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No. NG-T-2.8

Systematic Approach to Training for Nuclear Facility Personnel: Processes, Methodology and Practices

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SYSTEMATIC APPROACH TO TRAINING FOR NUCLEAR FACILITY PERSONNEL: PROCESSES, METHODOLOGY AND PRACTICES

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IAEA NUCLEAR ENERGY SERIES No. NG-T-2.8

SYSTEMATIC APPROACH TO TRAINING FOR NUCLEAR FACILITY PERSONNEL: PROCESSES, METHODOLOGY AND PRACTICES

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2021

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FOREWORD

The IAEA's statutory role is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world". Among other functions, the IAEA is authorized to "foster the exchange of scientific and technical information on peaceful uses of atomic energy". One way this is achieved is through a range of technical publications including the IAEA Nuclear Energy Series.

The IAEA Nuclear Energy Series comprises publications designed to further the use of nuclear technologies in support of sustainable development, to advance nuclear science and technology, catalyse innovation and build capacity to support the existing and expanded use of nuclear power and nuclear science applications. The publications include information covering all policy, technological and management aspects of the definition and implementation of activities involving the peaceful use of nuclear technology.

The IAEA safety standards establish fundamental principles, requirements and recommendations to ensure nuclear safety and serve as a global reference for protecting people and the environment from harmful effects of ionizing radiation.

When IAEA Nuclear Energy Series publications address safety, it is ensured that the IAEA safety standards are referred to as the current boundary conditions for the application of nuclear technology.

Safe, reliable and efficient performance of nuclear facilities cannot be achieved solely through high quality equipment and documentation. Sufficient numbers of adequately trained, qualified and motivated personnel, able to fulfil their responsibilities and perform their tasks to the required standards, are critical in achieving excellence and preventing unacceptable risks to the personnel, public, facility and environment. Therefore, attaining and maintaining the competence and qualification of the personnel is central to ensuring the safety, reliability and efficiency of such facilities, whether operating or newly built. This includes management, operations, maintenance, engineering and technical support, and training personnel, as well as contractor personnel. Adequate training on performance under abnormal and emergency conditions is crucial for ensuring competence.

This publication compiles experience gained worldwide using the systematic approach to training (SAT) in nuclear facility personnel training. The approach has proved its effectiveness in nuclear and other safety critical industries over decades and is recognized as the best international practice in nuclear training. Using SAT, competence requirements can be established for certain jobs in a nuclear facility to ensure that incumbents have attained all the required competencies. The evaluation of training effectiveness is an inherent feature of SAT and helps to demonstrate that personnel performance has improved and training is of value for the organization.

The SAT process not only improves personnel performance, but also often identifies needed improvements in nuclear facility processes, procedures, equipment and organization. Analysis of job requirements identifies the knowledge, skills and attitudes needed in all areas, not only the technical areas. Management competencies, interpersonal skills and human performance related competencies are also identified and effectively addressed in training programmes based on SAT.

Nuclear facility operators around the world, including those with the best performance records, advocate SAT, and regulatory authorities in many Member States mandate or strongly recommend the use of SAT for nuclear facilities such as nuclear power plants.

This publication includes good practices, offers recommendations from the experts in the field on the entire set of activities within the SAT process and provides examples of the application of SAT. It builds on the information provided in Technical Reports Series No. 380. A key feature of this publication is a demonstration of how SAT serves as one of the important processes in a nuclear facility management system and how it integrates with other processes.

Appreciation is expressed to all Member States for their valuable contributions and to all participants listed at the end of this publication. The IAEA officer responsible for this publication was L. Halt of the Division of Nuclear Power.

EDITORIAL NOTE

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1. INTRODUCTION

1.1. BACKGROUND

Training is an important tool to achieve and maintain the required competence of various categories of personnel in all nuclear facilities. High quality and effective training and qualification of personnel are necessary to achieve high safety and efficiency standards in nuclear facility performance. Training and qualification combined are a key feature of the integrated management systems of nuclear facilities. As the use of a systematic approach to training (SAT) has progressed in several nuclear applications, the approach has demonstrated its usefulness. Since Technical Reports Series No. 380 [1] was published in 1996, the nuclear industry has accumulated an enormous amount of valuable experience in the field of personnel training. The SAT process has become more formalized and lessons learned concerning its application in a wide spectrum of nuclear facilities have accumulated. There arose a greater need for the formalized and standardized training process to be applicable to an increasingly wide range of nuclear facility jobs.

For these reasons, Member States recommended through the Technical Working Group on Managing Human Resources (TWG–MHR) that the IAEA produce a publication that would incorporate recent experience and guidance in nuclear training based on a systematic approach and expand the scope to include other nuclear facilities in addition to nuclear power plants (NPPs). This report has been developed to meet that request, and it builds on Technical Reports Series No. 380 [1], which has played an important role since its publication, guiding managers and training staff in introducing the basic principles of SAT.

This publication supports IAEA Nuclear Energy Series No. NG-G-2.1, published in 2009 [2]. NG-G-2.1 includes an overview on the use of SAT for ensuring competence of personnel, which is detailed in this publication.

1.2. OBJECTIVE

The purpose of this publication is to update the SAT process with lessons learned and good practices that have been demonstrated to enhance facility performance. It provides a basis for establishing and sustaining the quality and reliability of training and qualification for all main categories of nuclear facility personnel.

1.3. SCOPE

This publication is applicable to nuclear facilities such as NPPs, nuclear fuel cycle and radioactive waste management facilities, and research reactors. It is applicable to the entire life cycle of the facilities, including planning, construction and commissioning, operation and decommissioning. The processes and methodology presented in this report can be used to identify job specific training requirements for any nuclear facility job or function and then to meet these requirements through the SAT process. While SAT is recognized in the nuclear field as an important approach and methodology to achieve high quality, reliable and effective training, this report has been developed focusing on safety considerations and the practical examples are provided mostly from this standpoint; however, SAT methodology can be used in other areas (e.g. in nuclear security) too. Guidance provided here, describing good practices, represents expert opinion but does not constitute recommendations made on the basis of a consensus of Member States.

1.4. STRUCTURE

This publication presents the SAT process at different levels and discusses the importance of nuclear training as part of an integrated management system in Section 2. Section 3 discusses the relationships between the nuclear industry, educational institutions and training systems, and the benefits, roles and forms of cooperation. Section 4 primarily describes managers' and leaders' responsibilities in training. Section 5 describes the importance of training policies. Section 6 describes how to achieve effective SAT based training using consultation forums and committees. Section 7 describes the five interrelated SAT phases and processes, their essential elements, and challenges in applying a graded approach. Sections 8 through 12 describe the five phases: analysis, design, development, implementation and evaluation. Section 13 presents different SAT applications. Section 14 describes the processes which ensure contractor personnel competence.

1.5. USERS

This publication is primarily intended for users from the following organizations:

— Nuclear facility operating organizations in all phases of the life cycle wishing to establish effective, high quality training programmes or to improve their training systems;
— Regulatory organizations responsible for setting requirements and performing independent regulatory reviews of nuclear facility personnel training;
— Facilities using sources of ionizing radiation;
— Organizations involved with the transport of radioactive material;
— Entities involved in the nuclear industry sector (suppliers or contractors to nuclear facilities such as NPP vendors, training organizations, technical support organizations, developers and suppliers of training materials and tools such as those for simulator training, and educational institutions such as technical schools and universities);
— International organizations that provide assistance to countries and nuclear facilities in enhancing safety, increasing efficiency and improving performance.

The main personnel from these organizations who would benefit from the use of this publication are:

— Management and supervisors responsible for the competence and qualification of their facility personnel;
— Training and human resource managers and specialists;
— Regulatory personnel.

The necessary involvement of various levels of management is discussed in detail. Therefore, this publication will be especially useful not only for training specialists but for corporate and nuclear facility managers — from the highest executive level to first level supervisors. Regulatory authorities will find in this report many updates regarding nuclear training practices that may be effectively used in national nuclear regulatory systems. Educational institutions and those in academia will find suggestions in this report for proactive cooperation and partnership with the industry for training. Facility vendors and providers of training services and training tools will learn more about the training considerations from the international community of end users to develop them as 'knowledgeable customers' in the training field.

2. NUCLEAR FACILITY TRAINING AS PART OF AN INTEGRATED MANAGEMENT SYSTEM

According to IAEA safety standards [3], a management system has to be used to provide a single framework for the arrangements and processes necessary to address all the goals of nuclear industry organizations, including safety, health, environmental, security, quality and economic elements, and other considerations such as social responsibility. The training and qualification of personnel in a nuclear facility needs to be viewed as one of the important supporting processes within the organization's overall management system and has to be fully integrated into this system. Ensuring the needed competence of personnel is an important objective of managing human resources at a nuclear facility and can be defined within the overall framework of the management system.

The organization needs to ensure that all personnel have the competencies needed to perform their assigned tasks by doing the following [2]:

— Recruiting individuals who have education, experience and qualifications suited to their jobs;
— Retaining individuals with attitudes and values appropriate to work in the nuclear industry;
— Providing initial training and qualification programmes based on job responsibilities that are systematically developed and implemented;
— Authorizing personnel for the unsupervised performance of tasks based upon the standards required for their jobs, supporting the safe and reliable operation of a nuclear facility;
— Providing refresher and continuing training programmes that ensure personnel maintain the competencies necessary for their jobs and are prepared to take on emerging tasks for unanticipated situations, as well as for potential advancement;
— Managing the training programmes to ensure that the facilities and human resources needed to maintain and implement the training programmes are available, and that the quality of training continues to provide value to the organization.

2.1. FORMALIZATION OF THE TRAINING PROCESS

It is a good practice — according to Ref. [2] — to establish a formal, procedure based personnel training model for the management and implementation of training as part of the facility's management system. Documents, information and knowledge management related to training have to be subject to the relevant overall policies of a nuclear facility and requirements established within a nuclear facility management system. Various methods can be used to evaluate training quality and effectiveness; data from self-assessments and independent reviews of the quality and sustainability of training programmes are particularly useful.

2.2. INTERFACES OF THE TRAINING PROCESS

Various interfaces with external organizations are helpful in developing, supporting and enhancing the training system of a nuclear facility. In addition to the statutory interface with the regulatory body in the area of training and qualification, interfaces and partnerships with the following entities are encouraged:

— High schools, universities and institutions providing basic knowledge and skills in technical and non-technical disciplines (e.g. any national apprenticeship training system);
— Nuclear specific national training organizations, facility/equipment vendors;
— External national training organizations (including centralized training organizations/centres);

— Technical support organizations;
— International organizations such as the IAEA, Institute of Nuclear Power Operations and World Association of Nuclear Operators (WANO);
— Training and educational associations and networks;
— Other industries with high standards in personnel training and qualification such as the aviation and petrochemical industries.

The internal interfaces need to ensure full alignment of the training process with other processes in the facility's management system and have to prevent the isolation of training from the facility's needs, inputs, feedback, and management support.

2.3. ROLE OF GOVERNMENT AND REGULATORY BODIES

Although the prime responsibility for the safe operation of a nuclear facility, and hence the qualification and competence of its staff, rests with the operating organization, both governments and regulatory bodies have important and complementary roles to play in the process.

One of the key roles of government is to create a framework including the necessary legal requirements to ensure the competence of all parties having responsibilities related to the safety of facilities and activities [4]. The government is responsible for the development of the national policy and strategy for safety, which, in turn, influences the training necessary to maintain the competence of sufficient suitably qualified and experienced personnel (SQEP). An important first step in determining the required content of training programmes is to specify the entry level requirements, based on national standards and requirements.

Another important role of government is to ensure that the national system of higher education institutes (HEIs) is both comprehensive and of a sufficiently high quality to produce suitable candidates for recruitment into the nuclear industry. The level of active support needed from government will vary from country to country and, for countries with well developed nuclear programmes, may be minimal. However, for countries embarking on nuclear power generation for the first time, significant development of the educational infrastructure may be needed. This has to be considered as part of the government's broader workforce planning strategy [5], which needs to address not only the staffing of the various organizations involved, but the development of the education and training infrastructure. In this context it has to be emphasized that the 'technical' school system is just as important as the university system, since a large number of staff working in nuclear facilities will come from this sector.

The role of the regulator in the licensing of a nuclear facility is to satisfy itself that the operating organization has put in place appropriate arrangements to ensure that all the staff, including contractors of the nuclear facility, are competent and qualified to carry out the roles, responsibilities, tasks and activities assigned to them [4]. A typical example of this is the requirement that control room reactor operators and their supervisors be formally licensed or authorized to carry out their duties. The SAT process provides a mechanism to demonstrate and document that personnel are competent. The SAT process and methodology are used by many regulators as a basis for the evaluation of training programmes. It is therefore desirable that the operating organization share its SAT arrangements openly with the regulator and encourage dialogue between the two parties. This will contribute to a shared understanding of the arrangements, process and goals of the SAT programmes, allow for feedback from the regulator, as appropriate, and provide for improvements to the programmes accordingly.

The direct involvement of the regulator in the SAT process varies from country to country. Taking, again, the example of the control room reactor operator position, in some countries the regulator is involved in specifying the training content as well as the process and practice for examining trainees prior to granting a licence; indeed, the regulator itself may conduct the actual licensing test. In other cases, especially when the SAT process is well established and proven, the regulator may formally approve the training and authorization process but not get directly involved in licensing or authorizing individuals.

However, even in these cases, the operating organization needs to encourage representatives of the regulatory body to observe all aspects of the training process, including assessment and authorization, and raise any questions/concerns they have with training and/or facility management.

3. THE RELATIONSHIPS BETWEEN NUCLEAR INDUSTRY, EDUCATIONAL INSTITUTIONS AND TRAINING SYSTEMS

The complexity of the work and diversity of the workforce in the nuclear industry requires that all workers continuously have access to, and engage with, the appropriate level of education and training needed to competently perform their work. The level and type of work will determine the amount of training and education required for each worker. Training and education are also required to enable new technologies and techniques to be learned. Non-nuclear specialists working in the industry also need some specialized nuclear training and education. To achieve a cohesive workforce that shares the same goals of success and safety required in the nuclear industry, a rigorous educational and training process has to be in place to provide the necessary skilled employees. To achieve this goal, educational institutions, including colleges, technical schools and universities, need to provide an ongoing and sustainable pipeline of individuals educated in the sciences and mathematics necessary to be successful in the industry. Furthermore, those institutions need to provide individuals grounded in business management and leadership skills, with a strong emphasis on ethical behaviour.

A strong and close relationship exists out of necessity between the nuclear industry and both the educational and training systems. Educational institutions need a steady flow of new students and funding, and the industry needs a constant influx of well educated, trained and skilled personnel for the various facilities. This requires good points of contact with strong feedback mechanisms between educational institutions and the industry and its training organizations.

The conceptual differences between education and training are important. Education encompasses the need to maintain completeness and continuity of knowledge. It is essentially a knowledge driven process, usually involving academic or other educational institutions as suppliers, and students as customers. Training is generally understood to refer to learning of skill, information or attitude which, applied with the requisite knowledge, will deliver the required result. Training is essentially an application driven process, primarily involving training organizations as suppliers, which can also be HEIs, and workers as customers.

3.1. FORMS OF COOPERATION

To strengthen the ties between the industry and educational institutions, a number of initiatives may be implemented, such as the following:

— Establishing strategies that benefit both parties, such as demonstrating how providing education and meaningful training benefits the industry and provides HEIs with a steady stream of customers;
— Funding chairs within cooperating HEIs;
— Adding industry specialists to the pool of teachers to share their knowledge with the industry learners as well as with the general student body;

— Establishing campus clubs or organizations geared towards the industry that would publish material highlighting the many benefits of working in the industry and organize field trips to various nuclear sites as well as facilitating internships which could lead to long term employment;
— Collaborating with industry through student internships as part of the curricula;
— Creating an external advisory board of representatives from industry that can advise on the content and structure of the programme;
— Acquiring equipment similar to that used in industry, to the extent possible, to improve educational programmes.

The link between industry and learning institutions may be most effective if it is not concentrated on only higher levels of education, but at all levels from secondary school to the doctoral level. This link between education and industry needs to not be viewed as a short term initiative, but as an ongoing process that requires long term planning, implementation and evaluation. Entire curricula need to be developed, courses planned and developed, and effective instructors hired to lead the learning process.

3.2. BENEFITS OF COOPERATION

Close cooperation between industry, universities and government has been recognized by most countries as a vital factor in improving nuclear education and in attracting young talent [6]. The communication between academia and industry benefits both partners in several ways:

— The knowledge and skills of people graduating from university can be better matched to the needs of the industry, allowing industrial training to be more focused on specific industry needs.
— During a dialogue between academia and industry, the possible areas of cooperation can be better defined. This cooperation can manifest itself in such industry actions as student placements, joint research projects and visiting professors, and by providing advisory information to university staff who design and teach the curriculum.
— Collaboration with industry can bring additional, very valuable resources to the university in the form of donated equipment, contributions of time by industrial personnel to help with teaching, and in some cases, funds that allow the university to make investments in items such as new equipment.

The development of reference curricula for education and training in key nuclear areas, at a national, regional and international level, will facilitate the mutual recognition of credits, degrees and qualifications. In some countries, training organizations representing the entire nuclear community have collaboratively produced a unified curriculum which is being used to both educate and train potential nuclear workers. Partnerships between the nuclear industry and educational institutions can be formed to improve the national educational infrastructure in science and technology and to provide qualified workers for nuclear facilities. Formal partnerships can be utilized to form joint technical training and qualification programmes that become part of the nuclear facility's staffing pipeline.

3.3. ROLE OF GOVERNMENT IN THE RELATIONSHIP BETWEEN EDUCATION AND INDUSTRY

Governments can act to support certain areas of research and education by making funds available via research initiatives or government departments. Government funding of HEIs also allows educational courses to be established and maintained.

In some areas of nuclear technology, a level of understanding is required that is only available via tertiary education beyond HEIs. As nuclear technology is utilized in the power sector, as well as in areas such as medicine, industry and agriculture, it is vital that governments support nuclear education at HEIs.

The safe and efficient use of nuclear technology requires a certain number of experts in nuclear specific areas — for example, in nuclear reactor engineering, reactor physics, health physics, radiochemistry, nuclear materials, nuclear instrumentation and controls, radiation detection and radiation protection. The required number of experts in these disciplines may be small but the government has a role to play in maintaining educational provisions to ensure continuity in the supply of qualified nuclear specialists.

The nuclear industry does not always recognize the important role it has in supporting nuclear education within HEIs. There are two common reasons for this put forward by industry:

— Industry considers education to be wholly the responsibility of government.
— Industry provides in-house training for its workers and therefore does not see the value in engaging with the HEI sector.

This denies industry the following advantages of collaborating with universities:

— Industry can provide scholarships for students studying nuclear subjects. This motivates the best students to choose nuclear options and establishes early contact between the students and industry.
— Students can apply for an internship and get hands-on experience with a nuclear company, possibly at a nuclear licensed facility, or they can be assigned diploma work which requires industry involvement.
— Implicit and tacit knowledge can be transferred when practising professionals participate in the development and delivery of courses and lectures, sometimes as visiting professors/lecturers/researchers.
— Educational upgrades can be made available to industry employees via HEIs (e.g. short courses or day release courses for continuous professional development or part time study towards a formal qualification).

Educational institutions can gain much from effective interaction with industry, such as the following:

— Industry input into discussions on programme/course curricula.
— Industry contact/experience for lecturers to enhance their understanding of the industry.
— Network development, which can be exploited to do the following:
    • Find placements for students;
    • Receive support for research;
    • Obtain financial support, training tools, teaching materials and aids;
    • Use industry facilities to provide practical education.
— Industry operating experience needed not only for improvement/relevance of the education technical content, but also for developing knowledge management and cultivating positive attitudes.
— Quality and credibility increases to education through involvement of highly competent professionals and managers as visiting lecturers.
— Industry experience in the use of proven and effective training methodologies such as SAT.

4. ROLES OF MANAGERS AND LEADERS IN TRAINING

This section primarily describes managers' and leaders' responsibilities for ensuring that training is used as a tool for continuous performance improvement. It describes the roles and responsibilities of all levels of managers for the training and competence development of facility personnel.

4.1. LEVELS OF MANAGEMENT AND LEADERSHIP

In most nuclear facilities there are generally three levels of management and leadership: corporate/executive managers, senior managers, and first level managers/supervisors. The functions at each level are addressed in the following subsections.

In this publication, middle level management is not defined specifically. The particular organizational structure of a nuclear facility and its number of management levels depend upon many factors, including the size of the organization and applicable industry regulations. Also, the term 'line manager' is used in this publication for identification of any manager, leader or supervisor in an organization's structure. This term is used typically to identify a 'line' for various functional areas such as operation, maintenance, or engineering and technical support.

4.1.1. Corporate/executive managers

Corporate/executive managers have policy making functions which include the following:

— Setting strategic goals and objectives;
— Developing long term plans which establish policy for nuclear safety;
— Sustaining quality and business performance;
— Allocating financial and human resources;
— Approving the content of management and leadership training programmes;
— Integrating training policy into the overall human resources strategy;
— Setting policies that affect the safety culture;
— Establishing a programme to make the necessary changes to any of these functions, based on prior performance in achieving defined objectives.

4.1.2. Senior managers

Senior managers include the facility manager, training manager and site department (or functional area) manager(s) leading those who have direct influence on operation and support and training activities. Senior managers have execution and control functions which include the following:

— Implementing policies of the operating organization related to safety, quality, performance, human resources and training;
— Establishing and perpetuating a strong safety culture through their management and leadership practices;
— Controlling and verifying safety related activities.

4.1.3. First level managers/supervisors

Typical functions of first level managers include shift supervisors, maintenance supervisors and technical group heads. These managers have an important influence on the behaviour of staff under their supervision and have unique insight regarding the strengths and weaknesses of personnel performance. First level managers and supervisors are responsible for the safety, quality, performance and training of all personnel under their supervision and leadership.

4.1.4. Roles and responsibilities of corporate/executive managers and leaders related to training and qualification

The corporate managers and leaders of the operating organization are responsible for establishing and promoting an overall training policy addressing the training, qualifications and performance of their

own personnel. They are also responsible for qualification requirements and contractual performance criteria of contractor personnel and need to have a basic understanding of the SAT approach and its benefit for the organization, including its contribution towards continuing performance improvement.

Following the integrated management approach, the policy related to training and qualification needs to be consistent with the other management system elements and the goals and objectives described by the company.

Corporate managers and leaders are responsible for ensuring the financial and organizational means to fulfil the facility personnel training goals in an efficient and effective manner. They have to ensure that the necessary resources such as training facilities, training material and instructors are of adequate quality and are readily available. In particular, they have to ensure that sufficient resources are available to enable the release of staff members to attend their required training activities.

The operating organization is responsible for the recruitment and training of facility personnel and for the definition of competence levels for all work positions. Only qualified persons with appropriate attitudes shall be entrusted with functions important to safety. These functions and the related duties and responsibilities shall be clearly indicated in the management system documentation of the operating organization. The responsibility for ensuring that individuals are appropriately qualified and maintain their qualifications rests with the operating organization.

To maximize the cost benefit of training, organizational arrangements have to be implemented to verify the training effectiveness in terms of the impact of training on individual performance as well as on the company's safety and business performance. To support management attention to and oversight of training activities, and to continuously identify possible strengths and weaknesses, corporate managers and leaders have to implement a suitable reporting system. As part of the integrated management system activities, it is good practice for corporate managers and leaders to be involved in the self-assessments and support the implementation of external reviews of the training programmes and processes.

Organizations responsible for operating several facilities may consider the option to establish a centralized training function to support and standardize training activities, on-site and in the field, and to ensure that training and qualification standards are met as defined in the training policy. Often such centralized training functions support the facilities with standardized basic training programmes and modules. These functions may also participate in the training evaluation activities to disseminate lessons learned and good practices (see Annex I).

4.1.5. Roles and responsibilities of facility managers, directors and vice presidents related to training and qualification

The facility manager has the overall responsibility for and plays an important role in the development and implementation of training programmes to ensure the competence and qualification of the facility personnel. In general, regulators hold facility managers and leaders accountable for discharging these responsibilities.

These responsibilities include the following:

— Establishing qualification requirements;
— Implementing a SAT based training system to ensure and maintain a high level of personnel knowledge, skills and performance;
— Meeting regulatory requirements;
— Providing necessary resources;
— Monitoring training programmes;
— Maintaining competence;
— Establishing a mechanism for evaluating training effectiveness;
— Establishing effective human resources management, including the related policies.

These responsibilities are at a strategic level and are often discharged through training consultation forums and committee structures. There are various training consultation forums and committee structures in place around the world, usually consisting of two to three different levels. However, a good practice is for the structure to include one high level committee at the facility level, led by the most senior facility manager. This forum or committee needs to provide strategic management direction, oversight and advice to ensure appropriate planning, implementation and maintenance of the facility training programmes.

The following responsibilities are typically assigned to facility managers and leaders:

— Define and assign responsibilities and authorities to all facility organizational units which report directly to the facility manager, including responsibilities for training and qualification of facility personnel;
— Establish appropriate qualification requirements and standards of performance for all facility jobs;
— Meet relevant regulatory requirements;
— Ensure that identified performance weaknesses are incorporated into the corrective action programme;
— Monitor, evaluate and control performance of all facility activities, including those related to training and qualification;
— Provide or arrange for the necessary resources and staff to implement training policy and programmes, including the adequate training and continuing competency of instructors;
— Maintain personnel competence, through continuing training and knowledge management;
— Ensure that individuals accept responsibility for their own competence and professional development.

4.1.6. Roles and responsibilities of other senior managers and leaders related to training and qualification

The facility manager is ultimately responsible for facility personnel qualification and performance; however, many training and qualification related responsibilities will be formally delegated to facility department managers, who will be held accountable. Department managers are usually the ‘training programme owners.’ This includes the responsibility for ensuring job descriptions are updated for all positions within their departmental areas, detailing responsibilities and the standards of performance for each position. These descriptions serve as a prerequisite to support the SAT activities.

The following responsibilities are typically assigned to other senior managers and leaders:

— Act as the overall training programme owner in their area of responsibility;
— Provide subject matter experts (SMEs) to assist in the SAT process;
— Approve the content and scheduling of all training programmes for facility personnel;
— Ensure that trainees attend scheduled training sessions and make up missed training in a timely manner;
— Assist in the implementation of training by providing the training department with qualified SMEs, on the job training (OJT) instructors and OJT assessors within their area of responsibility;
— Ensure, in close cooperation with the training organization, that their personnel are provided with all training needed for their job assignments and approve final decisions on the qualification of their personnel;
— Ensure the adequacy of the trainee performance and personnel competence assessment;
— Approve job assignments based upon successful completion of required training and attainment of the required qualifications;
— Observe training regularly and provide constructive feedback;
— Monitor and evaluate the performance of training programmes and their effectiveness based on systematic evaluation of individual and facility safety and business performance;
— Ensure instructor and trainee performance is directed towards the goal of achieving improved performance;
— Implement knowledge management initiatives to maintain adequate specialized technical knowledge;

— Ensure that appropriate changes are made to training programmes when performance deficiencies are identified or organizational or job changes occur.

4.1.7. Roles and responsibilities of first level managers and supervisors related to training and qualification

First level managers and supervisors have the best insight into the effectiveness of training while directing, observing and controlling the job activities of their subordinates in the field. They have to ensure that the knowledge, skills and attitudes (KSAs) provided through training are used in the day to day activities. The use of these managers in identifying performance gaps, lack of required knowledge and other aspects of personal competence is highly important to the training improvement process. Often, these managers and supervisors support the SAT process as SMEs, as on the job instructors or as OJT assessors. A part of these responsibilities is often discharged within the training committees acting as the training expert.

The following responsibilities are typically assigned to first level managers and supervisors:

— Observe day to day activities of the personnel under their supervision and identify performance improvement opportunities;
— Verify through assessment of on the job performance of former trainees and during the pre-job briefings that their personnel have acquired the competence needed to perform their job assignments;
— Assist the training organization with technical expertise for all phases of the SAT (e.g. as an SME);
— Release trainees for scheduled training and ensure that missed training is undertaken in a timely manner;
— Support training and the consultation forums and committees as required;
— Participate in trainee performance assessment audits and activities;
— Take part in reviews and activities to evaluate training effectiveness;
— Take part in assessing the quality of services provided by internal and external training organizations;
— Participate in knowledge loss risk assessment activities, identify key SMEs and activate a mentoring programme when it is needed.

4.1.8. Roles and responsibilities of the training manager

The facility training manager has to assist facility managers in carrying out their responsibilities for establishing and disseminating policies and procedures concerning facility personnel training and qualification. These policies and procedures are part of the facility management system documentation hierarchy. This makes it clear to facility department managers that these policies and procedures apply to their departments and that the procedures have the full support of the facility manager. In organizations operating several facilities, training policies and procedures may be directed at the organization at a corporate level to maintain a level standard across all facilities. In this case, the facility training manager has to ensure that the general policy is adapted locally as required. The training manager is typically a member of the senior management team within a facility.

The following responsibilities are typically assigned to training managers:

— Act as the ‘primary conscience’ for the SAT implemented at the facility;
— Ensure the coordination of all training for facility personnel, including that provided by external sources;
— Support the implementation of facility training policies;
— Procure and maintain all training tools, equipment and materials, including simulators and mock-ups;
— Provide a programme for training and qualification of all instructors in technical and teaching abilities, including those who provide training in the facility;

— Ensure a programme of quality assurance for training programmes executed on a routine basis, for organizational, facility and contractor partner organizations;
— Provide periodic reports to the facility manager, facility department managers and training committees on the results of the evaluation of training effectiveness;
— Maintain records on the training and qualification of all facility personnel;
— Ensure that quality assurance audits on contractor personnel training and qualification are performed as required to meet the facility requirements;
— Oversee and review the results of self-assessments and external reviews for the training department, particular training programmes and the entire training system;
— Be accountable for the corrective actions assigned to the training department;
— Ensure the incorporation of relevant operating experience and human factors elements into training programmes;
— Implement knowledge management initiatives to preserve critical knowledge with other senior managers.

4.1.9. Interfaces between senior managers and training organizations

Training organizations provide a service to facility departments and need to be responsive to the needs of the facility. The relevant individuals in facility departments and training organizations need to establish communication mechanisms that ensure they maintain close contact and cooperation with line organizations.

A healthy training consultation process, such as training forums and/or committee structures owned and run by the line management, supports the interface between the line and the training organization. It is expected that the training organization will be represented at all relevant training forums and committees to provide expert advice and guidance as appropriate. The assignment of responsibilities and duties between the training organization and the facility has to be clearly identified and described, based upon the facility management system's procedures.

It is important that instructors maintain their technical knowledge by regular participation in work activities at the facility to ensure they maintain credibility with trainees and facility personnel. For example, at some facilities, during plant refuelling and maintenance outages, certain training activities are suspended (e.g. routine simulator training), and instructors are integrated into the appropriate facility departments. This is a good practice as it provides assistance to the facility while maintaining instructors' experience and competence and maintaining contacts with the line organization. However, for facilities that continuously have long outage periods, the organization has to be able to continue with training activities as required and other appropriate measures can be implemented to maintain instructors' technical knowledge (e.g. by delegating them to departments regularly).

5. TRAINING POLICY

It is good practice for the operating organization to formulate and promote a training policy dealing with the training, competence, qualification and performance of facility personnel. This policy is the commitment by the operating organization and the facility to personnel training and acknowledges the importance of training to support and enhance the safe and reliable operation and maintenance of the facility [7].

5.1. GOALS, SCOPE AND PURPOSE OF THE TRAINING POLICY

A training policy includes the organization's vision for training and its role in supporting safe and reliable facility operation via the continuous development of the KSAs of its employees. It provides the organization with the training mission, the training philosophy and the strategy to achieve the expected outcome.

The training policy will need to be adapted and shaped to suit the characteristics of a country's national and regional education and training models. Within the policy, the operating organization has to clearly define the goals and scope of training and the roles and responsibilities for all aspects of the training process. This information on responsibilities has to be included not only in the training policy but also in the written procedures supporting the training approach. The descriptions will include personnel involved in training, from corporate and senior management to employees. Contractor employees have to be included to the same extent as facility employees.

Different nuclear facilities may have different requirements for their training programmes, and these differences need to be reflected in the training policy. For example, some facilities rely almost entirely on their own employees for the performance of all maintenance, including outages, while other facilities routinely use outside contractors. Those facilities that make use of such contractors need to specify in their training policies how the quality of outside contractors' work and their qualifications will be ensured.

The training policy needs to be based upon the longer term needs and goals of the facility and support the facility's performance improvement policy. The policy has to be evaluated at regular intervals to ensure that it is consistent with current needs and goals. Factors which can change a training policy include: company or facility reorganization, operating experience and events at the facilities of the operating organization or at other facilities, significant upgrading or refurbishment of the facility, commissioning or decommissioning of a facility, changes to the national education/training system, and regulatory requirements.

It is important for the training policy to be known, understood and supported by all persons concerned. It is beneficial to have facility department managers and the facility training manager take part in developing the training policy and implementation procedures as a way of facilitating their acceptance of the policy (see Annex II).

5.2. TRAINING PROCEDURES

There is a need to support the implementation of the training system with procedures. The procedures would typically cover all aspects of the training system and need to be consistent with the goals and objectives stated in the training policy. Procedures assist staff members in their execution of the different training related activities and ensure that the implementation is done in a consistent way throughout the organization.

Typically, training procedures would include details on the following aspects:

— Overall organization of training;
— Performance requirements of the training organization;
— Organization and performance of training committees;
— Quality management of training, as part of an integrated management system;
— Execution of each of the SAT phases;
— Qualification of instructors;
— Installation and maintenance of training facilities;
— Preparation of training programme descriptions;
— Organization of OJT, related assessment of trainee performance, and task performance evaluation;

— Guidance on conducting training evaluation and self-assessments, and dealing with training performance issues;
— Requirements and methods for maintaining training records.

Training procedures detailing the performance of all SAT phases are an important part of training documentation. These detailed procedures have to define the entire SAT process, and need to include, in particular, process flow charts, checklists, templates, worksheets and other job aids.

5.3. SELECTION AND RECRUITMENT

The selection, recruitment and training policies need to be established with a view towards long term return on investment and the assumption of job stability within the operating organization. Therefore, selection, recruitment and training need to be coordinated to ensure that, collectively, facility personnel have the KSAs needed to attain the organization's goals and that they are able to adapt to new technologies and new requirements.

5.4. RELATIONSHIP BETWEEN TRAINING AND KNOWLEDGE MANAGEMENT

Knowledge management is an integrated, systematic approach to identifying, acquiring, transforming, developing, disseminating, using, sharing and preserving knowledge relevant to achieving specified objectives. Without an appropriate training system, any knowledge management process will suffer. Training is one of the key methods to prevent the loss of critical knowledge by nuclear facilities. Considering this role, development of the training system has to consider all the training related needs of knowledge management and there needs to be a close linkage between the two processes.

Experience has shown that operating organizations often underestimate the time required for the transfer of knowledge and experience from specialist staff to new incumbents. This transfer can require several years to be effective. Not providing a suitable overlap of experienced specialists and new incumbents could potentially result in significant loss of knowledge and experience.

6. TRAINING CONSULTATION FORUMS AND COMMITTEES

Consultation, discussions and cooperation between the line organizations, the training function, managers and the workforce are essential elements of effective SAT. It is common practice to achieve this using training consultation forums and committee structures. These are excellent mechanisms to involve senior and first level managers and leaders as well as SMEs in training activities and to strengthen manager and other staff ownership for personnel competence, training and qualification. The key responsibilities of the forums and committees are the following:

— Act as the focal point for the training programmes specific to their representative work group or department or function;
— Collect and analyse nuclear facility performance information to evaluate the effectiveness of training;
— Meet routinely to formulate advice needed to improve the effectiveness of training;
— Verify that recurring training problems are identified, and preventive measures are planned and implemented.

6.1. LEVELS OF TRAINING FORUMS AND COMMITTEES

Training forums, also referred to as training committees in this publication, are typically established at three levels at a nuclear facility: strategic, department and curriculum.

A strategic level training committee takes a strategic view of the ongoing and future training requirements and deliverables. Chaired by the senior manager at the facility, it will include all the relevant department managers and senior training personnel.

The second (department) level training committees review the training and qualification aspects for a particular department or category of personnel, including the following:

— Operations staff;
— Maintenance personnel;
— Engineering and technical support personnel;
— Training and qualification of managers and leaders (in terms of management competences);
— General facility staff;
— Training staff.

The third (curriculum) level training committee is functional at the work group level for specific departments and reviews the ongoing training curricula, activities and programmes, while receiving feedback from the workforce regarding opportunities to use training for improving their performance and the team performance.

The guidance and advice provided above are suitable for large nuclear facilities. For smaller facilities, variations of the above structure may be more appropriate. Whichever structure is selected by a facility, it will be important to include the ability to maintain strategic oversight of the training and qualification status of employees and supporting contractor personnel, and a routine review of the ongoing training programmes. The link between training as a performance improvement tool and the safety and efficiency of the facility performance has to be a common theme running through the meeting discussions. In some cases, it may be appropriate to establish a single training committee for the entire nuclear facility, or to consider assigning the function of a training committee to another already established facility entity like a facility safety committee or senior management meeting. The descriptions, duties and tasks for the three levels of training committee are presented in Table 1.

Training is only one part of the process of producing competent personnel and needs to be supported by appropriate experience in the workplace. This is demonstrated by the authorization and licensing processes used in many countries. Trainees undertake training programmes and then spend a period of time gaining experience in the workplace, usually under some form of supervision, before their competence is assessed, and they are authorized to independently perform tasks and deemed to be competent.

TABLE 1. TYPICAL MEMBERSHIP, ROLE AND RESPONSIBILITIES OF FACILITY TRAINING COMMITTEES

	Strategic level training committee	Second level training committee	Third level training committee
Chairperson	Senior facility manager	Department manager	Work group manager or supervisor
Participants	Facility work group/ department managers, for example: Production/operations department manager or	Responsibility for establishing the training committee resides with the facility manager and could include the following: Selected deputies to the work	The following personnel need to be involved in the third level training committee working activities and are invited to the meetings as necessary:

TABLE 1. TYPICAL MEMBERSHIP, ROLE AND RESPONSIBILITIES OF FACILITY TRAINING COMMITTEES (cont.)

	Strategic level training committee	Second level training committee	Third level training committee
	vice chairperson Engineering department manager Site nuclear service manager (or safety department manager) Technical department manager Maintenance department manager Chemistry department manager Health physics (radiation protection) department manager Training department manager (training centre manager) Nuclear oversight/site quality assurance manager	group (or department) managers Selected first level managers Selected experienced job incumbents Training manager(s)/ supervisor(s) responsible for the work group (or department) personnel training programmes	Instructors and OJT[a] coordinators First level managers and supervisors Job incumbents (inexperienced job incumbents may be utilized as well as experienced job incumbents to provide insight and challenge assumptions)
Tasks	Maintain a strategic focus on the training and qualification requirements of the facility to meet the business plan objectives Review feedback from the department level training committees on the overall training effectiveness of the facility personnel training with a particular focus on the business plan performance indicators Review the qualification requirements and status of actual competence of all site personnel Review the relevant facility training feedback reports, and adopt necessary decisions regarding the corrective and preventive actions Consider the results of training needs analyses, evaluate the problems and barriers, review and approve the training related advice and other management initiatives suggested through the needs analyses	Review the overall training effectiveness of the work group/ department personnel training based on the department business plan objectives Review feedback from the curriculum level training committees on the overall training effectiveness of the facility personnel training with a particular focus on the business plan performance indicators Review the qualification requirements and status of actual competence of the work group/ department personnel Initiate and review post-course evaluations Review planned changes in the facility (procedures, job scope, equipment, organizational structure) for potential training implications Review operational experience feedback, including in-facility and industry experience (with WANO[b] information, for the NPPs[c]) to identify possible training implications/omissions	Identify, as necessary, any new or changing training needs or initiate additional training based on identified needs Identify any specific training needs of the work group/ department job classifications based on planned changes in the facility (procedures, job scope, equipment, organizational structure) Review and identify operational experience feedback, including in-facility and industry experience (with WANO[b] information, for the NPPs[c]) to identify possible training implications/omissions Review the work group/ department personnel task lists where appropriate to ensure accuracy of tasks required for training Provide feedback to the department training committee on any aspects of initial or continuing training that may support performance improvement opportunities

TABLE 1. TYPICAL MEMBERSHIP, ROLE AND RESPONSIBILITIES OF FACILITY TRAINING COMMITTEES (cont.)

	Strategic level training committee	Second level training committee	Third level training committee
	Evaluate and reinforce the involvement of facility line managers in support of training needs and processes Review and facilitate feedback from the facility to the training department and from the training department to the facility	Review, as necessary, specific training needs analysis records or even initiate additional training needs assessment based on feedback from the curriculum review committees	
Tasks	When necessary, initiate a comprehensive evaluation of the entire training system Identify the actions and commit necessary resources to maintain the quality and effectiveness of the personnel training Monitor and track the completion of identified actions	Review the specific training needs of the work group/ department job classifications Every quarter, review training evaluation reports (checklists), and unsolicited feedback from employees and from the curriculum review committees Review and instigate, as necessary, corrective and preventive actions Evaluate and reinforce the involvement of the work group/ department first level managers in support of training needs and processes Lead department specific self-assessment reviews of the training programmes with regard to personnel training Communicate relevant information to the facility senior managers and to the facility training committee	
Typical frequency of meetings	Every six months, unless senior facility management specifies more frequently	Quarterly, unless department management specifies more frequently	Quarterly, unless work group management specifies more frequently
Organization of training committee meetings	Identify persons responsible for organization of training committee work activities and meetings Prepare annual plans for the training committee meetings and have them approved by the training committee chairperson Prepare agenda for a training committee meeting and have it authorized by the training committee chairperson and submitted to the training committee members and other meeting participants in sufficient time to allow attendees to read the meeting material Complete the record of minutes of the training committee meeting, attach necessary materials, obtain the approval of the training committee chairperson and submit the original to the training group with copies to all training committee members		

[a] OJT: on the job training.
[b] WANO: World Association of Nuclear Operators.
[c] NPP: nuclear power plant.

7. SAT PHASES AND PROCESS

SAT consists of the following five interrelated phases (see Fig. 1):

— *Analysis*: This phase comprises the identification of training needs, tasks or competencies selected for training, and KSAs required to perform a particular job.
— *Design*: In this phase, training objectives derived from the training requirements identified during the analysis phase are developed, questions to assess achievement of training objectives are developed and training objectives are organized into a training programme.
— *Development*: In this phase, training materials are prepared so that the training objectives can be achieved.
— *Implementation*: In this phase, training is delivered by using the training materials developed.
— *Evaluation*: During this phase all aspects of training effectiveness of both training programme and training system are evaluated, followed by feedback leading to training and facility performance improvements.

7.1. INTEGRATION OF SAT BASED TRAINING AND NUCLEAR FACILITY PERFORMANCE IMPROVEMENT

Performance improvement and SAT have common origins. In particular, the evaluation phase of SAT and the associated feedback loop have much the same focus and objectives as a performance improvement model. Evaluation of training has to be conducted to improve training programmes and performance. Evaluation needs to be continually and systematically undertaken to determine the effectiveness of training programmes in producing competent employees that are necessary to achieve the organization's mission, goals and objectives.

