IMPORTANCE OF TRAINING FOR NUCLEAR POWER PLANT SAFETY AND RELIABILITY

There is worldwide interest in improving the safety and reliability of nuclear power plants — aims, which to a high degree depend on the competence of the plant personnel. To maintain and enhance the qualifications and competence of nuclear power plant operations personnel, it is essential that they acquire and maintain fundamental knowledge and practical skills through relevant, practical-oriented education and training, through adequate on-the-job training and through continuing training.

In nuclear power there can be no compromise with safety; high safety and quality standards must be established and strictly maintained, and this can be achieved only with thoroughly qualified staff. Although there are various ways of achieving the required level of qualifications and competence, the same level must be attained in every country which operates a nuclear power plant.

For countries about to embark on or in the process of implementing a nuclear power programme, a lack of qualified personnel with competence to perform the key tasks and functions of nuclear power plant operation and maintenance can be a major problem and constraint.

The International Safety Advisory Group (INSAG) in its 1988 Report [1] included among the basic safety principles for nuclear power plants the following:

— One of the most important lessons to be learned from abnormal events, ranging from minor incidents to serious accidents, is that they have so often been the result of incorrect human action:

— The operating organization must recognize the high technology aspect of nuclear power plants and must ensure that its staff is able to manage it satisfactorily.

— The human error component of events and accidents has been too great in the past. The remedy is a twofold attack, through design, including automation, and through optimal use of human ingenuity in unusual circumstances.

— The operating organization is responsible for providing all equipment, staff, procedures and management practices necessary for safe operation, including the fostering of an environment in which safety is seen as a vital factor and a matter of personal accountability for all staff.

— Although an emphasis on safety might sometimes appear to be in conflict with the requirement to achieve a high capacity factor, this conflict is more apparent than real and can at most be transitory, in that the factors of design, construction and operational management that promote safety generally coincide with those that contribute to reliability in operation. Reliability in the long term is not served by compromising safety in the short term.
Training of maintenance staff goes beyond the teaching of basic task skills and must emphasize the potential safety consequences of technical or procedural error. The training and qualification of maintenance staff should reflect the realization that where there has been a record of plant operational unreliability and faulty, spurious and accidental activation of safety systems in the past, it has often been caused by errors in maintenance procedures and practices. The training must cover such incidents. The testing of maintenance staff should examine their familiarity with these lessons.

Several studies of accidents and incidents that have occurred at nuclear power plants have shown that human error has been a large contributing factor and that inadequate training or knowledge of the personnel has contributed to those human errors. A highly competent operating and maintenance staff is a most important component in the 'defence in depth' strategy for ensuring nuclear power plant safety and protection of the public.

GUIDEBOOK ON TRAINING TO ESTABLISH AND MAINTAIN THE QUALIFICATION AND COMPETENCE OF NUCLEAR POWER PLANT OPERATIONS PERSONNEL

Since the IAEA published its Guidebook on the Qualification of Nuclear Power Plant Operations Personnel in 1984 [2] there have been important developments in the approach to training adopted by operating organizations in many countries. It is now accepted that to develop training programmes solely on the basis of experience is inappropriate for the nuclear power industry and a systematic approach to training is necessary.

Organizations have recognized the continuing impact which inadequate knowledge and skills have on those incidents in which the human factor is a root cause and have taken the initiative to review and improve the development and implementation of their initial and continuing training programmes. The Guidebook on Training to Establish and Maintain the Qualification and Competence of Nuclear Power Plant Operations Personnel [3] presents an approach which is not only comprehensive and systematic in its methodology but also cost effective in its implementation.

Because the responsibility for plant safety and for the competence of plant personnel rests with operating organizations, the Guidebook is aimed at the management and training staff in those organizations. The adoption of a systematic approach to training and qualification as described in the Guidebook is strongly recommended for all operating organizations, on the basis of the experience and judgement of those who have implemented or are implementing such an approach and have obtained the benefits that it can produce.
RECOMMENDED AREAS FOR IMPROVEMENT IN INITIAL AND CONTINUING TRAINING

Responsibility, quality and competence throughout the entire organization of a nuclear power plant are required in the performance of every task and function. This is especially true for tasks connected with the operation and maintenance of the plant, and with the management, initial training and continuing training of operating and maintenance personnel.

