Selection, education and training of personnel for nuclear power plants

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Abstract: This report identifies the main objectives and responsibilities of the operating organization for the selection, qualification and training of personnel for new and existing nuclear power plants to establish and maintain a high level of competence of personnel and to ensure safe operation of the nuclear power plant. The publication can also be used as a recommendation for the recruitment, training and qualification of personnel for nuclear installations other than nuclear power plants.

KEYWORDS: RECRUITMENT, QUALIFICATION, TRAINING OF PERSONNEL, NUCLEAR POWER PLANTS, EMPLOYEES, RECRUITING, COMPETENCE, SAFE OPERATION, RECOMMENDATIONS, REQUIREMENTS, EDUCATIONAL BACKGROUND, EXPERIENCE, TRAINING POLICY.

1. Introduction

The overall objective of a country’s nuclear security regime is to protect persons, property, society and the environment from harmful consequences of a nuclear security event. This material provides recommendations on the recruitment, selection, qualification, training and authorization of personnel working in all safety related functions and at all levels of nuclear power plants [1].

Requirements for the operation of nuclear power plants are established in Safety Standards Series No. SSR- 2/2 (Rev. 1), Safety of Nuclear Power Plants: Commissioning and Operation [2], while requirements for the design of nuclear power plants are established in Safety Standards Series No. SSR- 2/1 (Rev. 1), Safety of Nuclear Power Plants: Design [3].

Requirements on establishing, sustaining and continuously improving leadership and management for safety and an effective management system for all facilities and activities are established in Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [4].

The purpose of this material is to provide recommendations on the recruitment, qualification and training of personnel for nuclear power plants to meet the requirements established in SSR- 2/2 (Rev. 1) [2], in particular Requirements 4, 7 and 18.

It is expected that this information will be used primarily for land based stationary nuclear power plants with water cooled reactors designed for electricity generation or for other production applications (such as district heating or desalination) and identifies the main objectives and responsibilities of the operating organization for the recruitment, qualification and training of personnel for new and existing nuclear power plants to establish and maintain a high level of competence of personnel and to ensure safe operation of the nuclear power plant.

2. Recruitment and selection of personnel for nuclear power plants

2.1 Staffing arrangements for nuclear power plants

Requirement 4 of SSR- 2/2 (Rev. 1) [2] states that “The operating organization shall be staffed with competent managers and sufficiently qualified personnel for the safe operation of the plant.”

Paragraph 3.11 of SSR- 2/2 (Rev. 1) [2] states that “A long term staffing plan aligned to the long term objectives of the operating organization shall be developed in anticipation of the future needs of the operating organization for personnel and skills.”

The staffing plan should be regularly reassessed and updated to reflect organizational changes. Such changes can result from changes to work programmes, the adoption of new technology, the addition of reactor units or from changes in stages of the lifetime of the plant.

Organizational changes might also occur as a result of feedback of operating experience, especially when significant improvements in safety or in the understanding of root causes can help to avoid the recurrence of events.

Issues such as the age profiles of plant personnel, advances in automatic control and changes in waste management policies should also initiate a reassessment of the staffing plan. Fluctuations in staffing and staff motivation (e.g. for plants facing shutdown) should be taken into account when performing the periodic reassessments of the staffing plan.

2.2 Recruitment policy

The recruitment and selection policy at a nuclear power plant should be aimed at retaining a pool of experienced staff with a broad range of operational and safety expertise.

Staff motivation and career development should be considered in the recruitment and selection processes. Promoting personnel within the operating organization ensures that high quality work is rewarded and provides a motivation for personnel to enhance their competence to enable them to apply for higher positions.

Job stability is also an asset that the operating organization should use to sustain staff motivation while finding the right balance between internal promotion and external recruitment.

When it is not possible to recruit individuals with the necessary experience, consideration should be given to recruit personnel directly from schools, technical colleges and universities. Specialized training should then be planned and provided, including on the job training on specific systems and equipment and simulator training at the plant and at other organizations, as appropriate.

The selection of candidates for vacant positions should be based on a candidate’s potential to develop the necessary competence, through additional training, experience and development. A candidate’s potential for occupying higher positions may also be taken into account.

2.3 Selection of candidates

The selection of candidates for vacant positions should be based on a candidate’s potential to develop the necessary competence, through additional training, experience and development. A candidate’s potential for occupying higher positions may also be taken into account.