Managers of nuclear facilities need to embrace their roles in evaluating training to improve its effectiveness in the same way as they need to embrace facility performance improvement. They are responsible for the behaviours of their employees and for the outcome of those behaviours.

7.2. INITIAL AND CONTINUING TRAINING PROGRAMMES

Training of personnel comprises initial training and continuing training. Initial training needs to be provided to workers before they are assigned to a position, job or task within a nuclear facility. The goal of continuing training is to maintain and enhance the performance level of nuclear facility personnel.

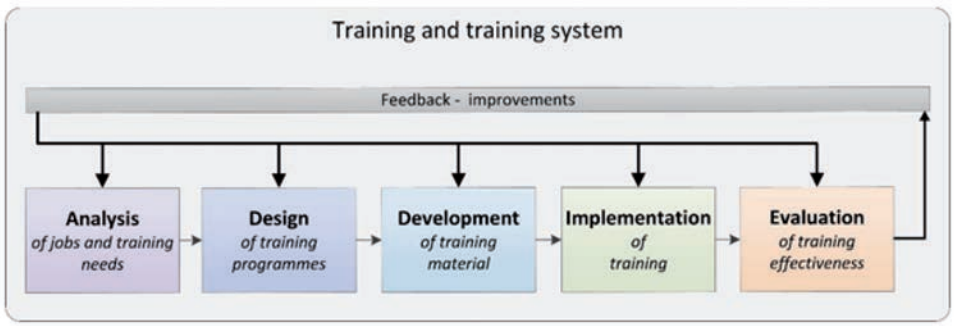

FIG. 1. Overview of the SAT process.

Continuing training has to be undertaken for identified persons throughout their working life as it is necessary to ensure that their KSAs are maintained and current in both theory and practice.

7.3. INCORPORATING OPERATING EXPERIENCE

Incorporating operating experience in the training content and the adequate conduct of training on operating experience in both initial and continuing training programmes are important to ensure lessons learned from other nuclear establishments and facilities are disseminated. The incorporation of the operating experience can be used to improve the quality and capability of the ongoing training programmes and activities (see Fig. 2). Training on operating experience, including human factor errors, needs to promote understanding and analysis of the events, stressing the root causes and corrective/preventive actions needed for the nuclear facility, including an understanding of how this influences safety culture.

7.4. BENEFITS OF USING SAT

The most significant benefits from deploying SAT are ensuring both the quality and the relevance of training. These make a significant contribution to the safety and efficiency of nuclear facilities. Some key identified benefits include the following:

— Real training needs are identified and the corresponding training is delivered to the facility personnel.
— A consistent mechanism for development of competent personnel to a required standard is established.
— Competencies and criteria to assess trainee performance are developed and approved by facility managers.
— Clear requirements for personnel qualification are established.

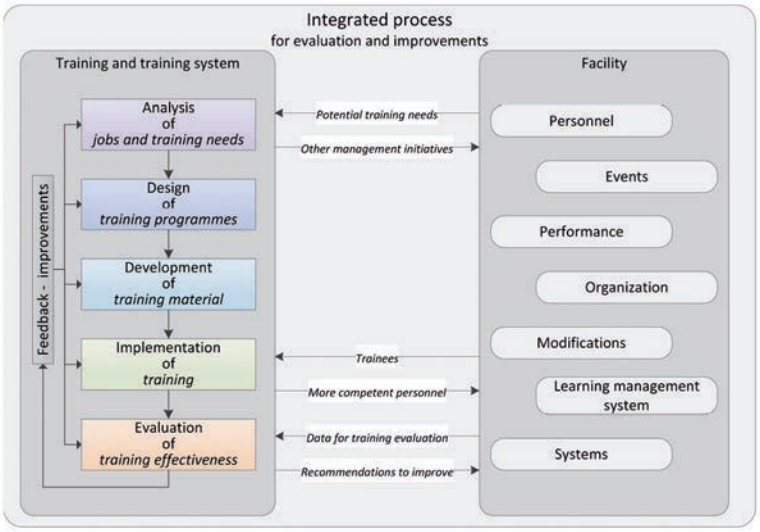

FIG. 2. Integration of training for nuclear facility performance improvement.

— Training programmes, training facilities (including tools) and instructors correspond to the identified needs of the organization.
— Trainees know what to expect from training and how their performance will be assessed.
— The facility managers know what training is conducted for their personnel and what results and effectiveness are expected.
— Relationships between the managers and their staff are improved due to the improved communication, consultation and clarity on expectations for personnel performance.
— A sound basis for external review of a training system is provided (e.g. by a regulator or international organizations such as the IAEA, Institute of Nuclear Power Operations and World Association of Nuclear Operators).

7.5. ESSENTIAL ELEMENTS OF SAT

Experience with deploying SAT in nuclear facilities around the world has identified the following three essential elements of an effective SAT:

— Seeking performance improvement;
— Systematically derived initial and continuing training programmes;
— Consultation and involvement of managers, leaders and workers.

7.5.1. A goal of performance improvement

The primary focus of a SAT is to drive performance improvements in people and organizations. It is not specifically aimed at ensuring compliance, although the correct application of SAT would ensure all the necessary risk activities are identified through the analysis of training needs and included in any subsequent training programmes. These performance improvements seek to protect and enhance the nuclear safety margins established for the facility, as well as improve (facility) plant and personnel performance to support business profitability. It is important to effectively monitor the facility business indicators to track how effective the training is in improving safety and business profitability.

7.5.2. Systematically derived initial and continuing training programmes

In order to ensure a systematic approach in the training programme, the ADDIE cycle — analyse, design, develop, implement and evaluate — processes are undertaken by the facility line organizations with support from the training functions. In this respect the training function is effectively the custodian of the SAT and its role is to coach, guide, provide expert assistance and maintain an overview of how the line organizations are implementing the ADDIE model.

The training programmes themselves will support the needs of ‘task based’ workers such as field operations staff and maintenance technicians and ‘knowledge based’ workers such as systems or design engineers. In some cases, such as control room operators, the role will require a mix of task and knowledge based activities and the programme will need to be developed to cater for such requirements. By following a systematic and controlled series of training processes it is possible to maintain quality control over both the training programme content and curriculum and the standards of training delivery and effectiveness. It is good practice to formally review the training programme content and revise the curricula on an annual basis considering that any necessary new or additional learning materials can be incorporated. This will typically be reviewed and formally agreed at the relevant training forums or committees.

7.5.3. Consultation and involvement of managers, leaders and workers

The use of consultation forums and committees is arguably the most important element of a SAT. The direct involvement of managers, leaders and the workforce in the development and approval of training programme content ensures engagement and ownership of training and responsibility for performance of their teams and people. It enables workers to have a real and direct input into their professional and personal development by empowering them and recognizing their significant role in driving and delivering performance improvement. It also fosters the appropriate behaviours in the leaders and workforce — reinforcing self-improvement as part of the organization's nuclear safety.

7.6. CHALLENGES OF SAT — APPLYING A GRADED APPROACH

There are numerous training models deployed across the industrial world, all of which seek to ensure that employees are suitably qualified and experienced to carry out their work to a desired standard. The choice to use a SAT is based on the ability to identify the specific tasks and activities that can impact nuclear safety, specifically those tasks and activities that, if not conducted correctly, will have a direct impact on nuclear safety and reactivity controls. Training people is expensive and a significant business overhead. If not managed in the right way, it will become a cost burden that will add no safety or economic value to the business. In order to ensure a maximum return on this investment a graded approach to the implementation of a SAT is needed across the broad spectrum of positions, roles and responsibilities (see Fig. 3). This is a challenging process and will require the experience of training and line personnel who have been actively involved in implementing the SAT approach. Some roles and positions will require detailed and thorough implementation of all the ADDIE cycle stages; others will not. This graded approach needs to be based on consideration and weighing of the nuclear safety risks as a priority, in some circumstances followed by the commercial business risk to the facility.

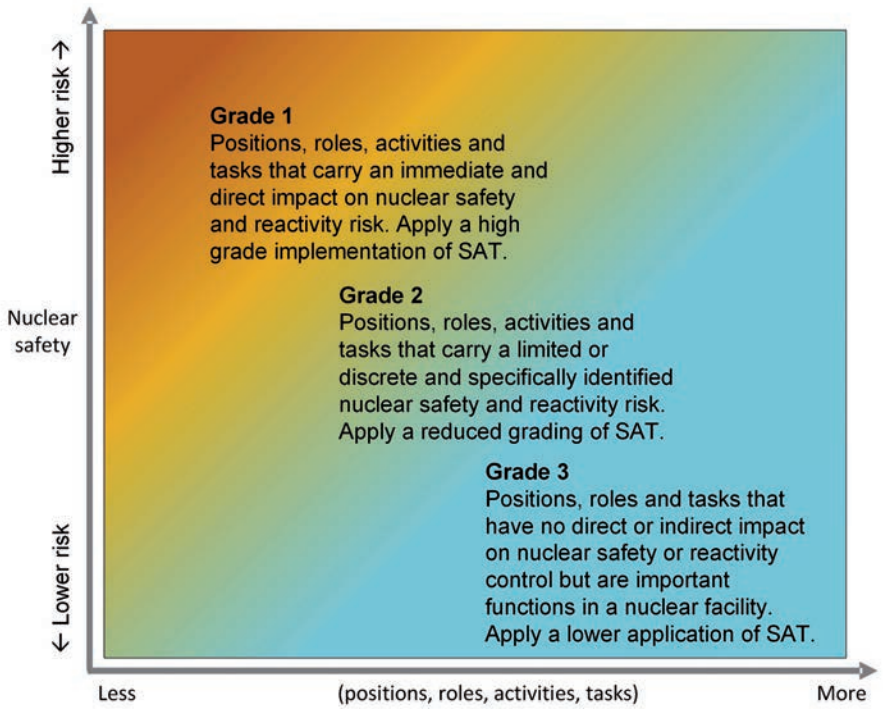

FIG. 3. Graded approach to SAT.

Prioritizing the roles and tasks to be trained into an order for a graded, gradual roll out means assessing each task and activity and assigning it a grade (priority) of 1, 2 or 3 based on the following:

— Its relative importance to safety, safeguards and security;
— The magnitude of any hazard involved;
— The life cycle stage of the facility;
— The mission of the facility;
— The particular characteristics of the facility;
— Other relevant factors.

The implementation of a SAT based approach requires ongoing commitment from the leaders, workers and instructors to keep the model running effectively. It requires expertise to support the ADDIE process, both from the instructors and the line organizations. The organization needs to understand the SAT and how it works to obtain a return on the investment required by the model. For all training programmes in a nuclear facility, it is good practice to have in place the three essential elements described in Section 7.5.

The level of implementation of the ADDIE cycle is the most challenging aspect of trying to determine how to structure implementation of the SAT approach (see Annex III). Section 7.6.4 summarizes examples of good practice for typical applications of the SAT for several roles and positions.

7.6.1. Graded approach — grade 1 roles

The first grade addresses predominantly ‘task based’ positions and roles with significant nuclear safety control responsibilities which have a direct and immediate impact on reactivity control. This includes operational department staff (main control room (MCR), field operators, etc.), maintenance technicians undertaking tasks such as instrumentation and control activities on the reactor control systems, and chemists who are involved in sampling and analysing primary reactor coolant systems.

Owing to the high level of nuclear safety risk attached to these activities, it is good practice to apply a ‘high grade’ of SAT (grade 1). This would include the following:

— A detailed job and task analysis (JTA) and/or job competency analysis (JCA) for all activities and tasks to identify nuclear safety impact potential and the requisite KSAs needed to ensure safe completion of the activity or task;
— Frequent (i.e. quarterly) training committee reviews and approval of the ongoing training programmes to ensure consistency and quality of the training programmes together with regular reviews of the effectiveness of the training in supporting performance improvement;
— Active involvement of line management in overseeing the training programmes to ensure quality, consistency and effectiveness.

7.6.2. Graded approach — grade 2 roles

Grade 2 includes positions, roles and activities that have a mix of task based and knowledge based requirements with significant nuclear safety responsibilities such as systems and maintenance engineering, nuclear engineering, technical support engineers and scientists, and roles that already have a professional knowledge centred qualification (i.e. BSc, BEng, MSc, PhD, etc.). It is good practice for training for such roles and tasks to include the following:

— A graded approach to SAT application in their respective training programmes, considering their pre-qualifying knowledge and the impact of the role or activity on reactivity control;
— An initial training programme designed to consider existing qualifications and knowledge;

— Where identified as necessary, a detailed JTA and/or JCA for the specific activities and tasks to identify nuclear safety impact potential and the requisite KSAs needed to ensure safe completion of the activity or task;
— Regular (i.e. every six months) training committee reviews and approval of the ongoing training programmes to ensure consistency and quality of the training programmes together with regular reviews of the effectiveness of the training in supporting performance improvement;
— Active line management involvement in the oversight of the training programmes to ensure quality, consistency and effectiveness.

For roles identified as not having a direct or immediate impact on nuclear safety or reactivity control, it may be appropriate to apply a limited job/role analysis based around a register of competent staff or SQEP rather than a full JTA.

It is appropriate to apply a reduced SAT grade (i.e. grade 2) to these positions, roles and activities based on the discrete and specifically identified nuclear safety and reactivity risk activities and tasks associated with these positions.

7.6.3. Graded approach — grade 3 roles

Grade 3 includes positions, roles and activities in nuclear facilities that have no direct or indirect impact on nuclear safety or reactivity control but remain important functions. These include finance, business support, human resources, stores, restaurant staff, some maintenance and engineering support services and some functions outside the nuclear island. These are roles that typically have a qualification centred on technical or professional knowledge (i.e. BSc, BA, diploma, associate degree, etc.). For these roles, it is good practice to apply a very limited SAT, particularly for activities that individuals are already pre-qualified to perform and are suitably qualified and experienced to carry out.

In these positions, roles and activities, it is appropriate and good practice to apply the following:

— Initial training programme designed to consider existing qualifications and knowledge;
— Annual training committee reviews and approval of the ongoing training programmes to ensure consistency and quality of the training programmes together with regular reviews of the effectiveness of the training in supporting performance improvement;
— Active line management involvement in the oversight of the training programmes to ensure quality, consistency and effectiveness.

For these roles and activities, which do not carry a direct or immediate nuclear safety related link, it would not be appropriate to carry out a full JTA and/or JCA similar to the MCR operator role. In most cases, a limited job/role/competency analysis based around a competency or SQEP register would be enough to determine the training needs. These roles and activities would typically require a very limited or reduced approach to the implementation of the full ADDIE cycle and would be subject to a lower SAT graded application (i.e. grade 3).

7.6.4. Implementing the graded approach

In deciding on the extent of implementation, it is important to consider the purpose of the training. Individuals need to be competent and suitably qualified and experienced to carry out their assigned tasks, and SAT is one way of achieving this. However, SAT is not necessarily the most appropriate training model for the full range of roles required to support a nuclear facility.

Table 2 gives examples of good practice for typical applications of the SAT for roles and positions.

TABLE 2. GRADED APPROACH TO SAT IMPLEMENTATION

High grade SAT implementation (grade 1)	Mid-grade SAT implementation (grade 2)	Low grade SAT implementation (grade 3)
Positions: Main control room operators, including reactor operators, senior reactor operators, shift supervisors and shift managers Field operators with roles/activities and tasks identified via a JTA[a] as having a direct nuclear safety or reactivity impact potential Maintenance and engineering roles/activities and tasks identified via a JTA[a] as having a direct nuclear safety or reactivity impact potential Maintenance instrumentation and control, electrical & mechanical technicians and craftspeople with roles/activities and tasks identified via a JTA[a] as having a direct nuclear safety or reactivity impact potential Chemists working on the primary circuit processes and associated equipment and plant Radiation protection personnel working on the primary circuit processes and associated equipment and plant	Positions: Systems and maintenance engineering Technical support engineers and scientists Procurement engineering Fire engineering Industrial safety engineering Field operators, chemists, radiation protection personnel with limited or no direct or indirect nuclear safety or reactivity impact potential Maintenance instrumentation and control, electrical and mechanical technicians and craftspeople with limited or no direct or indirect nuclear safety or reactivity impact potential	Positions: Finance and business support Human resources, stores, restaurant staff Maintenance, engineering and technical support service functions outside the nuclear island identified as having no direct or indirect nuclear safety or reactivity impact potential
A task to training matrix or equivalent to ensure all the difficulty, importance and frequency ratings for identified tasks are included in the initial and continuing training programmes (see Annex IV).	For specific activities and tasks that will have a nuclear safety or reactivity impact potential, a task to training matrix or equivalent to ensure all the difficulty, importance and frequency ratings for identified tasks are included in the initial and continuing training programmes. For other activities and tasks, a limited JCA[b] based around a competency or SQEP[c] register is used to determine the training needs.	
A detailed JTA[a] and/or JCA[b] for all activities and tasks is completed to identify nuclear safety impact potential and the requisite KSAs[d] needed to ensure safe completion of the activity or task.	Where identified as necessary, based on a review of pre-existing qualifications, experience and competencies together with the specific activities and tasks that will have a nuclear safety or reactivity impact potential, a detailed JTA[a] and/or JCA[b] is completed to identify the discrete KSAs[d] needed to ensure safe completion of the activity or task.	Where identified as necessary, based on a review of pre-existing qualifications, experience and competencies, a limited JCA[b] based around a competency or SQEP[c] register is completed to determine the training needs.

TABLE 2. GRADED APPROACH TO SAT IMPLEMENTATION (cont.)

High grade SAT implementation (grade 1)	Mid-grade SAT implementation (grade 2)	Low grade SAT implementation (grade 3)
Create a register of roles, activities and tasks that require formal authorization, licensing or permission for individuals to carry out work independently.		
Regular routine reviews of the effectiveness of the training in supporting performance improvement are conducted by the relevant committee.		
Active line management involvement in the oversight of the training programmes is needed to ensure quality, consistency and effectiveness.		
A continuing training programme is put in place and approved by the relevant committee.		
An initial training programme is put in place and approved by the relevant committee.	An initial training programme is designed to take into account existing qualifications and knowledge, approved by the relevant committee.	
Training forums/committees are in place and active, typically meeting every three to six months.		Training forums/committees are in place and active, typically meeting every 6 to 12 months.

[a] JTA: job and task analysis.
[b] JCA: job competency analysis.
[c] SQEP: suitably qualified and experienced personnel.
[d] KSAs: knowledge, skills and attitudes.

8. SAT IN DEPTH — ANALYSIS PHASE

8.1. OVERVIEW OF THE ANALYSIS PHASE

The analysis phase comprises the identification of job specific tasks and/or competencies selected for training and the KSAs required to perform a particular job (see Fig. 4). New training programmes begin with the analysis phase and proceed through the other phases. Mature programmes commonly use the analysis phase as part of the revision process to maintain and improve existing programmes and materials and to satisfy new training needs which may have been identified.

8.2. PURPOSE OF THE ANALYSIS PHASE

The purpose of the analysis phase in the ADDIE cycle is to determine training needs and identify job specific training requirements.

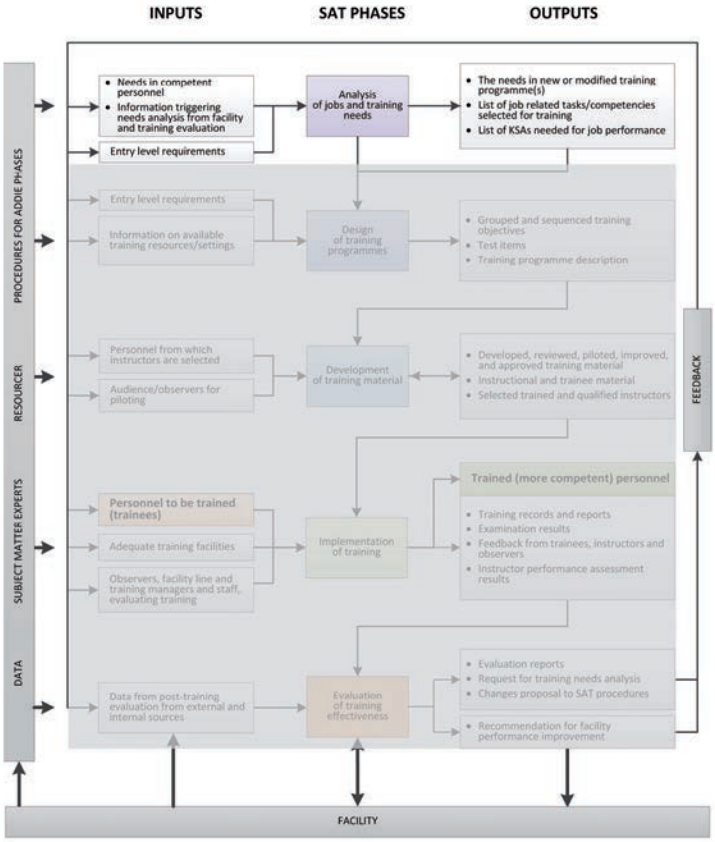

FIG. 4. The SAT analysis phase. KSAs — knowledge, skills and attitudes.

8.3. ESSENTIALS OF THE ANALYSIS PHASE

The quality of work in the analysis phase is crucial for the quality of the other SAT phases. Top quality work entails the following:

— Procedures that define the analysis process;
— Availability of key facility personnel, including managers and SMEs (e.g. job incumbents, training staff), trained in the process and committed to being involved through its completion;
— Availability of data required for analysis, including data from the facility vendor;
— Job analysis to identify and document the tasks and competency statements required for job performance;
— Tasks and/or competencies being selected for training;
— Task and/or competency analysis being conducted to determine the KSAs required for the job;
— The process and results being documented and updated regularly.

8.4. INPUTS TO THE ANALYSIS PHASE

Examples of inputs to the analysis phase are shown in Fig. 4. For existing nuclear facilities, the evaluation of data used to monitor facility performance is an important input to the analysis phase. Improvements in training programmes can be used to improve overall facility performance. For new facilities, the availability of relevant data from the facility's vendor is important for the analysis, design

and development phases of SAT. The provision of this data has to be considered as a condition in the contractual agreement for the new build.

8.5. PERFORMANCE ANALYSIS

Often, training alone is not the optimum way to solve an identified performance deficiency. Before any training is selected as the solution — whether refresher, new or improved training — a thorough root cause investigation is suggested to ensure the right solution is chosen.

In order to decide whether training solutions or other management initiatives are needed, the following questions can be answered to determine the best option:

— Are the employees capable of performing their jobs?
— Is the performance deficiency due to a lack of knowledge, skill or attitude?
— Have previous employees been able to perform the job (or task) successfully?
— Has the nature of the job or task changed?
— Is the identified deficiency specific to training?
— Can the manner in which the job or task is being performed be improved?
— Is correct behaviour being encouraged or discouraged?
— Is incorrect behaviour being rewarded or punished?
— Are there any policy, procedural, equipment, physical or emotional barriers to performing the job or task correctly?
— Can the deficiency be corrected by an initiative other than training?

8.6. TRAINING NEEDS ANALYSIS

To implement the analysis phase of SAT, the following three activities are generally required:

(i) Training needs analysis (TNA);
(ii) Job analysis;
(iii) Task and/or competency analysis.

In Fig. 5, we see the relationships between different methods of analysis that may be performed during this phase. The most important point is that regardless of which method of analysis is used, each provides very similar outputs, including the KSAs needed for successful job performance. These KSAs provide the basis for the training objectives that are developed during the design phase.

The first step in the analysis phase is to identify whether training is needed and, if so, what is required to develop or change the training programmes. A performance analysis and TNA are performed to evaluate potential training needs, to suggest and approve training solutions, and — where it is possible — to suggest other management initiatives to improve facility performance.

The training related outputs from TNA may include the following:

— The need for a new training module or activity for a particular job or task;
— The need to modify an existing training module or activity;
— A new or modified task or competency to be addressed in the training programme;
— Particular KSAs to be addressed in training, to improve performance.

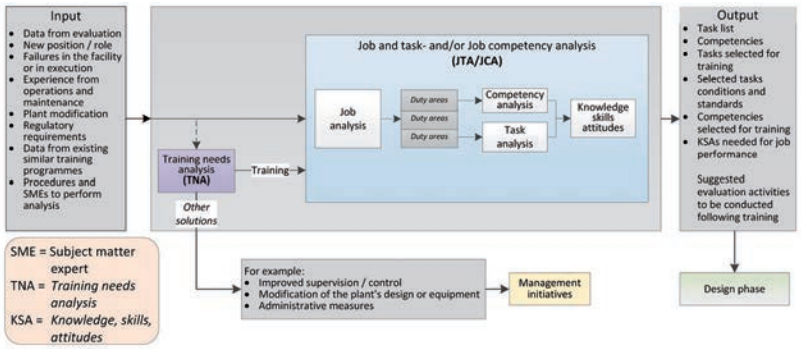

FIG. 5. Overview of the SAT analysis phase process and activities.

These outputs can be used as inputs to the job analysis, and subsequently to task or competency analysis. Other suggestions to improve the training system or SAT process may be generated from the TNA, such as the following:

— Changes to the organization of training;
— Changes to the training methods, training facilities or training tools;
— Enhancement of instructor competence;
— Estimation of resources required for training (human resources, time and cost) from the nuclear facility.

However, it may also happen that no training related actions are identified from the TNA. Proposals for non-training solutions (i.e. other management initiatives) can also be generated from the TNA and communicated to the facility management.

Performing a TNA requires the following:

— Definition of the process from initiation through to implementation, review, approval and distribution of the outputs;
— Blank forms for analysis of the problems or new needs, for formalizing training suggestions/ solutions, for estimating economic impact, and for tracking the TNA results;
— Multidisciplinary staff competent in the evaluation of facility performance, training, and performance improvement techniques.

8.7. OVERVIEW OF JOB AND TASK ANALYSIS AND JOB COMPETENCY ANALYSIS

The JTA is a key requirement of the analysis phase for task based workers and task linked activities. JCA is a key requirement of the analysis phase for knowledge based workers and knowledge related activities.

Job analysis is a systematic technique used to obtain a validated task list and/or competency list for a specific job (e.g. reactor operator, maintenance technician or system engineer). A job can be divided into functional units called duty areas, which are each a distinct major activity involved in performing the job (e.g. a duty area for a maintenance mechanic could be maintaining pumps and fans). Duty areas are a convenient way of organizing tasks or competencies when conducting a job analysis (see Fig. 5).

A list of duty areas is very much dependent on the nature of the job. Duty areas may be identified based on the following:

— Operation modes;
— Systems, structures and components;

— Equipment classification;
— Management duties.

Examples of duty areas for operations positions are the following:

— Normal operation;
— Abnormal conditions;
— Design base accidents;
— Beyond design basis accidents;
— Response to alarm actuation;
— Routine and administrative activities.

The job analysis process involves the following:

— Developing a list of duty areas (at an appropriate and convenient time);
— Developing a task list and/or a competency list;
— Validating the task list and/or competency list;
— Selecting tasks and/or competencies for further analysis.

An important consideration when conducting a task or competency analysis is the entry level of personnel in terms of their education, specialized training and experience. The depth of analysis will change depending on the requirements established for prior education, training and experience. For example, detailed identification of some underlying academic knowledge in areas such as mathematics, physics and thermodynamics may not be necessary if personnel are required to possess this knowledge prior to employment. Similarly, analysis for some maintenance personnel craft skills may not be necessary if personnel are required by the facility to have specific craft skills prior to employment. In every training programme, the entry level of the trainees' KSAs needs to be considered. By properly establishing the entry level requirements, new learning will build upon what trainees already know, and not waste time and resources on remediation. The entry level requirements have to be identified and documented, and then they need to be reflected in the training programme description during the design phase of SAT.

Figure 6 shows an example of a training programme and the relationships between entry level requirements within initial training. Job competence requirements are determined from the analysis phase. This can be summarized as what job and tasks or activities a job incumbent has to be able to perform to the identified standards and what KSAs a job incumbent needs to possess. The entry level requirements have to be based on a familiarity with the general level of KSAs of the trainees and a careful review of documents such as job descriptions or personnel qualification requirements. Normally, the qualification requirements, including generic entry level requirements, are defined in the standards or regulations across the industry.

The entry level requirements have to be set at a point where most trainees have the required KSAs. Any required KSAs that the trainees do not possess upon entry to the training programme will have to be taught. The gap between job competence requirements and entry level requirements has to be addressed by initial training programmes. Continuing training programmes provide the closed loop that ensures, together with the job experience, that job competence is continually maintained according to the established standards.

Analysis needs to produce sufficient information to be able, in the SAT design phase, to define measurable, performance based training objectives. All methods of analysis have advantages and disadvantages, so each situation has to be considered to determine the most appropriate method to use. However, while selection of an appropriate analysis phase method is important, many factors influence

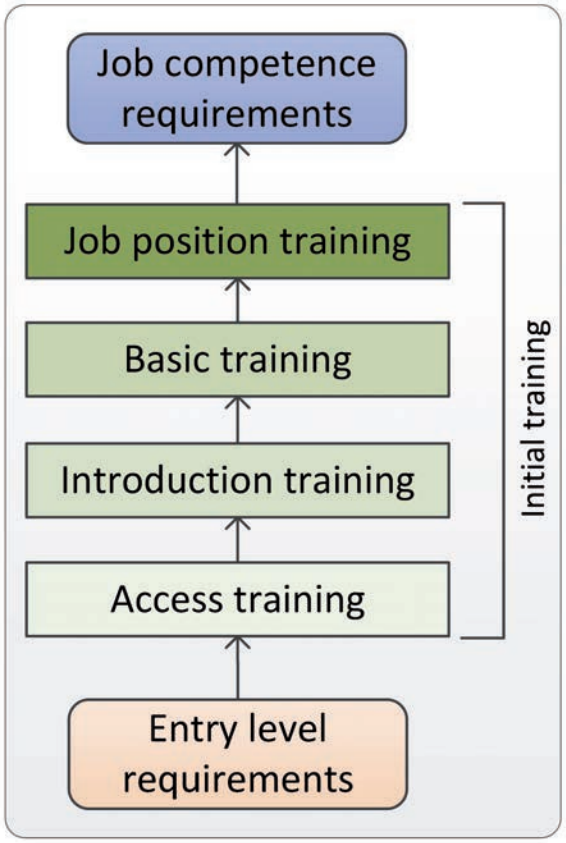

FIG. 6. Entry level requirements.

the success of the analysis phase and subsequent training programme development, regardless of the method chosen and used. Examples of these influencing factors are the following:

— Availability of SAT based training procedures;
— Experience and ability of training staff;
— Availability of instructional/SAT specialists who help conduct analysis;
— Availability of competent job incumbents or experts, commonly referred to as SMEs;
— Current status and quality of the training programme;
— Availability and quality of design and operating documentation;
— Availability of documentation of a facility management system;
— Availability of regulatory authority documents;
— The complete support and involvement of nuclear facility managers.

Reference [8] contains examples of national or corporate practices regarding the use of various analysis phase methods and techniques. A task and/or competency analysis is performed to identify the associated KSAs for each task or competency. These KSAs are then used in the design phase to develop cognitive, psychomotor and affective training objectives. The cognitive, psychomotor and affective training objectives respectively identify what a trainee needs to know (knowledge), needs to be able to perform (skills) and needs to value (attitudes).

8.8. JOB AND TASK ANALYSIS AND JOB COMPETENCY ANALYSIS

During task analysis, the KSAs required to perform tasks are identified. If necessary, tasks may be split into task elements. Task statements are analysed to identify the job related KSAs.

Attitudes may be defined not for particular tasks but for the duty areas or for the entire job instead. Task analysis involving splitting tasks into elements may be time consuming and resource intensive. It needs to be used only when sources of information such as accurate procedures are unavailable, for tasks that are very complex and critical to nuclear safety and plant/facility performance.

The KSAs may also be defined directly from the task statements without splitting the tasks into elements. A combination of these two approaches to task analysis may be used (i.e. for some complex and critical tasks, the task elements and the associated KSAs will be identified, and for other tasks, KSAs will be derived directly from task statements). The flow chart in Fig. 7 gives an overview of activities within JTA/JCA.

The traditional JTA method can be used for any job at a nuclear facility but is best used for operations and maintenance jobs of which a significant portion consist of psychomotor tasks. In general, this method results in good identification of necessary job skills and some cognitive (knowledge) objectives, and a very good linkage to performance based training objectives.

The traditional JCA method involves essentially the same basic activities and steps as JTA. The major difference is that in JTA, job activities (tasks) are identified, while in JTA, job competency statements are determined and analysed to identify the related KSAs that support the competency. The KSAs are then generally grouped together and sequenced.

8.8.1. Job and task analysis

Task analysis is the second major activity performed within the analysis phase when using a JTA method. Task analysis is required for all tasks identified both for initial and continuing training. Essential data to be collected or produced for each task for which trainee performance will be formally assessed include the following:

— Method for assessing task performance (e.g. performance, simulation, discussion, walkthrough);
— Location where trainee's knowledge and performance will be assessed;
— Conditions for performance (e.g. facility operation mode);
— Standards of performance;
— Special tools, equipment and references used in task performance;
— Safety precautions.

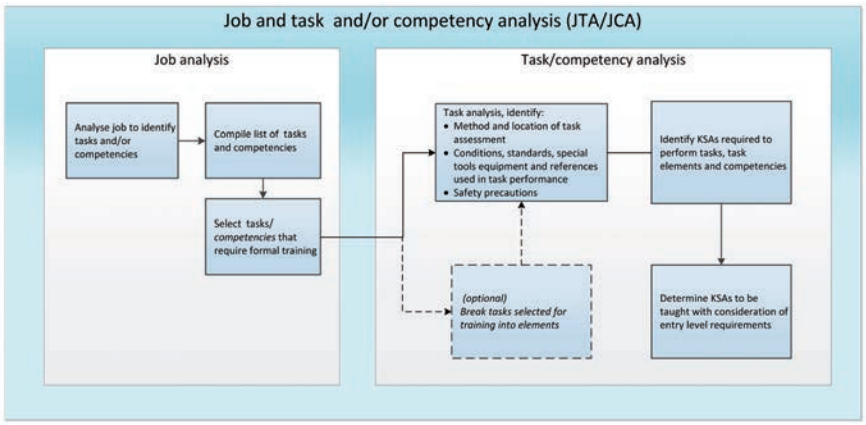

FIG. 7. An overview of activities within job and task analysis and job competency analysis.

Task analysis may involve splitting tasks into their elements, subtasks or steps. Task elements are typically identified for complex tasks that are not sufficiently addressed in the facility procedures, or for tasks having a potentially high impact on safety. If task elements are being identified, it is important to define critical subtasks (steps) and criteria for assessing successful completion of the subtasks. The KSAs required to perform each element of the task or the entire task (if the task is not split into elements) are identified, and KSAs to be taught are determined with consideration of the entry level requirements. Results of the task analysis provide data from which enabling training objectives are produced, typically during the design phase.

8.8.1.1. Source documents

Documents needed to conduct a thorough task analysis include the following:

— Validated task list produced during job analysis;
— Source documents used in the job analysis;
— Task analyses performed for similar nuclear facilities or for similar jobs and tasks;
— Operating procedures;
— Technical documentation;
— Safety and related standards.

8.8.1.2. Panel of experts

Task analysis is performed by competent SMEs such as experienced job incumbents or supervisors in conjunction with the instructor assigned for the training programme, under coaching of an SAT expert.

8.8.1.3. Job aids

A task analysis procedure to ensure the quality and efficiency of the task analysis process and results typically includes the following job aids:

— Template for task analysis data collection;
— Template for identification of task elements (steps);
— Template for identification of KSAs, entry level requirements and KSAs to be addressed in the training programme.

8.8.1.4. Review and validation of data

Review and validation of task analysis data have to be performed by experienced SMEs and trainers. Approval of task analysis data is typically performed by the training manager and the manager of the facility's relevant department.

8.8.1.5. Examples of task statements

The task statements need to be short, clear and consistent; for example:

— Radiation technician: Determine the location of radioactive hotspots.
— Control room reactor operator: Manually control steam supply to the de-aerator.
— Electrical maintenance technician: Perform preventive maintenance on air circuit breakers greater than 600 V.

8.8.2. Job competency analysis

The JCA method is typically used for knowledge based workers and leadership positions. When using traditional methods of document analysis, surveys and interviewing, the amount of time needed to complete the JCA procedure is similar to that needed for the JTA method. However, if a detailed task analysis is performed during the JTA — including the detailed identification of all task steps and special tools and equipment used in task performance — then the JTA may be much more time consuming and resource intensive compared with a JCA. However, if in order to save resources, the JTA is not used for the jobs containing psychomotor (skills) tasks critical to nuclear safety and having critical steps that have to be performed correctly, it may negatively affect training, on the job performance, safety and efficiency of the nuclear facility.

The JCA method is best used for management positions and for engineering support personnel. In general, the method results in good identification of high order cognitive tasks: the abilities and related knowledge required to perform these tasks. Examples of competency statements for management positions include the following:

— Develop management expectations for a culture of safety;
— Ensure competence of the contractors;
— Influence government and the business community to facilitate incoming investments;
— Evaluate employee behaviour and attitudes towards improvements in working practices;
— Establish effective corrective action programmes;
— Fulfil senior manager responsibilities during severe accidents;
— Handle disciplinary problems;
— Ensure the supply chain meets nuclear facility requirements;
— Coach employees for better performance.

8.8.3. Combined job and task analysis and job competency analysis

Combining JTA and JCA can be an effective method of analysis, particularly in smaller to medium sized analysis activities, which are most common in facilities with existing analyses and training programmes that need to be supplemented or modified. In the job analysis, tasks and competencies are identified simultaneously. Tasks and competencies are then processed according to the respective descriptions in previous sections. The work is suitably performed with a template adapted for the related method.

8.9. SUPPLEMENTARY ANALYSIS METHODS AND TECHNIQUES

The methods and techniques listed below are examples of ways to increase effectiveness and efficiency during the SAT analysis phase.

Supplementary analysis methods include the following:

— Tabletop JTA and JCA methods undertaken by a panel of experts or experienced incumbents without observing a worker in action (detailed further in Section 9.9.7);
— Combined JTA and JCA.

Supplementary analysis techniques include the following:

— Verification analysis;
— Document analysis;

— Using templates;
— Functional and topic analysis.

More detailed information on the use of supplementary analysis methods and techniques may be found in Refs [8] and [9]. Some of these methods and techniques are often used together to produce results from the analysis phase to address the varied nature of the tasks that make up the job and to be efficient in the use of resources.

8.10. ANALYSING COMPLEX TASKS AND HIGHER ORDER COGNITIVE COMPETENCIES

In the cognitive (knowledge) domain, lower order objectives such as knowledge, comprehension and application generally represent early stages of learning, while higher order objectives, such as analysis, synthesis and evaluation, represent more advanced stages of learning. Examples of higher order cognitive competencies include the following:

— Make choices based on reasoned arguments;
— Break down a problem into its parts;
— Determine the quality and importance of different pieces of information;
— Identify critical components of a new problem;
— Solve problems in which students must select the approach to use;
— Predict consequences and outcomes;
— Discriminate among ideas;
— See patterns and organization of parts (e.g. classify, order);
— Use information methods, concepts or theories in new situations;
— Weight the relative value of different pieces of evidence to determine the likelihood of certain outcomes/scenarios.

Many jobs include simple, complex and critical tasks. JTA alone can then be insufficient. A job may evolve into the following:

— Well defined comparatively simple psychomotor (skills) tasks (e.g. disassemble a pump);
— Well defined but comparatively complex psychomotor (skills) tasks that require the use of many cognitive abilities (e.g. start a turbine);
— Higher order cognitive competencies (e.g. predict the impacts of certain malfunctions on the system).

The analysis of psychomotor tasks with prescribed sequential steps is not normally difficult. Task analysis in such cases identifies task elements, their sequence, corresponding KSAs and performance standards. The greatest difficulty lies in performing analysis for the higher order cognitive competencies, in particular, determining performance standards.

For higher order cognitive competencies, JCA or combined JTA and JCA methods need to be considered. In addition, the following resources are essential:

— Competent SMEs that include experienced managers possessing, in particular, excellent analytical abilities.
— An experienced SAT expert competent in coaching analysis activities for complex jobs and tasks.
— Job aids that include:
    - Hierarchy of cognitive abilities;
    - Guidelines for writing statements of cognitive abilities and higher order cognitive competencies;
    - Generic statements of cognitive abilities.

8.11. INTERPERSONAL, MANAGEMENT AND HUMAN PERFORMANCE COMPETENCIES

Historically, analyses have been primarily focused on the technical aspects of nuclear facility jobs. As a result, they have not always identified the human performance, interpersonal and management related competencies. Experience has shown, however, that technical competencies related to the nuclear facility and its processes on their own are not sufficient to ensure the competence of nuclear facility managers and personnel. Non-technical competencies have not always been fully identified, primarily because many of the technical SMEs are not familiar with this subject. SAT teams implementing such analysis for the first time may look to analyses that have been performed at other facilities and even in other industries, using techniques such as verification analysis and templating that may significantly facilitate the successful analysis of these non-technical competencies.

8.12. SELECTING THE ANALYSIS METHOD

It is clear from the preceding sections that there is no one analysis method that is appropriate for every situation, every nuclear facility and every job. Each nuclear facility needs to determine the types of analysis appropriate for its needs. Collaboration between those responsible for personnel training and those responsible for facility operation, with the advice of experienced SAT experts, has to lead to the selection of the most appropriate method for a particular nuclear facility and particular job.

8.13. OUTPUTS

Whatever analysis methods are chosen, the outputs of the SAT analysis phase have to be the training needs determined as follows:

— Titles of jobs and corresponding training programmes requiring development or modification (and specific suggestions for training);
— Validated lists of job related tasks or competencies together with a determination of which tasks or competencies require formal training;
— Lists of KSAs required for job performance and those which are selected for training;
— A determination of what evaluation activities will be conducted following the training.

8.14. LESSONS LEARNED FROM THE ANALYSIS PHASE

The analysis phase of SAT is critical to ensure high quality, effective, performance oriented training. The important factors to achieve success in performing the analysis phase include the following:

— The nuclear facility management’s commitment to performance improvements and the value of high quality training;
— A well established and controlled process;
— Availability of procedures, guidelines and templates;
— Availability of competent SMEs and involvement of managers;
— A trained analysis team;
— A SAT expert qualified in analysis performance to coach the team of SMEs;
— Appropriate information technology (IT) support;
— Various analysis methods and techniques appropriately selected and implemented.

The use of tabletop analysis (i.e. consultation rather than observation; see Section 9.9.7. for details) and other techniques may be effective for saving resources. For example, training objectives may be directly defined from task or competency statements during task analysis, omitting the need for the identification and documentation of KSAs. However, the use of simplified methods and techniques requires highly competent experts and facilitators.

Both technical and non-technical competencies and KSAs need to be considered, including human performance, interpersonal and management related competencies. The management and maintenance of the data generated by the analysis phase have to be conducted. For this purpose, training procedures have to clearly specify the analysis process, the individuals responsible, and that the review and validation of analysis data need to be conducted periodically according to the requests identified through training programme evaluations and TNA.

For new builds, the owner/operator has to carefully consider any requirements for the development, supply and use of SAT based training programmes and make sure that requirements for the training programmes are clearly specified in the contract. The owner/operator also needs to ensure that its personnel are trained on the SAT process and participate in the analysis phase.