Important training related weaknesses which have been identified in this area include: inadequate training and continuing training of operations and other plant personnel; inadequate adherence to and emphasis on established procedures; insufficient degree of 'safety culture' or safety awareness; overconfidence about knowledge of the plant and in the ability to control it; man-machine interface problems; and deficiencies in management, organization and operations procedures.

In connection with these problems, it has been observed that managers and supervisors often do not sufficiently motivate or control personnel, or are insufficiently involved in training and qualification matters to ensure that high performance standards are achieved and maintained and that personnel adhere to established procedures.

Discussion of some of the recurring problems in the development, qualification and evaluation of personnel and in the associated training programmes have led to the following recommendations:

- Training programmes should include such important topics as: quality assurance principles; plant administrative procedures; response to accidents which progress beyond the design basis; stress management; diagnostics; team training; and operating experience.
- Plant specific lists of tasks should be maintained complete and up-to-date.
- Learning objectives should provide measurable requirements and standards for evaluating trainee performance.
- Programmes should include detailed lesson plans setting out learning objectives and written procedures on how to conduct training and assure consistent quality in training.
- Training methods and materials should be appropriate for the stated learning objectives.
- Sufficient details of specific significant events (root causes, lessons learned, applications to the plant) should be included in training.
- On-the-job training should be adequately controlled and evaluated.
- Guidelines and qualification checklists should be used to ensure uniformity of on-the-job-training.
- Supervisors and managers should receive adequate training in leadership, communications, stress management, motivation, and supervisory and related skills.
— Standards should be specified for trainee performance during simulator training and should provide a basis for meaningful assessment of individual and team performance.
— Personnel should be assessed in terms of performance based training requirements, so that the personnel qualifications and training needs are clearly determined.
— Post-training feedback should be formally collected and used to improve training.
— Instructors should maintain and improve their technical knowledge and skills and their instructional abilities.
— Personnel should be assigned independent work only after receiving the required training and being qualified for the job.
— Continuing training should cover the areas of observed performance deficiencies, plant or procedure changes, and infrequently performed but difficult and important tasks.
— Continuing training should be recognized as an essential part of operations activities.
— Training programmes should include periodic drills to ensure that the personnel can respond to emergencies.

ORGANIZATION AND STAFFING OF A NUCLEAR POWER PLANT

A well structured nuclear power plant organization ensures that qualified personnel are in place to perform all functions necessary for operational safety, reliability and efficiency.

There should be effective plant organizations not only for normal operations and for outages (the organization for which is similar to that for day-to-day operations) but also for emergencies.

The structure and functions of a nuclear power plant organization should be reflected in a set of posts that collectively comprise all the duties, responsibilities and authority necessary for safe, reliable and efficient plant operation. During emergencies, the plant organization must be such as to ensure maximum impact and efficiency in responding to and controlling the emergency situation, in order to return the plant as soon as possible to safe and normal conditions.

A nuclear power plant organization should be structured to include clear lines of command and communication. The functions of all plant posts should be well defined and should include direct operating functions, support functions and monitoring/evaluation functions.

The plant organizational structure, staffing levels and training programmes should ensure that an adequate number of qualified personnel are and will at all times be in place to perform the required normal, abnormal and emergency functions. In
the planning of the staff necessary for plant operations, it is advisable to allow for
some overstaffing (especially for key functions which have long training pro-
grammes). An effective training organization is essential for developing and
maintaining a fully qualified plant staff. The use of training centres offers significant
advantages over training conducted exclusively at the plant site.

The use of contractors to assist the plant staff is essential for major repairs,
for dismantling large components for maintenance and for some specialized services.
The availability of qualified contractor personnel is important in these functions.
The availability of outside assistance for refuelling and major repairs has a signifi-
cant influence on the size, structure and competence requirements of the plant
organization.

PERSONNEL EDUCATION, RECRUITMENT AND SELECTION

The technical education system in most countries consists of general education
(divided into primary and secondary schools) and technically oriented education
(vocational and apprentice education, technical schools, technical universities). The
total education period for craftsmen is about 12 years, for technicians 12 to 14 years,
and for (technical) university graduates 16 to 17 years.

The differences in abilities developed by the education systems of different
countries are significant. Many developing countries experience difficulties in
organizing technical education systems oriented towards the needs of modern
technologies. This is due to inadequate teaching facilities, the lack of qualifications
and/or experience of the teaching staff and absence of an industrial tradition.