The selection process should include the following steps:

(a) Establishing criteria (including medical criteria) for accepting or rejecting applications and for classifying acceptable candidates;
(b) Obtaining information about candidates, including security information, in accordance with any relevant regulatory requirements;
When selecting candidates to work as control room operators or as other personnel who might have to respond to an emergency, their ability to work together as a team in such conditions should be considered. In the allocation of staff to particular teams, likely personal interactions should be taken into account.

Candidates for managerial and supervisory positions should be selected on the basis of criteria that include appropriate attitudes to safety and that emphasize proven, conservative, safety enhancing decision making skills. The following factors should be taken into account:

(a) Management skills, including analytical, supervisory, leadership and communication abilities;
(b) Experience (performance in previous jobs);
(c) Education and training;
(d) Knowledge of plant operations;
(e) Psychological and medical criteria;
(f) Attitudes towards nuclear safety;
(g) Attitudes towards learning and self-learning;
(h) Attitudes towards the training and career development of personnel.

2.4 Recruitment programme for new nuclear power programmes

An operating organization planning to build a first nuclear power plant (or the first of a new type of plant with significant technological differences to existing plants) should begin its recruitment programmes earlier than those operating organizations that already have experience with such a plant and can call upon an existing pool of expertise.

Initial recruitment should be completed in sufficient time before the commissioning of a plant to allow personnel to gain experience of the design, construction and commissioning stages by working alongside contractors and commissioning personnel, and to receive appropriate training and familiarize themselves with the plant.

By participating in these stages, personnel will acquire a better understanding of the design intents, the assumptions on which the safety criteria are based and the technical characteristics of the plant.

The operating organization should prepare a schedule showing how the initial recruitment and selection of personnel will be planned and implemented. If a plant is the first of several of a type to be built, the period covered by this schedule should begin with the start of the construction work. As additional plants are constructed and operated, this period might be reduced.

3. Competence and qualification of nuclear power plant personnel

Competence is the ability to apply skills, knowledge and attitudes in order to perform an activity or a job to a specified level in an effective and efficient manner. Competence may be developed through education, experience and formal vocational training.

Qualification is a formal statement resulting from an assessment or audit of an individual’s competence to fill a position and perform all duties assigned to that position in a responsible manner.

The criteria for competence and qualification should be established in such a way as to ensure that the competences are appropriate to the tasks and activities to be performed.

The operating organization should ensure that all personnel who perform duties that affect safety have a sufficient understanding of the plant and its safety features and sufficient other competences (e.g. leadership, management and supervisory skills, and ‘soft skills’ such as team working and communication) to perform their duties safely. All such personnel should be trained in safety management in their areas of responsibility and in accordance with their assigned duties and tasks.

The functions and the related duties and responsibilities of qualified personnel should be clearly indicated in the structure of the operating organization and in the job description for each position. For each category of personnel, the necessary competence may be defined by means of the following:

(a) Educational level (academic qualification);
(b) Previous experience (including direct and related experience);
(c) Initial training and continuing training.

3.1 Educational background

Education provides the general knowledge and develops the attitudes, behaviors and intellectual skills that are the foundations of competence. Appropriate criteria for educational background should be established for all positions at the plant. These criteria should be taken into consideration in the preparation of training programmes for plant personnel. In turn, training programmes should be used to complement formal education with practical and job related knowledge and skills.

The scope of knowledge, and therefore the criteria for educational background, should be commensurate with the position to be occupied. Managers and technical specialists should possess a wide knowledge of general science and technology (physics, mathematics, chemistry, thermodynamics).

The following practices in relation to the educational background of nuclear power plant personnel are commonly applied [5]:

(a) Managerial positions (e.g. plant manager, deputy plant manager, operations manager, safety manager, maintenance manager, quality assurance manager, technical support manager, training manager) are usually occupied by university graduates in engineering or physical sciences.
(b) The other positions for which a university degree is normally expected are those of shift technical adviser and safety engineer. Reactor physicists, radiation protection officers, plant chemists and maintenance engineers will also generally have university degrees, and some of the more junior personnel might also have completed university level education.
(c) Supervisors (e.g. for the plant, unit, shift and control room) will often have a degree from a university or engineering college. Control room operators are typically expected to have a diploma from a technical school, although they might instead have a degree from a university or engineering college.