The nuclear industry has accumulated a lot of experience in the development of SAT based training programmes, and particularly in performing analyses. The use of this experience is one of the cornerstones for success in implementing the SAT process.

9. SAT IN DEPTH — DESIGN PHASE

9.1. OVERVIEW OF THE DESIGN PHASE PROCESS AND ACTIVITIES

In the design phase, training objectives are derived from the requirements identified during analysis (see Fig. 8). Questions to assess achievement of the training objectives are developed, and the training objectives are organized into a training programme.

9.2. PURPOSE OF THE DESIGN PHASE

The design phase serves to develop clear training objectives organized in a logical, pedagogical sense for effective learning in modules, courses and training programmes to achieve desired results.

9.3. ESSENTIALS OF THE DESIGN PHASE

It is essential that key personnel be available during the design phase, including instructor/training specialists and SMEs (e.g. job incumbents, training staff) trained in the SAT process. These people must be committed to involvement throughout the SAT process. The main activities during the design phase are the following:

— Develop training objectives;
— Select suitable training settings;
— Organize the training objectives into meaningful units and sequence those units;
— Develop test questions;
— Compile a basis for evaluation activities (i.e. assessments);
— Develop training programme description for initial training and a framework for continuing training;
— Develop a work plan including compiled evaluation activities and an estimate of resources required.

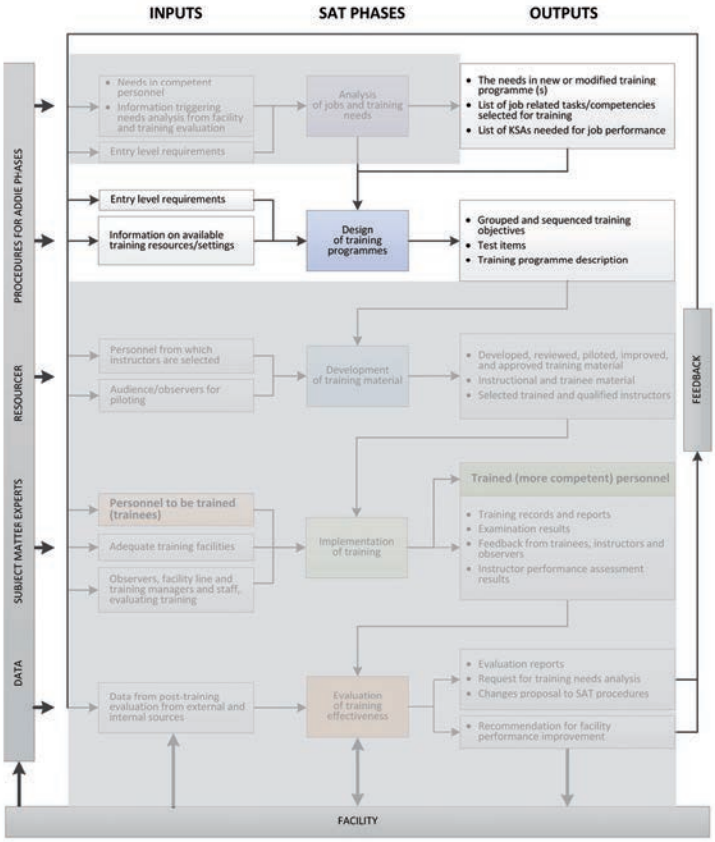

FIG. 8. The SAT design phase.

9.4. INPUTS TO THE DESIGN PHASE

Examples of inputs to the design phase are shown in Fig. 9 and include the following:

— Procedures that define the design process;
— Entry level requirements;
— List of tasks and/or competencies with associated KSAs selected for training;
— Availability of data required for design, including data from existing relevant internal or external training programme.

9.5. TRAINING OBJECTIVES

The first step within the design phase is to convert the selected training tasks or competencies and associated KSAs into measurable training objectives. This is performed while taking into consideration the following:

— The entry level requirements needed for the training programme (formally stated in a training programme description);
— The domain to which the training objectives belong (cognitive, psychomotor or affective);
— How achievement of the training objective will be assessed.

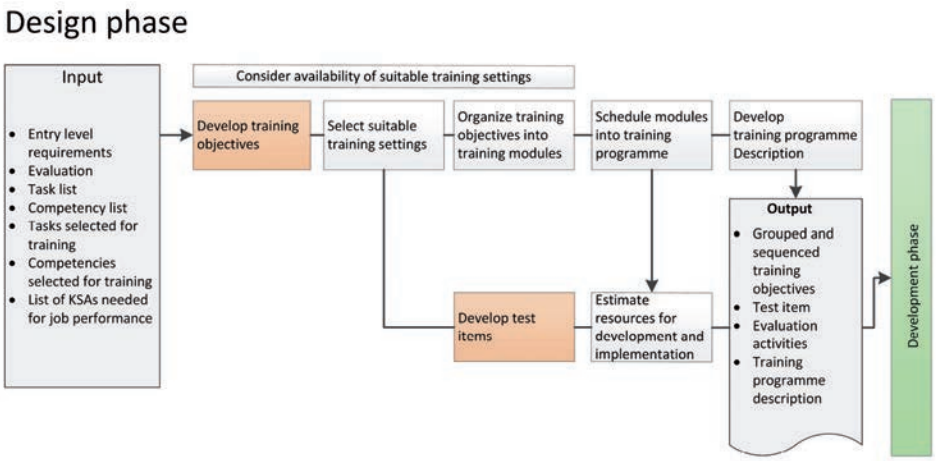

FIG. 9. Overview of the design phase process and activities.

Training objectives serve to do the following:

— Define what the trainee will know and be able to do after training;
— Form the basis for questions and tests;
— Guide development of training programme content.

Generally, a training objective is a statement that specifies measurable behaviour that a trainee has to exhibit after instruction. Training objectives need to be:

— Specific;
— Measurable/observable;
— Attainable for target trainees within the scheduled time and specified conditions;
— Relevant and results oriented;
— Targeted to the learner and to the desired level of learning.

9.5.1. Three components of training objectives

Training objectives normally have the following three components:

— *Conditions* under which the action will take place;
— *Action* statement describing behaviour the trainee has to exhibit;
— *Standards* detailing the nature of satisfactory performance.

9.5.1.1. Conditions

A properly developed training objective clearly states the conditions that will exist at the time of trainee performance and assessment. Conditions of performance define the facility situation, environmental aspects and resources available to aid trainee performance. Typical conditions may include the following:

— Facility operating mode;
— Safety considerations or hazards;
— System or equipment status;
— Tools or materials to be used;
— References available;

— Environmental conditions;
— Problem situations or contingencies (e.g. abnormal or emergency).

Following are some examples of conditions:

— During normal conditions;
— Given __ failure;
— During shift turnover;
— Using the __ tools;
— Using __ procedure;
— Using __ survey results;
— From memory;
— Through observation.

9.5.1.2. Action

The action statement for the training objectives describes the behaviour that trainees need to be able to exhibit upon successful training. Such statements include all three domains (cognitive, psychomotor and affective). The action statement describes the specific action that the individual is expected to exhibit under the given condition. This statement usually involves an action (verb) being done to a thing (object), for example, 'perform a diagnostic check on the pump'. When the training settings and resources available are considered in developing the training objectives, it impacts the selection of the verb. The verb in the training objective for classroom or self-study training would be different from the verb in the objective developed for laboratory, workshop, simulator or OJT. This is because classroom and self-study activities tend to be cognitive (knowledge based) while laboratory, workshop, simulator and on the job objectives tend to be psychomotor (task based). However, the objectives from a cognitive domain may be addressed in both these types of training settings.

Examples of action statements in the three main domains include the following:

— Affective (attitudes) domain:
  - Prevent __.
  - Exhibit __.
— Cognitive (knowledge) domain:
  - State the purpose of the __ system.
  - Identify the personal hazards associated with the __ system.
  - List consequences of improperly performing a __.
  - Locate the __ alarm annunciator.
  - Predict the consequences of __ component failure on the __ system.
— Psychomotor (skills) domain:
  - Perform __.
  - Assemble __.
  - Practise __.

The following are examples of verbs that can be used in each domain to describe the action being taught and assessed by a training objective or by a task or competency statement:

— Cognitive domain (evaluation): Given an unusual occurrence report, evaluate its completeness and acceptability in accordance with the subject guidelines.
— Psychomotor domain (simulate/imitate): Given the loss of flow simulator and the prescribed action conditions, simulate the reactor operator actions required for a coolant leakage event in accordance with the procedure.

— Affective domain (response): Prevent violations in accordance with nuclear facility policies and procedures.

9.5.1.3. Standards

Standards describe the level of performance that the trainee has to meet for successful completion of the task or the criteria for satisfactory behaviour. The standard refers to the quality of the end product or the precision of the process. The standard statement may be qualitative or quantitative. It is usually expressed in terms of adherence to a procedure, time limits, completeness, accuracy, quantity or quality.

Following are examples of standards for a task to be performed:

— Within 20 minutes;
— In full accordance with the __ procedure;
— Without error;
— Without entering a limiting condition of operation;
— Identify components of __;
— Within 5 mm.

9.5.2. Classification of training objectives

Training objectives are often categorized using cognitive (knowledge), psychomotor (skills) and affective (attitudes) domains. These three domains were devised by Bloom and others, and subsequently revised [9]. The domains are part of the learning taxonomies devised by these theorists — that is, the categories or domains that describe the layers of deepening understanding as one learns. Training objectives from cognitive, psychomotor or affective domains describe the expected outcome of a training programme in part or on the whole. Training objectives inform the instructor what specific subject matter is to be taught and clarify to the trainees what will be included in the training and what will be expected from them in terms of performance after the training.

In order for a trainee to perform satisfactorily, it is important that the training objectives really match the characteristics of a person who is skilled and successful in the targeted tasks and/or competencies in all three domains — cognitive (knowledge), psychomotor (skills) and affective (attitudes). Based on this, designers develop training objectives in the required domains. Often there are general training objectives that cover several tasks and/or competencies.

There are two types of training objectives: terminal objectives and enabling objectives (which support terminal objectives). These are explained in the following subsections.

9.5.3. Terminal training objectives

A terminal objective states the purpose of the training. A terminal objective is usually written in behavioural terms, stating the expected outcome in terms of performance, conditions and standards. Terminal objectives are usually derived from task or competency statements and describe the measurable performance and/or observable behaviour the trainee needs to demonstrate upon completion. Terminal objectives are intended for long term retention and are therefore written at the level of performance requirements for the job and are reinforced through continuing training as needed.

Terminal objectives derived from psychomotor (skills) task statements need to always have the three elements of conditions, action and standards. It may not be possible to relate terminal objectives derived from competency statements or from higher order cognitive task statements to a performance standard, but they always define observable behaviour. (See the next section for an example.) In addition, when writing a terminal objective, the training setting has to be determined in order to consider the available resources and facility constraints.

9.5.4. Enabling training objectives

Enabling objectives are developed from individual or grouped KSAs to describe the behaviour necessary for trainees to achieve mastery of the terminal objectives. They support the terminal objectives and address task or competency elements as well as the KSAs required for performance. Such objectives are typically lower order behaviours or actions and are derived from the task/competency elements and KSA statements that result from the task/competency analysis. Meeting an enabling objective helps a trainee attain one or more terminal objectives.

Like terminal objectives, enabling objectives also need to relate to conditions, actions and standards. The conditions may sometimes be implied rather than stated:

— *Conditions* under which the action will take place;
— *Actions* the trainee has to exhibit;
— *Standards* of satisfactory performance.

The following example shows how enabling objectives support a terminal objective:

— Terminal objective:
  - Operate vacuum pumps to establish underpressure in the condenser.
— Enabling objectives:
  - Indicate the starting sequence for the vacuum pumps.
  - Describe the flow path of exhaust gases from the ejector system during normal operation and during startup.
  - Explain why vacuum pumps may not run during normal operation.

9.6. DESIGN OF INITIAL TRAINING PROGRAMMES

A training programme is a planned and organized set of training activities, devised to achieve all the specified training objectives. In various national or corporate practices, different terminologies are used to describe elements of a training programme. In this publication, the generic structure shown in Fig. 10 is used to describe training programme elements.

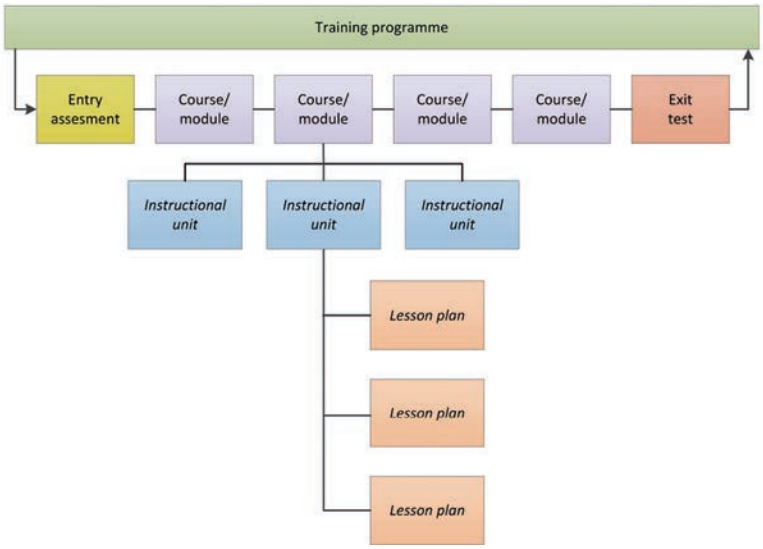

FIG. 10. Example of a generic training programme labelled with terms used in this publication.

Training courses and their instructional units are sometimes referred to as modules; these are so termed in this publication. In some training programmes (e.g. for control room or maintenance personnel), large portions of the programme containing several modules and their own 'exit assessment' are referred to as phases.

Following are some examples of training courses:

— Theory/fundamentals courses;
— Design of the facility, systems, structures and components;
— Normal operation;
— Abnormal conditions;
— Design basis accidents;
— Beyond design basis accidents;
— In-facility/on-site/OJT courses (e.g. complex OJT in the field or in a control room).

Guidance for the initial training programmes for operating NPPs may be found in Ref. [10]. Examples of training programmes may be found in Ref. [11] for the commissioning phase, in Refs [12–14] for the operating phase, and in Ref. [15] for the decommissioning phase.

The designing of a training programme is an iterative process. Selection of training settings is normally performed in parallel to developing the training objectives and to defining the lessons and instructional unit. The typical sequence would be as follows:

— Group and sequence training objectives into lessons;
— Group and sequence lessons into instructional units or modules;
— Group and sequence instructional units or modules into courses;
— Group and sequence courses to define the training programme.

Entry assessments (pre-tests) can be used as part of the assessment process to determine when and where an individual with prequalifications can join a programme, to ensure all trainees are qualified to commence the programme.

The overall approach to the design of training modules used for many job positions is to develop an applicability matrix (a simple tool showing the applicability of a practice based on the size of the team performing it and the amount of innovation in the work being performed) using data from the analysis phase. The tabletop method may be effectively used for this purpose.

9.7. DESIGN OF CONTINUING TRAINING PROGRAMMES

Continuing training is designed to maintain and enhance the competencies of the employees to support the safe and reliable operation of a nuclear facility and personnel performance improvement. Figure 11 shows how continuing training relates to the competence development of nuclear facility personnel. This demonstrates that there may be a general upward trend in the competence of personnel after completion of initial training. For some areas of the job, there is a need for periodic continuing training to maintain the required level of competence.

Continuing training programmes typically address the following:

— Refreshing knowledge of selected fundamentals, including seldom used knowledge and skills that are necessary to support nuclear safety;
— Nuclear facility equipment modifications and changes to systems and components;
— New or upgraded procedures;
— New regulatory requirements and/or refreshing knowledge of regulations;
— Nuclear industry and non-nuclear industry lessons learned;

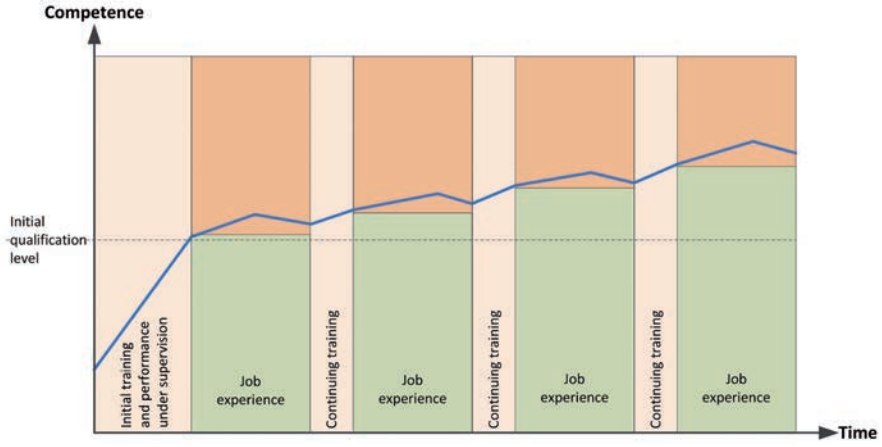

FIG. 11. Competence development through continuing training.

— Tasks/competencies identified in the analysis phase via the difficulty, importance and frequency rating for the continuing training (see Annex V);
— Abnormal and emergency conditions training and exercises;
— Identified performance improvement opportunities (e.g. remediation).

The training forums and committees play a key role in determining the specific content of continuing training. This includes agreeing to the proposed curriculum content and leading the reviews of the training effectiveness and its impact on facility and personnel performance improvement. The frequency for continuing training will vary, depending on the specific risk or safety requirement for a particular topic. For example, for MCR operations staff, some topics associated with safety case fault studies and schedules may be required to be completed on an annual or biannual basis as determined by the difficulty, importance and frequency rating. In some circumstances, the regulator may specify specific topics that need to be refreshed annually.

The timescale for continuing training will differ based on the type of technology and the organizational structure of the facility. Typically, shift operations crews at NPPs will participate in 80 hours of annual continuing training, including MCR simulator training and emergency scheme training activities. In some circumstances, this number of hours may increase due to regulatory or organizational requirements. Typically for maintenance, chemistry and radiation protection technicians, 40 hours per year is sufficient to meet the needs of the workforce. For engineering support staff, 40 to 60 hours are required, depending on the exact role and nature of the engineering. The programme content determined through analysis of the training needs has to be the real indicator of the required timescale to complete effective continuing training. This will also vary for different roles and positions and departments.

The continuing training may be performed on-site, with some portions off-site (e.g. for management staff or for personnel performing non-destructive testing). Parts of continuing training may also be performed at external training or educational organizations, or at the supplier's or vendor's facilities.

The training staff, including training managers and instructors, need also to complete regular continuing training. This may include involvement in the facility's operational activities to ensure they maintain their technical competence. Examples of continuing training programmes may be found in Ref. [16].

9.8. JUST IN TIME TRAINING

Just in time (JIT) training is provided to individuals and teams to prepare them for upcoming evolutions and maintenance activities. JIT training may be conducted using any training setting. It is characterized by many of the same activities that are applicable to initial and continuing training. It is important that JIT training be conducted as close to the time of the planned activity as practical for the team or crew involved in

the actual task or activity, and that sufficient time be available if needed to repeat the practice of infrequently performed activities when appropriate or requested. In some cases, JIT training incorporates likely or potential failures or complications in planned activities, to allow personnel to prepare for and execute potential mitigation strategies.

Examples of tasks and activities for which JIT training may be considered appropriate and desirable for operations, engineering and maintenance staff include the following:

— Planned reactor shutdown in preparation for a refuelling or maintenance outage;
— Facility startup following a refuelling outage;
— Initial startup of new or modified equipment;
— Core physics testing;
— Preparing for testing and maintenance of equipment (e.g. safety relief valves);
— Contingency actions for anticipated severe weather or other environmental conditions.

9.9. SELECTING THE TRAINING SETTINGS AND APPROACH

The following subsections describe considerations for training settings and the training approach. It is also possible, and often advisable, to combine several settings and approaches into one ‘blended learning’ approach.

Blended learning incorporates a virtual classroom setting via a digital learning platform (e-learning) with other modes of instruction (see Fig. 12). This increases the possibility of flexible yet controlled learning in varied environments using customized settings, modes, methods, training tools and aids.

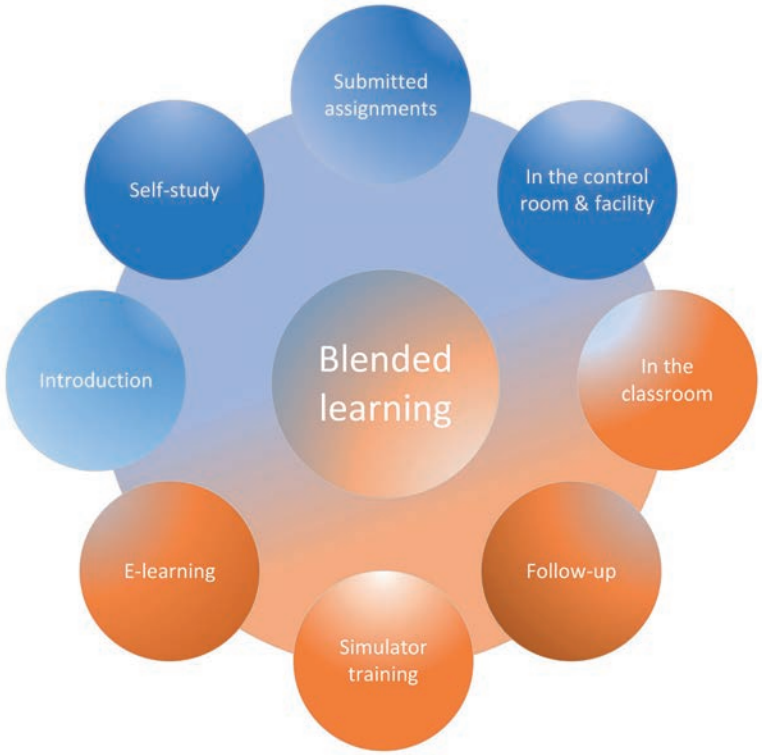

FIG. 12. Blended learning incorporates two or more modes of instruction such as these.

9.9.1. Training settings

The training setting is the environment or location in which training takes place. A decision on an appropriate setting to be used for a specific training session is made at the design phase of SAT. The type and level of training and the training objective have a direct bearing on the mode of instruction and the subsequent selection of the training setting.

The training of nuclear facility personnel may take place in the facility, on the site or off the site. The most commonly used training settings include classrooms, simulators, OJT, laboratories, workshops, mock-up facilities and self-study. For newly built nuclear facilities, training may be performed at the new facility as well as at various other locations such as the vendor's training facilities or at the reference nuclear facility.

The choice of setting needs to also consider the optimal method of evaluation. Consider the following:

— Written tests can be used to evaluate learning in each of the training settings. However, they are best suited to measure knowledge and sometimes attitudes, not skills.
— Oral tests can also be used to evaluate learning in each setting but are most appropriate for settings which include hands-on training activities. Oral tests are particularly suited to measuring communication skills and attitudes as well as higher order cognitive skills.
— Performance tests can be used to evaluate skills and are the best method to measure actual performance to job specific standards.

9.9.2. Training modes

The training mode is the way in which the training takes place, for example in groups or individually. A decision on an appropriate mode to be used for a specific training session/lesson is made at the design phase when training settings are identified for particular lessons.

9.9.3. Training methods

The training method refers to the particular technique used for providing instruction, such as the following:

— Lecture;
— Demonstration;
— Observation;
— Practice;
— Walkthrough;
— Drill;
— Discussion/facilitation;
— Oral questioning;
— Role playing;
— E-learning;
— Self-study;
— Experiential.

Self-study and e-learning are terms that apply to the training setting, mode and method. In selecting training settings for particular lessons, the designers of a training programme need to consider which training methods will be used. For achieving a particular terminal training objective, a number of training sessions may be required in which different training settings and methods will be used. Less interactive training methods, such as lecturing, can be effective for delivering a large amount of material in a short

period of time and are suitable for a small or large group, but will generally result in a lower retention of knowledge by the trainee.

9.9.4. Training tools and aids

Trainers may use one or many training tools and aids when delivering a lesson. These include the following:

— Simulators (e.g. basic principles, part task, full scope and analytical simulators; human performance simulators; flow loops);
— E-learning systems;
— Software systems and products (e.g. various databases, modelling complexes, computer codes);
— Mock-ups and physical models;
— Actual equipment;
— Video and audio;
— Printed texts;
— Charts, diagrams and drawings (e.g. design or piping and instrumentation diagrams);
— Projectors or monitors to display slides and other electronic media;
— Photographs;
— Flip charts and white boards;
— Video and audio recording equipment (e.g. used in full scope simulator training or in instructor training).

In selecting training settings, consider that particular training settings and methods require particular tools and aids. If significant resources are needed to acquire them, this may impact the selection. The next section provides more elements for consideration.

9.9.5. Factors affecting selection of training settings

The personnel responsible for training design, development and implementation need detailed knowledge of the different training settings that are available, as well as the strengths and limitations of each setting. They will need to determine the training setting that best serves the achievement of the training objectives and is compatible with the:

— Nature of the trainees' jobs;
— Number of trainees to be trained;
— Entry level of trainees;
— Type of training objectives being addressed (e.g. cognitive, psychomotor or affective);
— Components of training objectives (i.e. conditions, actions and standards);
— Preferable methods of assessment;
— Resources required (including training tools and aids);
— Hazards/risks;
— Accuracy in reproducing conditions defined by the training objective.

Selecting a setting depends largely upon the nature of the training objectives. Generally, training objectives which embody tasks are best presented in OJT, simulator training and workshop training, while objectives which embody knowledge may be effectively achieved using all training settings, including classroom settings.

Settings need to be selected to minimize hazards for the trainees, in particular radiological hazards where dose received might not be maintained 'as low as reasonably achievable' (ALARA).

Certain tasks, and their associated terminal and enabling objectives, may require different settings at different times. For instance, a task may first be addressed in the classroom and later at the simulator or OJT. It is also advisable to identify alternative settings for training objectives. Constraints or limitations due to the facility or resources available may dictate the selection of particular settings.

Detailed information on the most commonly used training settings and considerations for the appropriateness of various training settings are given in Table 3.

9.9.6. Assigning training settings

In the analysis phase, a method for assessing each training objective is identified, such as performance, simulation, discussion or walkthrough. For each competency, the method of assessment is identified during the competency analysis. This identifies the training setting to be assigned for that terminal training objective.

Training objectives for achieving the required level of performance or competency may be addressed in different lessons, units and courses and may require different training settings. To assign the training settings, various techniques (explained below) are used.

One technique uses a task to training matrix (see Annex IV for an example) typically generated during the analysis phase. This matrix serves to maintain data on all tasks identified, whether they are selected for training or not. For each task selected for training, the training settings are identified and then, in the design phase, are described more precisely. After training objectives are organized, training settings are more precisely assigned when defining the lessons that are included in particular training modules. Normally, a training setting is assigned to the entire instructional unit — such as an MCR simulator setting.

Table 3 provides examples of training and assessment settings as well as examples of test types for various types of training. The primary method of testing identified is the predominant method used to assess achievement of the objectives from the particular domain; the secondary method is the supporting method.

TABLE 3. SUITABILITY OF TRAINING SETTINGS AND ASSESSMENT METHODS

Domain of training objectives	Training settings (in descending order of suitability)	Assessment method (for the terminal objectives, in descending order of suitability)	Type of test (primary and secondary)
Cognitive (knowledge)	All training settings (classroom is one of the most commonly used)	Discussion Walkthrough Simulation Performance	Primary: Written and oral Secondary: Performance
Psychomotor (skills)	OJT, simulator or laboratory/workshop	Performance Simulation Walkthrough Discussion	Primary: Performance Secondary: Written and oral
Affective (attitudes)	Classroom OJT, simulator or laboratory/workshop Self-study	Discussion Performance Walkthrough Simulation	Primary: Oral and performance Secondary: Written

9.9.7. Organizing training objectives

Grouping and sequencing the training objectives can help to define the content and structure of the lessons and training modules, and from this can emerge a sequence for instruction using various techniques. Some of the ways to group and sequence objectives include the following:

— By training objective domain.
— In categories of fundamental knowledge/theory.
— Grouped by duty area.
— By component, system and structure in a nuclear facility.
— According to the relationships among them, such as the following:
  - *Dependent*: Mastery of one requires prior mastery of another.
  - *Supportive*: Mastery of one helps master another.
  - *Common*: They share the same action and/or condition.
  - *Independent*: No strong relationship exists; mastery of one is not related to mastery of another.

In the cognitive (knowledge) domain, lower order objectives such as knowledge, comprehension and application generally represent early stages of learning, while higher order objectives such as analysis, synthesis and evaluation represent more advanced stages of learning.

The following method can be used to organize training objectives when the number of objectives is not too large:

— Write each of the training objectives on a card or sticky note.
— Arrange them on a table or post them on a wall or board.
— Rearrange the objectives to show different relationships.
— Recognize that there are many ways to organize.
— Consider groupings and sequencing options for defining the lessons and training modules.

For a large number of training objectives, the process of organizing is always iterative and requires consideration of the hierarchical structure of the training programme.

9.10. DEVELOPING QUESTIONS AND CONSTRUCTING TESTS

Well designed tests provide a valid and reliable indicator that training objectives have been achieved. Establishing a direct relationship between the actual job requirements, the training objectives and the individual test questions improves the validity and reliability of tests. Questions are developed to be consistent with the training objectives. The purpose of the question is to measure trainee performance against the criterion (i.e. standard) stated in the training objective. Trainees' performance is a measure of their learning. One useful technique is to assess the trainee before training, during training and after training. These assessment activities inform both the trainee and the instructor how well the trainee has mastered the objectives, and how well the instructor presented the training. This evaluation is necessary but not enough to determine training effectiveness alone. It does, however, yield important indicators.

The three basic methods of testing are written, spoken and performed.

Assessments in the case of on the job, laboratory or simulator training may be tests or practical demonstrations of acquired skills. Facility walkthroughs can be used in assessing knowledge of the location or identification of systems and components. Performances have to involve actual performance of a task whenever practical. Simulated performance needs to take place under conditions that are as realistic as possible.

Written tests are the primary type of assessment used for knowledge. Written test formats include multiple choice, essay, short answer, matching and labelling questions. Oral tests are the primary method

used to assess attitudes, and can also be used to assess knowledge. Oral tests may range from interviews for managers and professional staff, to more structured one on one questioning and teams of oral assessors for authorization tests. Performance tests are the primary means used to assess skills but can also be used to assess knowledge and attitudes, particularly when combined with the use of simulators. Performance tests are frequently combined with follow-up oral questioning. Types of performance test [11, 12, 17] may range from less formal — such as satisfactory completion of job assignments for managers and professional technical staff — to very structured on the job, workshop, laboratory and simulator tests for operations, maintenance and technician jobs. For each training objective, one or more test questions have to be produced. Selection of question format is guided by verbs related to the training objectives, as described by Bloom and other theorists. Verbs linked to each of the training objectives suggest one test format to be more appropriate than others, as per Table 4.

For example, within the cognitive domain, the highest level of learning is *evaluation*. Some of the verbs associated with this level are assess, explain and evaluate. In contrast, knowledge is the lowest level in the cognitive domain. Some of the verbs associated with that level are define, identify and label. For a training objective such as: "Identify the exposure limits for ionizing radiation" (*identify* being the lowest level), a suitable test method might be multiple choice. However, for a training objective such as: "Determine the reasons why personnel are violating facility safety rules" (*determine* indicating the highest level), an oral test would be more suitable in order to allow the trainee to show the depth of his or her understanding of the situation.

Assessment of those KSAs which cannot be assessed in the facility is performed through simulator exercises that allow trainees to demonstrate their ability to deal with normal, abnormal and emergency conditions. In addition to assessing the performance of individual trainees, simulators are used to assess an operating crew's ability to perform effectively as a team.

The training programme design also has to prescribe the assessment method for each module and for the final test.

9.10.1. Develop written test questions

Five steps are involved in developing questions for written tests:

— Determine the number of questions to be developed;
— Determine question format;
— Develop questions;
— Validate question content;
— Incorporate questions into a test bank for future use.

TABLE 4. SELECTION OF TEST QUESTIONS GUIDED BY VERBS

Description of the verb	Examples of the verbs	Related test format
Knowledge verbs	Recall, describe, define	Written
	Identify, list, arrange	Completion/short answer
	Discriminate, select	Multiple choice
	Classify, relate, label	Matching
Skills verbs	Start, shut down	Performance
Higher order learning verbs (synthesis of knowledge or application to novel situations)	Synthesize, evaluate, outline	Essay, performance

The appropriate number of questions for each training objective depends on a number of factors. Although at least one test question has to be developed for each training objective, certain considerations justify developing more than one test question for a single training objective. For example, tasks used to develop the training objectives that were rated at or near the maximum importance or difficulty would suggest a larger number of test questions than those tasks rated near the minimum. It is advisable to write at least two test questions for each objective, to ensure multiple versions of a test are made available as remedial tests or to replace a test when its security has been compromised.

For written tests, the following question formats are typically used:

— Short answer;
— Completion and fill in the blank;
— Multiple choice;
— Matching;
— Essay.

Determination of question format needs to be guided by the verb found in the training objective's wording, and has to be based on understanding of which format best suits a particular situation. However, for written tests, any question format can be used to test any level, if the question is appropriately developed. Examples of questions in various formats used for written tests are provided in Table 5.

TABLE 5. TEST QUESTION TYPE EXAMPLES

Question type	Example
Fill in the blank	A positive displacement pump has to be started with its suction valve __ and its discharge valve __.
Multiple choice	*Select ONE correct answer.* The atoms of a chemical element all have the same (stem): (a) Atomic number (correct choice) (b) Relative atomic mass (distractor) (c) Number of neutrons in the nucleus (distractor) (d) Number of nucleons in the nucleus (distractor)
Matching	Match the alarm in the left column with its appropriate tone in the right column. Tones may be used more than once. (a) Fire — (1) Pulse tone (b) Reactor building evacuation — (2) Wailing siren (c) Site evacuation — (3) Steady tone (4) Bell ring 5 sec/2 sec
Structured essay	A pressurized water reactor at full power has the following conditions: Core flow (100%) T_{avg} (308.9°C) Core ΔT (15.6°C) Steam generator ΔT ($T_{avg} - T_{steam}$) (6.7°C) The reactor is operating at steady state power with four loops operating. One reactor coolant pump trips, resulting in a three loop operation. The rod control system is in automatic mode. The reactor has not tripped. Sketch graphs of reactor coolant system mass flow, reactor power, core ΔT, and steam generator pressure versus time if no operator action is taken. Use the same time axis for all graphs. Calculate the final reactor power, T_{avg}, core ΔT, and steam generator ΔT.

9.10.2. Develop skill and knowledge test questions

The information in this section has been taken from Ref. [16].

Test items can be written after the number of test items is determined and the format is selected. The answer keys can be written at the same time. For each test item, a correct answer needs to be supplied to develop an answer key. The answers need to be unambiguous so that grading of the test item will be consistent. The minimum response for full credit has to be given and indications need to be given of the relative value of partial responses. This kind of information is obvious in multiple choice and matching test items, but short answer and essay test items leave room for interpretation. To prevent interpretive inconsistencies in grading short answer or essay test items, the designated instructor can include the minimum answer required for full credit. After the test item and answer key are written, the point value needs to be assigned in a clear and consistent manner. The assignment is based on a point scale with the easier test item assigned a lower point value and the more difficult test item assigned a higher point value.

To determine ease or difficulty of a test item, consider the criticality of the enabling objective that is being tested to the overall mastery of the terminal objective which will allow successful performance of the job task. Consider also the level at which the objective being tested is written. For example, if you are writing multiple choice test items for three enabling objectives, two of which are written at the knowledge level of Bloom's taxonomy to support a third which is written at the comprehension level, then the point value assigned to the higher level would be higher than the point value assigned to the lower level.

However, the following basic principles apply across all test item formats:

— Ensure that the concept is relevant to the ability to perform the job;
— State the test item concisely;
— Choose the higher level;
— Make sure the test item matches the training objective;
— Omit unnecessarily difficult or irrelevant test items;
— Limit the test item to only one concept or topic;
— Avoid copying text directly from reference materials;
— Avoid 'backwards logic' test items;
— Ensure that the test item discriminates between those who have mastered the objective and those who have not.

Content validation is the process by which test questions are determined to be sound and incontestable as to meaning and correct answer. Each question has to be reviewed by several SMEs. All need to agree on what the question is asking and the correct response. These validation reviews have to be documented. It may also be possible to validate new test questions against previously used questions that have been demonstrated to be effective.

A test question bank needs to be developed and routinely updated. The questions in the test bank will be used to construct entry level tests, pre-instruction tests, progress tests, or post-instruction tests. A tracking system needs to be developed to correlate test questions to training objectives.

9.10.3. Develop the test specifications

During development of test specifications, training objectives are broken down into the following three levels:

— Knowledge of facts, terms and symbols;
— Understanding of principles and concepts;
— Application of information, principles and concepts.

Tests need to have the appropriate number and mix of questions based on the importance of each area being tested and the level of each training objective. For example, if half of the training objectives are written at the level of understanding principles and the majority of questions used relate to knowledge of facts, terms and symbols, then the test is not representative of the required depth of learning. Training objectives that are critical to job performance need to be represented by more questions on the test. The test specification is developed so that these concerns are addressed. The completed test specification has to be reviewed by SMEs and facility management. This review can help to ensure that a sufficient number of training objectives are tested to represent an accurate assessment.

9.10.4. Assemble the test

Tests are assembled using the following general guidelines:

— Select questions appropriate to the test specifications.
— Group questions with the same format (e.g. all multiple choice together).
— Group items of similar content to help the trainees' concentration (e.g. reactor topics together).
— Add a place for the trainee's name, clearly marked page numbers, sufficient space between the questions and clear distinctions between the different sections of the test.
— Prepare the answer key at the same time. This is especially important for essay and short answer questions and is very useful in identifying problems.
— Write test directions clearly and include them in the test — consider a model answer to help clarify directions.
— Change content of tests from one use to the next, so they are not compromised.

9.10.5. Consider additional factors

The classical SAT suggests that test questions be developed during the design phase. However, several factors may defer this to the development phase, and the developers of a training programme need to consider these factors if test questions created in the design phase more precisely define the content of the training material to be developed later. Computer based testing is a typical example of when developing test questions may be postponed until the development phase of SAT.

9.11. TRAINING PROGRAMME AND TRAINING COURSE DESCRIPTIONS

Descriptions of the training programme and courses are important documents produced in the design. The components of these documents include the following:

— *Training programme title*: State the job (or job classification) which the programme addresses or the title of the generic (common to several jobs) training programme.
— *Training programme identifiers*: Include the following details:
  • Identifier;
  • Revision number;
  • Date of issue/revision.
— *Purpose of training programme*: Briefly state the content of the training programme with reference to the training and qualification requirements an employee needs to meet in order to independently discharge the position's duties.
— *Entry level requirements/prerequisites*: Describe requirements for an individual's entry into the programme using various documents, including regulatory requirements, hiring policies, job descriptions, and quality assurance programmes. These typically address the following four areas:
  • Experience;

    - Educational background;
    - Specialized training to be completed before entering the programme;
    - Medical requirements.
- *Training programme requirements*: Describe topics needed to meet regulatory requirements, licensing commitments and facility or operating organization regulations.
- *Training courses*: List the training courses in the programme with their identifiers, titles and brief descriptions of their content.
- *Length and schedule* (for initial training programme): Indicate the nominal length of the programme with a schedule outlining projected lengths and sequence of training courses as well as milestones.
- *Continuing training*: Outline periodicity, length and other overall requirements and considerations for the content and implementation of continuing training.
- *Assessment*: Describe requirements for assessment at the conclusion of training to measure achievement of terminal objectives. Assessments are required at the conclusion of all initial training programmes as well as at designated segments of continuing training programmes. The assessment cycle for the continuing training has to be defined in the nuclear facility (or other authority) regulations. Also describe remedial actions in the event of failure or poor performance.
- *Job analysis data*: Include a list of task/competency statements as an appendix to the training programme description. This may contain a task to training matrix cross-referencing all tasks/competencies selected for training with all training courses in the training programme. Tasks that are determined as not to be trained are identified too.

A training course description needs to be developed for every training course included in the overall training programme. Aspects of these descriptions are detailed below. The training course description contains the terminal training objectives which define the content of the training and qualification programme and, if applicable, the list and brief description of the training course guides that may be essential for OJT using job performance measures (JPMs) or other OJT instruments.

The training course description contains the following elements:

- *Training course title*: State the name of the course.
- *Training course identifiers*: Include the following details:
    - Identifier;
    - Revision number;
    - Date of issue/revision.
- *Goals of the training course*: Briefly describe the KSAs the training course will provide.
- *Entry level requirements/prerequisites*: List the training and qualifications which have to be completed before the course may be taken.
- *Length of the training course*: Estimate the duration of the training activities associated with the training course.
- *Assessment*: List the requirements for assessment at the end of the training course. End of course assessments measure achievement of the terminal objectives and may measure achievement of enabling objectives.
- *Instructional units*: List the instructional units in the training course, identified by their number and title.
- *Instructional unit description*: Include the following elements:
    - Title;
    - Identifier;
    - Terminal objectives;
    - *Prerequisites*: Any requirements to enter the instructional unit (in particular, other instructional units in the training course that have to be completed before entering this instructional unit).
    - *Lesson plans*: A list of all lesson plans in the instructional unit identified by their number and title.

- *Assessment*: Requirements for assessment conducted at the end of the instructional unit. Assessments at the end of an instructional unit measure achievement of terminal training objectives as well as enabling training objectives.

— *Task to training matrix*: Include a matrix cross-referencing all of the tasks/competencies and lessons. Different approaches and formats may be used to formalize a task to training matrix, but the generic tasks identified through job analysis need to be used for specific (individual) job positions. Concurrently, the competencies may be used for some job positions or for job classifications/families, if the training programme addresses the general tasks common to a group of job positions. A task may be addressed in more than one lesson and lessons may address more than one task. See Annex IV for an example.
— *Training course guides*: List and briefly describe the training course guides. If no JPMs exist for the training course, the training course guides are unnecessary. For continuing training programmes which may consist of instructional units or even lesson plans omitting the identification of formal training courses, training course descriptions may be unnecessary. However, a training course guide may be needed when continuing training includes task qualification or requalification.

9.12. ESTIMATING RESOURCE REQUIREMENTS

Before the training programme description is approved, the resources required to develop and implement the training programme need to be estimated. These resources include the required reference documentation, SMEs, instructors, instructional specialists, training material developers, facilities, equipment, software, funds and time. This estimate is important as a project management tool. When the available resources are less than the estimated resources required, revisions to the draft training programme description have to be considered.

Generally, the most expensive elements in the development of the training programme are acquiring the training facilities, tools and associated training materials. For the development of training materials, the labour required for the development of each hour of training material is highly variable and depends upon all the factors that have been discussed.

To estimate training facilities and tools required, include the resources required for the following:

— Design and construction of a new training centre or new training premises;
— Classrooms;
— Laboratories and workshops;
— Mock-ups;
— Real facility equipment;
— Simulators;
— E-learning systems;
— Audiovisual aids;
— Tools and equipment;
— Offices and furnishings.