The managerial posts in a nuclear power plant are mostly occupied by
personnel with university degrees in engineering. Leading personnel in the main-
tenance, technical, health physics and chemistry departments and shift technical
advisors (where used) also normally have university degrees in engineering, physics
or chemistry. Shift supervisors are preferably university graduates, but in many
cases these posts are occupied by individuals without engineering degrees. The
remaining plant posts are filled by vocational and technical school graduates.

Attracting and keeping competent personnel for plant operation is of great
importance because this is one of the key factors in achieving high plant availability
and safety. The selection of nuclear power plant operations personnel includes
prescribing formal acceptance criteria (such as age, education, experience and
health) and evaluating candidates' personalities, skills, knowledge and aptitudes
through a review of personal history, interviews and tests.

Utility management should, as part of its manpower development policy,
stimulate personnel to improve their knowledge and skills. This can be achieved by
combining on-the-job training and job rotation with classroom training. It is also
important to provide career development opportunities.
SYSTEMATIC APPROACH TO TRAINING

A systematic approach is recommended for the development, implementation and evaluation of both initial and continuing training. This offers significant advantages in consistency, efficiency, cost effectiveness, management control and accountability in the training and qualification of operating and maintenance personnel. Without an adequately systematic approach, there is a risk that important elements will be omitted.

A systematic approach to the development and implementation of initial and continuing training programmes together with the development of training solutions to operational problems is the most cost effective and comprehensive approach. With this method, all job competence requirements are established and achieved, thus ensuring that the human aspects associated with high levels of nuclear safety and availability are not compromised. Operational experience is used systematically to review and upgrade training programmes. A systematic approach to training also offers the flexibility to adapt to new trends, e.g. the development and implementation of symptom based procedures. It provides for management monitoring of and responsibility for personnel performance at all levels, including evaluations to ensure that staff are adequately qualified.

A training programme based on a systematic approach should be defined and implemented for each group of personnel. The job specific training and qualification programme should develop and improve the knowledge and skills necessary to perform assigned tasks and functions under all conditions. Training programmes for supervisors and managers should be designed to develop their supervisory and management skills. Control room supervisory personnel should be trained in stress management and in relevant behavioural sciences. In addition, they should be provided with supervisory, leadership and communications training.

Instructors must be well qualified technically and have teaching competence. They should be required to keep up to date in their own technical area and teaching skills as well as in their knowledge of the job requirements, plant system changes, current practices and operating procedures.

Advantages of a systematic approach to training

A systematic approach to training and qualification has the following advantages over traditional approaches:

— It identifies the specific competence (knowledge and skills) needed for each job position.
— Training programmes are developed with explicit learning objectives that meet the trainees' needs.
— Training is conducted according to an established pattern and in the same manner for all trainees.
— Trainees master the learning objectives (have the required competence) before they begin work in their assigned posts.
— Training programme results are carefully evaluated and the programme effectiveness is maintained and improved.
— Greater management control and increased accountability are permitted.

Steps involved in a systematic approach to training

The steps needed to establish performance based training include (see Fig. 1):

Analysis
— Conduct needs analysis
— Conduct job analysis
— Select tasks for training
— Conduct task analysis

Design of training programme
— Establish performance standards
— Select training setting (environment)
— Determine trainee entry level knowledge and skills
— Develop learning objectives
— Organize learning objectives
— Develop test items
— Construct tests
— Develop training plan

Development of training programme
— Specify learning activities
— Select training methods
— Develop training materials
— Develop lesson plans

Implementation of training programme
— Implement training plan
— Conduct training
— Assess trainee performance
— Document training
FIG. 1. Establishing a training programme on the basis of a systematic approach to training. Requirements and Problems for the First Nuclear Power Plant

Evaluation and improvement of training programme

- Collect information
- Analyse information
- Initiate corrective actions
DEFINING COMPETENCE REQUIREMENTS

The first step in designing a performance based training programme is to perform appropriate analysis, i.e. to identify training needs and to conduct job and task analysis for selected jobs. The analysis identifies the required knowledge, skills, attitudes and performance standards for selected important tasks.

The basic competence requirements for specific jobs in a nuclear power plant can be derived from job and task analysis. This analysis, together with the resulting performance standards, are the best sources of data on the competence needed by an incumbent holding a specific job. Job and task analysis results are used to ensure that personnel are competent to perform all known predictable tasks and to avoid improper operations due to lack of training or incorrect training.

