Nuclear power: Training for safety and reliability

The best international practices are being emphasized to help countries strengthen nuclear plant training programmes

by F. Mautner-Markhof and K.V. Mahadeva Rao

A central challenge for industries anywhere is to maintain safe and reliable operation of their plants and facilities. These objectives cannot be achieved solely by improvements in equipment and hardware. They critically depend upon the qualifications, experience, and competence of people carrying out various tasks and holding different levels of responsibility.

In the nuclear power industry, training has assumed increasingly greater importance over the past 15 years. During this period, several studies have shown that human error has been a major contributing factor to incidents at nuclear power plants. In turn, these errors often can be traced back to deficiencies related to training.

Over the years, the IAEA has established a range of services directed at helping countries strengthen their training practices, approaches, and facilities for nuclear power personnel. This article reports on Agency programmes in the context of international developments in the field.

Key elements of evolving approaches

A strong emphasis on safety has characterized the development of nuclear power technology. In the early years, personnel involved in plant design, construction, and operation were pioneers in nuclear technology and the strength of their base of knowledge was able to offset any weaknesses in training, which was evolving simultaneously. Training techniques used for staff of conventional power plants were first adapted to suit the requirements of nuclear plant operations personnel. In the 1970s, as nuclear technology entered its commercial industrial phase, the tendency was to develop more specific operating procedures in increasing detail. Training programmes were designed accordingly, this time for a new generation of operators having different educational and professional qualifications.

In 1979, the Three Mile Island (TMI) accident in the United States jolted the industry. It challenged the belief that such an accident could not happen, particularly in the Western industrialized world, given the emphasis on safety and the defense-in-depth strategy adopted in the design, construction, and operation of nuclear power plants. The accident's root cause was traced to human errors, and inadequate training and qualification. In prompt response, the US nuclear industry voluntarily formed the Institute of Nuclear Power Operations (INPO) and subjected the prevailing training methodology to a critical review. Borrowing from techniques used in military training, a systematic approach to training (SAT) was developed and an industry-wide commitment to SAT was made in 1981. In addition, training programmes of nuclear utilities were reviewed by INPO accreditation teams to promote a uniform standard of training across the board. At the same time, the US Nuclear Regulatory Commission strongly urged that SAT be used as the basis for training nuclear power plant personnel, and it mandated full-scope simulator training. As a result of these and other measures, US nuclear utilities have achieved a sustained improvement in all plant performance indicators.

Following TMI, other countries with operating nuclear power plants also conducted detailed analyses of their plant designs, as well as operations and maintenance procedures. They made necessary modifications, and in most cases, they strongly recommended the use of SAT. Most countries with significant nuclear power programmes now use SAT as the basis for developing, implementing, and evaluating their training programmes for nuclear power personnel. Although many countries

Ms. Mautner-Markhof and Mr. Mahadeva Rao are staff members in the IAEA Division of Nuclear Power, Department of Nuclear Energy and Safety. Also contributing to this article was Mr. Andrei Kossilov of the Division of Nuclear Power.

do not have systems for formal accreditation of training programmes, important elements of SAT and of an accreditation process have been incorporated in their training programmes.

The critical role of operations personnel has been rightly emphasized by every country with a nuclear power programme. Maintenance training, however, has received far less attention and there is widespread agreement that it must be improved. The competence of maintenance personnel is essential for reducing events connected with equipment failure or malfunctioning systems.

Training techniques and methods

Personnel who are properly trained and qualified for jobs and responsibilities at nuclear power plants are not available directly from university-level institutions or technical colleges. New recruits therefore have to be trained in areas going beyond their academic or vocational qualifications. Existing staff also require continuous training to maintain and upgrade their skills and knowledge.

These diverse types of training can be provided at a dedicated training centre at a nuclear power plant; at a centralized training facility serving the needs of a number of similar nuclear plants; or at a national training facility. External training organizations also can provide specific types of training. Whichever approach is followed, the training site must have facilities for classroom teaching, workshops with mock-ups and models for maintenance training, and simulators for operations personnel with attendant workshops and laboratories. Training on full-scope or partial nuclear plant simulators serves the goals of both safety and reliability, and these two cannot be treated separately. Simulator training has become one of the most effective and important means for upgrading the skills and attitudes of operations personnel.

Another important component is on-the-job training (OJT). The trainee performs the required work under the close supervision and with the assistance of the responsible supervisor. Thus, he or she becomes an integral part of a team that subsequently has to function well. Although the effectiveness of OJT is enhanced by educational qualifications and classroom training, it cannot be replaced by theoretical training.

Simulator, OJT, and other types of training should be based on SAT. It is also important to emphasize the need for top-quality trainers with good teaching skills. They should have practical and up-to-date experience, as opposed to only academic experience and qualifications.

An overview of SAT. The Systematic Approach to Training (SAT) is a process which encompasses the analysis of training needs and the competencies required to perform a given job; the design of training to meet these needs, which involves converting the competence requirements into training objectives including identification of appropriate training tools and settings; the development of training materials and tools such that all objectives can be met, as well as the training of trainers; the implementation of training according to the procedures and materials developed (training can be implemented in the classroom, workshop, simulator, and by self-study and OJT); the evaluation of training performance during and at the conclusion of training; and feedback of evaluation results into the relevant phases and parts of the training process and programmme, as well as to other needed plant improvments. SAT is thus a logical and self-improving system. It goes from identifying tasks and competencies required for performing a job to the implementation and evaluation of training for those competencies.