Information from the TNA helps to estimate the resource. It is only at this point in the SAT process that a detailed schedule for the development of training can be finalized and specific resources identified and committed for the development of training materials and tools. If major new training facilities are to be established, it is suggested that a detailed specification for the new training centre or the new training tools be developed before significant investments are made. Using estimates of resources, a work plan for the development and implementation of the training programme needs to be developed and approved by the facility's senior manager. For a newly built nuclear facility and a newly developed training system, a comprehensive plan for the establishment of the entire training system has to be developed and approved prior to embarking on the establishment of any individual training programmes.

9.13. TRAINING COURSES THAT APPLY TO MORE THAN ONE JOB

Examples of training courses that may be used for various job positions are:

— Fundamentals, basic theory and facility design;
— General employee training (GET);
— Management training;
— Regulations;
— Human factor and human performance related competencies;
— Nuclear security;
— Administrative or financial issues;
— Advanced technologies used in the nuclear industry;
— Training on the use of information technology tools.

The overall approach to designing training modules that will be used for many job positions to develop an applicability matrix using data from the analysis phase (see Fig. 13).

Training in some of the areas mentioned above is often performed using outside, part time or adjunct instructors or SMEs. To maintain high standards of training for the nuclear facility personnel, the facility managers have to implement measures to ensure that the appropriate systematic methods are used by such instructors or SMEs. Facility training standards, procedures and guides need to be used by all instructors to achieve the quality and effectiveness needed.

9.14. OUTPUTS

The outputs of the design phase include the following:

— Grouped and sequenced training objectives.
— Test questions.

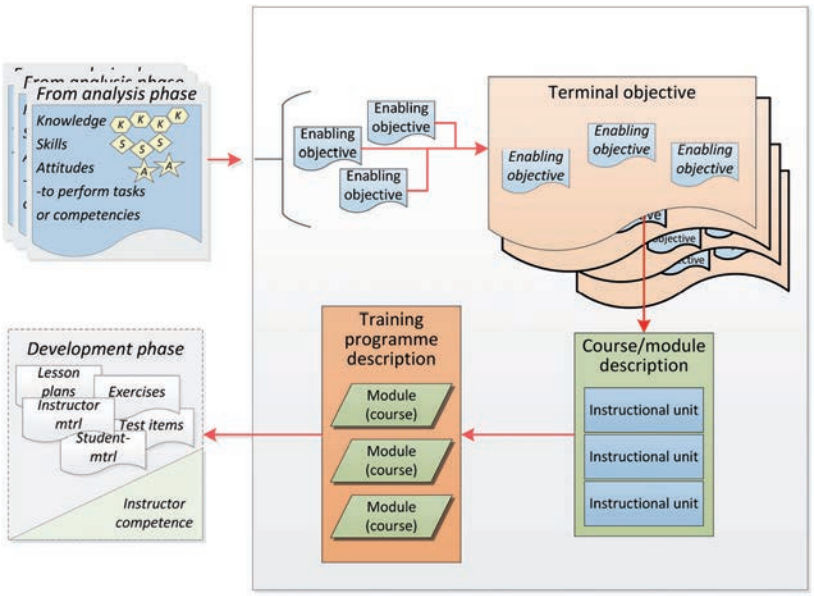

FIG. 13. Overview of the design phase. Mtrl — material.

— Training programme description that specifies, in particular:
  - Sequence of achieving the training objectives;
  - Structure of initial training programme, including various elements of training programme (e.g. lessons, training modules like instructional units and courses, and their sequence and tests);
  - Cross-reference matrix establishing a relationship between training objectives and elements of the training programme;
  - Entry level requirements for trainees to enter both the entire training programme and its particular parts (e.g. training courses);
  - Training settings to be used to achieve training objectives;
  - Length and schedule of initial training programme;
  - Requirements for assessment at the conclusion of the whole training programme and each of its parts;
  - Structure and generic content of a continuing training programme;
  - Work plan to develop training materials and to acquire necessary training tools, produced using the estimates of resources needed for the development and implementation of training (e.g. the estimates of resources needed such as labour, funds, time, expertise, technical infrastructure, SMEs and instructors).

9.15. LESSONS LEARNED IN THE DESIGN PHASE

The following are considerations that have to be emphasized when performing and evaluating activities of the design phase:

— The design phase — in particular, the development of training objectives and test questions — is one of the most resource intensive SAT phases from a methodological point of view.
— Incorrect development of training objectives and test questions may negatively impact safety and overall performance, including performance of personnel.
— Training and assessment standards contain job related data for measuring task and competency performance.
— Selection of training settings considers tasks/competencies, training objectives and any constraints regarding the availability of instructional and other resources.
— Training objectives are used to identify training content and satisfactory trainee performance.
— Training objectives identify observable and measurable trainee action or behaviour.
— Test questions need to be appropriate for the training objectives. There is no one unique way to identify questions best suited to particular training objectives. Guidelines and experience have to be actively employed.
— Training objectives have to be compatible with expected entry level requirements for the trainees, including expected entry level skills and knowledge.
— Training objectives have to be organized (grouped and sequenced) to assist trainees in effective learning, and making the transitions from one skill or knowledge level to another, to master the terminal training objectives.
— Pre-tests are often developed to determine trainees' entry level and to identify remedial training and exemption from training requirements as applicable.
— Progress tests are developed to evaluate trainee performance and determine whether there is a need for additional assistance.
— Post-tests are developed to measure trainees' satisfactory completion of training, and serve as one of the main tools for the qualification and authorization of personnel.
— The nuclear facility needs to have a strategy/procedure for review and approval of data from the design phase.

10. SAT IN DEPTH — DEVELOPMENT PHASE

10.1. OVERVIEW OF THE DEVELOPMENT PHASE PROCESS AND ACTIVITIES

Development of training material is a major effort that requires efficient and effective management (see Fig. 14).

The following activities are typically performed when developing training materials:

— Establish a management framework for the development of training material according to available development phase procedures;
— Analyse output data from the design phase;
— Distribute the scope of work among developers and monitor the development process;
— Develop and review the first version of the training materials;
— Develop tests for level 2 evaluation (to measure learning) if their development was postponed from the design phase;
— Provide trained and qualified instructors to implement training materials;
— Identify the audience for the pilot training;
— Validate training materials and tests (using, in particular, piloting);
— Improve training materials and prepare to issue the first revision of training materials;
— Initiate activities to acquire remaining training facilities, training tools and aids in time to be available for lessons;
— Approve training materials;

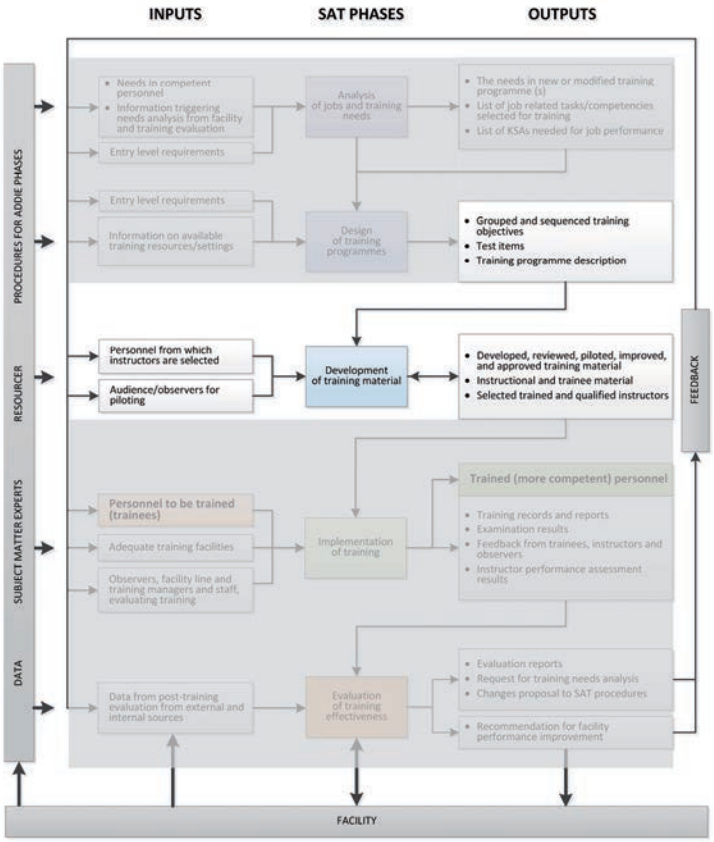

FIG. 14. The SAT development phase.

— Ensure that training materials are organized in a structured information base for easy tracking, use and modification.

Materials from similar facilities or training programmes may be efficiently used in the development phase. The availability of appropriate outsourced material may significantly decrease resource (time, funds) expenditures for the whole training programme. When using existing training material, the nuclear facility will need to ensure that it is consistent with the results of the analysis and design phases performed for the facility's jobs and training programmes (see Fig. 15) by answering the following questions:

— Is it appropriate to the expected trainees' entry level knowledge and skills?
— Does it cover the training objectives?
— Is it consistent with training objectives?
— Is the quality of existing materials suitable (e.g. terminology, technical correctness, style, reading level, quality of illustrative/graphic material)?
— Are necessary training settings (e.g. a workshop training for maintenance personnel) and training tools (e.g. a simulator modelling beyond design basis accidents) available?

10.2. PURPOSE OF THE DEVELOPMENT PHASE

The purpose of the development phase is to produce the training materials necessary for the implementation of initial and continuing training programmes and to ensure the availability of trained and qualified instructors to implement the training.

10.3. ESSENTIALS OF THE DEVELOPMENT PHASE

Training materials are developed for all planned training courses/modules and for all lessons used in all training settings. All training materials have to be reviewed for methodological and technical accuracy. Piloting of training materials needs to be undertaken as appropriate, and training materials have to be improved accordingly.

10.4. INPUTS TO THE DEVELOPMENT PHASE

All of the outputs from the design phase are used as inputs to the development of training material during the development phase. In addition, the instructors to implement the training programmes need to be selected, trained and qualified by the end of the development phase. Therefore, an essential input to this phase is the selection of personnel who will serve as potential candidates for the instructor positions.

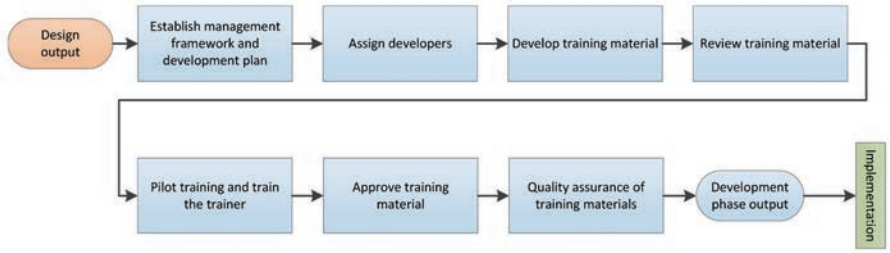

FIG. 15. Overview of the development phase process and activities.

10.5. DEVELOPMENT OF TRAINING MATERIALS

Training material is developed for both the instructors conducting lessons and for the trainees. For various training settings, different terms may be used for instructor material, such as lesson plans for classroom or workshop/laboratory training, scenario/exercise guides for simulator training, and OJT guides for on the job training. Using the common term 'lesson plan' for all situations, the overall suggestions for instructor and trainee material are provided in the rest of this section.

10.6. DEFINING LESSON CONTENT AND TRAINING METHODS

The content of the lesson is defined by the terminal and enabling training objectives addressed in the lesson, and by the elements of objectives (conditions, actions and standards) that require the use of particular training activities to develop the associated KSAs. Training objectives are organized and training settings are defined for each lesson during the design phase.

For each lesson, terminal and enabling objectives are assigned. Selection of training methods has to be based on the lesson objectives and the training setting. It is important to use a variety of methods and activities which best support the training objectives. The following factors may impact the selection of the training methods:

— Background and ability of the trainees;
— Number of trainees;
— Time planned for the delivery of the lesson;
— Resources (including time, funds and competent developers) available for developing the lesson material;
— Availability of planned training tools and aids.

The developers of lesson content need to be familiar with adult learning theory (summarized in Section 11.5.). Adults learn and retain information more efficiently by performing practice based activities. Typically, an effective training strategy would strive for approximately 30% presentation and 70% application. The developers of training material have to be aware of the effectiveness of a particular training method in assisting the various types of activities performed during the lessons.

10.7. DEVELOPING LESSON PLANS

Lesson plans outline the curriculum and serve as the main document defining the instructor's activities in conducting the lesson. They ensure consistency in the delivery of training from instructor to instructor and from trainee to trainee. A lesson plan allows the instructor to adequately prepare for the training session. Lesson plans are used by the instructor as the primary training tool to guide the learning process and utilize the training material. Typical lesson plan contents are outlined in Table 6.

The content of the lesson material is derived from the components of the enabling training objectives. The sequenced enabling objectives may be used as the content headings in the body of the lesson. However, just listing training objectives is not considered adequate because it may lead to subjective instruction. The outline needs to be developed in sufficient depth to assure mastery of the training objectives and coverage of all test questions being used for trainee assessment as well as consistency between instructors.

TABLE 6. ITEMS TYPICALLY INCLUDED IN LESSON PLAN

Cover page: lesson plan content summary	Programme title and its ID[a]
	Course title and its ID[a]
	Instructional unit (if any) and its ID[a]
	Lesson title and its ID[a]
	Who developed/revised the lesson plan and who reviewed and approved the lesson plan, with the associated signatures and dates
	Revision number and effective date of revision
	Length in hours
	Lesson purpose/main goal
	Terminal and enabling objectives
	Training setting
	Training tools and aids
	References
	Materials (e.g. title and ID[a] of a handout)
	Prerequisites (requirements for trainee experience and previous training)
	Historical change summary (brief description of what changes have been made to the lesson plan, when, by whom and why)
Body of the lesson plan	Introduction, including purpose of the lesson, length and outline of activities; administrative information such as breaks, smoking policy, emergency exits, rules of behaviour; and statement of training objectives, including feedback from trainees to ensure the training objectives are clear to them
	Main body where the lesson content is specified and detailed for both the instructor and trainee activities
	Summary with highlight of important points, review of training objectives, and guidance and time to perform a question and answer or discussion session
	Information for the instructor and trainees on evaluation of the lesson conduct, including reference to the evaluation forms/media to be used and time allocated for evaluation/feedback
Attachments	Test questions (written or oral) to be used as appropriate
	Optional test questions related to training objectives
	Evaluation forms to provide trainee and instructor feedback

[a] ID: identification number.

10.8. DEFINING AND DEVELOPING TRAINING TOOLS AND AIDS

Each enabling training objective and each portion of the lesson plan outline needs to be evaluated to determine what training tools and aids need to be used for effective presentation of the material and, consequently, for effective learning. The most suitable training tools and aids are determined from the standpoint of the needs, training method selected and resources available.

Information and supporting data for several lessons, the whole instructional unit or for the entire training course may be compiled into a trainee guide via different formats such as apps, simulation programmes and other e-learning material, books, handouts or presentations. The reading and comprehension level of training materials have to be consistent with the expected entry level knowledge and skills of the trainees and must be clear, accurate and concise. Suggestions for the type of information to be provided include the following:

— Information and data which support the training objectives;
— Training objectives themselves;
— Applicability to the job and why it is important to learn the material;
— Charts, graphs, tables and other illustrations emphasizing key points;
— Space for the trainee to incorporate notes and comments;
— References to the facility controlled documents (rather than replicating them).

Job aids are used by the trainees to acquire information, for practice and for assessment of trainees when used in written, oral or performance tests. Among others, job aids may include the following:

— Computer (e.g. interactive) software;
— Worksheets (e.g. to perform calculations);
— Checklists that specify detailed critical actions for a procedure, or trainee selection of the appropriate choices;
— Samples;
— Labels fastened to a device or equipment;
— Flow charts;
— Laminated posters;
— Notebooks;
— Procedural guides;
— Glossaries;
— Diagrams;
— Decision making tables or trees;
— Case study material;
— Virtual mock-ups.

Case studies may be used effectively for achieving training objectives that are in the cognitive (knowledge) and affective (attitudes) domains.

10.9. INFRASTRUCTURE FOR TRAINING MATERIAL DEVELOPMENT

For the efficient development of training materials, an adequate infrastructure needs to be available, including procedures to produce training materials, hardware, software and staff supporting the development and production of training materials.

In order to minimize resource expenditure, reduce rework, ensure quality of training material and preserve knowledge, it is suggested that a computerized system for the production of training material be provided. This facilitates the centralized management of training material data, and the organization of

the entire knowledge base (including reference material, digital copies of facility documentation or access to this documentation, graphics and e-learning modules).

10.10. MATERIAL FOR CLASSROOM TRAINING

The lesson plan is a very important document used to specify the training activities and guide the instructor. The lesson plan has to be as detailed as required for the instructor to effectively convey the content of the lesson material and to facilitate the learning process. A typical lesson plan uses a three column format as in the sample template in Box 1.

BOX 1. SAMPLE LESSON PLAN TEMPLATE

Keywords and instructor activities		Supporting information, details of instructor activities, and anticipated or planned trainee activities
1. INTRODUCTION		
Introduction and rules Write name and telephone number on a flip chart	5 mins	Self-introduction. Provide brief overview of qualifications to establish credibility with trainees. State the main goal and length of the lesson. Briefly state the activities to be performed within the lesson. Review the classroom rules: Location of restrooms; Emergency exits; Use of telephones; Breaks.
State objectives Slide 1 Ask questions such as: Are the objectives clear for you? Why are knowledge/skills addressed in the objectives important for your job performance and for the whole nuclear facility?	10 mins	State terminal and enabling objectives, highlighting what the trainees need to be able to do at the completion of the lesson (stating enabling objectives) so that trainees know precisely what will be required of them. Review each objective in turn. Clarify objectives if not clear to the trainees.
Agenda Slide 2	2 mins	Present lesson plan overview and agenda (main topics).
2. LESSON PLAN BODY		
Enabling training objective 1 (ETO-1): Slide 3 — Diagram of system Overview whole system	10 mins	List of all components with technical details (e.g. pump capacities, where the electrical supplies are located). Include slightly more information here than is required to meet the objectives, as there could well be detailed questions from the trainees and it is useful for preparation.
ETO-2: Slide 4 — 3D picture of first pump Components of the system — first pump	10 mins	Detail location and other pertinent facts. Rotate a three dimensional picture, explaining a function during normal operation, design, a basis for the design, and connections.

Slide 5 Technical characteristics of first pump	5 mins	Explain the main technical characteristics.
ETO-3: Slide 6 Component connections	7 mins	Line diagram to show the positioning of components with respect to each other. Detail of connections and valves associated with first pump in the system.
Ask questions such as: Where is the first pump located?	4 mins	Detailed answer. Write the answers on a flip chart and provide feedback using Slide 6.
3. SUMMARY		
Summarize key points Slide 7 — key points	7 mins	Have trainees summarize key points.
Review training objectives Slide 8	2 mins	State training objectives, linking to the key points.
Discussion	15 mins	Ask whether sufficient knowledge on the topics of the lesson was conveyed. Ask if there were any difficulties in understanding the lesson material. Provide additional information on the most important difficulties identified. Refer to the handout and other reference material where information may be found. If any questions or requests are not responded to now, identify how to contact you for later follow up.
Evaluation	8 mins	Distribute evaluation forms and very briefly explain how to complete them. Highlight that narrative comments regarding the strengths or weaknesses of the lessons are the most valuable feedback for improvement.

10.11. MATERIAL FOR SIMULATOR TRAINING

A wide range of simulators are used for various job classifications. This section provides information on developing training materials primarily for full scope simulator training of MCR personnel. However, many of the approaches and examples presented are applicable to other types of simulators.

Simulator training consists of two main parts:

— Simulator exercise preview, typically in the classroom, for full scope simulator training;
— Simulator exercise at the simulator facility.

Lessons plans and trainee guides are developed for the exercise preview. The simulator exercise guides (SEGs) usually serve as a basis for the lesson plans for the preview sessions. Using the SEG for the exercise preview, the appropriate questions asked by the instructor need to be developed and included in the lesson plan, together with the trainees' anticipated responses and the correct answers. Information clarifying various phenomena, such as processes, relationships between the components

and processes, and nuclear facility safety considerations, which is not included in the nuclear facility operating documentation, has to be included in the trainee guide.

If the scenario involves training of not only control room operators but also other shift personnel such as field operators, electrical control room operators, refuelling operators, or maintenance personnel, the coordination of personnel activities, communications and teamwork need to be reinforced. Attention has to be paid to the leadership behaviours required by the leaders of the control room crew. The trainees need to be advised regarding how their individual performance, teamwork and supervisory abilities will be assessed.

The simulator exercise typically involves three types of activities:

— Pre-exercise briefing;
— Exercise;
— Post-exercise critique.

SEGs formalize simulator scenarios that can be classified in three categories:

— Demonstration (or familiarization) scenarios when the instructors demonstrate the operation, facilitating the learning process by explanations and questions to the trainees;
— Training scenarios when the instructors help the trainees;
— Assessment scenarios when the instructors observe but do not interfere with the trainees directly.

For the assessment simulator sessions, training material such as JPMs are used in some national training practices. Instructor materials need to be developed for all three categories of scenarios. Facility operating documentation usually serves as the primary basis for the material for trainees.

10.11.1. Simulator exercise guides

SEGs are the ‘lesson plans’ for conducting training at a simulator. They are the documents that contain-training objectives for the scenario and govern the implementation of scenarios, and they contain an outline of the sequence of events as well as the criteria to assess trainees’ performance. The following should be included in an outline for a simulator exercise guide:

— Title.
— Identification number.
— Effective date.
— Training programme and course.
— Time required.
— Signoffs by the developers, reviewers, training manager and nuclear facility operations manager.
— References.
— Initial conditions.
— Malfunctions.
— Information for pre-exercise briefing.
— Training goals:
    - Generic goal of training;
    - Specific terminal and enabling training objectives.
— Scenario summary description.
— Common trainee errors.
— Outline of scenario actions:
    - Evolution or event sequence;
    - Instruction actions, activities and supporting information (including role plays and questions to the trainees);

    - Expected responses of trainees (for each job position).
— Criteria to assess individual and group performance (e.g. procedure compliance, problem solving, communication, teamwork and supervisory competence).
— Guidance for post-exercise critique.
— Time for completing evaluation forms and discussing evaluation results.

It is essential that the SEG contain sufficient information on how to operate the simulator. All exercises have to be prepared in advance and run through according to the sequence and real time operation planned in the scenarios to check satisfactory simulator performance and the adequacy of the simulator scenarios. The SEGs for any simulators used in the training need to reflect and reinforce the operating standards of the facility, such as a conservative approach to safety, use of procedures and the rules for communication. The SEGs have to define the content of the pre-exercise briefing and post-exercise critique.

For full scope exercises, the pre-exercise briefing typically includes the following:

— Training objectives.
— Scenario summary.
— Simulation limitations.
— Shift turnover information, such as the following:
    - Changes/modernizations made at the nuclear facility;
    - Equipment out of service;
    - Evolutions in progress;
    - Abnormal equipment lineups;
    - Planned evolutions or maintenance activities;
    - Facility conditions (e.g. power, core flow, fuel loading, scheduled refuelling);
    - Facility maintenance and outage history.
— Assignments for shift positions.
— Reinforcement of special safety concerns (critical steps).

The post-exercise critique typically includes the following:

— Trainee's self-assessment, comments and questions.
— Review of training objectives and the degree of their achievement.
— Review of exercise using exercise records (e.g. records of facility parameters and evolutions, trainees' actions and communications; video records; comparison of trainee responses to malfunctions with reinforcement of correct responses).
— Critique of trainee performance observed during the exercise, including the following:
    - Reinforcement of proper individual and team performance;
    - Reinforcement of applicable theory and procedures;
    - Discussion on trainee errors and areas for improvement;
    - Soliciting additional questions from trainees and encouraging discussion on correct answers.

If the simulator provides capabilities to train personnel other than control room personnel, the SEGs need to include all necessary data needed for their effective training as well. If performance of any non-control room personnel is imitated by the instructors, necessary instructions have to be included in the SEG in order that the instructors are able to adequately respond. In some cases, it is impossible to predict and formalize all requests to the instructors and therefore the instructors need to have a high level of operational competence to perform realistically during the scenarios.

For the training of system engineers or maintenance managers, special demonstrations and training scenarios can be developed that demonstrate the impact of low quality maintenance work on the performance of control room personnel and on the performance of the whole nuclear facility.

10.11.2. Trainee material for simulator exercises

Nuclear facility operating documentation normally available in a control room is the main training material for the control room crew. However, it is still likely that there will be some additional trainee material that needs to be provided and possibly prepared, even for full scope simulator training, and especially for initial training. Training materials need to emphasize the differences between the actual facility and the simulator. For simulators that are not full scope or do not replicate the control room (e.g. part task or analytical simulators used to provide an understanding of the facility processes and behaviour), specially developed trainee materials may need to be provided.

10.12. MATERIAL FOR ON THE JOB TRAINING

OJT is formal training conducted and assessed in the work environment. An OJT guide is an instructors' document that outlines instructor and trainee activities, training objectives, training content and resources necessary for the consistent implementation of OJT. JPMs or other OJT assessment instruments are tools used for the development of objective based OJT materials. These identify the elements, procedural steps (including critical steps), knowledge and skills necessary to perform the task. They also identify the initiating cue that prompts or signals the trainee to begin the task, identify the terminal and enabling objectives and the conditions under which actions occur, and establish standards that measure satisfactory performance of the elements and thus the task.

Since OJT may involve essential safety considerations for the trainees and equipment, it is important that OJT material be carefully reviewed by the SMEs and instructional specialists. The material also has to be evaluated by the appropriate training supervisor and approved by the facility line manager.

There are numerous formats for OJT guides. An example of a possible format is as follows:

— Cover page:
  - OJT guide title;
  - OJT number;
  - Training programme (and training course, if applicable) title;
  - Effective date;
  - Reviews and approvals.
— General requirements — instructions to both the OJT instructor and the trainee:
  - Record of the instructor and trainee names and identification;
  - Terminal and enabling training objectives;
  - Related task numbers and associated JPMs or other assessment instruments;
  - References, including facility procedures, vendor manuals, facility drawings and design or piping and instrumentation diagrams;
  - Prerequisites for the training to be completed by the trainee;
  - Required facility conditions;
  - Safety precautions and procedural limitations;
  - Required tools, materials and aids;
  - General instructions to the OJT instructor and assessor (for the training and assessment);
  - General instructions to the trainee (for the training and assessment).
— OJT guide body:
  - Typically in a two column format similar to the style used for classroom training (see Box 1);
  - Knowledge requirements;
  - A template for a knowledge assessment record;
  - Practical performance requirements;
  - A template for a performance assessment record.

— A trainee self-study guide if developed. It may include training objectives, associated content, review questions, and answers to the review questions.

Drills are often used as part of OJT. Training material for a drill (a drill scenario) may include the following:

— Drill title and identification number.
— Purpose, scope and objectives.
— Identification of the developers, reviewers and approvers of the drill, with their signatures and dates.
— Revision number and effective date.
— Precautions and limitations.
— Technical safety requirements.
— Drill team guidelines:
    - Drill ground rules;
    - Standard drill conditions;
    - Actions to be simulated;
    - Responsibilities.
— Drill team preparation:
    - Estimated drill duration;
    - Drill team aids;
    - Pre-drill notifications;
    - Pre-drill briefing;
    - Instructions to drill participants.
— Drill event guide:
    - Initiating cue;
    - Conditions and response/evaluation criteria;
    - Drill termination.
— Post-drill activities:
    - Facility restoration;
    - Post-drill notifications;
    - Post-drill discussion.

10.13. MATERIAL FOR WORKSHOP, LABORATORY AND MOCK-UP TRAINING

Training materials for workshop, laboratory and mock-up training are similar to those provided for OJT or simulator training since the aim of these settings is to simulate actual facility conditions as far as practicable. The content of the material needs to be consistent with that used for OJT. When training on mock-up equipment, facility procedures need to be used as much as possible. Interactive models and virtual mock-ups may be used effectively in the workshops to support the acquisition of required knowledge on the equipment design and task performance steps. Safety considerations need to be clearly stated in the training material and conveyed to the trainees.

10.14. MATERIAL FOR E-LEARNING

E-learning is widely used for both training and assessment. Examples of competency areas for which these systems are developed and used are as follows:

— Regulations;
— Fundamentals;

— Procedures;
— Systems, structures and components;
— Comprehensive training for particular job positions or specific duty areas;
— Maintenance activities;
— General training and knowledge assessment for all site personnel (e.g. training required for site access or GET);
— Control room equipment;
— Facility layouts, virtual walkdowns and emergency drills;
— Decision making under emergency conditions;
— Training of management staff;
— Training for various nuclear facility life cycle phases (including design, commissioning, operation and decommissioning).

10.15. MATERIAL FOR SELF-STUDY

Self-study training material is developed for self-paced training settings. Self-study material is used to support and supplement the different types of training described above. Written self-study guides typically contain the following:

— Cover page similar to that for classroom lesson plans with an indication of the time it is anticipated that the trainee will take to complete the self-study assignment;
— Introduction defining the purpose of the self-study guide and providing advice on using the material and obtaining assistance from an instructor;
— Training objectives;
— References;
— Content developed to support the achievement of the training objectives;
— Exercises;
— Test questions for self-assessment;
— Test answer keys.

10.16. REVIEW, VALIDATION, PILOTING AND APPROVAL OF TRAINING MATERIAL

Material developed for use in training programmes has to be reviewed prior to its use to ensure it is complete, technically accurate, instructionally relevant and supports the training objectives. Whenever possible, the material needs to be tested in advance of actual implementation. The goal of such a review is to ensure that training materials meet the following needs:

— Development according to the established procedures (following the prescribed formats and containing complete set of data);
— Technical accuracy and validity;
— Support for achievement of the training objectives;
— Support for the learning process.

The review needs to be undertaken by an expert or experts who provide(s) feedback to the material's developer. Lesson plans, trainee material including job aids and handouts, training aids and test questions have to be reviewed, and deficiencies need to be identified for correction. Each question and the test as a whole have to be validated. This typically includes the following three types of activity:

— Peer review validation panels;

— Analysis of the results of piloting (pilot training);
— Continuous analysis of trainee results (this is particularly important for early implementation of new training programmes and training courses).

Reliability can be a problem with written and oral tests. Reliability may be affected by ambiguous test questions, multiple correct answers, typographical errors, adverse testing conditions, interruptions, limited time and complicated answer sheets. Trainee readiness and scoring errors also affect test reliability. A valid test measures exactly what it was intended to measure. A test may be reliable but not valid. A written test can be reliable in measuring knowledge of certain welding fundamentals but not valid for measuring welding skill.

10.16.1. Piloting material

After revisions resulting from the review of training material have been made, the training materials need to be piloted on a small group of persons including trainees who possess the entry level requirements expected of future trainees and other personnel. Ideally, this group has to include the following participants:

— An SME, to review the accuracy, relevance and context of the material presented;
— An instructor or other training SME to review the appropriateness of the training methodology and training setting, and consistency of SAT application;
— A line manager or 'owner' of the training whose staff typically take such a course;
— A few trainees, possessing the expected entry level requirements.

During this piloting of the training materials, the actual environment in which the training is to be conducted needs to be simulated as closely as practicable. The training materials have to be presented as intended for actual use and all tests have to be administered and scored. Data need to be collected for subsequent analysis and used to improve lesson plans, presentation material, handouts, job aids used for exercises and other training material, as well as to check the instructor's teaching skills and to evaluate the instructor's attitudes. Video recording of the pilot sessions may also be helpful.

Piloting of the whole training course may not always be feasible, particularly with instructional units of lengthy duration. An alternative is to conduct a small group pilot of the most important or difficult sections of the instructional unit of the training course. Lessons not piloted during a small group review have to receive increased monitoring during their first run implementation.

Results from the pilot training are valuable in determining the extent to which the training helps achieve the intended training objectives. Feedback from the small group or failure of the trainees to achieve satisfactory test results may necessitate revision of the training materials or training methods. In the event of low scores, care has to be taken to check that the test questions relate to the job related KSAs and hence to the training materials used in the lessons. Post-training questionnaires completed by the trainees supplemented by interviews can be used to provide data to assist in evaluation of training programme difficulty, length, clarity, terminology, pace and structure.

10.16.2. Approval and maintenance of training materials

The development phase procedures need to clearly identify the process and records for approval of all training material and the process and records of changes to the material. It is good practice for both training and nuclear facility managers to be involved in the approval of training materials.

10.17. OUTPUTS

Expected outputs at the end of the development phase are the following:

— For the identified training programme, all training materials for all training settings — including instructor and trainee material — have been developed, reviewed, validated, piloted, improved as necessary and approved;
— All training tools and aids have been acquired (developed or purchased);
— All training facilities and premises are available;
— Instructors required for the delivery of training in all training settings have been selected, trained and qualified.

10.18. LESSONS LEARNED/GOOD PRACTICES

The following are considerations that have to be emphasized when performing and evaluating activities of the development phase:

— Significant time, labour and financial resources can be saved by using and adapting previously developed materials; however, the external/outsourced materials have to be carefully examined and modified as necessary to meet the training programme requirements and objectives.
— Appropriate training methods need to be employed to assure a helpful learning process, interactive training sessions and enough practice, and to avoid a recurring problem — that of domination of a lecturing style.
— Appropriate training methods and tools need to be used for the effective and reliable achievement of the defined training objectives.
— Training material has to be reviewed, validated, piloted, improved as needed, and approved before its release and use for actual training.
— Piloting of training material needs to be organized in a helpful way, to produce reliable data for improvement of training material.
— Special care needs to be taken to keep test questions secret, and their validity has to be examined and ensured.
— If external contractors are involved in the development and supply of training material, the nuclear facility training and line managers need to have controls in place to monitor and evaluate the quality of products supplied — for this purpose the nuclear facility personnel involved in the training development project have to possess adequate competence to control the quality.
— Competent instructors are one of the main factors in ensuring quality training. Selection and training of instructors have to be done early. Availability of sufficient numbers of competent, motivated and qualified instructors has to be assured by the training and nuclear facility managers. Qualification of the external instructors needs to be carefully checked.
— Projects requiring involvement of external organizations need to be initiated in a timely manner and completed during the development phase. Specific attention has to be paid to such projects for new builds (e.g. for a full scope simulator supply project).
— Due attention has to be paid by both the managers of a newly built facility and the supplier of a simulator to the challenges and risks associated with the development of a simulator, including development of training materials for simulator training. The following challenges need to be taken into consideration:
    - Potential lack of data and documentation;
    - Potential lack of experienced SMEs, instructors and test operators;
    - Potential lack of national requirements for simulators, simulator training and personnel authorization/licensing;

- Potential lack of experience of the customer in such a complicated field as simulator development and training;

— Any full scope control room simulator has to be ready for training in sufficient time to allow training prior to the facility startup.
— Tracking of changes in facility design and documentation during construction need to be ensured and used for a configuration management of the simulator hardware, software and training materials.

11. SAT IN DEPTH — IMPLEMENTATION PHASE

11.1. OVERVIEW OF THE IMPLEMENTATION PHASE

During the implementation phase training is conducted using training materials, tools and aids developed during the development phase (see Fig. 16). The SAT implementation phase also includes the assessment of whether personnel have achieved the standards identified in the training objectives. The standards and associated assessment methods are determined during the analysis and design phases.

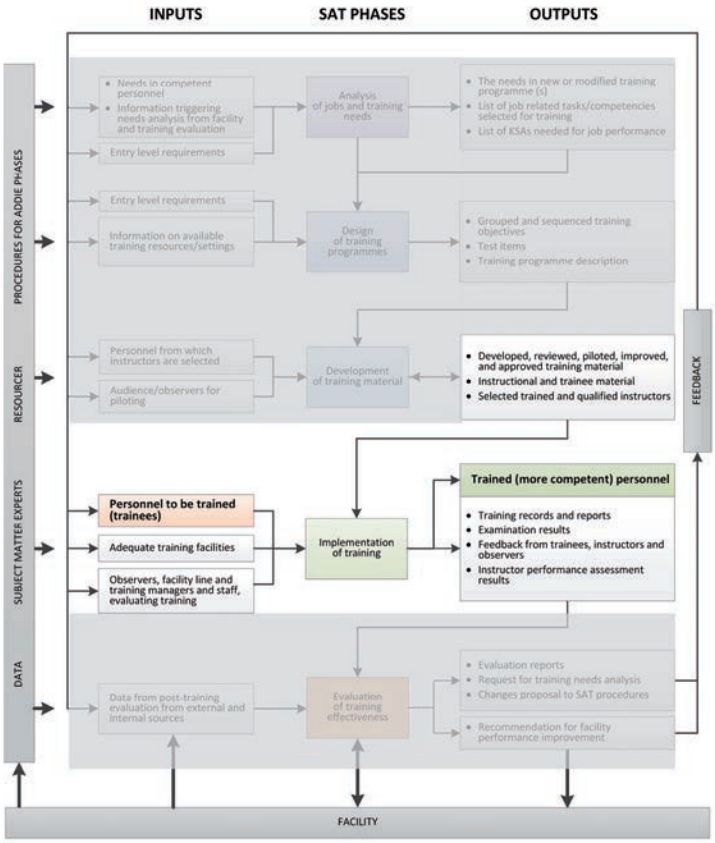

FIG. 16. The SAT implementation phase.

11.2. PURPOSE OF THE IMPLEMENTATION PHASE

The purpose of the implementation phase is to carry out training using the training materials, tools and aids developed and acquired during the earlier phases of SAT. SAT based training is developed using training objectives derived from the analysis of job needs. Such training has to be performed by suitably trained and qualified instructors.

11.3. ESSENTIALS OF THE IMPLEMENTATION PHASE

An essential prerequisite for conducting the implementation phase is the availability of prepared instructors, trainees, approved training material and a suitable training environment. Available, motivated and trained personnel are the most essential product from this phase.

11.4. INPUTS TO THE IMPLEMENTATION PHASE

When starting implementation activities, the following are needed:

— Procedures/supporting documentation for implementation;
— Approved training material;
— Qualified instructors;
— Trainees;
— Adequate training environments;
— Observers for evaluation of training.

11.5. ACTIVITIES PERFORMED DURING THE IMPLEMENTATION PHASE

During the implementation of training, the following activities are performed (see Fig. 17):

— Scheduling of training;
— Logistical arrangements and establishment of a training environment;
— Pre-testing trainees and making necessary adjustments;
— Preparations by the instructors to conduct training;
— Conducting training;
— Assessing trainee performance;
— Receiving feedback from trainees, instructors and observers by performing in-training evaluations;
— Providing feedback to trainees based on test results;
— Conducting remedial training, if necessary;
— Providing feedback to instructors and training managers;
— Generating and maintaining the training records.

In preparing to implement training, it is necessary to establish conditions that allow trainees to give maximum attention to the training process. This can be achieved by releasing the trainees from job duties while in training and by selecting a suitable time for the training sessions. Training after normal working hours, on weekends and during vacation periods is generally less efficient and effective than training during normal working hours. Training during normal working hours also demonstrates management's commitment to and support of the value of training.

Implementing training partially during working hours enables participation and support from the trainees' colleagues and makes the real working environment available during the studies.

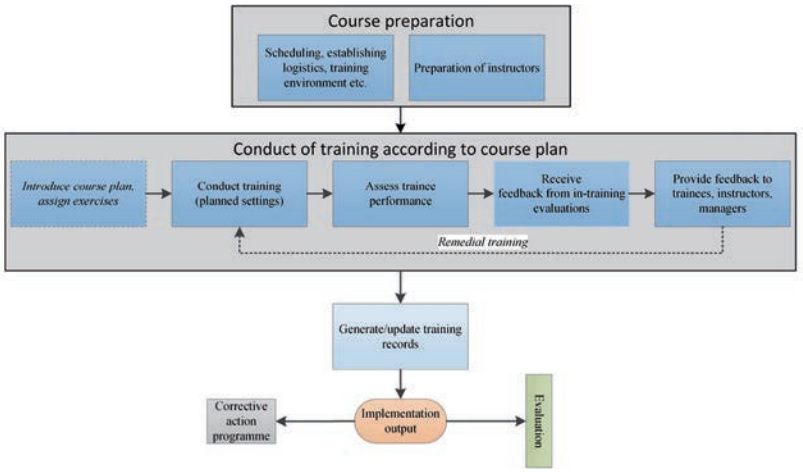

FIG. 17. Overview of the implementation phase process and activities.

The efficiency, effectiveness and impact of the training also depend on the availability of a suitable training environment. There has to be sufficient light, adequate heating, cooling and ventilation facilities, and very little outside disturbance. It also helps if some recreation and refreshment facilities are available for trainees near the training area.

Logistics refers to the planning and coordination of physical details such as facilities, room arrangements, and equipment set-up for the delivery of training. When considering the facilities, it is important to do the following:

— Ensure schedules, announcements and other training related notices are up to date;
— If not previously decided during the design and development phases, determine room size and seating requirements;
— Arrange for the appropriate number of rooms to be available, especially if additional rooms for small groups (breakout sessions) are needed during the training.

It is essential for the training staff to know and apply the principles of adult learning (see Table 7) while conducting the training. Adults are motivated to learn by both extrinsic and intrinsic motivators. Elements such as wages, salaries, promotions and better working conditions are extrinsic motivators for adults. More persistent motivators are intrinsic ones such as the need for self-esteem and broadened responsibilities, influence and achievement. When training adults, the instructor may appeal to both the desire for job advancement and the desire for life enrichment in promoting the topics of training sessions. The instructor needs to involve the trainees in discovering the value that the training programme has to offer for their own lives.

TABLE 7. EIGHT PRINCIPLES OF ADULT LEARNING

Principle	Explanation	Suggestions for application
Readiness	Learning happens when they are ready to learn and can see a reason for learning.	Motivate trainees early. Explain what they will learn, how they will use the knowledge and skills, and why the KSAs[a] addressed are important to them.
Application	Adults learn by doing, when they are active rather than passive participants.	Strive for a 30/70 split in conducting training: 30% lecture and 70% trainee activity/involvement.

TABLE 7. EIGHT PRINCIPLES OF ADULT LEARNING (cont.)

Principle	Explanation	Suggestions for application
Context	Organize information (content) internally based on how the information is to be used (context).	Stress how KSAs[a] will be used. Deliver the content in its job context.
Exercise	Factors/key contributors most often repeated are best remembered.	Plan to repeat critical KSAs[a]. Always highlight safety considerations and link them to defence in depth, reinforcing that personnel and manager competence is one of the important ways to prevent undesirable events. Reinforce the role of organization in preventing human errors.
Effect	Learning is strengthened when accompanied by a pleasant or satisfying feeling; it is weakened when associated with an unpleasant feeling.	Give positive feedback. Praise/reinforce success. When giving critical feedback, avoid introducing a 'blame cycle.' Cultivate a serious and respectful atmosphere that that reinforces the instructor's ability to apply instructional skills.
Primacy	What is stated first creates a strong impression.	Present correct information the first time. Be credible and introduce your qualifications at the beginning of the lesson before you start to talk about the lesson objectives.
Intensity	A vivid, dramatic, and exciting learning experience teaches more than a routine and dull experience.	Use training media that appeals to the trainees' senses. Very low and very high stress lead to low productivity; moderate intensity maintains the needed attention and high productivity in learning.
Recency	Start and end with key learning objectives.	Include the most important objectives and key considerations at the beginning and at the end of the lesson.