Job and task analysis for complex and highly intellectual tasks — and the determination of the corresponding performance standards — are difficult. The competence requirements for such jobs have to be higher than those derived from analysis because of the necessity to cope occasionally with unpredictable sequences of events.

Some utilities confine job and task analysis to direct operating posts because of the importance of these posts and because there are no similar jobs in other industries. However, the methodology can be applied, with the resultant benefits, to all other posts in the nuclear power plant organization.

Job and task analysis is time consuming and costly and requires the involvement of experienced experts. This is the reason that some utilities are reluctant to base their training programmes on job and task analysis and continue to conduct traditional topic based training. This approach is, however, generally regarded as shortsighted, and neither efficient nor cost effective in the medium and long term.

DESIGNING A TRAINING PROGRAMME

A performance based training programme requires quantified performance standards in the development of learning objectives and the assessment of trainees.

The design of training programme includes:

- Establishing trainee performance standards, which are then used to develop learning objectives and tests for the training programme.
- Selecting the appropriate setting for the training and assessment of trainee performance (classroom, laboratory, on-the-job, simulator or self-study). This involves consideration of the relative advantages and disadvantages of each setting and of a number of constraints related to resources and facilities.
- Supplementing classroom training, which is very efficient for developing knowledge, by other techniques designed to develop hands-on skills and teamwork. Laboratory, simulator and on-the-job training are best for developing
job skills but are costly to conduct and can only accommodate a limited number of trainees, and self-study is inexpensive but can only be used for a very limited number of learning objectives.

— Determining the expected entry level knowledge and skills of trainees (which later become prerequisites for entry to the training programme) before the training programme content can be defined.

— Developing intermediate and terminal learning objectives for each task that has been selected for inclusion in the training programme.

— Organizing the learning objectives in an effective sequence.

— Developing test items and tests for use in assessing trainees before, during and after the training programme is completed.

— Developing a training plan after other design activities are completed to guide the development and implementation of the training programme.

DEVELOPING A TRAINING PROGRAMME

The development phase of a training programme expands the design by specifying the learning activities, training methods, lesson plans and other training materials.

The development of a training programme should take into account the details of how people learn. Guides for the conduct of on-the-job training are particularly important in view of the weaknesses found by IAEA OSART missions in this essential aspect of training.

Training materials such as simplified system descriptions and flow diagrams (process and instrument diagrams) should be provided to ensure understanding of the plant and system functions. As far as possible, training materials and facilities should represent actual plant conditions. Initial and continuing simulator based training for the control room shift team personnel should be conducted on a simulator which replicates the power plant control room desk and panels and has software of sufficient scope to cover a full range of normal, abnormal and emergency operating scenarios. The effectiveness of classroom instruction should be enhanced by the use of visual aids to demonstrate actual plant conditions.

Modern training techniques use a variety of media including simulations, computers, films, videotapes and videodiscs. Audiovisual media are beneficial to the learning process when properly integrated into a structured lesson. In addition to the static media of slides and transparencies, those involving movement (films and videos) can transmit information more satisfactorily, e.g. on maintenance and refuelling activities. Computer based training has advantages in terms of flexibility in delivering self-paced instruction and tests. However, it is expensive if the numbers using it are small or the material needs frequent revision.
Various training methods can be used by an instructor to enhance the learning process — lectures, demonstrations, practical exercises, discussions, oral questioning, role playing, walk-throughs and self-pacing. The options available to an instructor are largely determined by the choice of the training setting.

Well prepared training materials are essential to the successful implementation of a training programme. These include textbooks, handouts, system diagrams, models, simulators and lesson plans.

— Textbooks are useful reference sources, particularly for staff involved in the development of written training materials. For trainees, standard textbooks will invariably contain a certain amount of irrelevant information.

— Handouts for trainees should be formatted for easy use, relate to the series of learning objectives covered in a single training session and be developed using guidelines intended to promote efficient learning.

— Scale models of certain plant components are helpful in support of classroom training sessions. Full scale mockups enable procedures to be rehearsed until competency is achieved and are particularly useful for rehearsing operations to be conducted in high radiation zones.

— Lesson plans are essential controlling documents for guiding the learning process and for outlining instructor and trainee activities. They should be produced for all training settings — classroom, workshop, laboratory, on-the-job and simulator.

The production of new training materials is costly and hence, where possible, existing training materials should be reviewed for suitability. Reactor vendors and utilities operating identical or similar plants are useful sources of materials.