3.2 Work experience

Experience is the knowledge gained and the skills developed while performing the duties of a position. Three principal grades of experience can be distinguished as follows:

(a) General plant experience, which comprises a general knowledge of nuclear power plants and their related activities. This sort of experience may be gained by occupying various positions at different plants.
(b) Plant familiarity, which is the detailed knowledge of a particular plant or activity, and which can only be obtained through day- to- day work in a particular position.
(c) Breadth of experience, which relates to knowledge not directly connected with the duties of a particular position. It includes a knowledge of interfacing activities, and a wider knowledge of the plant and the operating organization, which might extend to other activities outside the plant.

General plant experience provides broadly applicable knowledge of the properties of the plant (or of maintenance or similar activities). This type of experience can be acquired by working at different plants. Working in several plants can add to the general plant experience of operating personnel, and performing maintenance activities in different types of plant adds to the general plant experience of maintenance personnel.

By performing these tasks and duties in operating plants, a knowledge of plant behavior is accumulated over a period of time, which can be applied generally to a range of plants. Operators who need formal authorization should have sufficient general plant experience, of which a part might have been acquired in other plants, including in conventional power plants. This type of knowledge appears to be retained for long periods, even after work at a plant has ended.

4. The approach to training nuclear power plant personnel

The operating organization should formulate an overall training policy. This policy should describe the commitment of the operating organization and managers to the training of personnel, and acknowledge the essential role of training in the safe and reliable operation and maintenance of the plant.

The training policy should be known, understood and supported by all relevant personnel. Managers, including the training manager, should be involved in developing the training policy.

A training plan should be prepared on the basis of the long term needs and goals of the plant. This plan should be reviewed periodically in order to ensure that it is consistent with current (and future) needs and goals.

4.1 Systematic approach to training

Factors that should be taken into account in the review of the training plan include: feedback of operating experience; significant modifications to the plant or to the operating organization; changes in regulatory requirements; changes in the national education system; fluctuations in staffing; and specific staffing problems (e.g. loss of staff, lack of motivation) for plants that are approaching shutdown.

A systematic approach to training should be used for personnel [6–8]. The systematic approach provides a logical progression, from identification of the competences necessary for performing a job, to the development and implementation of training towards achieving these competences, and to the subsequent evaluation of this training.

A systematic approach to training includes the following phases:

(a) Analysis. This should comprise the identification of training needs and of the competences necessary to perform a particular job.

(b) Design. In this phase, competences should be converted into training objectives. These objectives should be organized into a training plan.

(c) Development. In this phase, training materials should be prepared so that the training objectives can be achieved.

(d) Implementation. In this phase, training should be conducted using the training materials developed.

(e) Evaluation. In this phase, all aspects of the training programmes should be evaluated on the basis of data collected in each of the other phases (e.g. operating experience data, performance indicators, modification data, procedure changes and inputs from supervisors and job incumbents). This should be followed by feedback leading to improvements in the training programmes and to plant improvements.

4.2 Training settings and methods

Training should be carefully controlled and structured to achieve the training objectives in a timely and efficient manner. The following training settings and methods should be considered:

(a) The classroom is the most frequently used training setting. Its effectiveness should be enhanced by the use of appropriate training methods such as lectures, discussions, role playing, critiquing and briefing. Training aids and materials such as written materials, presentations, audio and video based materials, scale models and simulators should be used to support classroom instruction, as necessary.

(b) On the job training should be conducted in accordance with guidelines developed by experienced personnel who have been trained to deliver this form of training. Progress should be reviewed, and assessments should be performed by an independent assessor.

(c) Simulator based training for control room operators, shift supervisors, responsible managers and technical support personnel should be conducted. The simulator should be equipped with software of sufficient scope to cover normal operation, anticipated operational occurrences and a range of accident conditions. Other personnel may also benefit from simulator based training.

(d) Training mock-ups and models should be provided for activities that need to be performed quickly and skillfully and which cannot be practiced with actual equipment. Training mock-ups should be full scale if practicable.

(e) Training should be provided in laboratories and workshops to ensure safe working practices in these environments.