[a] KSAs: knowledge, skills and attitudes.

11.5.1. Scheduling implementation

Well structured and prepared training schedules promote the efficient use of trainee and instructor time, facilities and equipment. Training needs to be incorporated in the nuclear facility's work planning schedule. This will ensure that the work planned is not dependent upon resources that are scheduled for training and it ensures that the individuals scheduled for training will attend their courses. Schedules need to include sufficient time for test preparation and correction, subsequent participant review, record keeping, coaching and assistance, and self-study. They need to be flexible enough to allow minor adjustments as warranted by trainee performance. Training programme and course schedules need to be developed and distributed to the trainees, relevant managers and instructors, revised and re-issued if necessary, and stored as a permanent record of training activities completed. Continuing training schedules are typically developed on a rolling annual basis, taking into consideration the established cycle of continuing training and requirements for the minimum duration of training for particular job classifications.

11.5.2. Pre-testing trainees

Entry level testing is used to determine whether prospective trainees have the fundamental knowledge and skills needed to actively participate in the training programme. Such testing is typically performed for initial training programmes within the selection and recruitment process. However, if entry level testing has not been performed at the earlier stages, it may be conducted at the beginning of the SAT implementation phase.

Specifically, the entry level test and pre-test results are used to do the following:

— Confirm that trainees meet the entry level requirements of the programme;
— Identify additional learning needs of trainees who did not satisfy the entry level criteria;
— Identify parts of the training programme for which an accelerated schedule could be applied owing to the trainees' existing qualification or knowledge of the material;
— Identify exemptions from training for particular trainees;
— Identify objectives that have not been satisfactorily met by previous training or where trainees have not retained the information;
— Provide information for evaluation of the training programme's effectiveness;
— Define a learning strategy and adjust the training scope based on weaknesses and strengths of a group of trainees.

11.5.3. Instructor preparation

Prior to conducting each lesson of a training module, instructors need to have enough time to prepare. It is common practice to provide an experienced instructor with preparation time approximately equal to the time required to present the lesson. If training materials need to be modified, then additional preparation time may be needed. During preparation, the instructor will need to review the total content of the lesson and identify the parts which need more attention or special explanation. The emphasis of the lesson may be modified based on trainee pre-testing results. The instructor will need to review the status of training facilities and materials needed for training. Any correction or repairs to training materials or facilities have to be completed prior to the start of the training session. In addition to reviewing the lesson plan, instructors will need to review the procedures for assessment of trainee performance and trainee tests relevant to that particular portion of training. If any tests are planned for the session, the instructor may also need to ensure adequate arrangements are in place for test administration procedures, storage, retrieval, reproduction, and instructions during and after testing.

The instructor will need to possess delivery skills that include the following:

— Verbal skills (volume, enunciation/pronunciation, pace, pause, variety, pitch);
— Non-verbal skills (facial expression and eye contact, posture, body movement, gestures, grooming).

Effective communication between the instructor and trainees has to be established, and it is important that the instructor know the audience and understand the trainees' perspective about the training. The instructor needs to establish trust and credibility with the audience in order to maintain interest and motivation.

11.5.4. Overall considerations for assessing trainee performance

Assessment of trainee performance during and at the completion of training is an essential component of the training assessment and feedback cycle. In addition to determining whether trainees are achieving the training objectives, assessments also give feedback information to instructors and nuclear facility managers on the effectiveness of the training programme. Feedback information from the assessment can also be used to make improvements to the training programme. Typically, trainees are monitored during the delivery of the training (using progress tests) and upon completion of a particular module or session (with final tests).

Trainee performance and progress during training can be monitored closely and continuously. The data for this progress monitoring need to be derived not only from tests but also from daily discussions and questions from trainees during lectures or practical exercises. For example, it is a good practice to carefully analyse trainee comments generated during simulator training sessions to identify common concerns and to adjust training emphasis, training materials or training tools accordingly, if necessary.

All tests, whether concerning simulator training or OJT, and whether written or oral tests, need to be based on the training objectives and assessments/tests that are developed in the design phase of SAT. Assessments used to verify competence upon completion of training have to be directly related, as far as possible, to actual job tasks performed in the job environment with routinely available tools and procedures to replicate real time working conditions.

Test results need to be provided to trainees as soon as reasonably possible after testing. The results can also be reviewed jointly by the instructor and trainee. Deficiencies in performance can be identified and advice can be provided to trainees on necessary improvements. Trainees not meeting pre-established standards may need remediation training before progressing to the next stage of training.

11.6. IMPLEMENTING VARIOUS TYPES OF TRAINING

11.6.1. Classroom training

11.6.1.1. Conducting classroom training

Suitable room arrangement is important for effective classroom training. There are different styles, including classroom style, round table, U shaped, hollow square and conference style. Selection depends upon the size of the group, instructional method selected and training aids used. Effective classroom training is influenced by the availability of sufficient time between lessons to allow trainees to review and consolidate knowledge from the content of previous lessons. In implementing a training programme, a balance has to be sought between classroom training periods and periods reserved for trainee self-study. Classroom training needs to alternate with practical training including OJT, simulator training or training in workshops and laboratories.

11.6.1.2. Assessing trainee performance during classroom training

All three methods of testing — written, oral and performance — may be used to assess trainee performance in the classroom training setting (level 2 evaluation of learning). Written testing has the advantages of enabling the instructor to examine a large group of trainees simultaneously and of allowing sufficient time for trainees to work out numerical examples, produce diagrams and sketches, and describe answers. Written tests also provide an objective record of trainee performance. One limitation of written tests is that some individuals have difficulty expressing their knowledge clearly and in a logical sequence in writing.

When a response requires the use of training materials, facility documents, drawings, training aids or some component, care needs to be taken to ensure that these are made available to the trainees in due time, or that the trainees know that they are responsible for obtaining these in order to answer the question.

Oral tests have to be performed using established and clear standards and procedures for administering oral assessments and need to be well documented. The advantages of oral tests include the following:

— Allowing the trainee to express understanding of the topic in his/her own words;
— Giving the assessor better insight into the trainee's overall knowledge and allowing a more in depth investigation of the trainee's understanding of the subject through additional questions;
— Enabling the option to provide immediate feedback to trainees when an incorrect response is given.

The disadvantages of oral tests are the following:

— Individual assessment of each trainee may require a lot of time.
— Quality and effectiveness of an oral test depends on the examiner's skill, and several qualified examiners may need to participate in the oral assessments used for final qualification tests.

— If the procedures for oral tests are not followed by the examiner there is a potential for personal bias, inadequate sampling of the trainees' knowledge or interference by factors not related to the training criteria.
— Some individuals are not able to communicate clearly in an oral test setting, owing to factors such as nervousness or poor communication skills; however, this itself may be a useful indicator of the trainee's ability to handle stress.

One effective assessment approach for classroom training is to combine written and oral tests, thus taking advantage of the benefits of both. Performance type assessments can also be used in the classroom training setting, for example for assessment of skills in using software or personal protective equipment. Assessments using e-learning technology are commonly used in the classroom training setting. Appropriate facilities need to be made available for oral tests to provide for privacy and avoid distraction.

11.6.1.3. Indicator analysis

There are several performance indicators that can indicate the effectiveness of the training in different training settings. An elemental indicator for written exams is the number of trainees who passed. However, this indication by itself is not sufficient to indicate effective training. Test question analysis provides a more substantial indication of effective training and can indicates when training delivery was weak, questions were inadequate to measure knowledge, or individuals taking the test do not take tests well. Question analysis has to be used together with other methods to evaluate training effectiveness.

Analysing indicators associated with testing activities includes assessing whether trainee reaction to the training (customer satisfaction) indicates training effectiveness. These indicators are constructed during the process of using written, oral and performance tests and are important factors in determining training effectiveness. Also, different warning flags provide additional indication of potential training problems. Examples include the following:

— Student dissatisfaction, which could indicate deficient instruction, facilities, training setting, equipment, etc.;
— Poorly developed evaluation activities, which could indicate deficient instructor/developer skills, lack of oversight in the development or administration of evaluation activities, etc.;
— Poor or inadequate evaluation policies, procedures and practices.

These warning flags need to be identified, examined and evaluated throughout the evaluation process by competent individuals trained to identify and report evaluation related deficiencies.

11.6.2. Simulator training

11.6.2.1. Conducting simulator training

Simulator training for NPP control room operators and supervisors is usually a statutory requirement in countries with nuclear power programmes, and is typically defined in detail in national regulations. While simulator training for personnel other than those in the control room is also performed, methods of training may vary significantly, including the following:

— Use of replica or non-replica simulators developed for certain job positions, such as refuelling machine operators;
— Use of non-replica simulators for study of complex phenomena and processes, including severe accident management and response;

— Performing activities within the replica MCR simulator scenarios but imitating actions through additional ‘soft’ interface and communication channels, or using a role play method — for instance, during a drill;
— Training using demonstration scenarios on the replica MCR simulators but without direct manipulation of the controls;
— Use of virtual reality simulators for training of maintenance personnel or to study phenomena in a research reactor.

11.6.2.2. Assessing trainee performance during simulator training

Effective simulator training requires that individual and team performance be assessed during and at the completion of training programmes. Achievement of performance based training objectives can be tested by several means, including assessments using both the static and dynamic simulator modes. Team performance evaluation requires involvement of behavioural competence to suggest the best composition of a team.

The trainees’ performance is typically assessed using criteria associated with the following:

— Awareness and control;
— Event diagnosis;
— Immediate and subsequent actions;
— Desk and panel operations;
— Use of technical specifications, operating procedures (for normal and abnormal operation, and emergency operating procedures) and other operating documentation;
— Communications;
— Supervisory skills;
— Teamwork skills.

Depending on the stage of the training programme implementation, some or all of these criteria are used for assessment. Computerized recording of trainee actions and simulated facility parameters, including video recording, are widely used in observation and assessment by the instructors or other assessors, for automatic assessment by a computerized system and for post-exercise critiques. Assessment of the achievement of training objectives from the cognitive (knowledge) domain may be performed also in other ways, including oral testing during and after performance of assessment scenarios and using in-built capabilities of simulators that use a graphics interface instead of real consoles and panels, such as in an e-learning system.

Assessment of trainee performance during simulator training has to include observation by the facility’s senior operations managers as part of initial, continuing and requalification training as a matter of routine management observations of training and formal test oversight.

11.6.3. On the job training

11.6.3.1. Conducting on the job training

Conducting OJT typically includes the following steps:

— Preparation and introduction;
— Explanation;
— Demonstration;
— Practice under supervision;
— Assessment of trainee performance.

The OJT needs to be performed in accordance with the OJT guides and the safety of trainees and equipment have to be maintained throughout.

11.6.3.2. Preparing the trainee for on the job training

The trainee is prepared for OJT by being familiarized with all relevant information, such as the following:

— Target dates to complete particular parts of the training;
— Training objectives;
— OJT checklists, JPMs or qualification cards;
— References;
— Instructions on the task and the use of the tools and materials;
— Supporting study materials and technical documentation, including drawings, flow diagrams, procedures and system descriptions;
— Typical errors, error prevention and other human performance improvement tools;
— All necessary industrial and radiological safety precautions.

Reference materials have to contain all necessary data on systems or components included in the training (descriptions, functions, precautions for their operation and maintenance, safety limits, alarms, controls, trips, interlocks, normal and abnormal operating modes, etc.). In addition to studying training material, the trainee needs to review important items with the OJT instructor.

11.6.3.3. On the job training explanation, demonstration and practice

Prior to any demonstration, the instructor explains its purpose, appropriate procedural steps, the consequences of improper performance, and current industry practices relevant to a particular item of the demonstration, and answers trainees' questions. The instructor may demonstrate how to perform the activity depending upon the method of practice selected. The practical work of the trainee follows these demonstrations, and follows one of the following two approaches:

— Performing the particular task, under supervision (for example, starting a circulating water pump or disassembling and repairing a component or instrument);
— Walkthrough of the activity with a qualified instructor.

If practical work includes performing particular tasks, it will include two stages: (1) the trainee performs and the instructor intervenes to correct any errors or to address any safety implications; and (2) the trainee performs unassisted under supervision, with the supervisor only intervening if safety is about to be compromised. When the trainee and instructor are confident that the trainee has mastered a specific item of the training programme and that the trainee is able to achieve the relevant training objectives, a request is made for an assessment of trainee performance, to be undertaken by a designated assessor who was not the original instructor.

11.6.3.4. On the job training instructors and coordinators

OJT instructors are typically individuals who are qualified for and sometimes working in the position they conduct training for. In some national practices, a qualified training department instructor may fulfil the role of the OJT instructor in agreement with the relevant facility manager. OJT instructors

need to receive instruction on the proper methods of conducting such training and have to understand their role in the training process. This includes instruction on the following:

— Overall concept of OJT;
— Methods of developing required trainee KSAs during the OJT;
— Methods of performing trainee progress assessments (e.g. the use of OJT checklists or JPMs);
— Application of established training standards in the trainee assessment process;
— Actions to be taken to prevent injury to personnel or damage to equipment;
— Actions to be taken when the trainees do not satisfy the assessment criteria.

In addition to the required technical and instructional skills necessary, the individuals assigned as instructors for OJT need to possess the appropriate attitudes towards nuclear safety culture and knowledge of human performance and the application of error prevention techniques. An individual from the relevant facility department is typically assigned to coordinate the department OJT programme. The main coordination duties will include the following:

— Acting as a liaison between the trainee, facility and training department;
— Controlling the training schedule and assigning milestones in the training process;
— Monitoring trainees' progress;
— Coordinating training assignments to take advantage of opportunities to train on infrequent work activities;
— Documenting the training process using the training records produced by the OJT instructor;
— Evaluating OJT effectiveness;
— Maintaining OJT documentation in coordination with the nuclear facility line managers and training staff.

11.6.3.5. Assessing trainee performance during on the job training

KSAs are assessed during OJT to ensure that the individual is competent to carry out the assigned task or activity. Performance is typically assessed based on the particular OJT guide and using relevant checklists, JPMs or qualification cards. Performance is assessed using either the 'simulation', 'discussion/walkthrough' or 'performance' method. The preferable method is 'performance'.

Performance assessment requires the trainee to demonstrate proficiency in a specific activity using appropriate procedures, tools and equipment, and adhering to safety considerations. Conditions during performance assessment need to be as realistic as possible. Ideally, performance of the actual activity is required. If facility conditions or other limitations do not allow this, then a walkthrough with a discussion or simulation of the activity can be used for the assessment.

The person designated for the assessment needs to meet the following requirements:

— Be qualified for the job and tasks being assessed;
— Possess the same characteristics as an OJT instructor;
— Be suitably qualified and experienced to act as an OJT assessor.

The assessor provides all the information the trainee would have to actually perform the task, but coaching or other forms of assistance are not allowed.

The trainee assessment process can be described as follows:

— The training coordinator schedules the assessment in agreement with the trainee and assessor.
— The assessor conducts an assessment using the pre-established assessment procedure and standards (e.g. using JPMs).

— If the assessor finds that the trainee meets the established standards, he or she provides written confirmation of this satisfactory assessment. If not, the assessor directs the trainee to the specifics of the substandard KSAs identified for remediation.

The assessor provides feedback to the training department and OJT instructor on any necessary improvements in OJT based on any deficiencies detected during trainee assessment.

The OJT instructor may observe the assessment session but is expected not to intervene. Participation of the OJT instructor enables him or her to obtain information on the outcomes of training and to draw conclusions regarding possible improvements in both the trainee performance and the OJT.

11.6.4. Workshop, laboratory and mock-up training

11.6.4.1. Conducting workshop, laboratory and mock-up training

Many aspects related to conducting classroom and simulator training, and especially OJT, are applicable to workshop/laboratory training. In many situations, this setting is a more favourable environment for learning a skill than the OJT setting; an example is fault finding in an electrical circuit. As with all training activities, the conduct of this training needs to be in accordance with an approved lesson plan designed to achieve the training objectives and needs to be delivered by a competent, experienced instructor. The safety of trainees and equipment needs to be maintained throughout the session. This can best be achieved by ensuring that adequate prerequisite safety training has been built into the overall training programme and that the ratio of trainees to instructors allows for close supervision.

The size of trainee groups in the workshop/laboratory needs to ensure every trainee has the opportunity for hands-on practice. While this can be maximized if trainees work as individuals, the use of small groups usually benefits the learning process by allowing the trainees to share progress and knowledge in a cooperative manner. In addition, the high cost of equipment may necessitate group work in cases such as training on maintenance of high integrity steam safety valves.

The steps to conduct workshop/laboratory training are generally the same as for OJT (see Section 1.8). The introduction to the lesson is as important in the laboratory or workshop as in a classroom lesson or for OJT. Trainees' attitudes in all cases will be greatly influenced by the first few minutes of the lesson. As with all training, it is imperative that the trainees understand the objectives and duration of the session, how it will be structured, the opportunities available for practice and the method and standards for assessment.

The lesson plan needs to include in its introduction a review of prerequisite KSAs prior to the presentation of the session's material. This section of the training will often take place in a classroom near the laboratory or workshop. Trainee materials will include all written materials needed (or references to where they can be found), together with a list of tools and equipment that will be used. At some point, the instructor will demonstrate the task, building on knowledge and skills previously acquired.

In concluding a lesson, the instructor needs to discuss or review the following:

— The entire task, including its critical steps, to tie together the separate items learned in the lesson;
— Errors made by the trainees, reinforcing correct knowledge and correct actions;
— Questions raised by trainees;
— Problems that arose in conducting the practical exercise, and ways in which they could be solved;
— References and suggestions for further study and practice;
— How the work relates to the next lesson.

11.6.4.2. Assessing trainee performance during workshop, laboratory and mock-up training

Unlike in the case of OJT, the assessment of performance during workshop, laboratory and mock-up training will often be conducted within the workshop/laboratory training session and not as a separate

session using an independent assessor. It needs to be made clear to the trainee in advance whether the instructor's observing and questioning is part of the teaching technique intended to help the trainee achieve the training objectives or is part of the formal assessment process where workshops and laboratories are often used for conducting formal qualification tests. In this case, the assessment is performed in a similar way to that for OJT.

11.6.5. E-learning

11.6.5.1. Conducting e-learning

E-learning is used extensively for independent learning (i.e. in self-study), as well as supporting classroom/workshop/laboratory and simulator training. Even when e-learning is used for self-study, trainees may require support from an instructor. Normally the instructor's role is to clarify training objectives, to assist in the use of software, to monitor trainees' progress, and to detect and resolve difficulties in the learning process. One of the important responsibilities of an instructor is to verify that the e-learning content is up to date. Depending on how the e-learning is designed, the instructor may also play the role of facilitator, creating interactive exercises, running group sessions, monitoring on-line forums, and so on.

E-learning lessons typically include progress testing and final assessments. Instructors and trainees need to be able to obtain reports on trainee progress and assessment results. When stand-alone modules are used, a process and procedures for recording the training and assessment results need to be developed.

11.6.5.2. Assessing trainee performance during e-learning

Formal assessment does not typically form a part of e-learning when it is being used in a self-study setting, because it is difficult in this case to ensure the integrity of the assessment. However, formal tests are widely included in e-learning when used in the classroom training environment or even in remote mode when the integrity of the assessment is ensured by assigned personnel in the remote location. E-learning is also effectively used for pre-testing the trainees. Assessments using e-learning are also used effectively as preparation for formal tests or as the first part of a test after which a written or oral test is performed.

11.6.6. Self-study

11.6.6.1. Conducting self-study

Self-study modules need to be based on training objectives and well defined learning tasks that are clearly indicated to the trainee. The support person's role is normally to monitor trainees' progress through the module, to check that they are up to date with their work, to detect problems or difficulties at an early stage and to resolve them. In addition to assisting with difficulties and problems, the designated support person will be able to assist in finding suitable supplementary resources such as reference material.

A variety of self-study situations exists, for example:

— To prepare for other training settings such as the classroom, workshop/laboratory, simulator or OJT;
— To reinforce instruction received in any other training setting.

Self-study may be performed in a training centre, in the workplace or at home. The support and monitoring arrangements will vary according to location.

Self-study needs to be formally assigned to the trainee, and the trainee has to confirm acceptance and completion of the self-study. Appropriate training records have to be generated. It is important to ensure that the trainees are provided with sufficient time for self-study through the support of their line organization.

Self-study needs to be conducted according to a written self-study guide and may include written assignments independently evaluated by an instructor.

11.6.6.2. Assessing trainee performance during self-study

During self-study, self-checking is typically used by the trainees. For this purpose, the self-study materials usually include questions and their answer keys. Knowledge obtained by a trainee through the self-study may be formally assessed while conducting progress tests or through formal tests for the training courses or for the entire training programme.

11.7. OUTPUT FROM THE IMPLEMENTATION PHASE

The implementation phase has the following outputs:

— Personnel are trained;
— Trainee performance is assessed and analysed to provide information to support decisions as to whether training objectives have been achieved and to serve for further decisions on qualification/requalification and authorization (if applicable) of personnel;
— In-training evaluation is performed and necessary feedback is collected from trainees, instructors and facility managers;
— Performance of instructors is assessed;
— Test results are obtained and analysed;
— Trainee records and training programme records are generated;
— Training progress reports are produced.

11.8. EXEMPTION FROM TRAINING

Personnel from the nuclear facilities, including employees or contractors, may be exempted from either a specific part or segment of the training programme or from the entire programme. Any such exemptions need to be carried out in compliance with local rules and, where relevant, in compliance with national regulatory requirements. Equivalent education, training or experience on which training exemptions are based need to be verified and documented. Records need to be kept of all such training exemptions as part of the overall facility document management system records.

11.9. ADMINISTERING TESTS

The appropriate administration of tests requires consideration of the following aspects:

— Identifying regulations applicable to the conduct of tests relating to nuclear facilities;
— Establishing the controls for ensuring the integrity of tests;
— Preparing an assessor board — particularly for oral tests;
— Establishing the test environment;
— Verifying that training tools and supporting equipment (i.e. simulators) are suitable;
— Providing test directions;
— Conducting and monitoring tests;
— Using handouts;
— Assessing and grading;

— Reviewing the activity, comparing the performance and actual outcome with the expectations;
— Recording results and retaining records.

It is important for the nuclear facility management to understand the multiple purposes of testing: used primarily as a tool to support the qualification, requalification and authorization of facility personnel, testing also helps with employee selection, job placement and evaluation of training effectiveness and is a useful instrument for both teaching and feedback.

11.10. FEEDBACK TO TRAINEES

Trainees need to be provided with prompt, regular and objective feedback on their performance during training activities and on any assessments. Trainees will need to review their errors so they understand the correct responses and can provide feedback to the training organization on test content, structure and administration.

To provide maximum benefit, it is good practice to make test results available to the trainee as soon as possible. Test results can be discussed in a critique session to point out strengths and weaknesses, and to indicate areas for improvement. Trainees can be provided with feedback on specific KSAs that do not meet job performance requirements.

Finding the causes of trainees' incorrect answers during the assessments is not simple and more training is not always the solution. Careful evaluation of the aggregate results of oral, written and performance tests is typically done to identify potential areas of weakness both in the training and in the testing methods. If some of the test questions are frequently answered incorrectly, this may indicate a weakness in the questions, the performance of the instructor, the training material or how the assessments are performed.

11.11. PERFORMANCE NOT MEETING REQUIRED STANDARDS

Required performance standards need to be defined and clearly stated in the training materials. Trainees who perform below these standards of performance need to be provided with remedial training and retested. The necessary processes needed to manage circumstances when trainees cannot meet performance standards have to be defined in appropriate written procedures. It is usual that trainees will be unable to proceed to a higher level of training before their performance at the lower level is assessed as satisfactory.

Job incumbents performing below required standards during requalification or continuing training may be deemed unqualified for particular tasks or activities. Good practice is to remove them from the associated job duties and provide them with remedial training until they have successfully requalified. Continued failure to achieve required performance standards may necessitate the removal of the individual from the training programme and the job. This action will require the support of line management and will be easier to achieve if line management is involved in the assessment of trainees during requalification training. Information regarding trainee performance deficiencies needs to be used as feedback into the overall training programme evaluation.

11.12. IN-TRAINING PROGRAMME EVALUATION

The objective of in-training evaluation is to obtain the data necessary to maintain and improve the training programme content, training process and instructor performance. It also provides data for evaluation of training effectiveness. In-training evaluation can be performed for all training settings, at all locations and for training conducted by nuclear facility instructors or by external instructors.

In-training evaluation includes the following activities:

— Collecting, compiling and analysing feedback from trainees, instructors, and nuclear facility and training managers;
— Assessing instructor performance;
— Analysing test data;
— Taking immediate actions for improvement, if necessary;
— Keeping records of the in-training evaluation;
— Providing in-training evaluation data for the post-training evaluation of training programmes and evaluation of training effectiveness.

Feedback/critiques from trainees and instructors can be collected using interviews and questionnaires or surveys. Feedback on the lessons, on the training courses and on the entire training programme can also be collected using various evaluation forms and interview sheets.

Proactive nuclear facility line managers will monitor and evaluate the content, performance and quality of training provided for their personnel as part of their responsibilities for training. The facility line manager needs to discuss observations and evaluations with the instructor(s) and responsible training manager. The performance of each instructor who conducts training has to be evaluated on a regular basis in each training setting where the instructor conducts training.

11.13. TRAINING RECORDS AND REPORTS

The establishment of a training records system is an essential component of a training management process and training system. Types and management of records are normally specified in the integrated management system of the facility and in the training procedures. Trainee records need to be established both for the nuclear facility employees and for contractors who receive training through the facility or organization. At many nuclear facilities, training records are maintained throughout the complete operating phase of the facility or organization and, in many cases, are required and maintained for a specified time period as part of the statutory requirements.

Records of the training programme include:

— JTA or JCA data;
— Training programme and course descriptions;
— Lesson plans;
— Simulator scenarios;
— OJT guides;
— JPMs (and/or checklists or qualification cards);
— Trainee handouts and handbooks;
— Data on the actual schedule and trainee attendance;
— Training facilities used;
— Test material and assessment results.

Data on the individual progress of each trainee need to be recorded. These includes an indication of training programmes and their segments completed, any special qualifications or authorizations received, such as radiation worker or licensed operator, together with assessment results associated with various segments and training programme activities, hold points and milestones. Trainee records can also be utilized to record data on training received by the employees in external educational and training organizations, and their level of accomplishment.

For current and ongoing programmes requiring continuing participation by a group of individuals such as licenced operator continuing training, records of the participation and performance can be

established to easily identify any individual whose attendance, assignment completion or performance is marginal or unsatisfactory. Periodic reports on the status, adequacy and effectiveness of training activities and any significant training related events or problems are an essential input into the relevant training forum or committee and need to be provided to the facility senior managers and line managers for discussion and action at such committees.

11.14. LESSONS LEARNED/GOOD PRACTICES

From the worldwide application of SAT over many years, the following good practices have emerged:

— The availability of trainees (for initial and continuing training) has to be ensured. Some organizations — after investing enormous resources in the establishment or upgrade of a training system — suffer from poor trainee attendance. This may result from the following:
  - Poor attitude of managers towards training (and, hence, towards safety culture in general);
  - Untimely recruitment of personnel;
  - Lack of nuclear facility personnel to allow for release for training (e.g. insufficient number of operation shifts);
  - Lack of regulations prescribing certain training for the nuclear facility personnel;
  - Low quality and credibility of training (e.g. due to absence of quality training materials, instructors, or tools, or low relevance of training to the real facility needs);
  - Poor scheduling of training (e.g. a conflict of scheduled training with nuclear facility activities such as active commissioning, outages or modernization activities).
— For new builds, it is not appropriate for the personnel to sit in the classroom instead of gaining experience through participation in the commissioning activities.
— Training has to be conducted by staff who possess technical and instructional skills as well as appropriate knowledge and attitudes.
— Guidance on the conduct of quality classroom training — even though it may be well known by the instructors — needs to be used. It is not unusual for guidance and good practices for the use of training methods, such as case studies, not to be used in carrying out training, compromising the quality and the whole credibility of training.
— Simulator training is a specialist area requiring unique competence that has to be developed by the nuclear facility using worldwide good practices and involvement of the appropriate consultants at the beginning of the establishment of simulator training.
— Safety precautions for on the job, workshop and laboratory training have to be carefully considered and observed.
— The technical and instructional competence of OJT instructors and assessors has to be ensured.
— Self-study needs to be viewed as a formal training method and, therefore, subjected to application of SAT.
— Operating experience has to be adequately used in conducting all training programmes.
— The nuclear facility will never learn about the real results of training provided unless valid and effective tests are conducted.
— ‘A system is no better than its sensors’: without well organized in-training evaluation, there will be no sound data for the improvement of training.
— Performance of instructors has to be assessed to determine whether standards are being met and continuous improvement is being achieved.
— Nuclear facility managers need to personally observe and evaluate the training of their personnel. Managers who never or rarely personally observe training are not fulfilling their responsibilities and are not acting as appropriate role models for their subordinates.
— Training records are subject to the same management policies and standards as any other records of the nuclear facility management system.

12. SAT IN DEPTH — EVALUATION PHASE

12.1. OVERVIEW OF THE EVALUATION PHASE

The SAT evaluation phase focuses on the evaluation of training programmes and their contribution to personnel and facility performance (see Fig. 18). This includes determining the effectiveness of individual training programmes, the entire training system and the assessment of the competencies of individuals, which is performed during the SAT implementation phase.

Evaluation (the final row of boxes in Fig. 18) examines all aspects of training effectiveness in both the training programme and in the training system. Feedback is collected which leads to improvements in training and facility performance.

Evaluation is a dynamic process of assessing performance, identifying concerns and initiating corrective actions. By monitoring employee job performance, facility and procedure changes and operating experience, evaluation helps maintain and improve the initial and continuing training programmes. Everyone at the facility is involved:

— Senior management ensures all identified improvements are implemented.
— Line management provides constructive feedback, sponsors and encourages self-assessment, supports provisions and implements corrective actions.
— Training management and staff lead or participate in planning and implementing this phase.
— Job incumbents and trainees provide constructive feedback by completing surveys and initiating training requests.

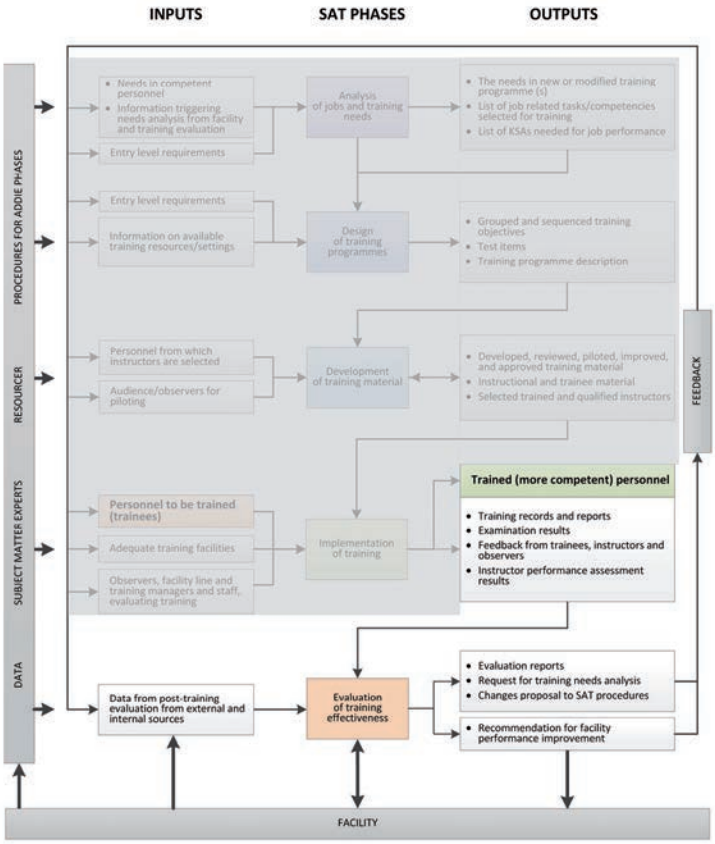

FIG. 18. The SAT evaluation phase.

Both nuclear facility line managers and training staff have to demonstrate ownership for the evaluation of training quality and effectiveness. While other individuals may be involved in supporting the collection or analysis of evaluation data, line managers and training staff need to be committed to and take responsibility for the quality and effectiveness of the training programme, the qualification of personnel achieved through training, and identifying ways to improve training.

Managers of a nuclear facility need to be forewarned of any possible training degradation. The training warning flags listed below may indicate problems in the training:

— Lack of ownership of personnel training and qualification;
— Weak self-assessments;
— Trainee dissatisfaction;
— Weak use of a systematic approach;
— Insufficient training experience on the part of facility managers and training staff;
— Distractions (i.e. low priority of training or suspension of training for long periods).

A systematic evaluation programme allows for necessary changes to be made to the SAT process. It can also demonstrate the impact of training on desired business results to justify the investment in training and provide suggestions for improving facility performance. Training evaluation has to be viewed at as an integral part of the evaluation and improvement of the nuclear facility's safety and performance (see Fig. 19).

12.2. PURPOSE OF THE EVALUATION PHASE

The evaluation phase serves to evaluate the effectiveness and quality of the nuclear facility's training programmes and of the entire training system as well as to generate suggestions for continuous improvement of facility performance.

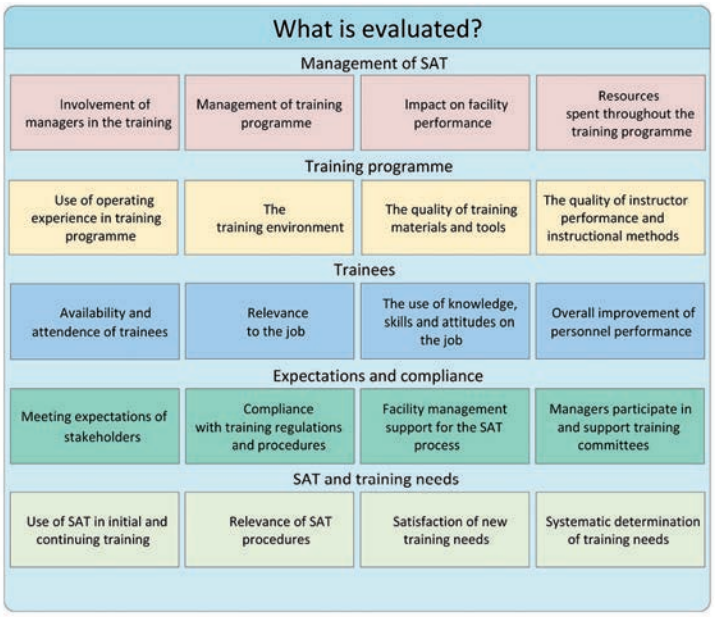

FIG. 19. The many components of evaluation.

12.3. ESSENTIALS OF THE EVALUATION PHASE

It is essential to identify the good practices in training programmes and in facility operations to generate data for improvement. This further ensures the quality of training and identifies what more can be done to improve on safe and reliable facility performance. Both nuclear facility line managers and training staff need to demonstrate ownership for the evaluation of training quality and effectiveness.

12.4. INPUTS TO THE EVALUATION PHASE

In addition to outputs from the implementation phase, the following examples are inputs to the evaluation phase:

— Data from in-training evaluation of the implementation phase:
  - Feedback from trainees, instructors and managers;
  - Test results;
  - Instructor performance assessments;
  - Training records and reports.

— Data from post-training evaluation from internal sources:
  - Input from facility managers;
  - Input from job incumbents;
  - Data from observation of job performance;
  - Facility operating experience feedback and performance indicators;
  - Data on facility modifications;
  - Inputs from internal reviews, inspections and audits.

— Data from post-training evaluation from external sources:
  - Industry-wide operating experience feedback;
  - Data from external reviews.

12.5. STAKEHOLDERS, OWNERSHIP AND RESPONSIBILITIES FOR EVALUATING THE EFFECTIVENESS OF FACILITY AND PERSONNEL

The training system has many stakeholders with expectations for training (see Fig. 20). The evaluation phase of SAT is an important source of information to serve their needs.

Corporate/executive managers have the ultimate responsibility for the operation and safety of the facility, including the training of personnel. This implies responsibility for ensuring that policies and goals for training include and integrate into the overall staffing strategy. Managers at all levels — corporate, nuclear facility, training organization — need to have well defined responsibilities for conducting training effectiveness evaluation.

Training committees can have a significant impact on the effectiveness of training. As well as an overall, higher level facility training review committee (or training advisory board) that reviews all committee inputs, individual training committees may be established for operations, maintenance, engineering, radiation protection/health physics, chemistry, training staff, and management training programmes. Participation of facility managers in these committees is important for their evaluation of training and improvement of performance.

Senior managers implement the strategies for safety, quality, performance, human resources and training. Nuclear facility line managers such as shift supervisors, maintenance supervisors and technical group heads bear the primary responsibility to assure that people perform their jobs safely and effectively. A training manager is typically a member of the senior management team within a facility and is the primary conscience for the SAT implemented at the facility.

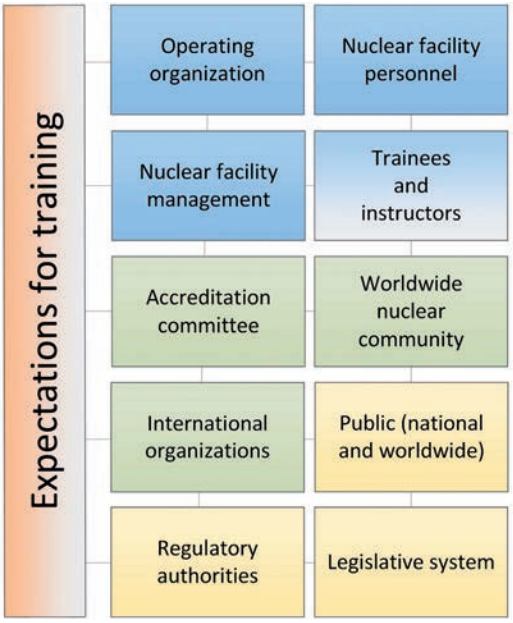

FIG. 20. Stakeholders with expectations for training.

Training personnel need to be responsive to the needs of the organization, working hand in hand with line managers and supervisors to ensure that training needs are properly analysed and that training is developed and implemented in the most effective and efficient way possible. The training organization has to actively and continually communicate with the line organization.

12.6. EVALUATION OF TRAINING EFFECTIVENESS

The evaluation of the impact and effectiveness of training is typically undertaken at four levels following the Kirkpatrick training evaluation model (see Fig. 21). The four levels are:

— *Level 1*: Trainee reaction to the training.
— *Level 2*: Trainee achievement of training objectives, typically verified through test results.
— *Level 3*: Transfer of competencies acquired through training to job performance or behaviour, typically observed and experienced in practice.
— *Level 4*: Impact of training on the business performance of the facility and/or organization.

These four levels assess various elements of the training or intervention. The first three levels are focused on the participants' perceptions and reactions, learning and change in behaviour. Level 4 focuses on business or organizational results.

12.7. TRAINING COURSE EVALUATION

12.7.1. Student reaction and learning

12.7.1.1. Level 1 and 2 evaluation activities

Evaluating a training course corresponds to both levels 1 and 2 of the Kirkpatrick model. This more focused evaluation includes both student reactions and student learning to identify effectiveness

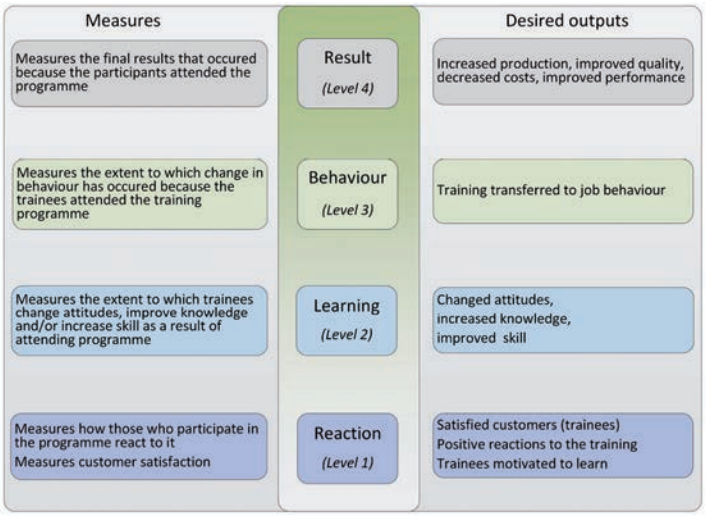

FIG. 21. Overview of the Kirkpatrick training evaluation model.

indicators. These indicators and a summary of training accomplished are documented. This evaluation provides a more substantial analysis of effective training but is not enough to determine that a training programme or course has been effective.

This analysis provides evidence as to whether entry level requirements were met. Pre-tests and post-tests can provide an excellent measure of whether training positively impacted student comprehension and retention.

12.7.1.2. Level 1 and 2 analyses of indicators

Training effectiveness evaluation summaries based on indicators and feedback from students, peers, instructors and student supervision have to be documented and reported. Corrective actions then need to be implemented to address both good and poor results to provide more effective training. By reviewing test results, comments from students, comments from students' peers and comments from students' supervisors, a training organization can get a good indication of training satisfaction and immediate learning retention.

12.7.2. Transfer of knowledge, skills and attitudes to the job

Evaluations at Kirkpatrick level 3 focus on the behaviour of individuals on the job. These behaviours have to be observed in the facility, on the job, at a predefined time after training to ensure that the learned competencies are actually used in the workplace. The assessments and observations need to be conducted at the end of the particular training segment, and then again on the job to assess whether the expected behaviours are being exhibited after the training has been received. The participants themselves, as well as peers and managers, also look for evidence of behaviour change on the job as a result of the transfer of knowledge, skills or attitudes. The manager's role is to reinforce the behaviours learned in training when the trained individuals are back on the job. They may evaluate these personally or seek feedback from other workers, peers or managers. Managers have also to engage training staff to take an active part in measuring the transfer of training to the job. Evaluation is conducted through post-training assessments of particular tasks. These assessments are based on the training objectives and refer to the same difficulty, importance and frequency that were initially identified during the job analysis. Post-training evaluation also needs to refer to the clarity of performance expectations, feedback from past trainees, time requirements, materials and equipment, and processes. A variety of other tools may also be

used to measure behaviour change, such as behaviour checklists, performance appraisals, focus groups, surveys or interviews. Level 3 evaluations also assess instructor performance.

12.7.2.1. Level 3 evaluation activities

Transfer of knowledge and skill to the job after training provides an excellent indicator of training effectiveness and takes the evaluation process to the third level of Kirkpatrick's evaluation model. This type of evaluation provides higher level performance indication for training effectiveness. This level involves line management in the evaluation process. Managers observe work in the field that is performed by workers who have recently completed the associated training. This feedback provides excellent training effectiveness indicators. Conducting line manager observation of field performance before the training takes place improves the validity of subsequent observations and yields a more accurate indication of effective training.

The value of this level of evaluation is that this feedback not only reveals effective training, it can also uncover training that has not been effective and provide input for training revisions. The effectiveness of these level 3 indicators is related directly to the number of observations performed. More observations by many individuals improve the validity and reliability of these indicators. This level of evaluation is very good but time consuming for line managers and supervisors. It is important for the training organization to persuade line managers of their value and to train them in good observation methods.