Training materials should be reviewed for technical accuracy and effectiveness in meeting the learning objectives. This can be achieved through presentation of the material to a small group of relevant trainees and from data obtained from the first run of the course. Review of existing training materials should be undertaken by instructors who are experts in the subject concerned and should take into account the expected trainee entry level, identified learning objectives, proposed learning activities and the training plan produced in the design phase.

IMPLEMENTING TRAINING AND ASSESSING TRAINEE PERFORMANCE

In implementing the training programme, a number of essential items have to be accomplished: preparing implementation procedures; securing the availability of trainees, training facilities and training materials; pre-testing of trainees; holding of the lessons; assessing trainees; and maintaining training records.
The implementation of training can be split into four main areas:

— preparing instructors
— pre-testing trainees
— delivering the lessons (or conducting the on-the-job, laboratory/workshop, simulator or self-study training)
— assessing trainee performance.

Developing competent instructors requires consideration of appropriate subject matter expertise and instructional skills. More advanced instructional training is required for duties associated with training settings outside the classroom and for activities associated with training design and development. All instructors should be assessed against performance standards for their competence to undertake defined tasks: this process is commonly referred to as certification. Instructors must be fully knowledgeable about the lesson plans, facilities and equipment they will utilize. Continuing training is required for instructors and should cover both technical knowledge and instructional skills.

Pre-testing of trainees is important in order to establish that they have the prerequisite skills and knowledge necessary to undertake the training programme.

The main conditions and advantages of classroom instruction and other means of training implementation can be summarized as follows:

— Classroom instruction is the most widely adopted training setting. Its effectiveness is enhanced by the use of media such as transparencies, audio and video devices and scale plant models.
— On-the-job training is usually conducted by job incumbents who have been instructed how to deliver this form of training. Progress is monitored through the training organization, and assessment is carried out by an independent assessor.
— Laboratory/workshop training requires adequate supervision to ensure safe working practices. Trainee group sizes should take into account the need to practise the skills taught and demonstrated by the instructor and will also be determined by the availability of the necessary equipment and tools.
— Self-study training can be undertaken in a variety of settings such as at home and the work place. In all cases the trainees require support from a designated instructor or qualified job incumbent.
— The use of simulators for initial and continuing training is essential for establishing and maintaining the qualifications and competence of operating personnel. This is discussed in more detail in the section on simulator training.

Techniques for the assessment of training include:

— written examinations
— oral questioning
— performance demonstrations.
Each technique has advantages and disadvantages. A combination of written and oral techniques has been found to be the most appropriate for knowledge testing, and performance demonstrations, supplemented by oral questions, for skills testing. Assessment of simulator training should utilize prepared checklists to improve objectivity.

Feedback should be provided to trainees following all assessments both during and at the end of a training programme.

Records of all training conducted, and details and results of all assessments should be produced and maintained.

MAINTAINING AND IMPROVING TRAINING PROGRAMME EFFECTIVENESS

The evaluation of training programme effectiveness involves several steps including internal evaluation by the utility and evaluation by an external organization. The evaluation is based on indicators of job performance and is supported by information and feedback from trainees, instructors and job supervisors.

Evaluation and improvement of training programme effectiveness should be considered as a continuous process which is essential for maintaining the required quality of training. Without evaluation, the training programme effectiveness would probably deteriorate, and this deterioration would not be detected.

The first step in evaluating the effectiveness of a training programme is to collect information from appropriate sources. This information includes:

- feedback from operating plant experience
- industry-wide operating experience
- reports from plant inspections and evaluations
- feedback from job supervisors
- feedback from on-the-job experience of graduates
- information from trainees
- feedback from instructors.

The criteria for evaluation of training programme effectiveness are related to performance standards established by the plant management. One aim of evaluation is to check that training programmes include all plant changes and changes to plant procedures. Some plant and procedure changes will necessitate modifications to simulator hardware and/or software.

Evaluation requires close co-operation between the training department and plant operations management.

An essential part of training programme evaluation is identification of root causes of performance deficiencies. This could be done by identifying the specific
symptoms of the problem, determining possible alternative causes and investigating these until they are confirmed or eliminated.

On the basis of the analysis of collected data and of established root causes of performance deficiencies, an action plan to improve and correct the training programme should be initiated. This may consist of improvement in the conduct of training or in changes to the training programme.

Implementation of changes in a training programme should be well documented and should follow the procedure established by the utility.