The use of SAT offers significant advantages over more conventional training approaches. In essence, it is a quality assurance process for ensuring the competence of nuclear power plant personnel, and for helping management more effectively monitor and improve training policies and practices.

SAT is now recognized as the international best practice for training nuclear power plant personnel. The approach can be adapted to suit the specific requirements and conditions of individual nuclear power plants, utilizing and building upon existing capabilities. It also incorporates aspects that promote a safety culture among staff and management. Regulatory bodies in a number of countries mandate or strongly recommend the use of SAT-based training for nuclear personnel.

IAEA assistance and support

IAEA programmes in nuclear power training are helping countries to apply the best international practices in their efforts to improve the qualifications and competence of their operations, maintenance, management, and technical support personnel. Toward this end, an International Working Group on Nuclear Power Plant Personnel Training and Qualification has been set up. Its objectives are to:

- provide advice and comments on the IAEA's current and future activities related to a broad integrated SAT-based approach to training and qualification of nuclear power plant personnel;
- establish mechanisms through the IAEA to provide countries with information, recommendations, and advice on nuclear power plant personnel training and qualification;

IAEA activities in support of training for nuclear power plant personnel, 1995-96

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- preparation of a technical report on nuclear power plant personnel training and evaluation
- preparation of a technical document on training performance indicators
- preparation of a reference manual on training centres in the world
- preparation of a technical document on measures to implement more effective on-the-job training
- provision of technical officers and training experts in support of technical cooperation projects and for transferring information on the systematic approach to training (SAT)
- organization of training advisory missions
- preparation of a technical document on training for maintenance personnel
- preparation of a technical document on the design of nuclear power plant training simulators and related assessment methodology
- organization of training courses

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- organization and implementation of safety review missions to nuclear power plants (OSART and ASSET missions)
- preparation of a technical document on training personnel for the management of accidents
- preparation of a technical document on the use of operating experience to identify operational safety issues in the field of human factors
- preparation of a technical report on organizational factors influencing human performance in nuclear power plants
- interregional education and training courses on optimized maintenance of nuclear power plants

IAEA technical cooperation projects

- Training in Nuclear Engineering, Algeria
- Manpower Development for Safe Operation of Nuclear Power Plants, China
- Upgrading University Training in Reactor Physics, Czech Republic
- Strengthening Training for Operational Safety at Paks Nuclear Plant, Hungary
- Establishing University Courses in Nuclear Engineering, Hungary
- Introduction of SAT in the Training Centre of BATAN and Support for the First Nuclear Power Plant, Indonesia
- Infrastructure including Training for Implementation of Nuclear Power Programme, Iran
- Nuclear Power and Safety Technology, Republic of Korea
- National Nuclear Training Centre, Mexico
- Upgrading of Training Facilities at Karachi Nuclear Power Plant Training Centre, Pakistan
- Development of Basic Principal Simulator for Karachi Nuclear Power Plant, Pakistan
- Support of Cernavoda Training Centre, Romania
- Upgrading Nuclear Power Plant Personnel Training Programmes, Slovak Republic
- Enhancement of Availability and Safety of WWER-type Reactors, Slovak Republic
- Enhancement of Operational Safety at Krsko Nuclear Power Plant, Slovenia
- Education and Training in Radiation Protection, Ukraine
- Training for Safe Operation and Management of Nuclear Power Plant, Ukraine
- Improving Nuclear Power Plant Operation Management, Regional Project for Eastern Europe

- promote exchange of information on national programmes, new developments, and experience from operating nuclear power plants and training centres;
- promote the effective implementation of relevant IAEA standards, guides, and other documents at the nuclear power plant level through training programmes and related activities.

The IAEA has recently prepared a new *Guidebook on Nuclear Power Plant Personnel Training and its Evaluation*, a revision of an earlier technical document (TECDOC-525) that had become the widely used international standard reference on SAT. This new guidebook reflects the experience gained in SAT implementation over the past 6 years. It emphasizes a broader concept of competence which includes not only technical knowledge and skills but also knowledge, skills, and attitudes concerning human factors. It further covers the role and responsibilities of management; the training of maintenance and management personnel; more effective and efficient methods of SAT analysis; and evaluation of the overall training process.

Another document, *Simulators for Training Nuclear Power Plant Personnel* (TECDOC-685), provides guidance on the procurement, establishment, and utilization of a simulator training centre. Other IAEA activities include the preparation of guidelines for designing nuclear power plant training simulators, and for using related assessment methodologies; the organization of regional and national workshops on the use of simulators and on the application of SAT in designing simulator-based training programmes; and the development of training performance indicators to facilitate management's monitoring of programmes.

IAEA training advisory services are further provided at the request of countries. The services are technical in nature and are not an auditing mechanism. Rather, training experts provide practical advice and guidance on the best ways to meet the needs and priorities of a specific nuclear power plant or country.

In Hungary, the IAEA under its technical cooperation programme has started a model project to strengthen training for operating and maintenance personnel at the Paks nuclear plant. It specifically aims to introduce SAT-based training, to assist in establishing a training centre for maintenance personnel, and to enhance safety culture. The project is serving as an example for other nuclear power plants in countries of Central and Eastern Europe and the former Soviet Union. Its successful completion in Hungary can serve as a model for similar types of nuclear plants operating elsewhere in the region. ❐