12.7.2.2. Level 3 analysis of indicators

When it comes to transferring learning to the field, the important factors to consider in analysing training effectiveness are: the number of observations, who conducted them, comments made on the observations, job incumbent performance indicators and warning flags. These indicators provide excellent feedback on the effectiveness of training and are essential to determine associated job performance improvement after the training has taken place. These indicators also indicate students' level of comprehension and their retention of knowledge, skills, and attitudes.

12.7.3. Return on investments

12.7.3.1. Level 4 evaluation activities

Organizational results are the focus of level 4 evaluations. The measurement taken before the intervention is compared with the measurement taken after the intervention to help identify the expected improvement resulting from training. Measurements may include such factors as electrical output, safety performance indicators, time, quality and environmental issues. The cost of the improvement intervention also needs to be evaluated. It has to be mentioned that a return on investment for training is straightforward to estimate, although it can only be done if the parameters are identified during the design phase of the training. Various data may be used to evaluate the impact of training on the organization's results, including the following:

— Nuclear safety event reports;
— Environmental safety reports;
— Safety system availability;
— Safety data including lost time, accidents, personnel injuries and near misses;
— Individual and collective radiation doses;
— Human performance errors;
— Key performance indicators used to determine the facility business target status;
— Number of consecutive days without events;
— Facility/plant availability data including maintenance rework and maintenance backlogs;

— Facility/plant outage data including duration, costs, and plant and equipment turnaround times;
— Equipment failure or plant damage rates.

Trying to determine how changes to business metrics are related to specific initiatives can be challenging. Clear and careful analysis of data is required with line management's agreement and participation. Continuous internal evaluation forms the cornerstone of training programme evaluation.

A formalized process to periodically request and receive manager feedback on job performance is considered to be an integral part of training programme evaluation. Managers, and particularly front line supervisors, are well qualified to identify on the job performance problems and anticipated changes in job requirements. They also need to be consulted regarding how well training is preparing new employees to perform their jobs and what continuing training is needed for current employees. The following specific feedback needs to be collected from managers and supervisors:

— Tasks for which recent trainees are inadequately prepared;
— Deficiencies in KSAs;
— Types of errors committed by incumbents;
— Anticipated new training needs;
— Suggestions for improvement in initial and continuing programmes.

Inputs and feedback are obtained through the training committees and forums as part of the management oversight of the health of the training programme (see Fig. 22).

12.8. OWNERSHIP AND RESPONSIBILITIES FOR EVALUATING THE EFFECTIVENESS OF NUCLEAR FACILITY PERSONNEL TRAINING

Line management has to own the evaluation of nuclear facility personnel training effectiveness, just as they own the training itself (see Fig. 23). However, all participants have to be fully accountable for the quality and effectiveness of their activities in the training process. From corporate and executive management to plant personnel, each worker has to be able to assess whether they and those reporting to them are trained effectively to carry out their responsibilities and tasks proficiently. Managers and supervisors need also to be able to evaluate whether training standards set by regulatory and accreditation bodies for nuclear facility personnel are effectively met. Knowledgeable work group managers are ultimately responsible to make a final determination that subordinate personnel are receiving effective training.

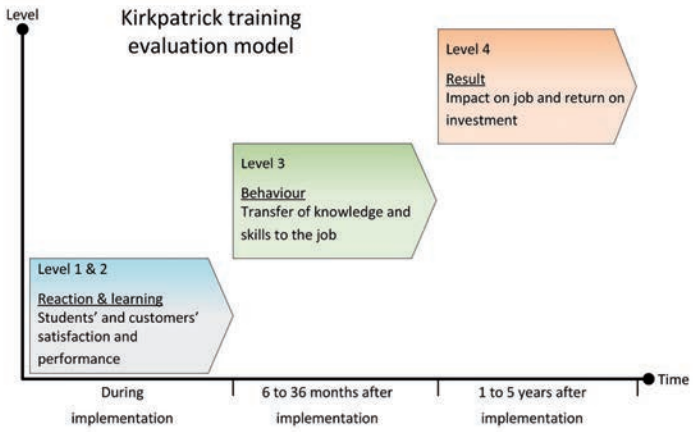

FIG. 22. Timeline of phases in Kirkpatrick evaluation model. TNA — training needs analysis.

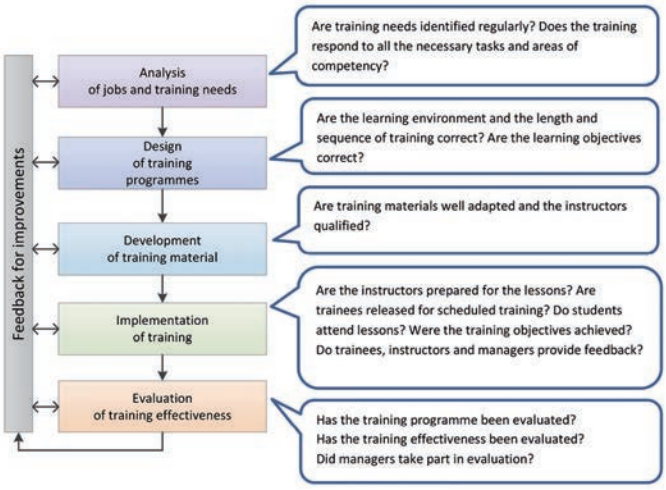

FIG. 23. Ownership and responsibilities for the effectiveness of training.

12.9. DATA FROM THE OBSERVATION OF JOB PERFORMANCE

Many facilities have programmes to regularly observe the conduct of facility activities. Personnel assigned to perform these observations have to represent a broad cross-section of those parts of the facility organization and its work groups affected by the activity being observed. In some cases, these form part of organized self-assessment programmes where observations resulting from these assessments are reported and corrective actions are identified. It is necessary to ensure that these corrective actions are implemented in a timely manner. Other facilities have less formal systems such as 'management by walking around', where managers are expected to spend a certain number of hours per week observing the conduct of activities for which they are responsible. Where these programmes for observing training and facility activities exist, they provide an important source of information for training programme evaluation and have to be a part of the facility's management system. These observations of job performance provide a particularly good opportunity for joint participation by facility work groups and the training organization. In this way, the facility and the training organization can ensure they are applying the same standards of performance in the facility and in training settings.

Job sampling is another method of observing job performance. Job sampling is the most direct and accurate way to evaluate knowledge and skills transfer from training to the workplace. It involves testing selected personnel at the level of the terminal training objective on selected tasks including psychomotor and cognitive tasks. Causes of inadequate performance are analysed and appropriate preventive and corrective actions suggested to the responsible facility manager and to the training staff.

12.10. INPUT FROM JOB INCUMBENTS

Feedback from job incumbents after they complete training and from representatives from the workforce are an important feature of the training forums and committees. Specific feedback from job incumbents could include the following:

— Tasks for which additional training was identified in order to perform the task correctly;
— Difficulties experienced in performing the job;
— Identified knowledge or skills deficiencies that are not addressed in the current training;
— Required attitudes, the importance of was were not reinforced during training;
— Differences between task performance on the job and how the task was taught during training;

— Changes in the job since the incumbent was assigned to it;
— Training which has not been used on the job;
— Suggestions for improving training.

12.11. PLANT FACILITY OPERATING EXPERIENCE FEEDBACK AND PERFORMANCE INDICATORS

Nuclear facilities need to make every effort to analyse events in order to identify any underlying causes related to human performance. The results of such analyses and resulting suggestions can then be linked back into the relevant training programmes and other affected areas such as procedures, equipment design and organizational arrangements. To correlate this with human performance, personnel competence and training, not only events but other facility performance deficiencies need to be considered in the analysis.

The following performance indicators for nuclear facilities identified by the World Association of Nuclear Operators (WANO) are an example of high level metrics against which the impact of improvement initiatives, including training, can be assessed:

— Unit capability factor;
— Unplanned capability loss factor;
— Forced loss rate;
— Collective radiation exposure;
— Unplanned automatic scrams per 7000 hours critical;
— Industrial accident safety rate;
— Safety system performance;
— Fuel reliability;
— Chemistry performance.

Data obtained from the analysis of operating experience and key indicators support the evaluation of training effectiveness at Kirkpatrick level 4.

12.12. INPUTS FROM INTERNAL REVIEWS, INSPECTIONS AND AUDITS

Almost any evaluation of facility activities has potential relevance to training. For example, an inspection of reactor protection system maintenance might conclude that technicians performing calibration checks of the equipment were damaging the detectors when they removed their test equipment. This deficiency may result from inadequate training, but it might also result from other factors such as excessive workload causing technicians to rush or poor work habits due to inadequate supervision or attitudes. Self-assessments within the management system are another important source of data for evaluating training effectiveness.

12.13. EXTERNAL EVALUATIONS OF TRAINING

External reviews of the facility training programmes will be carried out by organizations external to both the facility and training organizations. These may be international organizations such as WANO or the IAEA, or national organizations such as regulatory authorities. These independent evaluations can be viewed as a way to validate conclusions drawn by the internal evaluation process and to improve the training programme evaluation process. Independent reviews provide an opportunity to calibrate the quality and sustainability of training with external organizations. Independent review teams may bring a

different perspective to the evaluation of training programmes compared to the one the facility employs during its internal reviews or self-assessments.

Some Member States have a regulatory requirement that SAT based training be used for nuclear facility personnel. The regulator will conduct independent reviews/audits of the facility training programmes to validate the implementation quality of the SAT process. A typical regulatory review or audit of a SAT based training programme would look at both the quality of performance of personnel and the quality of training provided. For any job performance weaknesses identified, inspectors would be expected to focus particularly on training related to job performance.

Peer review missions such as WANO plant evaluations and IAEA Operational Safety Review Team (OSART) missions are also a form of independent review useful for comparing the quality of ongoing training programmes and their sustainability in relation to internationally recognized standards and criteria.

12.14. FORMAL EVALUATION OF A COMPLETED TRAINING PROGRAMME

At the conclusion of a training programme, a formal evaluation of it has to be performed. This evaluation needs to include a review of the final programme, course and lesson plan documents with an emphasis on the task qualification of trainees. Additionally, this evaluation has to include all feedback received during implementation, including trainee surveys, facility manager evaluations, data on new training needs provided by the facility and any other forms of feedback. The evaluation is typically conducted within three to six months of the programme's conclusion. Results of the evaluation will form part of the information provided to the relevant training committee.

Typically, a checklist for the process would include the following:

— Content adequacy including a review of the conduct of the TNA and JTA/JCA;
— Training objective quality and correlation between training objectives and content;
— Test question quality and correlation to the training objectives;
— Content coverage and delivery adequacy and quality;
— Test material adequacy;
— Training material availability and quality;
— Availability of suitable training records and reports;
— Internal audit results;
— Independent review results (e.g. from IAEA or WANO) or results from audits (e.g. by a corporate level organization or by a regulatory authority);
— Training related corrective actions taken.

12.15. MEASURING THE RETURN ON TRAINING INVESTMENT

The implementation of a SAT based training programme is a costly undertaking. It is increasingly important to identify the business benefit from such a model in terms both of safety and of facility operational and business performance.

Part of the review of training effectiveness and identifying the return on investment is identifying where the training requirement has come from. This could be assessed from a review of performance issues for a particular work group, from a problem identified by a line supervisor or manager, or from a problem identified (by a particular work group or a manager) as a potential threat to operation or productivity. The second consideration is to identify what the training intervention is trying to correct. Deficiencies may lie in the domain of knowledge, skill or behaviours and attitudes.

A number of commercial organizations now have processes in place that support calculation models for identifying the return on investment for a particular training activity [18].

Key indicators that can be used to calculate the return on investment include the following:

— Safety improvement measured as a reduction in reportable nuclear safety related events — based on the International Nuclear and Radiological Event Scale (INES) — due to reductions in human performance errors.
— Safety improvement measured as a reduction in personal dose and contamination events and reduced environmental events due to human performance error reductions, greater awareness of risk management, etc.
— Savings resulting from improved electrical generation due directly to improved personnel performance, measured in MW·h (time saved × MW·h price). This includes electricity generation increase due to reduced facility downtime resulting from improved efficiencies in MCR operator performance and improvements in the efficiency of maintenance work, and improvements in reactor 'return to service' times following power reductions.
— Savings resulting from loss avoidance, measured in MW·h (time saved × MW·h price), such as loss of unit/reactor trip or process plant failure for conventional and nuclear plants due to improved efficiencies and operator confidence in MCR performance.
— Savings resulting from improved efficiencies in maintenance or servicing activities, measured in availability of service function and reduced downtime charges.
— Savings due to direct replacement costs (i.e. reduced contractor service charges).

Nuclear facilities use various approaches and practices in establishing training performance indicators. Particular practices depend upon the facility's priority needs, its maturity in the evaluation of training and the availability of resources for — and data from — the monitoring, measuring and evaluation of training performance indicators.

Examples of factors used in establishing training performance indicators include the following:

— Improvement of performance:
  - Personnel error rate;
  - Control of key safety parameters;
  - Maintenance rework;
  - Individual and collective doses;
  - Use of error prevention and other human performance improvement techniques.
— Training committee(s) performance.
— Ownership of line managers:
  - Staffing level and quality of training department and OJT instructors;
  - Managers' commitment to training schedule;
  - Quality of training observation;
  - Adherence to training schedule;
  - Training attendance.
— Conduct of training:
  - Trainee satisfaction;
  - Quality of instructor performance;
  - Technical competence of instructor;
  - Instructional skills of training staff;
  - Technical content;
  - Quality of simulator training;
  - Material condition of training centre.
— Test pass rate.
— Use of operating experience.
— Training department support to other facility activities.

— Continuous improvement:
  - Integration with the facility's corrective action programme;
  - Adherence to self-assessment schedule;
  - Effectiveness of training initiatives;
  - Training compared with adverse trends.

12.16. OUTPUTS FROM THE EVALUATION PHASE

Expected outputs from the evaluation phase are as follows:

— Training evaluation reports are produced.
— Changes required to the conduct of any of the SAT phases are identified.
— Improvements to facilities used in training are suggested.
— Facility improvement suggestions are made, such as changes to:
  - Facility procedures;
  - Organizational arrangements;
  - Facility design.
— Data are provided to the TNA activity for deciding whether any modifications of training programmes are necessary.

12.17. LESSONS LEARNED FROM THE EVALUATION PHASE

Evaluation is an ongoing activity throughout each of the SAT phases. A continuous evaluation process ensures that suggested improvements are implemented in a satisfactory and timely manner.

13. SAT APPLICATIONS

13.1. OVERVIEW OF THE TRAINING MODEL

The specific education models and training programmes in place for the different positions and roles will vary from country to country, and in some cases, from organization to organization within Member States. There may be differences in the duration, scope and content of the education and training depending on the country's approach, which it established to suit its national educational institutions and cultural norms. The following sections provide generic guidance on the structure of different training programmes and will need to consider these national and regional requirements and expectations. SAT processes can be applied to all the nuclear safety significant aspects of nuclear facility training. The process is generic and different modifications of the phases of the method can be applied as appropriate to the various facility departments and functions, including personnel in the following areas:

— Management and leadership roles;
— Operations;
— Maintenance;
— Engineering;
— Technical support;
— Radiation protection;
— Chemistry;

— Training;
— Emergency preparedness;
— General areas.

Generally, countries establish entry level technical and experience requirements for entry into the training programmes. Some portions of initial training can also be provided by external training organizations based on an agreed training curriculum. Initial training programmes for facility personnel usually includes some introductory training followed by some nuclear fundamentals, and plant processes and systems, followed by role/job specific training. These segments of training are typically organized in sequence and may follow combinations of classroom, practical and OJT based on the specific role.

The exact duration of each segment will vary, depending on the role requirements and the training needs identified through the analysis phase of SAT, in particular those identified through the JTA for task based roles and activities and the JCA for engineering and knowledge based roles and activities. Table 8 presents an overview of the typical content of initial NPP training. The exact times and topics may vary according to the KSAs of new hires and the organization's training programme model.

The training forums and committees play a crucial role in the development, monitoring and evaluation of nuclear training and it is good practice to ensure that the relevant department and/or section training committee is directly involved in both the initial and continuing training programmes.

13.1.1. Nuclear fundamentals training

The nuclear fundamentals segment of training is designed to provide trainees with the theoretical knowledge necessary to understand the basis of facility operation. The topics covered during this phase typically include: nuclear physics; reactor physics; thermodynamics; hydrodynamics; heat transfer; basic facility design; radiation protection; chemistry; nuclear safety; and electrical fundamentals relevant to nuclear facility operation, instrumentation and control, material science and regulations. The delivery of this phase can be effectively supported by practical exercises using basic principle simulators and digital simulation models, laboratories or research reactors, various equipment models and mock-ups.

TABLE 8. TYPICAL CONTENT AND DURATION OF A GENERIC NUCLEAR TRAINING PROGRAMME

Department	Position	Induction (4 weeks)	Nuclear fundamentals (6–12 weeks)	Plant systems and processes (6–12 weeks)	Role specific (1–6 years)
Technical support	Chemist Health physicist	The exact duration of each segment will vary, depending on the role requirement			
Maintenance	Control and instrumentation tech. Mechanical tech.				
Engineering	Design engineer System engineer				
Operations	Plant operator Reactor operator Shift manager				

13.1.2. Plant systems and processes

During this segment of training, the topics will typically include the facility's plant systems, equipment and components together with the different modes of operation. System descriptions will include the system function, design, components, layout and operation. Limitations in technical specifications are discussed to instruct trainees on facility operational limitations and boundary conditions. Systems included in this training phase can be divided into groups, including primary systems, safety systems, secondary systems, auxiliary systems, electrical systems and instrumentation systems. During this segment, simulator demonstrations and hands-on practice, as well as facility tours can be used to familiarize trainees with equipment and locations. Categorization of nuclear facility systems will vary in different facilities, and is normally defined in the specific training requirements of the organization's training management system.

13.1.3. Role specific training

The role specific segment of the initial training will include a mix of further classroom training, mentoring activities and shadowing, together with OJT where relevant. For some expert roles that carry significant nuclear safety responsibilities — such as the nuclear safety engineer or the facility head of radiation protection — up to six years of role specific training may be required for trainees to become fully qualified and competent across the broad range of activities required. Training for other roles may take less time, depending on the exact role and any prequalifying education and training the trainee may already possess.

13.1.4. Simulator training

Comprehensive simulator based training programmes need to be provided to ensure that all operations personnel fully understand and are familiar with their facility's operating procedures, especially for emergency conditions. The trainees need to become familiar with actual facility operation and transient response using a facility referenced full scope replica simulator and/or other appropriate simulators. If a simulator that is based on the plant design is not available, a simulator of similar design can be used with additional instruction provided on any differences in the expected facility responses. Simulators are powerful tools in ensuring that operating procedures are properly understood, helping operators to develop and maintain diagnostic skills and enabling them to recognize departures from normal operating conditions and the underlying causes for such departures. Training also integrates diagnostics, communication, teamwork, human performance error prevention tools and conduct of control room operations with the technical training to simulate 'real life' working conditions, especially in the facility's control rooms. In preparation for simulator based training sessions, classroom presentations are delivered to develop understanding of the principles of operating procedures. Pre-exercise briefings are conducted to introduce scenario objectives, while post-exercise critiques are conducted to provide feedback about trainee performance and to stress important learning points. Training on a simulator is particularly suitable to developing thinking abilities using well designed scenarios that create situations requiring knowledge based evaluation and decision making.

Major areas covered during this phase of training are as follows:

— Normal operation: Normal operating procedures supporting normal facility operation through different operating modes.
— Abnormal operation: Procedures that are used under abnormal conditions and equipment malfunctions during normal and transient operations.
— Emergency operation: Procedures used to handle emergency conditions. Well designed training in emergency operating procedures will ensure that operating personnel have a good understanding of

the conceptual basis of those procedures, the related terminology and structure, and the personnel roles and responsibilities during the execution of the procedures.

13.1.5. Integration of behavioural requirements into nuclear training programmes

The personnel working at nuclear facilities carry with them a unique responsibility for nuclear safety. As employees in this sector, it is imperative that the individuals take personal responsibility for and demonstrate the appropriate behavioural competencies in support of protecting the nuclear safety boundaries. This is a requirement for all personnel working at nuclear facilities, and in particular for the operations and maintenance personnel. Working in teams requires significantly more interdependence of personnel than in other areas of facility operation. Teamwork requires that individual tasks and responsibilities be clearly assigned and understood by all the team members to help them provide each other with mutual support if necessary. Successful teamwork also requires communication and trust. Behavioural and human performance attributes can be developed, improved and reinforced through integration with technical training programmes. This includes simulator training, OJT and mentoring activities, all of which can be used to strengthen individuals' and teams capabilities.

Examples of important interpersonal/soft skills, human performance competencies and leadership behaviours which can be developed and reinforced through initial and continuing training of operations personnel include the following:

— Effective communication;
— Teamwork;
— Conservative decision making;
— Conflict resolution;
— Leadership;
— Human performance tools for error prevention;
— Observation and coaching.

13.2. MANAGEMENT AND LEADERSHIP TRAINING

Competent nuclear facility management is essential for safe and reliable operation. The competence of managers consists of two important components: competence in the relevant functional subject matter area (e.g. technical competence) and managerial competence. The competencies required have to be identified for all management functions at the nuclear facility (or facilities) and be used to design the selection, recruitment and training and development programmes for nuclear facility managers at various levels.

Using JCA, the competencies can be analysed and detailed for various functions/positions for corporate/executive, senior, middle, and first level managers of a nuclear facility. The required job specific competencies can be acquired with appropriate education, training, qualification and continuous development. This needs to be incorporated into a management and leadership development programme. Within this context, the training programmes for nuclear facility management can be determined using SAT, with a focus on the required management competencies.

13.2.1. Management roles and responsibilities

13.2.1.1. Corporate/executive managers

These managers have policy making functions which include setting strategic goals and objectives; long term planning to establish policy for safety, quality and business performance; and allocating financial and human resources.

13.2.1.2. Senior managers

Senior managers have the overall responsibility for safe operation of one or more nuclear facilities, including the responsibility for competence of all facility employees and contractor personnel. Department managers are senior managers in charge of specialized teams, departments or work groups related to one of the main facility functions.

13.2.1.3. First level managers and supervisors

The role of this level of management is to lead front line teams within facility departments. Specific management training is needed, especially for shift supervisors and safety engineers, because of their job related challenges in dealing with facility events. This specific management and leadership training needs to be focused on areas such as handling stress and risk based and conservative decision making.

The competencies required for fulfilling a particular manager's job have to be identified and analysed according to the facility's organizational chart and the manager's functions. As with other nuclear facility staff, it is a fundamental requirement that managers have the technical competencies required for their jobs, which includes having complete understanding of and ability to apply a body of knowledge and experience related to the area of technology for which they are responsible, such as nuclear physics, radiation protection, mechanics, electricity, automation or chemistry. The required competencies need to be derived from knowledge of the specific functions of a managerial position.

It is important that technical competence in their field of responsibility be required of senior managers. However, senior managers need to also have a wider range of knowledge outside their specific technical duties within the organization. Senior managers having an understanding of the scope and important aspects of other facility related disciplines will support cooperation between various work groups and the team building process within the facility management team. These are the prerequisites for developing a strong nuclear safety culture. All management staff of a nuclear facility therefore need to have basic understanding and knowledge of the following:

— Nuclear facility technology, design basis and physics;
— Design knowledge management;
— Safety philosophy and principles, including nuclear safety;
— Radiation protection and radiological controls, and ALARA principles;
— Nuclear regulations and requirements;
— Environmental management;
— Industrial safety and fire protection regulations and principles;
— Nuclear security regulations and principles;
— Facility specific regulations and requirements;
— Facility systems;
— Quality management principles;
— Emergency preparedness and management.

13.2.2. Management and leadership competencies

The responsibilities of managers are directly connected with the establishment of a safety and security culture, the role and responsibility of the operating organization, the provision of regulatory control and the verification of safety related activities. This is part of a manager's wider role in setting the standards and expectations for all staff in all aspects of company business. In addition, it is important that managers themselves visibly meet these standards and help staff to understand why they are appropriate. In addition to written policies, managers' visibility and their everyday attitudes and behaviours have a significant influence in establishing an organization's culture. Nuclear facility organizational, safety and

security, operational, and quality cultures are established and enhanced by managers personally sharing the organization's values and demonstrating adherence to policies, rules and procedures.

Nuclear facility manager selection, development and performance assessment have to be based on the experience of leaders in the operation of nuclear facilities. Competencies related to characteristics, values, knowledge and skills that lead to superior performance need to be defined and considered in the development of the facility specific management training programme. Examples of these include the following:

— Understanding and practicing the principles of safety and nuclear security culture;
— Understanding the principles of integrated (process based) management systems;
— Decision making and problem solving;
— Communicating within the organization and with outside stakeholders;
— Influencing stakeholders, colleagues and staff members;
— Effective management of human resources, including monitoring of individuals' performance and coaching staff members;
— Line management ownership for personnel competence, training and qualification;
— SAT;
— Motivating, empowering and developing people;
— Teamwork and team building;
— Management of change;
— Process and project management;
— Overall safety and risk management;
— Understanding the principles of financial management;
— Knowledge management principles;
— Human and organizational performance;
— Demonstrating behaviour as a leader and proactive member of the team;
— Stress resistance and mitigation skills;
— Establishing and promoting ethical behaviour through modelling;
— Time management skills;
— Promoting, facilitating and motivating the right behaviours;
— Understanding of and approaches to risk management for nuclear facilities.

13.2.3. Management training and qualification: Corporate management training

Corporate managers play an important role in setting management objectives, establishing the policies for nuclear safety, quality and business performance, and for allocating necessary resources. Typically, corporate managers in the nuclear business are promoted from previous senior management positions in the industry. In this case they are familiar with the challenges and the basic principles of managing nuclear facilities. If they do not have such a background, it is good practice to ensure they take actions to get an understanding of the standards, obligations and requirements relevant to managing nuclear facilities.

In many countries, managers — including corporate/executive managers — are subject to initial and periodic tests at the organization or facility level. In some countries, there are even requirements from the regulatory authorities for defined manager functions.

13.2.4. Management experience requirements

Experience requirements play a significant role in the qualification and authorization of managers, depending on the managerial level. Typically, the experience gained in nuclear facility management roles forms a prerequisite for movement through the managerial levels as follows:

— Facility/site vice presidents or directors: Five to ten years of experience in various fields of nuclear facility operation, including experience in direct operations functions.
— Senior department or function managers: Three to five years of experience in their field of responsibility or in comparable functions.
— First level managers and supervisors: One to three years of experience in their field of responsibility. For functions with particular safety significance (e.g. shift managers), more practical experience is preferred.

For new nuclear facilities, especially for the first nuclear facility in a country, it may be difficult to get candidates with the required practical experience. In this particular case, special provisions have to be made to get comparable experience (e.g. by having them get experience at other similar facilities or with suppliers). In this case, it is important that these managers be deeply involved in the commissioning phase of the facility. An alternative or supplementary option is to arrange for them to shadow experienced managers, perhaps from the facility vendor, to gain the required experience.

13.2.5. Initial training of managers

Training programmes for the development of overall leadership competencies are typically part of long term career planning within the nuclear facility or operating organization. Management training is therefore provided throughout the individual's career, rather than as a short term module in preparation for a particular job. A management training programme helps the organization control long term management training and ensure its continuity and completeness. In particular, for the design and the implementation of training modules, organizations may use external specialized management training providers. A wide range of programmes are available. Selection needs to take into consideration national and company specific management approaches.

One of the most effective methods in management training is the coaching and mentoring of candidates by experienced senior managers. For this purpose, succession planning has to consider the availability of a sufficient number of suitably experienced managers to coach others. A recognized good practice is to nominate candidates for positions with high safety relevance who have demonstrated management capabilities in temporary projects. Another good practice to acquire the needed management competence, especially for senior managers, is rotation among various facility work groups. For example, at some nuclear facilities, a period of working in the training department is a prerequisite for being promoted to a senior management position.

The objectives and content of the management training modules (in particular those provided by external providers), the quality of instructors and the training methods used need to be consistent with nuclear and industrial safety approaches. Training programmes offered by organizations with high standards in safety — such as those in the airline, chemical, medical and pharmaceutical industries — may be suitable. Before engaging any external training providers, it is important that the operating organization establish criteria to verify that they are familiar with the principles and challenges of the nuclear industry sector.

13.2.6. Continuing training of managers

A continuing training programme for managers also needs to be defined and oversight needs to be provided by the relevant training committee. This is especially important for any duties and tasks

which are performed infrequently but are important to facility, personnel, public and environmental safety — such as emergency response roles. The continuing training programme has to address both technical and non-technical competencies to refresh competencies but also to address any changes to management philosophy, policies and approaches.

13.3. OPERATIONS PERSONNEL TRAINING

The purpose of training programmes for operations personnel, including MCR staff, field operators, fuel handling and, in some cases, radioactive waste plant personnel, is to ensure that all who are involved in direct and indirect operation of the plant are suitably qualified and experienced to carry out their roles and duties. Operational staff is at the front line of nuclear plant and equipment operation, and their training and qualifications assume a particular importance for the nuclear safety of the facility.

13.3.1. Initial training programmes for authorized operators

Regulatory standards in different Member States define additional training requirements for authorized operators, which typically include roles such as shift manager, shift supervisor, shift engineer, control room operator and reactor operator. The exact titles and respective roles and responsibilities need to be defined and described in the supporting documentation for the training management system.

These training programmes build on the fundamentals, plant systems and process elements and are usually integrated into the role specific areas of these training programmes with a focus on the key responsibilities and duties, which typically include the following:

— Evaluation of facility status;
— Command and control;
— Decision making;
— Emergency preparedness organization and procedures;
— Work controls;
— Performance observation and feedback;
— Basic management skills;
— Application of operating experience;
— Planning and managing evolutions;
— Maintaining a broad view of facility operations;
— Operating philosophy;
— Emergency plan implementation;
— Transient and accident analysis;
— Application of design basis for facility operations;
— SAT.

All supervisory personnel are expected to demonstrate leadership in carrying out their responsibilities. The training programme structure includes management and leadership training, simulator training, OJT and a final test applicable to their work position.

13.3.2. Initial training programmes for field operators

Field operators are responsible for the operation of systems and components as directed by authorized operators, which includes operation of local control panels and local control rooms. The initial training programme is designed to ensure the operators understand the facility's systems configuration, the operation of such plant and equipment, and their specific associated operating procedures. Practical training needs to include simulator training, laboratory training and OJT as applicable to the specific job

duties. For example, turbine operators who are not authorized have to participate in control room simulator training to acquire the required skills. Usually, there are different OJT programmes for different field operator positions. During initial training, field operators can be qualified for one or several positions. OJT programmes need to include a detailed list of technical documentation and practical activities to be performed which are necessary to obtain a solid knowledge of facility systems, components, equipment locations, work practices, and operating and administrative procedures. The training programmes for field operators may include other functional responsibilities of their position, including emergency response capability such as firefighting and first aid training.

13.3.3. Initial training programmes for shift technical advisers

Some countries use shift technical advisers as full time members of the shift operations organization. Other countries incorporate these duties into other control room roles actively supported by nuclear safety engineering services from the sections with personnel working daytime. Their role is to provide independent nuclear safety engineering expertise on shift to the MCR team and the associated supervisors. Training provides them with the competencies to monitor equipment and system operation and to evaluate facility conditions during abnormal and emergency events. Initial training for the position of shift technical adviser has to include instruction in the following areas:

— Responses to accidents and analyses of facility transients;
— Application of engineering principles to protect the reactor core;
— Mitigation of facility accidents;
— Basis of facility and systems design;
— Reactor theory, thermodynamics, heat transfer and fluid flow;
— General operating procedures, technical specifications and administrative controls;
— Operational transient and accident analysis;
— Simulator training, including normal, abnormal and emergency operations;
— Accident response training.

13.3.4. Initial training programmes for fuel handling personnel

Different nuclear facilities use different practices in the area of fuel handling; the regulatory requirements for training and qualification of fuel handling personnel may also vary among Member States. Those facilities that are designed for on-line refuelling while operating at power use dedicated groups of operations personnel who are responsible for fuel handling activities. Training programmes for those groups need to enable them to perform their duties in a safe and efficient manner. The initial training programme has to be designed to make fuel handling personnel knowledgeable about configuration and operation of fuel handling systems, and applicable operating procedures. Practical training has to be conducted using various simulators, including part task or virtual reality refuelling machine simulators supported by relevant OJT.

Some Member States require authorized personnel to supervise fuel handling operations during shutdown conditions. In this case JIT training may be appropriate to refresh the operator's KSAs prior to beginning fuel handling activities. In addition, staff members who handle fuel need to have job specific training to ensure they are knowledgeable about fuel handling systems configuration and operation, and associated procedures. This training has to incorporate human performance techniques and operating experience to assist in preventing future errors.

13.3.5. Initial training programmes for radioactive waste plant personnel

The structure of the waste management programme, together with the national capacity for waste treatment and storage, will influence the workforce requirements and the supporting education and

training programmes. The number of SQEP staff required to manage the radioactive waste will depend on the type and method of waste treatments at the nuclear facilities themselves, the nature of the treatment and storage options available, and the national arrangements in place for long term treatment or storage.

The operational staff who are responsible for the collection, processing and storage of radioactive waste in the nuclear facility will need a combination of competencies similar to those of typical field operators. This will include the day to day operation, maintenance of radioactive waste treatment plant systems and equipment for gaseous, liquid and solid wastes, coupled with additional knowledge and skills associated with direct management and, in some cases, handling of radioactive wastes in both liquid and solid forms. These operational staff will normally be supported by a team of radiochemists or radiation protection staff who will conduct radiometric analysis and monitoring of the waste streams as part of the processing activities.

In some cases, the activities associated with radioactive waste handling are part of shift operations' responsibilities; in other cases these could be handled by a separate dedicated radioactive waste team working on a day shift or staggered shift (for example during an outage). For a twin unit NPP site this could include a team of 20 staff, however this number will vary depending on the size of the site, the number of units and the waste volumes generated. The personnel involved in the transport of waste from the site locations to national and international destinations for treatment and/or storage will need education and training in relevant transport regulations and requirements. This will include a basic understanding of the hazards associated with the radioactive wastes together with the necessary actions in response to a transport accident or event.

13.3.6. Continuing training for main control room operators

Based on the outcomes of the analysis phase of SAT, initial training topics need to be reviewed to determine which tasks and their associated KSAs have to be included in the continuing training programme for MCR operators.

The following may be addressed in this training:

— Nuclear fundamentals (e.g. reactor physics, applied thermodynamics, fluid dynamics);
— Facility plant and equipment systems, including any system or plant modifications;
— Operating procedures, including abnormal and emergency procedures;
— Infrequently used normal operating procedures such as facility startup.

Facility performance issues and conclusions from any performance observation programme need to be included in the training programme as part of a corrective action programme. New or revised regulatory requirements also need to be incorporated as well as operating experience including discussions on performance discrepancies and their causes.

Facility referenced simulator training is useful in maintaining and improving operating procedure usage, diagnostic capability and thinking skills. The scope of simulator scenarios has to extend from normal operating transients to emergency situations, including scenarios like MCR evacuation following a fire or release of toxic gases, or facility shutdown from outside the MCR.

Improving the preparedness of authorized operators to perform scheduled, but rarely performed operating activities needs to be considered as part of a well designed continuing training programme. For such cases, training needs to be delivered just before these activities take place — as JIT training.

It is considered good practice for part of the control room continuing training programme for authorized operators to be conducted in parallel with the training of field operators. Both programmes have to include some common classroom lectures, simulator scenarios or in-facility practical exercises where the complete operating crew is involved. This approach strengthens the crew's teamwork and improves communication among both groups. Entrance and exit tests can be implemented to confirm a required level of competency is obtained during the training process. Operating standards and expectations have to be reinforced or introduced through continuing training.

It is good practice for shift technical advisers to participate in continuing training activities with the MCR operators, including simulator training. This enhances the teamwork of operating crews.

13.3.7. Continuing training for field operators

Based on the outcomes of the analysis phase of SAT, initial training topics need to be reviewed to determine which tasks and associated KSAs have to be included in the continuing training programme. The topics selected for continuing training of the MCR crews will also be applicable for the continuing training programmes for field operators, although the depth and focus of the particular technical topics may vary according to the KSAs being refreshed.

The continuing training would typically aim to do the following:

— Maintain and refresh KSAs for field operators to accomplish routine, abnormal and emergency duties;
— Enhance the KSAs of field operators through timely training for infrequent, difficult and important maintenance tasks;
— Identify KSAs that are new or upgraded owing to changes in field operators' job scopes;
— Update and maintain field operators' knowledge of appropriate plant modifications and procedural changes for areas in which they are qualified;
— Share lessons learned from plant and industry operating experience to prevent occurrence/recurrence of errors or events;
— Outline identified improvement opportunities for personnel performance;
— Share expectations and standards set by line managers.

In addition to the theoretical training, field operators will benefit from refreshing practical hands-on training to help maintain and improve operating skills. This needs to be performed in the technological part of the facility or in a training environment using local control room simulators, a plant and equipment flow loop simulator or even, if applicable, a full scope simulator, if it is equipped for training of local field operators. The curriculum is also likely to include supporting roles and responsibilities that may need refreshing, including practical firefighting exercises or first aid exercises.

13.4. MAINTENANCE PERSONNEL TRAINING

Training and qualifications for maintenance personnel are particularly important for the safety and reliability of the facility and its operation. In maintenance personnel, training has to develop an awareness of how maintenance actions can have an adverse impact on the facility. A key aspect for the qualification of maintenance personnel is to focus on and reinforce the right performance and behaviour during operation and maintenance of nuclear facilities. Striving for excellence in maintenance personnel performance comprises an ongoing effort designed to significantly reduce facility events caused by maintenance personnel errors and support the required facility performance.

The maintenance training can be included as a part of the facility training or, for some fleet situations, a central maintenance training organization may be in place. Workshops, mock-ups, real facility equipment, physical models, maintenance performance simulators, flow loops and human performance simulators are appropriate tools for practical training and are most effective in developing maintenance skills. E-learning systems may be used for classroom training and self-study, and in support of workshop training. The training courses can be a combination of classroom theoretical training/e-learning and hands-on practical training. All of these training facilities and tools need to be provided and maintained to effectively support maintenance training.

Typically, nuclear facilities have access to dedicated classrooms, workshops with real or simulated equipment, or even complex maintenance training centres. OJT also plays a very important role in

maintenance personnel training. In many facilities, real equipment used for training — such as pumps, valves, breakers and instrumentation — consists either of components that were taken out of operation or of new spares purchased along with the parts necessary for facility operation.

13.4.1. Functions and duty areas of maintenance personnel

The first step when determining the training and the qualification requirements for maintenance personnel is to define the functional responsibilities and tasks associated with their positions. In a typical nuclear facility, these responsibilities and tasks are performed in three areas based on maintenance of different types of facility equipment: mechanical, electrical or instrumentation and control. In some cases, there will be a mix or combination of maintenance skills combined into a single role or position, depending on the particular norms used in the general vocational training programmes in a country.

Maintenance personnel are typically qualified by task or duty area, and therefore training programmes for different maintenance personnel positions vary in scope and duration. In some nuclear facilities, cross-training for several maintenance jobs is provided. That offers many advantages regarding optimization of the workforce. In some cases, it is possible to bring together a set of common KSAs for a particular group of plant items and equipment to cover the spectrum of tasks and competencies required for nuclear facility maintenance personnel at several levels. For example, a programme might group generic competencies applicable to all maintenance personnel such as radiation protection training, generic tasks such as surveillance techniques and methodologies, and specific tasks such as those associated with maintenance of a particular type of safety valve, pump or motor.

13.4.2. Training and development of maintenance managers

First level managers have an essential role in the implementation of management expectations in the field. By acting as role models, they set the standards and expectations, and their training has to consider this requirement. They act as a link between senior managers, technicians and craftspeople, and the ability to reinforce correct technical and behavioural requirements throughout the maintenance work activities is an essential feature of their responsibilities. It is good practice for training to be delivered to maintenance personnel by first level managers where appropriate and practicable, to help and support their credibility, internal communication and teamwork.

13.4.3. Initial training of maintenance personnel

The specific content of an initial training programme for maintenance personnel will need to consider the national and regional vocational training models deployed across the country. In some cases, the facility's programme will be used to fill any gaps in the maintenance personnel's existing training. In other cases, the maintenance programme may assume very limited base knowledge for all the maintenance personnel and include an extensive apprenticeship type training scheme over several years. In addition to the core skills the maintenance personnel would be expected to have, a typical initial maintenance training programme would include the following:

— Induction training, which provides basic knowledge of required safety practices including industrial safety;
— Fundamentals training, which is designed to provide knowledge of the basic theory, background principles and functionality of facility systems with respect to the operation and maintenance of a nuclear facility;
— Training on plant systems and processes, with a focus on the maintenance requirements;
— Facility specific training, which would typically include the philosophy of maintenance, documents governing maintenance, compliance requirements for standards and procedures, and the risks associated with maintenance activities in relation to operation and availability of the facility;

— Specialized job/position specific training reserved normally for the few maintenance personnel to be qualified to perform these tasks.

In some cases, core skills training may be required to fill in gaps in pre-existing qualifications.

13.4.4. Continuing training of maintenance personnel

Based on the outcomes of the analysis phase of SAT, initial training topics need to be reviewed to determine which tasks and their associated KSAs have to be included in the continuing training programme for maintenance personnel. The continuing training would typically aim to do the following:

— Maintain and refresh KSAs for maintenance personnel to accomplish routine, abnormal and emergency duties;
— Enhance the KSAs of maintenance personnel through timely training for infrequent, difficult and important maintenance tasks;
— Identify KSAs that are new or upgraded owing to changes in maintenance personnel's job scopes;
— Update and maintain maintenance personnel's knowledge of appropriate plant modifications and procedural changes for areas in which they are qualified;
— Share lessons learned from plant and industry operating experience to prevent occurrence/recurrence of errors or events;
— Outline identified improvement opportunities for personnel performance;
— Share expectations and standards set by line managers.

Examples of maintenance personnel training practices in various countries and nuclear facilities are summarized in Table 9; additional explanations and their emphasis are provided in the sections that follow.

13.5. ENGINEERING AND TECHNICAL SUPPORT PERSONNEL TRAINING

Typically, personnel entering engineering or technical support positions possess a significant level of relevant knowledge obtained by degree studies in engineering, science, technology, mathematics or a related technical field. The following suggestions for engineering and technical support personnel training assume satisfactory completion of the associated entry level prerequisite educational requirements. Recognizing that engineering organizations include personnel with diverse backgrounds, experiences and areas of expertise gained performing widely varying jobs, a systematic approach needs to be employed to identify the training needs of each department, group and individual worker. For many engineering and technical support functions, a JCA is more appropriate than a JTA. Often, a combined JTA and JCA is the most suitable method of identifying the competencies required for these functions.

Consideration of an individual's previous qualifications and experience in other programmes, education or training and working at other nuclear facilities or even in other industries and enterprises can be used to justify exemptions from portions of the training and qualification programme. Exemptions need to be based on satisfactory knowledge and skills verified by an appropriate management review process. For example, if the candidate has experience and training at another facility, a management review could include an objective, comprehensive technical interview with the candidate and/or an objective review of previous training and job performance records. The review may also include requiring the individual to complete a test on the subject matter, or an equivalent process to determine the level of knowledge and skills possessed. Training exemptions have to be documented and approved by line and training managers to ensure their appropriateness.