SYSTEMATIC APPROACH TO CONTINUING TRAINING

Continuing training is that training necessary to maintain and enhance the competence of nuclear power plant staff. It can also include training to improve the career development potential of selected individuals. Continuing training must therefore be regarded as an integral part of the operation of a nuclear power plant.

A systematic approach is essential, in particular for operating and maintenance personnel, to ensure that their levels of qualification and competence are maintained and upgraded when necessary.

It is well known that skills and knowledge acquired in initial training gradually deteriorate, especially those which are not regularly used in the actual performance of the job. Moreover, nuclear power plant operations will be modified in the course of experience.

Nuclear power plant operation is characterized by lengthy periods of continuous normal operation, in which only a limited range of operator action is necessary. Abnormal or emergency situations, when the operator's full knowledge and diagnostic skills are indispensable, are rarely if ever experienced. Continuing training is essential in order to maintain the required level of competence for dealing with such situations. Simulators or simulated environments play an important role in this type of continuing training for control room operations personnel.

In addition to abnormal and emergency situations, there are many other tasks and areas of individual knowledge and skills included in the objectives of initial training that are infrequently used. These can be identified from a job and task analysis and also require continuing training.

Operating and maintenance personnel should undergo formal continuing training on a regular basis, and the time needed for this should be taken into account when work schedules are established. Simulator training exercises for operators should be planned systematically and should reflect operating experience.
Among other items, the continuing training programme should contain the following:

- review of infrequent emergency procedures identified from initial training job analysis
- review of plant and procedure modifications.

As a result of ongoing development of reactor technology and the experience gained during plant operation, the design of each plant and its procedures will be modified and improved. Therefore, to maintain the required level of competence, an effective continuing training programme must include the updating of previously qualified personnel in those areas relevant to their job functions. A systematic review of recent operational experience and staff performance at the plant should be included in continuing training. This should involve discussion on performance discrepancies and their causes. The review should also take into account deficiencies identified by quality assurance and control measures.

Since the time for continuing training is limited, the programme has to be addressed to the specific needs of the different groups. Therefore, several different programmes have to be developed to make the continuing training effective and to keep the personnel motivated to participate in and benefit from continuing training in the medium and long term.

Continuing training should also include preparation of staff for future scheduled operations and maintenance activities.

Operational review of experience in similar plants through the use of incident reporting systems can be used to identify human errors and topics for inclusion in continuing training programmes. All utilities should have a formal system for receiving and reviewing reports from other plants (e.g. the IAEA Incident Reporting System (IRS)) and for directing reports, as needed, to the relevant experts and to the training sections of relevant plants.

Most important of all, many personnel performance problems can be reduced or corrected through continuing training, and lessons learned from incidents and events (at the actual plant and at similar plants) can be communicated to personnel through continuing training.

It is important to communicate to the staff through the continuing training programme any changes in plant systems design and in plant operating and maintenance procedures due to:

- improved procedures
- revised standards
- plant system modifications
- introduction of new techniques and technology
- regulatory authority requirements (changes in manning levels, requalification/relicensing frequency).
Any instructor engaged in a continuing training programme has to be highly qualified in the relevant subjects and in teaching proficiency. Management has to support continuing training programmes in the same way as other staff duties and has to relieve the participants from their normal duties at the appropriate times.

Continuing training is not only related to safety but also reduces costs because it leads to increased avoidance of incidents and accidents, decreased downtime and number of personnel accidents, and increased personnel motivation and incentive for outstanding as opposed to adequate performance. On the other hand, the overall effort in time and in human and financial resources for a continuing training programme is very significant, especially for the shift operating staff. Therefore, the integration of continuing training programmes into the normal operation and maintenance activities needs to be carefully considered by plant management and specialist plant engineers.

Continuing training effectiveness can be demonstrated by analysis of well defined operation indicators and their trends. Since continuing training is safety related, expensive and time consuming, its effectiveness has to be evaluated carefully and continuously. A well maintained performance oriented continuing training programme will be one of the main contributors to safe and reliable plant operation.

USE OF SIMULATORS FOR INITIAL AND CONTINUING TRAINING

The implementation of simulator training will vary with the type of training being undertaken, e.g. initial reactor operator training, continuing training, upgrade training, training for managers, for maintenance personnel and for other non-control-room staff. Consequently, care should be taken to design and conduct the training to meet the needs of the individuals and the team.

Simulator training exercises should be undertaken in three parts:

- pre-exercise briefing
- simulator exercise
- post-exercise debriefing.