(f) Self-study training should be encouraged. This does not have to be undertaken at a training facility, but in all cases the trainees should have support from a designated expert.

Typically, training should consist of periods of formal training in the classroom mixed with intervals of simulator, laboratory or workshop training, and should include practical training at the plant

5. Training programmes for nuclear power plant personnel

All new personnel starting work at a plant should be inducted into the organization and their working environment in a systematic and consistent manner. General personnel training programmes should provide new personnel a basic understanding of their responsibilities and of safe and secure work practices, the importance of quality management and of following procedures, and the practical means of protecting themselves from the hazards associated with their work. The amount of training to be provided on specific topics should be commensurate with the assigned duties of personnel. The basic principles of safety culture [9] should be taught to all personnel, and refresher training on general topics should also be provided periodically.

General induction training should be provided to each member of personnel or contractor working at the plant, to address the following:

(a) Introduction to the plant organization and administration;

(b) Nuclear safety principles (e.g. defence in depth);

(c) The management system;

(d) Safety culture;

(e) Non-radiation-related safety (e.g. electrical safety, rigging and lifting, work in confined spaces, chemical hazards, use of protective equipment, first aid);
(f) Radiation protection, including techniques for the optimization of radiation protection;
(g) Foreign material exclusion [10];
h) Fire protection, including fire prevention;
i) Environmental protection;
j) Use of human performance tools;
k) Nuclear security and access control;
l) Emergency alarms, escape routes and assembly points.

Training programmes for most positions at a nuclear power plant should include on the job training, to ensure that trainees obtain the necessary knowledge and skills in their actual working environment. Formal on the job training provides hands-on experience and allows the trainee to become familiar with plant routines.

However, on the job training does not simply mean working under the supervision of a qualified individual; it also involves the use of training objectives, qualification guidelines and trainee assessments. This training should be conducted and evaluated in the working environment by qualified, designated individuals.

Training programmes should include training in any new technologies and equipment that are introduced at the plant.

Suitable personnel should be trained in root cause analysis and the assessment of human and organizational factors, with the aim of creating a pool of staff who can evaluate events objectively and make recommendations on how to avoid their recurrence.

Training programmes for positions such as managers, nuclear safety experts and technical specialists, control room operators and senior technicians should provide a thorough understanding of the basic principles of nuclear technology, nuclear safety and radiation protection, and the design intents and assumptions, together with the necessary on the job training.

The training programme for other personnel (including technicians and personnel with specific manual skills) should be more practical, with supporting explanations of the underlying theory and of safety related aspects.

6. Training facilities and materials

The training facilities should provide for classroom training, computer based training, simulator training and individual studies.

The training materials provided should help the trainees understand the plant and its systems. Detailed technical information to be used as reference material should also be available in the training facilities. The effectiveness of classroom training should be enhanced by the use of visual aids.

The simulator should include the following features:

(a) A replica of the main control room and the supplementary control room;
(b) A realistic working environment, including aspects such as the use of documentation, logging systems and communication systems;
(c) A behavior that effectively simulates the behaviour of actual plant systems;
(d) The ability to simulate randomly selected failure combinations, severe transients, and infrequent and abnormal situations that have a low probability of occurrence;
(e) The ability to model auxiliary systems;
(f) Instructor aids (e.g. isolated booth, a means for freezing and reversing the simulation scenarios, automatic recording of the actions of trainees and the behavior of systems, video cameras and recording devices).

Maintenance personnel and technical support personnel should have access to workshops, laboratories and facilities that are equipped with mock-ups, models and actual components that enable these personnel to be trained in activities that cannot be practiced with installed equipment (e.g. because of high dose rates).

7. Conclusions

Training is an important tool to achieve and maintain the required competence of personnel working in nuclear facilities. Effective training and qualification of personnel are necessary for the achievement of high safety and efficiency standards in nuclear facility performance.

Training and qualification combined is a key feature of the integrated management systems of nuclear facilities. It is these considerations that led to this publication which consolidates the experience gained worldwide using the systematic approach to training (SAT) for nuclear facility personnel.

It provides a basis for establishing and sustaining the quality and reliability of training and qualification for all main categories of nuclear facility personnel. SAT has proved its effectiveness in nuclear and other safety critical industries over decades and is recognized as the best international practice in nuclear training. [11].

Bibliography