TABLE 9. PRACTICES FOR MAINTENANCE PERSONNEL TRAINING

Regular subjects	Additional subjects	Types of assessment of trainee performance
GET[a] for maintenance workers		
Plant layout Safety culture Industrial safety Radiation protection and ALARA[b] Fire protection Environmental protection Adherence to procedures Quality assurance/quality control Physical protection measures Nuclear security culture Emergency plans Plant organization and administration Human error prevention techniques (general) Information security	Human performance Standards and expectations Housekeeping Foreign material exclusion Correct component verification Safe driving Duty area training (valves, turbine, etc.) Overview of facility processes Reliability of work practices Nuclear waste	Written Oral Computer
Maintenance fundamentals and job specific training for maintenance workers		
Plant layout Standards, rules and regulations General system features Quality assurance/quality control Maintenance procedures and practices Surveillance and inspection Special maintenance skills Training on maintenance tasks selected for the particular maintenance jobs using SAT Safety culture Adherence to procedures Experience feedback Human error prevention techniques (specific to particular duties)	Structural materials, material testing, chemistry, corrosion protection Nuclear professionalism Industrial safety Radiation protection Duty area training (valve, turbine, etc.)	Written Oral Computer Performance (hands-on demonstration)
Training of first level maintenance managers/supervisors		
Facility management system Concepts and practices of safety culture Industrial safety Standards, rules and regulations Training on supervisory competencies/functions, supervisory and soft skills (e.g. coaching and mentoring, decision making, self-assessment techniques, teamwork training, communication, human performance techniques) Radiation protection/ALARA[b] Environmental protection Adherence to procedures Emergency procedures Plant modification Training on tasks/functions selected through SAT job analysis Experience feedback Nuclear security culture	Leadership and management responsibilities	Written Oral Computer Performance (hands-on demonstration)

TABLE 9. PRACTICES FOR MAINTENANCE PERSONNEL TRAINING (cont.)

Regular subjects	Additional subjects	Types of assessment of trainee performance
Continuing training for maintenance workers		
Tasks selected for continuing training through SAT job analysis Safety culture Industrial safety Radiation protection/ALARA[b] Environmental protection Adherence to procedures Quality assurance/quality control Facility access control Emergency plan Organization/administration Changes to standards, rules and regulations Facility equipment modifications Operating experience, review of events Human error prevention techniques	Specific technical training courses for craft given by the training organization or equipment providers, and managed by the line management	Written Oral Computer Performance (hands-on demonstration)
Continuing training for maintenance supervisors		
Safety culture Industrial safety Radiation protection/ALARA[b] Environmental protection Adherence to procedures Facility management system Quality assurance/quality control Facility access control Emergency plan Organization/administration Facility modifications Changes to standards, rules and regulations Operating experience, review of events Training on particular supervisory tasks/functions selected for continuing training Human error prevention techniques	n.a.[c]	Written Oral Computer Performance (hands-on demonstration)

[a] GET: general employee training.
[b] ALARA: as low as reasonably achievable.
[c] n.a.: not applicable.

13.5.1. Functions and duty areas

There is a wide spectrum of engineering and technical support functions and duties at nuclear facilities, including the following:

— Safety analysis;
— Facility and systems engineering;
— Facility life cycle management;
— Modification and configuration management engineering;

— Design authority;
— Reactor engineering and nuclear fuel management;
— Procurement engineering;
— Facility licensing and regulatory affairs;
— Support to the establishment and performance of quality management systems;
— Technical documentation development;
— Emergency preparedness engineering;
— Operations support, including procedure writing and document and record management;
— Engineering support for maintenance optimization;
— Outage management;
— Metrological engineering;
— Engineering support for radioactive waste management;
— Non-destructive testing/inspection;
— Nuclear material accounting;
— Nuclear physics and research engineering (e.g. for research reactors);
— Material management;
— Construction support;
— Information technology support.

13.5.2. Initial training for engineering and technical support personnel

The structure of the initial training for engineering and technical support personnel would follow the same path as that for the operations and maintenance staff, with the route through the programme being based on the needs of the employee. The goal of the initial training is to supplement new employees' pre-existing education by ensuring they gain the basic knowledge and skills needed in their jobs at the nuclear facility. Training takes place as quickly and efficiently as possible either within the facility itself or as part of an external engineering support organization. Typically, the initial programme can be completed in 12 months. However, for certain roles that require extensive experience in a particular activity or plant evolution, it may take several years to become fully qualified and experienced enough to perform independently (for example to be the head of nuclear engineering or design engineering). In these cases, it is typical to follow a training route that allows the trainee to approach authorizations in stages: for example, for activities and tasks that carry significant responsibilities related to nuclear safety. The typical engineering support personnel programme would be based on the following structure:

— Induction training, which provides basic knowledge of required safety practices, including industrial safety;
— Fundamentals training, which is training designed to provide knowledge of the basic theory, background principles and functionality of facility systems with respect to the operation and maintenance of a nuclear facility;
— Training on plant systems and processes, with a focus on the facility specific engineering requirements;
— Role specific training.

13.5.3. Engineering role/position specific training

The role/position specific training for engineering support staff needs to be designed to ensure that all the designated roles, responsibilities and authorizations are adequately scoped and included. The topics typically include a significant portion of mentoring activities. The training and qualification programme will be delivered in standard formats, including classroom, simulator, structured self-study and e-learning. OJT supported by coaching and mentoring is widely used for the training and competence development of engineering and technical support personnel. Some of the training may cross functional boundaries.

This training needs to be conducted or guided by the experienced members of each group, primarily using structured self-study and mentoring.

Mentoring may be appropriate for many job performance requirements for which it is impractical to use traditional, formal OJT. Mentoring is a process in which trainees are provided with direction, coaching and oversight by experienced personnel to ensure job performance requirements are understood and competency is achieved. As many engineering assignments are knowledge based, this can be accomplished using a variety of methods and may be conducted over extended periods. A mentor does not need to maintain continuous observation of a trainee. However, it is important that a mentor be able to assess the results of any work the trainee performs to ensure it meets all applicable standards.

Managers and supervisors who are qualified and authorized can act as mentors for the engineers undergoing training. In some cases, qualified technical experts may also be used to conduct position specific training and qualification.

13.5.4. Continuing training for engineering and technical support personnel

Continuing training is designed to ensure engineering personnel remain current with respect to facility modifications, procedure changes, operating experience and technical advances associated with their job functions. The latter is of special importance for engineering and technical support staff; facility managers need to ensure them opportunities to complete the necessary education, training and competence development through activities both on and off the site.

Continuing training for engineering personnel in the nuclear industry is typically a combination of generic training for the entire engineering population and targeted work group specific training. Multiple training methods and settings can be used for either generic or work group specific continuing training. Training methods for the engineering support staff may vary from informal seminars presented within work groups to complex hands-on laboratory training. Similarly, training settings may vary from formal classroom to JIT field training. Vendor training may be also provided, as appropriate, to specific work groups or individuals, and JIT training may be provided to individuals or groups before important activities such as refuelling outages. Continuing training needs to be based on performance and training needs, rather than a specific number of training hours.

Continuing training topics may include the following:

— Training to facilitate changes in job scope, new tasks or short term assignments;
— Needs identified by performance evaluation and TNA;
— Changes to codes, standards and regulatory requirements;
— Changes to facility systems and components;
— Communications related to equipment and personnel performance trends or issues, including those generated through the carrying out of engineering tasks, observation and coaching, facility condition records or human performance evaluation;
— Updates on facility and industry operating experience;
— Emerging nuclear, radiation, environmental and personal safety issues, and security issues;
— Results of engineering evaluations and inspections;
— Advanced technologies and techniques;
— Technical visits to other nuclear facilities or to vendor facilities;
— Identified improvement opportunities for personnel performance.

13.6. TRAINING ON RADIATION PROTECTION AND RADIOLOGICAL CONTROL

Training on radiation protection is required for many job classifications in all nuclear facilities. Personnel requiring radiation protection training are involved in a wide range of activities, including directing or supervising radiation protection and radiological control in the facility, operation and

maintenance, radioactive waste handling and emergency response. In addition to the training requirements of the general workforce in the facility, there is also a specialist group of workers who are employed as full time radiation protection and health physics experts, usually as part of the department or section.

13.6.1. Functions and duty areas

In order to define the training and the qualification requirements related to radiation protection and radiological control, the first step is to define the functional responsibilities and job specific requirements of personnel involved in radiation protection, followed by a TNA.

In order to assure appropriate levels of radiation protection and safe performance, consideration has to be given to various job categories involved in or subject to radiation protection; these are typically positions that do the following:

— Provide radiation protection instructions and compulsory advice;
— Oversee adherence to radiation protection standards;
— Adhere to radiation protection standards during their work.

The content of training for each of these categories has to be based on such factors as the potential for radiation exposure associated with the work, the level of supervision provided, the complexity of work to be performed, their role in performing radiation protection and radiological control, and the previous education, training and experience of the individuals.

13.6.1.1. Positions that provide radiation protection instructions and compulsory advice

Those who provide radiation protection instructions and compulsory advice typically include radiation protection and radiological control managers and ‘qualified’ radiation protection experts. A radiation protection/radiological control manager is responsible for the design, implementation and continuous improvement of radiation protection and radiological control programmes and the supervision of these programmes. Radiation protection managers may specialize in one of the radiation protection areas or techniques. Having responsibility for the whole radiation protection area requires broad knowledge together with significant experience associated with all aspects of radiation protection in the facility. A qualified radiation protection expert is an individual who, by statutory or regulatory certification through appropriate boards or societies, is duly recognized as being suitably qualified and experienced in a field of specialization related to radiation protection, such as health physics, dosimetry, medical physics or a similar relevant engineering or safety specialty. Qualified experts in radiation protection at a nuclear facility may deal with a wide range of protection and safety activities, such as the designation of areas, individual monitoring, planning for safety of personnel in activities involved in a major shutdown and emergency response preparedness.

13.6.1.2. Positions that oversee adherence to radiation protection standards

Responsibility to oversee adherence to radiation protection standards includes radiation protection officers, qualified radiation operators and nuclear facility managers.

Radiation protection officers are employees who supervise radiation safety within a facility and ensure that work is carried out safely and in accordance with the relevant national requirements. They typically provide the links between the workplace, the management, the qualified expert and the regulatory body, and they need to ensure that activities involving exposure to ionizing radiation comply with established regulations. They have to be fully familiar with the activities performed in a facility, its organizational infrastructure and working procedures and need to have a good understanding of the relevant regulatory requirements. They need to have sufficient authority to be able to perform these functions effectively. They can also support or train workers. A radiation protection officer would

typically be the central point of reference within a facility for all radiation protection matters and may carry out or directly supervise contingency plans in the event of an accident or incident. Duties could also include responsibilities relating to the safety aspects of radioactive waste management and protection of the public in the vicinity of the facility.

A qualified radiation operator is responsible for the day to day use of radiation sources. Qualified radiation operators need to be trained in the operation of the equipment and need to have a high level of expertise in their area of work. Qualified radiation operators have to be trained and qualified in proper use of work procedures and need to be fully aware of the radiation doses that are associated with specific procedures. For example, quality assurance associated with the operation of X ray test equipment has to be an essential component of radiation operators' training. Furthermore, they need to be trained in actions to take in the event of equipment failures or threats caused by events like fire or other external hazards in the vicinity of the facility.

The term 'nuclear facility manager' is used to describe those people responsible at all levels, including senior managers, for overseeing the use of ionizing radiation sources and personnel's adherence to the applicable radiation protection rules, regulations and procedures. 'Manager' training may include the basic principles of radiation protection, responsibilities relating to radiation risk management, the relevant legislation and regulations governing radiation protection, the concept and principles of safety culture and the principal elements of a radiation protection programme for occupational and public exposure. Managers have an important responsibility to ensure that all workers, including contractors, receive adequate training in radiation protection and safety.

13.6.1.3. Positions that adhere to radiation protection standards during their work

A radiation worker, in terms of radiation protection, is any person who has recognized rights and duties in relation to occupational radiation protection. Employment status (full time, part time or temporary) is not used to determine the appropriate level of training. The type and level of training may be adjusted to be commensurate with the individual's level of access, assigned duties, and type of previous training and experience. Radiation workers need to comply with any applicable rules and procedures for protection and safety as specified by the employer and nuclear facility, including use of the monitoring equipment and personal protective equipment provided. They need to cooperate with the employer and the nuclear facility with regard to protection and safety, including providing the employer and nuclear facility such information on their past and present work that is relevant for ensuring effective and comprehensive protection and safety for themselves and others. They are required to abstain from any action that could put themselves or others in situations that are not in accordance with applicable standards. They need to receive and comply with information, instruction and training in protection and safety that enables them to conduct their work according to relevant requirements.

A group of workers that requires particular support is the emergency response personnel such as firefighters, civil defence personnel, police and paramedics who are not usually employees of a nuclear facility. They are not exposed to radiation on a regular basis, and thus they are not normally included in the facility's occupational radiation protection programme. In such cases, training has to be carefully designed to ensure that the participants have a clear understanding of the specific hazards and risks associated with nuclear or radiological emergencies and how they are to respond to emergencies in specific nuclear facilities.

13.6.2. Initial training in radiation protection

The content and duration of the specific training programmes needs to take the following into account:

— Job specific requirements to be performed in a nuclear facility;
— The nature of the radiological hazards in the area to which the individual will be granted access, and the nature of the work to be performed;

— The type and complexity of protective actions that the individual might be expected to undertake in the areas to be entered, including an assessment of both routine and emergency actions;
— The individual's previous education, training and experience working with radioactive materials and in the vicinity of radiological hazards.

People in positions that provide radiation protection instructions and compulsory advice such as qualified radiation protection experts usually have a sound technical and professional educational background from public or industrial educational systems. As training in radiation protection is not often provided in national education systems, it must be provided by nuclear research institutions, specialized training providers and international organizations. Such courses typically include the following topics:

— Basic physics and mathematics used in radiation protection;
— Interaction of radiation with matter;
— Sources of radiation;
— Dosimetry calculations and measurements;
— Principles of radiation detection and measurement;
— Biological effects of ionizing radiation;
— Principles of radiation protection and the related international framework;
— Legal framework for radiation protection and the safe use of radiation sources;
— Assessment of occupational exposure due to external sources of radiation;
— Assessment of occupational exposure due to the intake of radionuclides;
— Methods of protection and the safe use of radiation sources;
— Individual and workplace monitoring;
— Health surveillance;
— Potential exposures;
— Medical exposures in diagnostic radiology, radiotherapy and nuclear medicine;
— Sources of exposure of the public;
— Safe transport of radioactive material;
— Radioactive waste management;
— Environmental dose assessment;
— Interventions in situations of chronic and emergency exposure;
— Emergency preparedness for a nuclear accident or radiological emergency;
— Assessment and response in a radiological emergency;
— Assessment and response in a nuclear reactor emergency;
— Monitoring in a nuclear accident or radiological emergency;
— Medical management of radiation injuries.

For specific applications and use of radioactive materials or isotopes, tailor-made courses can be developed to meet the organization's needs. Initial training of radiation workers is directed and tailored to the particular type of work performed, with a focus on working safely in radiation and radioactive contamination areas. Radiation workers need adequate information, instruction and training on the health risks due to their occupational exposure both in normal operation and in accident conditions, and on how they can contribute to the protection and safety of the facility and personnel. This information needs to ensure that they become confident regarding the effectiveness of radiation protection measures employed within the facility to guarantee their personal health and safety. Special consideration needs to be provided to female workers who identify themselves as possibly being pregnant. They need to be given adequate and specific information on the risk to an embryo or fetus due to radiation exposure. It is important for a female worker to notify her employer of her pregnancy status as soon as possible. National regulations usually establish requirements for the training, assessment of knowledge and performance, and qualification of workers prior to them entering facilities involving radiological hazards.

Radiation worker training would typically include the following topics:

— Basic radiological fundamentals and radiation protection concepts;
— Risks of exposure to radiation and radioactive materials;
— Procedures for entering and exiting authorized areas, including the use of work authorizations;
— Controls on radiation exposures;
— Use of protective equipment, including protective clothing and respiratory protective equipment;
— Alarms, warning signals and response actions;
— Requirements for interfacing with the radiation protection organization/personnel;
— Methods for requesting personal dose records and reports.

A part of the lesson addressing ALARA may include explanation of the ALARA concept and methods employed to reduce exposure such as time, distance and shielding.

13.6.3. Continuing training of radiation protection personnel

Based on the outcomes of the analysis phase of SAT, initial training topics have to be reviewed to determine which tasks and their associated KSAs need to be included in the continuing training programme for radiation protection personnel. The continuing training would typically aim to do the following:

— Maintain and refresh KSAs for radiation protection personnel to accomplish routine, abnormal and emergency duties;
— Enhance the KSAs of radiation protection personnel through timely training for infrequent, difficult and important tasks;
— Identify KSAs that are new or upgraded owing to changes in radiation protection personnel's job scopes;
— Update and maintain radiation protection personnel knowledge of appropriate plant modifications and procedural changes for areas in which they are qualified;
— Share lessons learned from plant and industry operating experience to prevent occurrence/recurrence of errors or events;
— Outline identified improvement opportunities for personnel performance;
— Share expectations and standards set by line managers.

13.7. CHEMISTRY PERSONNEL TRAINING

13.7.1. Functions and duty areas

In order to define the training and the qualification requirements related to chemistry personnel, the first step must be to define the functional responsibilities and job specific requirements of chemistry personnel involved in radiation protection, followed by a TNA.

13.7.2. Chemistry managers

First level managers have an essential role in implementing management expectations in the field. Acting as role models, they set the standards and expectations; their training needs to consider this requirement. They act as a link between senior managers, technicians and craftspeople. Their ability to reinforce correct technical and behavioural requirements throughout the chemistry work activities is an essential feature of their responsibilities. It is good practice for training to be delivered to chemistry personnel by first level managers where appropriate and practicable, to help support their credibility as well as internal communication and teamwork.

13.7.3. Chemistry personnel

Chemistry personnel are typically split into two work groups: those that monitor and control plant chemistry, and those that operate in the field and laboratories.

Chemistry personnel who monitor and control plant chemistry provide feedback on programmes such as system health and preventive chemistry and become strong advocates for optimum equipment performance. They make full use of chemistry fundamentals and seek excellence in the conduct of chemistry. These chemistry personnel support equipment reliability and materials management and understand the role of chemistry in satisfactory equipment performance. They provide the oversight necessary to ensure that the tools and proper chemistry controls are maintained and are an essential component of the radiation source term control.

Duties of chemistry personnel who operate in the field or laboratory areas include the collection, preparation and analysis of chemical samples. Chemistry field personnel are also typically involved in handling and manipulation of bulk quantities of chemicals as well as operating analysis equipment and instrumentation. Since their duties include working closely with hazardous chemicals, they require knowledge regarding the associated risks and countermeasures associated with handling accidents and guiding personnel exposed to such chemicals.

13.7.4. Initial training of chemistry personnel

Chemistry personnel are hired with a sound basic chemistry education according to their job requirements. Therefore, chemistry nuclear training programmes usually do not need to provide this basic training; they focus instead on training related to areas relevant to the respective plant/facility chemistry activities and additional elements which are not normally included in basic chemistry education. Chemistry professionals may need additional training in the specifics of radiochemistry, relevant nuclear facility plant processes, applicable safety standards, the influence of chemistry parameters on system and process reliability, and dose control.

Typical specific chemistry competencies required for nuclear facilities include the following:

— Facility/plant system training with a focus on chemistry aspects;
— Primary circuit chemistry including reactivity controls and criticality;
— Chemistry of specific radioactive waste treatment processes;
— Operational chemistry limits and conditions;
— Specifics of steam and water circuits in nuclear facilities, including corrosion mechanisms;
— Control of sulphates and chlorides;
— Control of heat exchanger fouling;
— Chemistry monitoring and trending;
— Laboratory standards and controls;
— Environmental controls;
— Analytical procedures including those used in emergency situations.

13.7.5. Continuing training of chemistry personnel

Based on the outcomes of the analysis phase of SAT, initial training topics need to be reviewed to determine which tasks and their associated KSAs have to be included in the continuing training programme for chemistry personnel. The continuing training would typically aim to do the following:

— Maintain and refresh KSAs for chemistry personnel to accomplish routine, abnormal and emergency duties;
— Enhance the KSAs of chemistry personnel through timely training for infrequent, difficult and important maintenance tasks;

— Identify KSAs that are new or upgraded owing to changes in chemistry personnel's job scopes;
— Update and maintain chemistry personnel's knowledge of appropriate plant modifications and procedural changes for areas in which they are qualified;
— Share lessons learned from plant and industry operating experience to prevent occurrence/recurrence of errors or events;
— Outline identified improvement opportunities for personnel performance;
— Share expectations and standards set by line managers.

13.8. INSTRUCTOR DEVELOPMENT

13.8.1. Instructor selection, training and qualification

Instructor competence is one of the most important factors contributing to high quality training in nuclear facilities. Instructors need to have a comprehensive theoretical as well as practical understanding of all aspects of the subjects they teach and about the relationship of the subject to the facility's performance. It is good practice for instructors to possess previous work experience from the area relevant to their field of training responsibility. For example, MCR simulator instructors should have previous control room experience at an appropriate level of seniority in a facility of the same design. The selection criteria for instructors have to include the technical KSAs required for the subjects to be instructed and the future jobs of the trainees. In addition, candidates need to demonstrate a good attitude towards training, excellent communication skills and an aptitude for instructing.

All instructors need to have the instructional KSAs needed to enhance training and learning or develop them through initial training. In addition, instructors have to be trained to use the SAT process and perform the SAT phases to which they contribute (and ideally, all five SAT phases). In many organizations, the instructor teams consist of a mix of permanent and rotating staff. The rotating staff need to come from the facility served by the training organization and have to be assigned as full time trainers for periods of one to three years. These rotating trainers do the following:

— Bring up-to-date experience into the training function;
— Provide feedback to the training programme;
— Add credibility, particularly with staff undergoing continuing training;
— Take training expertise back to the facility on completion of their rotation.

Part time instructors, including those who provide OJT in the facility, also need instructional KSAs. Training provided for these KSAs has to be tailored to the particular training and training settings in which the instructor will participate. The competence of external instructors needs to be confirmed, whether they conduct training on-site, in external training organizations or at external nuclear facilities. In the case where an external training organization is involved in conducting training for nuclear facility personnel, qualifications of external instructors need to be verified by the nuclear facility. The nuclear facility has to ensure that necessary measures are in place such as checking qualification records, collecting feedback from other customers and holding interviews to confirm the required level of competence of external instructors.

13.8.2. Functions and duty areas for instructors

Different categories of instructors may be involved in the analysis, design, development, implementation or evaluation of training programmes. Some common categories are the following:

— Full time instructors;
— Part time instructors;

— Contracted (external) instructors;
— Occasional instructors (e.g. invited lecturers);
— SMEs delivering certain portions of training;
— On the job instructors;
— Mentors/coaches.

Examples of instructor specializations include simulator instructors, classroom instructors and OJT instructors. There are also other specialist areas such as specialist SAT roles, simulator configuration management, instructional technologist, knowledge management activities and e-learning/blended learning specialists.

The functions of instructors depend upon the specific training setting, the jobs and the subjects that are delivered in the training. For example, one instructor may deliver only classroom training on design and operation of certain facility systems. Another instructor may deliver training in both classroom and simulator settings, or in a classroom and on the job. There are instructors who deal only with fundamentals, and others who specialize in management training but also serve as instructional specialists. Particular functions and duties need to be defined in the instructor's job description.

13.8.3. Initial training of instructors

A training programme on the fundamentals of instructional competencies would typically address the following topics:

— Understanding the basics of a nuclear facility integrated management system and the role of training as an important supporting process;
— Principles and practices of SAT;
— Organization and management of training for the nuclear facility;
— Role of the instructor;
— How adults learn;
— Incorporating operating experience into training;
— Appropriate training methods and techniques;
— Effective questioning techniques;
— Training aids;
— Using lesson plans and training materials;
— Conducting lectures;
— Conducting discussions;
— Developing and using case studies;
— Conducting practical demonstrations;
— Assisting trainees in solving problems associated with learning;
— Assessing trainee performance;
— Communicating and cooperating with the facility line managers;
— Training monitoring and training effectiveness evaluation techniques;
— Organizational and safety culture and their incorporation into the training programmes;
— Applying human and organizational performance improvement techniques.

To qualify for more specific and advanced training assignments, the instructor needs to demonstrate competence in carrying out training in various settings, developing particular training material or delivering training in complex subject areas such as management. This requires additional training, which may include the following:

— Designing training programmes;
— Developing tests;

— Developing e-learning content;
— Delivering laboratory or workshop training;
— Delivering simulator training;
— Conducting and supervising OJT, walkthroughs and facility tours;
— Developing and conducting emergency drills;
— Delivering training on teamwork;
— Delivering management training;
— Managing individualized instruction;
— Developing instructional evaluation methods.

Instructors who provide simulator based training for operations personnel need additional training in the operation of the simulator. This training needs to include both operation of the simulator and its use as a training and performance assessment tool. The instructor needs to learn to operate the simulator and perform functions such as initialize, freeze and snapshot; to insert malfunctions; to understand the boundaries of fidelity of the simulator and to operate equipment used in support of the training session such as video cameras and other recording equipment. Unique aspects associated with simulator training which need to be included in the instructor training programme are those relevant to the following:

— Diagnostic skills;
— Teamwork within the shift;
— Observation of trainee performance and providing feedback;
— Development of SEGs (scenarios);
— Operating experience in simulator training;
— Human performance tools;
— Effective simulator exercise briefings and post-exercise critiques.

Instructors need also to possess appropriate competence in performance evaluation and improvement.

13.8.4. Qualification of instructors

It is good practice for the facility training manager or manager of the relevant training organization, in conjunction with line managers, to observe instructors and evaluate their technical and instructional competence to perform training tasks as required for a specific job position.

Assessment of technical competence will need to be based upon the instructors' demonstration of the technical KSAs appropriate to the subject areas they teach. The final evaluation of instructors needs to be based on observation of their training sessions, at least once a year in each training setting where the instructor delivers training. This kind of assessment can be done by fellow instructors, training managers and facility line managers. Constructive feedback can be provided to the instructors based on assessment of their competence and performance.

A common practice is to have a phased instructor qualification programme — meaning that until qualifications are completed, the instructor candidate may only be allowed to instruct on specific technical courses or may only be allowed to undertake defined areas of SAT. If this approach is taken, the facility needs to document this progression, detailing the associated training and qualification requirements for each step.

13.8.5. Continuing training and development programmes for instructors

A continuing training programme needs to be established to maintain and improve both the technical and instructional competence of qualified instructors. The continuing training programme for instructors consists of two major elements: technical training and instructor skills training.

13.8.5.1. Continuing training for instructors to maintain technical skills

The purpose of this training is to maintain technical qualification and familiarity with elements such as job requirements, facility changes, operating experience and technical documents. Instructors need to maintain their job qualification by fully participating in the continuing training programme in the area of expertise for which they are providing instruction.

It is good practice for instructors to periodically work in the facility in the discipline for which they are qualified and for which they instruct trainees. Time during scheduled outages can be used for this purpose. In the case of simulator instructors for example, this time in the facility has to be on shift and include activities such as shutdown and startup associated with facility outages (this means observing such activities or, if permitted, performing these activities).

13.8.5.2. Continuing training to maintain instructional skills

Based on the outcomes of the analysis phase of SAT, initial training topics need to be reviewed to determine which tasks and their associated KSAs have to be included in the continuing training programme for instructors. The continuing training would typically aim to do the following:

— Maintain and refresh KSAs for instructors to accomplish routine, abnormal and emergency duties;
— Enhance the KSAs of instructors through timely training for infrequent, difficult and important tasks;
— Identify KSAs that are new or upgraded owing to changes in instructor job scopes;
— Update and maintain instructors' knowledge of appropriate plant modifications and procedural changes for areas in which they are qualified;
— Help instructors acquire knowledge and skills in the application of new training methods;
— Reinforce instructors' KSAs on the use of advanced training tools and aids;
— Describe changes in training related regulations or procedures;
— Share lessons learned from plant and industry operating experience to prevent occurrence/recurrence of errors or events;
— Outline identified improvement opportunities for personnel performance;
— Share expectations and standards set by line managers.

13.8.6. Instructors' professional development

Professional development activities may be identified through a variety of means and may include the following:

— Self-study (in particular using specialized publications in the training field);
— Working on rotational assignments;
— Cooperation with facility project teams;
— Attending conferences in the area of teaching techniques and new technologies;
— Conducting benchmarking activities;
— Attending management development training programmes;
— Attending human performance improvement training courses;
— Observing peer instructors.

Sufficient time needs to be allocated for instructor development activities. Many Member States allocate about one fifth of instructors' working hours to be allocated for instructor professional development.

13.9. EMERGENCY PREPAREDNESS TRAINING

Since actual emergencies involving a nuclear facility are only expected to occur infrequently, job experience in this area is rare. That makes emergency preparedness and related training essential to maintain and improve the effectiveness of the response. Emergency preparedness training is a learning process that needs to be designed to ensure that facility staff and staff from other participating organizations possess the essential competencies required to accomplish non-routine tasks under stressful conditions.

Response to an emergency condition requires a broad range of activities to be carried out by personnel from inside and outside the facility. When designing emergency preparedness training, consideration has to be given to the specific nature of tasks related to responding to an emergency. This section describes roles and responsibilities for the facility's operating personnel and crisis team members.

Emergency preparedness training is unique to a particular facility due to the nature of its staffing arrangements for emergency organizations. Typically, emergency response positions are additional roles assigned to the facility's operating personnel. It is common for regulatory authorities to detail the requirements for emergency response and emergency preparedness training. Duties and responsibilities of some emergency response personnel involve interacting with governmental agencies, public and the media. In addition, emergency response tasks are performed very infrequently, if at all, requiring extensive use of drills and exercises to maintain the necessary KSAs.

Although there are several organizations involved, facility managers play the most important role in emergency cases. Therefore, capabilities in handling those cases have high relevance in the training of nuclear facility managers.

Exercises and drills are the preferred methods for emergency preparedness training. Based on experience, emergency preparedness exercises including beyond design basis accidents provide the only realistic opportunity to evaluate the capabilities of the facility managers and staff, as well as staff from outside emergency response organizations. In confronting accident conditions, the handling of the scenarios will enhance the competence to cope with them and to maintain and improve the effectiveness of the response. Emergency preparedness exercises are a continuous learning process that need to be designed to ensure that facility managers and staff — and staff from other participating organizations — possess the essential KSAs required to accomplish non-routine tasks under stressful conditions.

In addition to the technical knowledge and skills which are essential for the management of emergencies, non-technical competencies are a real challenge for facility managers. These include leading and coordinating several teams under stressful conditions, making decisions under those circumstances, risk assessment and communication with all kinds of stakeholders.

All the elements mentioned above need to be included in management training programmes; and the emergency exercises have to demonstrate that managers are able to apply the required competencies successfully. To get real feedback and to identify areas for improvement, facility managers have to ensure that exercise drill contents, selected scenarios and related challenges are not known to incumbents involved in the exercise beforehand. Therefore, facility managers may consider delegating the development of emergency drill scenarios to organizations/staff members not involved in the performance of the exercise (e.g. those involved only as observers) both to maintain confidentiality and to undertake (external) independent scrutiny.

13.9.1. Functions and duty areas during emergencies

Typical functions in emergency preparation and response for emergency management team members and facility operating staff are explained in the subsections that follow. These are not exclusive, and the exact positions, titles, roles and responsibilities will vary based on the organization's individual arrangements.

13.9.2. Emergency management team members

Response to an emergency condition requires a broad range of activities that have to be carried out by facility and support personnel. The goals and objectives of emergency response at a nuclear facility include the following, taken from Ref. [19]:

"— to regain control of the situation
— to prevent or mitigate consequences at the scene
— to prevent the occurrence of deterministic health effects in workers and the public
— to prevent, to the extent practicable, the occurrence of stochastic health effects in the population
— to prevent, to the extent practicable, the occurrence of non-radiological effects in individuals and among the population
— to render first aid and to manage the treatment of radiation injuries
— to protect, to the extent practicable, property and the environment
— to prepare, to the extent practicable, for the resumption of normal social and economic activity".

The specific duties and responsibilities of the facility personnel vary and so does the level of qualification required. The following two subsections give examples of activities which need to be considered in the analysis of emergency preparedness training needs.

13.9.2.1. Management of the event

Management of the event includes the following:

— Administration including activating emergency control and coordination centres, record keeping, shift staffing and logistic support;
— Notification of national authorities;
— Radiological monitoring including availability of appropriate equipment for facility surveys, monitoring of ingestion pathways, sample collection and analysis, data assessment and trend monitoring;
— Off-site exposure assessment including source term evaluation, meteorological data evaluation, projected dose evaluation and correlation of in-facility and environmental data;
— Personnel dose assessment and control including dosimeter processing, exposure authorization and control, issuing work permits and specific radiation protection measures;
— Off-site protection measures including distribution of radio-protective prophylactic drugs, evacuation and sheltering procedures, traffic control, establishing evacuee reception centres and agricultural control;
— Operational intervention levels, which are directly measurable quantities (e.g. dose rates) that may be used as criteria for initiating protective actions;
— Medical services including first aid, screening of potentially exposed persons and treatment of highly exposed individuals;
— Accident analysis including the status of the main safety systems and fission product barriers, accident classification, possible corrective actions or actions to mitigate release of radioactivity;
— Public information including prompt warning of the public, activating a public information centre, maintaining information to the public and preventing public alarm;
— On-site recovery measures including emergency rescue, firefighting, use of respiratory protective equipment, access control to the affected facility and damage assessment and control.

13.9.2.2. Facility operating staff

The operating staff at a nuclear facility are responsible for recognizing emergency conditions and performing initial actions to mitigate the event. Typical responsibilities of operating staff in emergency conditions include the following:

— Initial accident analysis including the status of the main safety systems and fission product barriers, accident classification, possible corrective actions or actions to mitigate release of radioactivity;
— Initial actions to respond to consequences such as fire, flooding and medical emergencies;
— Determination of the appropriate emergency class or the level of emergency response and initiation of the appropriate on-site response;
— Initial response including counting, assembly and safe evacuation of facility personnel;
— Activation of the facility's emergency management team.

13.9.3. Initial training for emergency preparedness

The human capacity to respond to an emergency situation depends on the acquired knowledge, the capability to use this knowledge and prevailing attitudes. Determination of training requirements for emergency management personnel needs to be guided by a graded approach to SAT. However, this should recognize the unique nature of the individual's characteristics and response with a special focus on crisis management and decision making skills. As in other jobs, initial training can be provided through methods such as classroom lecturing and demonstration, simulation, drills and exercises. For control room personnel and members of the emergency management team, particular attention has to be paid to topics such as the following:

— Beyond design basis accidents;
— Severe accidents;
— Core melt scenarios;
— Hydrogen generation and steam explosions;
— Prevention and mitigation procedures (severe accident management guidelines);
— Radiological calculations, source term evaluation, meteorological data evaluation and projected dose evaluations;
— Managing emergency management teams under stressful conditions;
— Communication and decision making processes;
— Providing public and stakeholder information.

Emergency preparedness exercises provide training and evaluation opportunities that are necessary to provide facility staff with experience in implementing an emergency plan effectively. In addition to these exercises, supporting training is needed to prepare personnel to perform specialized emergency duties.

13.9.4. Continuing training for emergency preparedness

Continuing training programmes have to maintain, refresh and enhance the KSAs required for emergency preparedness training and address areas such as facility equipment and procedure changes, infrequently performed and complicated tasks, knowledge and skills weaknesses, drill and exercise performance and lessons learned from operating experience.

Typically, continuing training goals for emergency preparedness include the following:

— Maintain and improve the KSAs of emergency response personnel to accomplish emergency duties;
— Train emergency response personnel on new knowledge and skills when changes in job scope are identified, including new information on beyond design basis event scenarios and phenomena;

— Refresh emergency response personnel's knowledge of selected applied fundamentals presented in initial training;
— Reinforce awareness in emergency response personnel of their responsibilities for event mitigation and the impact on the public and the environment, and reinforce required attitudes;
— Maintain emergency response personnel's knowledge of appropriate facility modifications and procedural changes for their areas of responsibility;
— Emphasize lessons learned from drills, exercises and facility and industry operating experience.

13.9.5. Emergency preparedness drills and exercises

Emergency preparedness exercises need to be treated as learning opportunities and be designed to ensure that facility staff, and staff from other participating organizations, possess the essential KSAs required to accomplish non-routine tasks under stressful conditions. Exercises provide experience in collaboration between groups which normally may not work together. They have to be structured to provide experience working under conditions similar to those that may prevail during an accident.

The purpose of drills and exercises is to do the following:

— Demonstrate how effectively an emergency plan, or a section of it, is implemented;
— Demonstrate the effectiveness of the crisis management team;
— Confirm the adequacy of the plan(s) to deal with the emergency and identify potential improvements;
— Verify that the appropriate lines of communication can be established and maintained;
— Verify that all individuals participating in the exercise are familiar with and capable of performing the emergency duties assigned to them.

Drills and exercises have to address the following:

— The different segments of the emergency response plan;
— Related procedures such as those for health physics and emergency operations;
— Use of equipment.

Emergency preparedness drills and exercises need to be documented and evaluated to improve the emergency preparedness training programme and the emergency plan, and to implement procedures and new equipment. For any deficiency revealed, whether in procedures, equipment or personnel performance, the root cause has to be identified and appropriate corrective actions need to be taken promptly. Control of exercise and drill scenarios needs to be maintained to ensure the integrity of the evaluation process, and therefore information about scenarios and drills must not be communicated to the participants in advance.

13.10. SITE ACCESS AND GENERAL EMPLOYEE TRAINING

Site access training and GET have to be provided, in an appropriate combination, to all personnel. This includes contractors, who need to be trained prior to the start of their work at the facility. The following subsections detail this training.

13.10.1. Functions and duty areas for site access and general employee training

Site access training is needed to allow facility employees, contractors and visitors to safely gain unescorted access to certain areas at a nuclear facility. Site access training, as the title implies, needs to be completed before entering the site and is applicable, in a graded manner (i.e. selecting the appropriate training objectives and associated test questions), to all individuals accessing the site including contractors, equipment vendor personnel, construction and commissioning personnel, and visitors.

GET is the training provided to allow personnel to safely and effectively perform general duties in specified areas of a nuclear facility. GET is often accomplished within the first days of employment at the facility. GET supplements job specific training and is the initial step in providing each worker with a performance base to ensure they can perform assigned work without undue risk to themselves, their co-workers, the facility or the environment.

There may be some elements of GET that do not apply to all worker groups at a facility. For instance, workers in an office area who will not enter a radiation area may not need to receive detailed information and training on radiation safety and contamination control. However, these workers still need to be familiar with general emergency preparedness, workplace safety, company policy and administration, and other elements of the GET programme.

Some facilities combine site access training and GET into one programme with two stages. The first stage is applicable to all employees regardless of function or duty, and the second stage is a radiation and hazardous materials worker training programme specific to those employees who will more routinely come into contact with radiation or hazardous materials in their job functions. Other facilities make a distinction in the GET programme based on the period of time the trainee is expected to be working on-site.

13.10.2. Initial training for site access and general employee training

In determining the content of GET programmes, facilities need to look for common competencies required across all job categories at the site to ensure that personnel are capable of effectively and safety performing their jobs. It is important that the GET programme cover subject areas in a manner that relates to the worker's own job responsibilities. If too much of the material in the GET programme goes beyond the needs of the majority of employees who take the course, it can limit trainee retention of key concepts and information.

As there are often a large number of personnel requiring this type of training over any given year, many facilities choose to provide new employees with site access training and GET via e-learning. Other facilities provide it as self-study supplemented by structured briefings. Still others provide GET via traditional classroom lectures.

GET and site access training need to include an assessment element to ensure that they are providing workers with the necessary knowledge. Employees and contractor personnel need to be tested at the conclusion of training using an appropriate method of assessment. In addition, the facilities can incorporate an element of evaluation that looks at new employees after they are placed on the job, or the contractor personnel after they start to perform their tasks on the site, as well as at available operating experience, to identify common deficiencies in general employee knowledge that can be addressed through a modification of the training. At least once every two years, the programme needs to be updated or modified to reflect identified improvement opportunities. Facilities need to have in place a process for ensuring that all employees and contractors receive the updated information in a timely manner.

Typical subject areas included in site access training are the following:

— Basic site description and layout;
— Organizational structure outline including key management personnel;
— Basic knowledge of the site and facility administration;
— Basic concepts and principles of safety culture;
— General emergency preparedness (including types of emergencies, signals, gathering points and evacuation routes);
— Basic rules of behaviour at the site.

In addition to the above, the following subject areas are typically included in GET:

— Facility design and technology;
— Roles during emergencies;

— Radiation safety and contamination control practices;
— Industrial safety, including hazardous material control;
— Environmental safety;
— Physical protection measures;
— Quality assurance/quality control;
— Fire prevention/response;
— Facility operations, including work processes;
— Foreign material exclusion;
— Company policies, including those on procedure usage, foreign material exclusion, problem identification and reporting and fitness for duty requirements;
— Human error prevention and other human performance tools.

13.10.3. Continuing training in site access and general employee training

Refresher GET is provided every one or two years by some nuclear facilities to all employees at the site in the framework of their continuing training programmes. This may include a reinforcement of key principles and concepts and should include any significant changes to the initial GET programme. Contractors also receive refresher training covering certain parts of GET or site access training with the determined periodicity and undertake tests accordingly.

14. CONTRACTOR TRAINING

It is desirable for all vendors and contractors to use SAT for their programmes. However, this is not always possible and may not be something that can be required by the nuclear facility. In any case, the facility needs to ensure that the contractors they bring in have met the same requirements and qualifications as their own personnel for the work they have been hired to complete.

Contractor personnel are often utilized at nuclear facilities to perform work of a highly specialized nature or to supplement existing staff during periods of intense work such as refuelling and maintenance outages or extensive facility modifications. Contractors are defined as any personnel working within a nuclear facility or at the facility site who are not directly employed by the facility. In performing their work, contractors encounter many of the same challenges that facility personnel encounter, including assessment of risk, procedural compliance and effective communications requirements. Nuclear facility managers need to ensure that contractor personnel have the required competencies and qualifications to safely and effectively perform the functions they were contracted to do as well as to effectively interface with facility staff. These principles apply to ensuring the competence of both on-site and off-site contractor personnel.

14.1. PROCESS TO ASSURE CONTRACTOR PERSONNEL COMPETENCE

The general expectation is that both the contractor organization and the hiring nuclear facility organization have responsibilities for ensuring that only competent and qualified contractor personnel perform work at the facility. However, the ultimate responsibility for nuclear safety aspects rest with the operating organization.

Contractor competence and qualifications are not limited to the technical competence required to perform the specific task for which the contractor was hired. Site specific access competence and qualifications need to be demonstrated to ensure the contractor personnel are adequately trained to perform their work. This includes their use of human performance improvement principles and tools. If deficiencies

in the contractors' current qualifications are identified compared with those needed, it is the responsibility of the facility managers to establish formal means to ensure that those deficiencies are addressed.