To be successful, training on non-plant-specific simulators requires careful preparation and thorough explanation of the differences between plant and simulator. Exercises should be conducted until the training objective has been achieved. Instructors should help trainees to develop good operating practices, use procedures, improve diagnostic techniques, communicate effectively and work well as part of the shift team.

It is essential that the control room team be well trained on how and when to use procedures. Procedures may have limitations and thus should not be followed blindly. Rather, use of procedures should be coupled with an ongoing, logical
thought process: thus, there must be an emphasis on teamwork and diagnostics training in both the initial and continuing training programmes. The aim should be to provide operators with practice in applying the fundamentals of effective communication, teamwork and problem solving taught in the classroom.

It is not possible to use current simulators for accident scenarios which progress significantly beyond the design basis accident, e.g. into core degradation. This is due to limitations in computer models and supporting validated data. It is possible for the instructor to stage simulator scenarios that will progress beyond the design basis. Before the simulation goes beyond its validated boundaries, it should be terminated and the exercise continued through instructor-led discussion. In this situation use can be made of design-code-based information to review possible long term actions by the crew, which will enhance their knowledge base. In the event of such an accident, it can be envisaged that instructions with respect to plant manipulations will come from the emergency management group external to the control rooms; hence training need only develop the knowledge base and practise a range of plant manipulations, e.g. shutdown from the auxiliary shutdown room (subject to the appropriate handicaps, such as the wearing of breathing apparatus).

The simulator continuing training programme has to cover two main objectives:

— maintaining the required level of competence of plant operations personnel as defined for the initial training
— training for all significant modifications of plant operation caused by plant or procedure improvements and modifications.

Therefore, continuing simulator training is mostly used for the responsible shift staff, such as the shift supervisor, assistant shift supervisor and reactor operators. Thus, the continuing training programme has to be strictly performance oriented and the shift staff have to take their normal roles. The content of the programme has to be selected carefully, on the basis of observed performance deficiencies, the lessons learned from previous incidents and interviews with the participants.

Simulator exercises should emphasize:

— application of basic operation principles
— application of general rules and requirements of plant operation
— demonstration of systematic monitoring of plant transients
— teamwork and communications
— diagnostic skills and problem solving involving the team
— application of plant operating experience
— demonstration of leadership in stress conditions
— credible multiple failure scenarios
— discussions of accident sequences that might progress beyond the design basis with the possibility of core degradation.
ROLE OF PLANT MANAGEMENT IN TRAINING AND QUALIFICATION

Utility management is responsible for ensuring that plant personnel are fully qualified and for the efficient functioning of the plant organization. Management has to establish a manpower development strategy and staff recruitment policy and must define and decide on the training organization and training facilities.

Plant managers must ensure that plant personnel are adequately trained and must give sufficient attention to the quality and details of the established plant procedures for which personnel are to be trained. Some plant managers have underestimated the importance of training all personnel systematically and of establishing and effectively implementing continuing training programmes.

Plant managers have an especially important role to play in the fulfilment of their responsibility to ensure qualified and competent operations personnel (see also Ref. [4]). Operations management should be involved in defining continuing training needs and ensuring that initial and continuing simulator training reflects operating experience. Operations managers and supervisors should take action to ensure that personnel are trained to adhere to established procedures and that they do so in practice. The operating organization's management should evaluate the quality of the training provided both in the plant and at any separate training centres. Finally, senior plant management should foster a proper attitude in plant personnel towards their work through personal involvement in operations and training activities.

TRAINING REQUIREMENTS AND PROBLEMS FOR THE FIRST NUCLEAR POWER PLANT

The specific demands posed by nuclear power for qualified personnel and national infrastructure capabilities are especially relevant to developing countries, where a lack of resources or capabilities to meet requirements may constitute the principal constraint to the development of a nuclear power programme.

The effort required to establish and maintain the competence of nuclear power plant personnel and to strengthen or build up national industrial and education and training infrastructures to the necessary levels may exceed available national resources and capabilities or may not be compensated for, or justified, by the expected benefits of nuclear power. This would be especially true if it is anticipated that only one nuclear power plant will be needed in the country in the foreseeable future. In such cases, a country would most likely delay the decision to launch a nuclear power programme.

Experience indicates that the lack of a sufficient number of qualified personnel usually constitutes one of the most crucial constraints for developing countries seeking to start a nuclear power programme. Some of the most critical and costly problems have been associated with the insufficient numbers and the inadequate
qualification level of personnel, both professional (or graduate) engineers and technicians. In many respects the problem is more acute at the technician level. This is due in part to a lack of awareness of the importance of highly qualified, well trained technicians. Another cause is the lower economic and social status and recognition accorded the technician level occupations in some countries.

Comparable levels of competence to perform a given function in a nuclear power programme must be achieved in each country as it is the function which determines the required competence and level of qualifications, and these do not depend on the country or category of personnel, i.e. the level of qualifications and competence must be comparable regardless of whether a higher technician or professional (graduate) engineer is used to fill a particular post.

In a developing country, it may be appropriate to employ a larger number of personnel (overstaffing) in a nuclear power plant than in an industrialized country, owing to the smaller external support available, the greater difficulties in providing replacements for qualified personnel and the opportunity this provides to assign the best candidates to the most demanding jobs, on the basis of their performance during training.

In a developing country, simulator training (preferably on a plant specific simulator) and on-the-job training are of essential importance for operations personnel to attain the required competence.

A country which has decided to start its first nuclear power project cannot successfully accomplish this task if manpower development is limited only to the utility and the government regulatory organization. A country depending completely on imported equipment and industrial services and having no independent local expertise to evaluate plant performance is not qualified to start a nuclear power programme.

In developing countries, the reasons why technical abilities developed by the education system are sometimes limited include: a lack of qualified, experienced instructors; inadequate educational facilities in technical schools for conducting practical training, so that the teaching has to be, to a large extent, only theoretical; and inadequate incentives and tradition for, and insufficient appreciation of, the critical importance of acquiring practical skills and experience.

Most developing countries have not yet found a satisfactory solution to the problem of educating and training personnel of sufficient quantity and quality on the technician level [5]. Some of the most intractable problems regarding the development of qualified technicians are connected with the social and economic incentives and recognition, or lack thereof, of the status and occupation of a technician. Some cultural attitudes, such as the avoidance of working with the hands, constitute further obstacles which result in low social and economic recognition of technicians and low esteem for practical skills and capabilities. This constitutes a subtle but very real barrier to attracting good people and to providing them with the necessary education, training and experience. Thus, in some developing countries a greater emphasis has
been placed on theoretical versus hands-on education and training for both professional engineers and technicians.

For these and other reasons, the status and payment of technicians in some countries are not sufficiently high to make it easy to recruit and retain those most able to fill these positions. The lack of adequate financial compensation and social recognition is also very often the reason for the lack of properly qualified teachers/trainers of technicians.

National participation is an essential element in the development of every nuclear power programme as there are some tasks and functions for which organizations in the country must bear full responsibility.

Effective co-operation is essential between industry and those institutions providing education and training for nuclear power. The development of the industrial, education and training infrastructures needed to support nuclear power is a long term process which can take years or even decades, depending on the overall level of the country's infrastructures at the beginning of this process, and requires the active support of the government.

The operating organization responsible for a nuclear power plant must develop the capability to perform operational safety assessments (or use consultants qualified to do this). It is also essential that the regulatory organization within the country be in a position to review these assessments on an entirely independent basis. No person involved in the production of safety assessments should be involved in their review by the regulatory body.

It is highly recommended that before a country/utility begins contracting for a first nuclear power plant, an adequate number of personnel receive training to acquire all knowledge and skills needed for the successful negotiation and implementation of effective contracts with vendors, component manufacturers, consulting companies and others. These contracts should include clear, mutually acceptable and binding provisions for all appropriate training of operations personnel, including simulator training, within the framework of and as an integral contribution to a training programme based on a systematic approach.

Whatever organizations are used to provide initial training, the operating organization responsible for the operation of a nuclear power plant and for the training of plant personnel should discuss its training programme development and implementation with another utility which has already had experience in nuclear power plant operation, in the training of operations personnel, in the use of consultants and in contracting for training.

A utility involved in preparing for the operation of the first nuclear power plant in the country needs assistance from experienced foreign utilities and companies and from relevant international organizations. The most frequently used resources for assistance, advice and help are: reactor vendors, consulting companies, nuclear utilities and the IAEA.
IAEA training programme teams can be made available on request to Member States to provide advice and assistance on setting up, implementing, monitoring and upgrading programmes for the initial and continuing training of nuclear power plant operations personnel.

REFERENCES TO IAEA PUBLICATIONS