The first step, once the need to hire contractors and the duties they will perform have been identified, is to determine whether the work will be performed on-site. If the work is not to be performed on-site, the nuclear facility still has to establish quality criteria for the deliverables to be evaluated against. If the work is performed on-site, the nuclear facility needs to determine whether the work to be performed is the same as work that is performed by employees of the nuclear facility. If the work is the same, then the qualification requirements for the contractor need to be the same as for the employee. The facility can determine whether contractor personnel meet those qualifications and take compensatory action to close any gaps identified prior to the work being performed. Variables such as whether the contractor is working on a short term or long term basis, will be exposed to radiation or is performing work that could adversely affect nuclear safety can also impact the qualification requirements; these have to be considered accordingly.

If there are special KSAs required by the contractors, then task qualification criteria need to be established by the contractor and approved by the facility. Task qualification criteria need to consider education, experience and training. In addition, the nuclear facility has to specify any special qualification criteria that need to be met. Only when all qualification criteria (specific to both the task and the site) are met may the contractor proceed to perform any work [19, 20].

14.2. PRACTICES REGARDING CONTRACTOR PERSONNEL COMPETENCE

When ensuring contractor competence, nuclear facilities need to consider the following three broad areas:

— Activities and duties performed by contractors;
— Means of assuring contractor competence;
— Contractor personnel training programmes and courses.

14.2.1. Activities and duties performed by contractors

When contractor employees perform work that is dissimilar to other activities that are performed by facility employees, ensuring the competence of those contractors requires greater oversight on the part of the nuclear facility. There are some instances where, owing to the complexity or newness of the task which the contractor is being hired to perform, the facility does not have sufficient expertise to ensure that all requirements for task performance are stated. In these cases, the facility staff need to work closely with the contractor, as well as contact other organizations which have engaged in similar work, to ensure that the task performance requirements are comprehensively defined.

Contractors are frequently used on a long term basis to provide routine maintenance services as well as for facilities management and building services (e.g. administrative support, catering, cleaning, grounds maintenance). Specialized work that is not performed on a routine basis is often outsourced to a contracting organization. For instance, refuelling activities, specialized maintenance activities, non-destructive testing and other specialized activities are often contracted out.

14.2.2. Means of assuring contractor competence

The contract agreement between the nuclear facility and the contracted organization can be used to identify and address the training that will occur to ensure the competence of all contractor employees that will perform work at or for the nuclear facility. The contract agreement has to provide a mechanism for the nuclear facility to perform a review of contractor training programmes that are conducted and a means of addressing any identified training gaps. Nuclear facilities need also to look at the quality of previous work

performed by contracting organizations prior to issuing a contract. The contractor organization needs to provide the nuclear facility with information on corrective actions taken to address any significant quality issues that have been identified prior to work being performed at the facility.

The contractor organization will be required to provide proof of any formal qualifications (e.g. certificates or diplomas) as they pertain to the work being performed. At a minimum, the contractor needs to provide written documentation that any workers are competent to engage in that work and how their competence was determined. If contractor employees are trained by nuclear facility personnel, the contractor employee competence needs to still be individually assessed before they are allowed to perform any work at the facility. Nuclear facilities need to maintain written records of contractor performance for reference. In some cases, the nuclear facility may evaluate the contractor's training activities to confirm contractor personnel qualification. If there is any uncertainty regarding the competence of contractors to perform the specified work, the facility has to develop a means for assessing contractor competence prior to allowing any work to be performed. In this case, and especially for safety related activities, a close observation of the contractors' performance by the facility staff at the beginning of the work is an appropriate way to confirm their competence.

15. SUMMARY

The guidance and good practices provided in this publication are primarily intended for line managers and training staff of operating organizations, training organizations and nuclear facilities. This publication may also be useful for high level corporate executive managers, human resources managers and specialists, educational professionals, regulatory authority staff, nuclear facility vendors, and organizations developing and supplying training tools and materials or rendering other training related services, such as instructional expert support.

The complexity of nuclear technologies, the demand for qualified personnel and the substantial time required to produce competent managers and workers create unique challenges in the recruitment, training and qualification processes for nuclear facilities. Executive and senior managers need to devote sufficient support, funding and priority to the training and qualification of nuclear facility personnel, create a comprehensive training system to sustain safe and efficient operation, and act as a primary tool to support business performance improvement. The training and qualification of personnel in a nuclear facility needs to be viewed as one of the important supporting processes within the organization's management system and has to be fully integrated into this system.

The complexity of the work and diversity of the workforce in the nuclear industry require that all workers continuously have access to, and engage with, appropriate education and training to competently perform their work. The level and type of work will determine the amount of training and education required for each worker. Training and education are also needed to enable new technologies and techniques to be used. Non-nuclear specialists working in the industry also need some specialized nuclear training and education.

A strong and close relationship exists out of necessity between the nuclear industry and both the educational and training systems. Educational institutions need a steady flow of new students and funding, and the industry needs a constant influx of well educated, trained and skilled personnel. This requires a good interface with strong feedback mechanisms between educational institutions, the industry and its training organizations.

Managers and leaders have the responsibility for ensuring that training is used as a tool for continuous performance improvement. This publication describes the role and responsibility of managers at all levels for the training and competence development of facility personnel.

It is good practice for the operating organization to formulate and promote a training policy dealing with the training, competence, qualification and performance of facility personnel. This policy is the

commitment by the operating organization and the facility to personnel training and an acknowledgement of the important role of training to support and enhance the safe and reliable operation and maintenance of the facility.

Consultation, discussion and cooperation between the line organizations, the various personnel involved in training processes, managers and the workforce are essential elements of an effective SAT based training model. It is common practice to achieve this using a training consultation forum and/or committee structure. These are excellent mechanisms to involve senior and first level managers and leaders as well as SMEs in training activities and to strengthen managers' and other staff's ownership in the areas of personnel competence, training and qualification.

Performance improvement and SAT have common origins. In particular, the evaluation phase of SAT and the associated feedback loop have much the same focus and objectives as the performance improvement model. Training needs to be evaluated to improve training programmes and performance. Evaluation has to be continually and systematically undertaken in order to determine the effectiveness of training programmes in producing competent employees. Managers of nuclear facilities need to embrace their role in evaluating training to improve its effectiveness in the same way as they need to embrace facility performance improvement. They are responsible for the behaviours of their employees and for the outcome of those behaviours.

The most significant benefits from deploying SAT are ensuring both the quality and the relevance of training. These make a significant contribution to the safety and efficiency of nuclear facilities. There are numerous training models deployed across the industrial world, all of which seek to ensure that employees are suitably qualified and experienced to carry out their work to a desired standard. The choice to use SAT is founded on the ability to identify the specific tasks and activities that can impact nuclear safety, specifically those tasks and activities that, if not conducted correctly, will have a direct impact on nuclear safety and reactivity controls. Training people is expensive and represents a significant business overhead. If not applied and managed in the right way, it will become a cost burden that will add no safety or economic value to the business. In order to ensure maximum return on this investment, there is a need to apply a graded approach to the implementation of SAT across the broad spectrum of positions, roles and responsibilities. This is a challenging process and will require the experience of training and line personnel who have been actively involved in implementing a SAT approach. Some roles and positions require detailed and thorough implementation of all ADDIE cycle stages, others do not. This grading of approach needs to be based on the consideration and weight of the nuclear safety risks as a priority, and in some circumstances followed by an assessment of the commercial business risk to the facility.

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Annex I

BASIC INSTRUCTOR TRAINING PROGRAMME DESCRIPTION EXAMPLE

Training objectives are designed after they are derived from the training requirements identified during the analysis phase. Test questions meant to assess achievement of training objectives are then developed. Finally, the training objectives are organized into a training programme. A training programme description follows the template below.

Training programme description

Instructor

Originated by:

Reviewed by:

Approved by:

Revision	Amendment	Impact level	Date

Contents

(1) Purpose of instructor training programmes
(2) Responsibilities of various training roles
(3) Specific role prerequisites
(4) Overall instructor requirements
(5) Records
(6) References
(7) Attachments

1. PURPOSE OF INSTRUCTOR TRAINING PROGRAMMES

The purpose of the instructor training programme description is to establish the requirements for initial and continuing training of instructors. The programme is designed to train fleet and site certified instructors to provide training and evaluation in accordance with the systematic approach to training (SAT).

2. RESPONSIBILITIES OF VARIOUS TRAINING ROLES

2.1. Training programme owner (fleet training manager)

The responsibilities of the training programme's owner (often the fleet training manager) are as follows:

— Establish and maintain the fleet certified instructor training programme to improve instructional performance;
— Periodically monitor and assess training in all settings to ensure training needs are being met;
— Participate in and review the analysis and design of training courses and the development of tools and training aids.

2.2. Training manager (site)

The responsibilities of the site training manager are as follows:

— Ensure the qualification of instructors at the site (both initial and continuing) and set expectations for a trainee's progress through qualification(s);
— Conduct training observations and evaluations of instructor performance in all settings to ensure training needs are being met.

2.3. Training specialist peer group

The responsibilities of the training specialist peer group are as follows:

— Periodically review and recommend changes to the instructor training programme description, task to training matrix and qualification manual;
— Validate and prioritize training needs for instructors.

2.4. Training specialist

The responsibilities of the training specialist are as follows:

— Report instructor staffing, training and qualification status to the site training manager;
— Qualify to perform all the duties and responsibilities of the fleet certified instructor;
— Evaluate instructor performance;
— Participate as a member of the training specialist peer group;
— Mentor instructors.

2.5. Instructor

The responsibilities of the instructor are as follows:

— Achieve and maintain instructional and technical qualifications;
— Perform instructional and administrative duties and responsibilities in accordance with the training programme;
— Adhere to and reinforce organizational training standards and expectations;
— Participate in training sessions and workshops as assigned, to develop and improve effective instructional techniques.

3. SPECIFIC ROLE PREREQUISITES

To fulfil specific roles, instructors must meet the prerequisites in the following subsections.

3.1. Eligibility prerequisites for instructor candidates

In order to be eligible to train to become an instructor, candidates must do the following:

— Qualify in their specific technical area (e.g. a mechanical maintenance instructor will be qualified as a maintenance technician or higher);
— Satisfy position profile qualification and experience requirements;
— Demonstrate interpersonal skills that facilitate effective training (i.e. ability to adjust to different people in a group).

3.2. Initial instructor training

Initial instructor training includes classroom training and mentoring. The requirements for each instructor level are listed in the sections that follow.

3.2.1. Fleet certified instructor prerequisites

To become a fleet certified instructor, the candidate must have the following:

— SAT fundamentals;
— Mentoring position specific guides as identified in the task to training matrix and in the instructor qualification manual before working independently;
— Instructional techniques and standards.

Satisfactory performance on classroom/workshop instructor evaluation by the training manager, training group head, training specialist or existing designated fleet certified instructor.

3.2.2. Site certified instructor prerequisites

Site certified instructors are not full-time instructors but SMEs who assist in-training delivery. Such instructors have to complete the following requirements prior to working independently in the assigned training area:

— Site instructor certification workshop;
— Mentoring position specific guides as identified in the task to training matrix and in the instructor qualification manual;
— Satisfactory performance documented on a completed form by the site training manager, training group head, training specialist or designated fleet certified instructor during the first training delivery session.

3.2.3. Simulator instructor requirements

To become a simulator instructor, the candidate must have the following:

— Fleet or site instructor certification and operational control room experience;
— Local site specific instructions covering the use and operation of the simulator;
— Observed a simulation exercise.

4. OVERALL INSTRUCTOR REQUIREMENTS

Regardless of their specific role, all instructors must fulfil the requirements in the following subsections.

4.1. Initial instructor candidate qualifications

4.1.1. Staff performing instructional duties at all locations will be qualified based upon successful completion of the portions of the instructor training programme applicable to the position they are assigned. Qualification records are documented in the-learning management system database.
4.1.2. If equivalent work experience or qualification documentation is provided, the exemption process may be used.
4.1.3. Qualification of supplemental personnel who are contracted to perform instructional duties at the nuclear power plant will be evaluated case by case according to the duties to be assigned.

4.2. Continuing training methods and goals

4.2.1. Continuing training has to maintain and improve instructional and technical skills following initial qualification. For instructional skills, continuing training is used to correct instructor weaknesses and develop desired competencies in the various training settings as well as to introduce new training tools and techniques.
4.2.2. Activities that maintain and improve instructional skills may be conducted in group settings (lecture/discussions, role playing, coaching, etc.) or may be accomplished through self-paced instruction and individual sessions with instructor training personnel. Subjects appropriate for continuing training include the following examples:

— Refresher topics from initial instructor training as defined by the task to training matrix;
— New and advanced instructional techniques, methods, technologies, training equipment and media;
— Changes to regulations, standards or procedures.

4.2.3. Technical training is provided that will maintain and develop technical skills and ensure knowledge of trainee job responsibilities in all personnel who act as subject matter instructors. Personnel who provide plant specific training are kept current on plant and industry events and changes such as plant modifications, policies and procedures. Those with deficient technical skills receive upgrade training as appropriate.
4.2.4. Site certified instructors may be assigned to attend applicable portions of the continuing training sessions for fleet certified instructors, based upon management's observations of training and instructor evaluation results.

4.3. Continuing training schedules

4.3.1. In order to maintain familiarity with plant configuration, technician practices and procedure guidance, instructors have to complete a minimum of 32 hours of documented in-plant time per calendar year in their specific discipline.
4.3.2. Instructors certified for fleets or sites need to be evaluated at least once per three year period in each setting in which they have been qualified to teach.
4.3.3. Simulator instructors have to have at least one day of continuing training over a three year period to ensure standards are maintained for the simulator instructor role and have to be evaluated at least once per three year period in the simulator setting.

4.4. Exemptions from instructor training — initial or ongoing

4.4.1. Exemptions for equivalent training or demonstrated job knowledge need to be completed in accordance with the SAT implementation phase.

4.5. Remediation of instructors

4.5.1. Remediation has to be completed in accordance with the SAT implementation phase.

5. RECORDS

5.1. Training and qualification records have to be collected and maintained in the-learning management system.

6. REFERENCES

6.1. Guidelines for instructor training and qualification

6.2. SAT — analysis phase

6.3. SAT — design phase

6.4. SAT — development phase

6.5. SAT — implementation phase

6.6. SAT — evaluation phase

7. ATTACHMENTS

7.1. This section lists any documents that support this description.

Annex II

BASIC TRAINING POLICY EXAMPLE

A training policy includes the organization's vision for training and its role in supporting safe and reliable facility operation via the continuous development of the knowledge, skills and attitudes (KSAs) of its employees. It provides the organization with the training mission, the training philosophy and the strategy to achieve the expected outcome.

Executive sponsor	NN
Lead policy owner	NN
Policy reference number	XX
Version number	1.0
Date of effect	YYYY-MM-DD

1. POLICY STATEMENT

The training policy statement describes the organization's vision of training and its role in supporting safe and reliable plant operation via the knowledge and skills of its most valuable asset: its employees. In this example, sample statements and guidance are provided below.

1.1. The vision

Creating world leading nuclear professionals, equipping our people with the knowledge, skills and behaviours to support a high performing business.

1.2. The mission

Provide the right training to the right people at the right time.

Training is a critical tool supporting personnel investment and performance improvement. As such, the nuclear power plant is committed to and accountable for developing and sustaining training programmes that meet organizational and personnel needs. A systematic approach to training (SAT) is essential to ensure that training needs are accurately identified, training is effectively delivered to the right audience, and line managers are integrally involved.

1.3. Signatures

Signatures authorizing the document for and on behalf of the executive team of the organization appear on the title page.

2. ORGANIZATION'S TRAINING POLICY

2.1. Principles

This organization's training policy is based on the following principles:

— Anticipate and support changes in the organization's professions, and ensure the organization has the skills required to prepare for tomorrow;
— Harness training to enhance the group's performance;
— Prepare and support employee career development, looking at their job descriptions today and tomorrow, fostering their mobility and employability.

2.2. Policy standards

This organization adopts the following training policy standards:

— Training is a key leading indicator in succession management and of the long term health of the organization.
— Line managers are responsible for ensuring the effective training and qualification of their personnel.
— Line managers monitor personnel performance to ensure that training contributes to safe and reliable plant operation and to identify training opportunities and solutions.
— Training reinforces management standards and expectations. Training programmes integrate key messages and expectations (e.g. human performance) to embed expected future behaviour.
— Training provides the KSAs needed for independent job performance and incorporates operating experience from previous internal and external events.
— Training resources (personnel, tools, aids and facilities) meet the needs of the organization and the trainees.
— Training is developed and conducted following consistent, rigorous processes to ensure effectiveness.
— Personnel who are assigned training responsibilities are the organization's best and can influence others to achieve a higher level of performance.
— All personnel within the organization have a responsibility, and a role to play, in the SAT to deliver the key elements.
— Training processes, programmes, and content are standardized across the organization to the extent that is possible and practical.

3. TRAINING POLICY

4. CHANGE HISTORY

Version	Date	Changes made
002	2015-01-01	Editorial change to reflect new template.
003	2016-12-31	Periodic review on a three year cycle. Editorial change to reflect new executive sponsor.
004	2017-06-15	Editorial amendment to replace NN with NN as managing director.

Annex III

SAT IMPLEMENTATION EXAMPLE

In order to ensure the maximum return on investment, there is a need to apply a graded approach to implementing a systematic approach to training (SAT) across the broad spectrum of positions, roles and responsibilities (Fig. III–1).

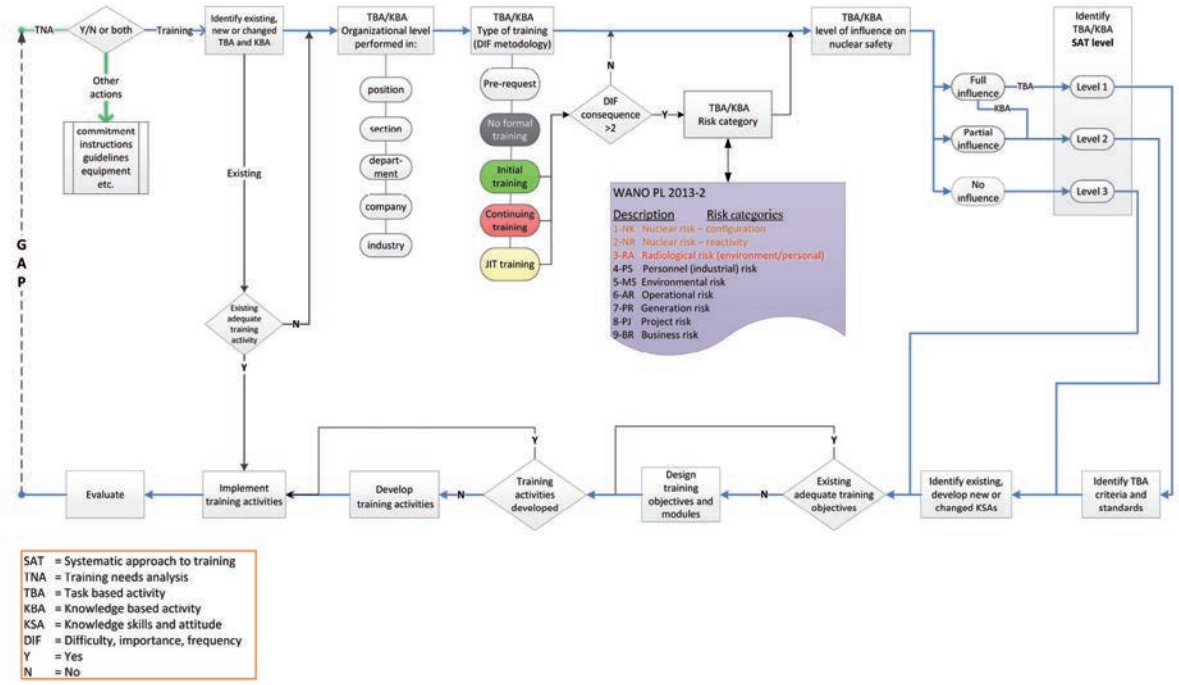

FIG. III–1. Stages in applying an ordered approach to implementing a SAT across the broad spectrum of positions, roles and responsibilities.

Annex IV

TASK TO TRAINING MATRIX EXAMPLE

A task to training matrix or equivalent to ensure all the difficulty, importance and frequency rating of identified tasks are included in the initial and continuing training programmes (Table IV–1).

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE

Programme name: Instructor			DIF[a] ratings			Training setting[b] (weeks)					Selected for initial or continuing training			Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
								Analysis phase										
		Conduct performance analysis	2.5	3.5	3.0		x					x	x					Instructors are not responsible for completing this analysis but need to be cognisant of the process.
		Conduct needs analysis	3.0	3.0	3.0	x	x		x			x	x					
		Conduct/revise job analysis	3.5	3.5	2.5	x	x		x			x	x					
		Conduct/revise task analysis	3.0	3.5	2.5	x	x		x			x	x					
								Design phase										
		Develop/reviselearning objectives	4.0	4.6	2.3	x	x		x			x	x					
		Organize/sequence-learning objectives	2.0	3.0	2.3	x						x						
		Develop/revise test questions	3.7	4.0	2.3	x	x		x			x	x					
		Develop/revise task to training matrix	3.7	4.0	2.3	x	x					x	x					
		Develop/revise training programme description	3.0	3.3	1.7	x	x					x	x					

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE (cont.)

Programme name: Instructor			DIF[a] ratings			Training setting[b] (weeks)					Selected for initial or continuing training		Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
		Develop/revise training plan	3.0	3.3	1.3	x	x					x	x					
Development phase																		
		Develop/revise training materials	2.6	3.3	2.6	x						x	x					
		Develop/revise student handouts	2.6	3.0	2.6	x						x	x					
		Develop/revise OJT/TPE[c] guides	3.0	3.7	2.3	x	x		x			x	x					
		Develop/revise mentoring guides	2.6	3.0	2.0	x	x		x			x	x					
		Develop/revise classroom lesson plans	2.7	3.3	2.3	x	x		x			x	x					
		Develop/revise training workshop guides	2.7	3.3	2.3	x						x	x					
		Develop/revise self-study guides	2.7	2.0	1.6	x						x						
		Develop/revise e-learning	3.3	3.3	2.3	x						x						Position specific
		Develop/revise tests	3.0	3.0	2.0	x	x		x			x	x					

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE (cont.)

Programme name: Instructor			DIF[a] ratings			Training setting[b] (weeks)					Selected for initial or continuing training			Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
		Conduct instructional/ technical review	2.0	3.0	2.0	x						x						
		Develop/revise qualification manual	4.0	4.0	2.0	x	x		x			x	x					
		Implementation plan																
		Prepare for training session																
		Conduct classroom training																
		Conduct on the job training																
		Conduct training observations																
		Facilitate training																
		Invigilate a test																
		Duty area																
		Implement corrective actions and briefing techniques																
		Analyse feedback																

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE (cont.)

Programme name: Instructor			DIF[a] ratings			Training setting[b] (weeks)					Selected for initial or continuing training			Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
		Provide target date for key performance metrics																
		Participate in external evaluation (WANO[d], ATV[e], TSAB[f] reviews)																
		Participate in internal self-assessment																
		Simulator instructors																
		Human factors/human behaviour																
		Deliver training on communications and briefing techniques																
		Deliver training on situation awareness management and enhancement																
		Deliver training on operation attitudes/behaviour types																
		Deliver training on stress awareness																

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE (cont.)

Programme name: Instructor			DIF[a] ratings			Training setting[b] (weeks)				Selected for initial or continuing training			Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
		Deliver training on the effects of shift work on operator performance																
		Deliver training on leadership styles																
		Deliver training on transactional analysis																
		Deliver training on control room management																
		Local simulator operational knowledge																
		Perform basic simulator operations																
		Operate camera and playback features																
		Operate sound monitoring radio and telephone operation																

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE (cont.)

Programme name: Instructor			DIF[a] ratings			Training setting[b] (weeks)					Selected for initial or continuing training			Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
		Create an initial condition and snap																
		Explain simulator facility security measures including access control																
		Configure the simulator for an emergency exercise																
		Diagnostics skills and decision making																
		Analyse and solve operator/ team shortfalls																
		Deliver operational decision making training																
		Provide training on all major faults identified on the fault training schedule																

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE (cont.)

Programme name: Instructor			DIF[a] ratings			Training setting[b] (weeks)					Selected for initial or continuing training			Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
		Course scheduling and course design																
		Provide feedback of operator claimed actions arising from safety case/operational comments																
		Create a simulator exercise guide including performance measures																
		Plan the frequency of training for particular faults																
		Perform the planning process prior to and following courses																
		Performance management, evaluation and feedback																
		Use the operator performance observation databases																
		Apply evaluation tools in practice																

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE (cont.)

Programme name: Instructor			DIF[a] ratings			Training setting[b] (weeks)					Selected for initial or continuing training			Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
		Carry out an effectiveness review of simulator assessment																
		Assessment invigilation and preparation																
		Prepare simulator exams and develop format and performance objectives Score operator performance during assessments Securely control exams of candidates before and after assessment																
		Technical coaching																
		Coach students from a similar environment Promote observed best practices																

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE (cont.)

Programme name: Instructor			DIF[a] ratings				Training setting[b] (weeks)				Selected for initial or continuing training			Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
		Use simulator freeze/backtrack and other features to enhance training																
							Achieve CRS[g] certified status											
		Role play a CRS[g] during normal operations																
		Role play a CRS[g] during plant transients																
		Role play a CRS[g] during abnormalities and post-trip																
		Role play a CRS[g] during an emergency exercise																
							Conduct of simulator training											
		Prepare simulator for training																
		Brief students prior to training																

TABLE IV–1. TASK TO TRAINING MATRIX EXAMPLE (cont.)

Programme name: Instructor			DIF[a] ratings			Training setting[b] (weeks)					Selected for initial or continuing training			Lesson plan number	Mentor guide number	Written test	Reference (form, procedure, etc.)	Notes
Duty area	Task ID	Task description	D	I	F	Class	P	SIM	MEN	OJT/ TPE	No	I	C					
		Identify critical and safety significant performance tasks Evaluate students'/teams' performance during initial and continuing training																
										Site certified instructor training								
		Conduct classroom instruction as a site certified instructor																

[a] DIF: difficulty (D), importance (I) and frequency (F). See Annex V for more detail on rating these aspects.
[b] Training settings: classroom (Class), performance (P), simulator (SIM), mentoring (MEN), and on the job training or task performance evaluation (OJT/TPE).
[c] OJT/TPE: on the job training/task performance evaluation.
[d] WANO: World Association of Nuclear Operators.
[e] ATV: accreditation team visit.
[f] TSAB: training standards and accreditation board.
[g] CRS: control room supervisor.

Annex V

DIFFICULTY, IMPORTANCE AND FREQUENCY RATING PROCESS EXAMPLE

The analysis of psychomotor tasks with prescribed sequential steps is normally straightforward. Task analysis in such cases identifies task elements; their sequence; corresponding knowledge, skills and attitudes; and performance standards. The most difficulty lies in performing analysis for the higher order cognitive competencies — in particular, determining performance standards for them. Job analysis difficulty, importance and frequency ratings are defined as follows, each with a corresponding number rating (Fig. V–1).

Difficulty (D) is a measure of how difficult a task is to perform or learn:

(1) This task is very easy to perform. Someone with no training and no knowledge of the job could perform it adequately.
(2) This task somewhat easy to perform. Someone with basic job knowledge could perform it with no formal training, or it requires only a minimal briefing prior to performance.
(3) This task is moderately difficult to perform. Minimal classroom or on the job training is required to perform it to the required standard.
(4) This task is somewhat difficult to perform. A significant amount of training and experience is required to perform it to the required standard.
(5) This task is very difficult to perform. Extensive training and practice is required to it to the required standard.

Importance (I) is a measure of impact/risk of a task being performed properly. When rating risk importance, focus on the tasks, not on individual roles:

(1) This task is not important for safe and efficient plant operation. Failure to perform this task properly would have no effect on safe operation.
(2) This task is somewhat important for safe and efficient plant operation. Failure to perform this task properly might have a negative effect on plant operation, but does not impair the ability to safely operate the plant.
(3) This task is moderately important for safe and efficient plant operation. Failure to perform this task properly would have a negative effect on plant operation but would pose minimal risk to safe plant operation.
(4) This task is very important for safe and efficient plant operation. Failure to perform this task properly might cause injury or equipment damage or would have a high probability of affecting safe plant operation.
(5) This task is critical for safe and efficient plant operation. Failure to perform this task properly would cause injury or equipment damage, or would impact safe plant operation.

Frequency (F) measures how often an individual performs the task:

(1) This task is performed less than once a year.
(2) This task is performed about once a year (once every six to twelve months).
(3) This task is performed about once a month (once every three weeks to five months).
(4) This task is performed about once a week (once every two days to two weeks).
(5) This task is performed about once a day.

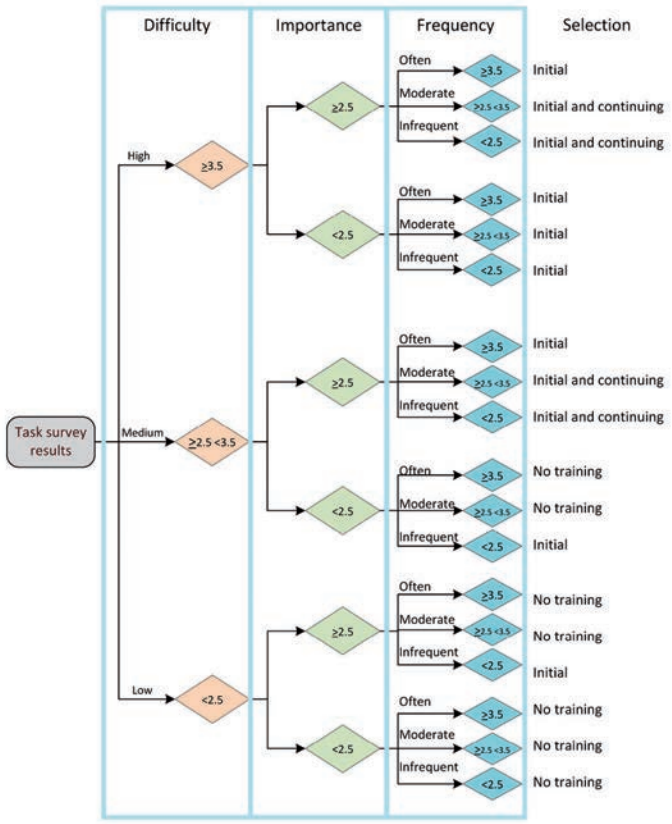

FIG. V–1. Job analysis training section matrix — difficulty, importance and frequency ratings.

GLOSSARY

adjunct instructor. An assistant instructor or an instructor attached to a facility, usually for a limited period of time.

affective (attitudes) domain. One of three areas categories of learning objectives/training objectives, it contains those relating to attitudes (feelings, perceptions and values). The accepted taxonomy (ascending order or level of complexity) within this domain is:

— Attending: Pays attention to received stimuli or events.
— Responding: Reacts positively to stimuli or events by participation.
— Valuing: Demonstrates belief in the worth or value of an event or activity.
— Organization of values: Compares various values and prioritizes them.
— Characterization by values: Displays an attitude characteristic of a pervasive, consistent and predictable set of values. (See also attitudes, cognitive domain and psychomotor domain.)

analysis. (a) The fourth level in the cognitive (knowledge) domain, it involves breaking down an idea into its constituent parts and examining their inter-relationships.
(b) A method of subdividing a problem to be able to make decisions; examples are algorithms, network analysis and critical path analysis.

analysis phase. The initial phase in the systematic approach to training. This phase serves as the foundation for training programme design, development, implementation and evaluation. The analysis phase assesses performance requirements or deficiencies to be able to identify the competencies, in terms of knowledge, skills and attitudes, needed for an individual or group to effectively and efficiently perform the job or jobs being analysed.

analytical simulator. A type of control room simulator designed to study facility behaviour in detail.

application. The third level in the cognitive domain, it involves making use of appropriate theories and facts to solve a new problem. (See cognitive domain.)

assessment. A structured activity by which the knowledge, skills and attitudes of an individual are measured at the end of a training session/course/programme to determine the extent to which training objectives have been met.

assessor. An individual, assigned to conduct an assessment, who is fully qualified at, or above, the level to be attained by the trainee in the area to be assessed. (See also assessment.)

attitudes. The observable characteristics of individuals resulting from their personal emotions, values and feelings that determine ways in which they interact with others and their work, and so affect their interpersonal relationships and approach to their job and safety issues. Together with knowledge and skills, attitudes provide the full requirements to competently undertake a given job or task. Attitudes are sometimes termed affective abilities. (See also affective domain, knowledge and skills.)

blended learning. Learning that uses two or more learning media and which typically includes elements of computer based training, self-study and tutorials, lectures, etc.

Bloom's taxonomy. The classic example of a learning taxonomy which matches learning descriptors with six categories describing the learner's depth of understanding, for example "understand" versus "recognize". Three domains or areas are identified: affective (attitudes), cognitive (knowledge) and psychomotor (skills).

case study. A presentation to individuals or groups of a real or hypothetical situation, used as a substitute for real situations, used in order for the participants to gain experience by applying analytical, decision making and problem solving skills.

certification. In some training practices, the process by which an authoritative organization/body provides written endorsement of the satisfactory achievement of competence of an individual. A certificate habitually follows the satisfactory completion of a performance based training programme or of a theoretical course of study. In other practices, also termed qualification.

cognitive (knowledge) domain. One of three areas used to classify learning objectives, containing those relating to knowledge based mental processes. The accepted taxonomy (ascending order or level of complexity) within this domain is:

— Knowledge: Recognizes and recalls information.
— Comprehension: Interprets, translates or summarizes given information.
— Application: Uses information in a situation different from original learning context.
— Analysis: Separates wholes into parts until relationships are clear.
— Synthesis: Combines elements to form new entity from the original one.
— Evaluation: Involves acts of decision making based on criteria or rationale.

(See also knowledge, affective domain and psychomotor domain.)

competence. (a) The ability to put knowledge, skills and attitudes into practice in order to perform activities or a job in an effective and efficient manner within an occupation or job position to identified standards.
(b) A combination of knowledge, skills and attitudes in a particular field, which, when acquired, allows a person to perform a job or task to identified standards. Competence may be developed through a combination of education, experience and training.
(c) The term 'competency' is also applied to a generic task or a function (e.g. for nuclear facility manager jobs).

comprehension. The second level in the cognitive domain or knowledge area. (See cognitive domain.)

condition (for training objective). Circumstances under which the training objective must be met. These commonly include the presence or absence of particular tools, equipment or work aids; adverse working environment; the working status of equipment; and facility operating mode (normal, emergency, etc.). One of three parameters that need to be stated or implied when compiling a training objective, the other two being performance and standard. (See also training objective.)

continuing training. A systematic training programme, provided after initial training, which is necessary to maintain and enhance competence for a particular job. Continuing training includes the consequences of equipment modifications and procedural changes, and lessons learned from internal operating experience and relevant external experiences. (See also initial training and refresher training.)

criterion. A characteristic or measurement with which other characteristics or measurements are compared, usually being a standard against which something is measured. In training, it is a

measure of trainee performance. In test validation, it is the standard against which test instruments are correlated to indicate the accuracy with which they predict individual performance in a specific area. In assessment, it is a measure used to determine the adequacy of a performance or behaviour. In evaluation, it is the measure used to determine the adequacy of a product or process. A criterion in the training context is sometimes termed a standard.

curriculum. A set of learning objectives covered within a specified course of study.

design phase. The second phase of a systematic approach to training. In this phase, the outcomes of the analysis phase are used to prepare specifications for training programme development and implementation: the design phase includes determining expected trainee entry level competence, identifying training objectives, developing test items and tests, selecting training settings and developing the training programme description.

development phase. The third phase of a systematic approach to training, following the design phase. This phase involves establishing learning activities; selecting training methods, modes and media; reviewing and selecting existing course materials; developing new training and assessment materials; developing and ensuring instructor competence; reviewing, piloting, validating, improving as necessary and approving training material and tests.

duty area. A segment of work that typically represents a distinct major activity of that work comprising several tasks that may be related.

e-learning. (a) Education or training which is delivered, enabled or mediated by information and computer technologies; the technology and services which help create, manage and deliver those activities.
(b) The learning process created by interaction with digitally delivered content, services and support.

element. In the training context, a subtask (part of a task). An element is a discrete action or step undertaken by a trainee as part of a training session or executed by a job incumbent during the performance of a task.

enabling training objective. (a) A statement of intent, especially the expected outcome of a segment of training which includes the expected performance and associated standards, and states or implies the associated conditions.
(b) A statement that describes competencies that trainees need to master before the terminal training objective can be accomplished.

evaluation. (a) A series of activities used to measure the adequacy and effectiveness of a training session, course or programme. Evaluation can happen once, periodically or continuously, depending on the frequency of the activity.
(b) The sixth and highest level in the cognitive domain. (See also cognitive domain.)

evaluation phase. The final phase of a systematic approach to training, following implementation. In this phase, effectiveness and quality of the nuclear facility training programmes and of the entire training system is evaluated; data for improvement of the training programmes and entire training system is generated; necessary changes to the conducting of SAT process and performance of the whole training system are initiated; and recommendations for improvement of the facility performance are generated as well.

evaluation report. A report generated as a result of a formal evaluation of a training session, course or programme, or the entire training system. (See also evaluation.)

facility referenced simulator. A simulator that represents a specific nuclear facility in its design, including the control room physical layout and control board hardware and the software/modelling. Generally, for a facility referenced simulator, standards are defined for the required fidelity between the facility and the simulator.

formal training. Training provided in a structured manner or in an organized situation by a recognized instructor, such as classroom training based upon a lesson plan.

full scope simulator. A simulator incorporating detailed modelling of those systems of the referenced facility with which the operator interfaces in the actual control room environment; replica control room operating consoles are included.

general employee training (GET). Essential training given to all employees of a particular organization or at a specific site. At a nuclear facility this training may include specific health, safety, emergency, policy and procedures required to safely and effectively perform general (not job specific) duties in controlled areas.

graded approach. The process of proportioning resources in a manner that results in the highest safety (or other targeted) benefit, soonest, based upon considerations related to relative hazards and risks.

imitation. The lowest level in the psychomotor domain. (See also psychomotor domain.)

implementation phase. The fourth phase of a systematic approach to training, following the development phase. This phase includes delivery of the training and assessment of trainee performance.

initial training. A systematic training programme designed to ensure that workers possess the necessary competences prior to being assigned independent job responsibilities. (See also continuing training.)

instructional unit. A segment of instruction addressing one or more related terminal objectives; an instructional unit may contain several training sessions/lessons. Also termed module.

in-training evaluation. A continual evaluation of training programmes which is performed while training is in progress. (See also evaluation.)

job aid. A device (such as a documented procedure or checklist) that is designed to provide guidance on the performance of a specific job or part of a job.

job analysis. A method used to obtain a detailed listing of the duties of a specific job. (See also task analysis.)

job and task analysis (JTA). A combination of job analysis and task analysis. (See also job analysis and task analysis.)

job competency analysis (JCA). A type of analysis used for identification of knowledge, skills and attitudes required to perform a job to required standards. JCA concentrates on the analysis of generic tasks or functions rather than on analysis of tasks. (See job analysis.)

job performance measure. A test used to assess the level of performance of a job incumbent or trainee on a specific task, or set of tasks, against pre-determined standards. Also known as task performance evaluation. (See also performance, standard and task performance evaluation.)

just in time (JIT) training. Training performed immediately before the related knowledge, skills and attitudes are needed rather than being done on a standard training schedule — commonly the primary approach for infrequently performed tasks such as pre-outage, new equipment and pre-evolution events.

knowledge. (a) The mental constructs used in acquiring and understanding facts, and the application and reassembling of facts to think creatively, solve problems and make judgements. Together with attitudes and skills, knowledge provides the full requirements to undertake a given job or task. Knowledge is sometimes termed "cognitive" ability.
(b) The lowest level in the cognitive domain. (See also cognitive domain, attitudes and skills.)

knowledge management. An integrated, systematic approach to identifying, acquiring, transforming, developing, disseminating, using, sharing and preserving knowledge, relevant to achieving specified objectives.

learning objective. A precise specification of what is to be learned in terms of the expected performance, the conditions under which the performance is demonstrated and the standards or level of performance. (See also terminal objective.)

lesson plan. An instructor's document that outlines instructor and trainee activities, training objectives, content, timeline, and resources necessary for the consistent delivery of instruction.

licence. A legal document issued by a regulatory body granting authorization to perform specified activities relating to a facility or activity.

line manager. Any manager, leader or supervisor in an organization's structure.

management training. Training in topics that are related specifically to the management aspects of the job positions, duties and responsibilities of managers. Many topics are in the affective domain and include soft skills. Management training addresses core abilities and core competencies of managers, but some management training includes (but is not limited to) topics such as establishment of an integrated management system, legislative matters, regulatory aspects, security, finance and budgetary control. (See also affective domain and soft skills.)

manipulation. The second level in the psychomotor domain. (See also psychomotor domain.)

mentoring. Providing new or inexperienced job incumbents with guidance and feedback, primarily concerning methods to implement their responsibilities. Mentoring is often provided by either experienced job incumbents or line managers of job incumbents, as a collateral duty, rather than a full time responsibility.

mock-up. Physical replication of facility items or equipment used for hands-on training, or just in time training or pre-job briefings. (See also just in time training.)

mode. The way in which learning or training takes place. Examples are large group, small group and individual. A decision on an appropriate mode to be used for a specific training session is made at the design phase of a systematic approach to training. (See also design phase and setting.)

naturalization. The highest level in the psychomotor domain. (See also psychomotor domain.)

needs analysis. In training, a method used to determine — based on analysis of facility and personnel performance gaps — potential training needs for an individual or group.

operations. Personnel working in the authorized facility.

organization of values. The fourth level in the affective domain. (See also affective domain.)

ownership (of training/training programme). The situation in which an individual or group has participated in and contributed to one or more phases of a systematic approach to training and is thereby entitled to 'own', be committed to and take responsibility for all or part of the associated training or training programme. Formal ownership would normally be documented. Both line managers and staff need to demonstrate ownership for training and for its evaluation.

performance. The display or achievement of ability in undertaking a specific activity. In training, the conditions of performance and the standards required are normally specified. Performance is the main output used in the behavioural approach to learning or training, where the actual performance is compared with the expected, pre-specified performance under stated conditions and standards. (See also conditions and standards.)

performance based training. Training based on mastery criteria in which the relevant knowledge, attitudes and skills required for competent job performance have to be demonstrated by the trainee. The systematic approach to training is one example of performance based training. (See also systematic approach to training.)

performance criterion. Part of a training objective that describes or measures a trainee's observable behaviour (or the product of that behaviour) and is acceptable as proof that the objective has been achieved. Also termed "performance standard".

practical exercise. A technique used during a training session that permits trainees, through hands-on participation, to acquire and practise the knowledge, skills and attitudes necessary to successfully perform one or more training objectives.

precision. The third level in the psychomotor domain. (See also psychomotor domain.)

psychomotor (skills) domain. One of three areas used to classify learning objectives, containing those relating to physical skills (movement and coordination). The accepted taxonomy (ascending order or level of complexity) within the psychomotor domain is as follows:

- — Imitation: Observes a skill and tries to repeat it.
- — Manipulation: Performs a skill according to instruction rather than observation.
- — Precision: Reproduces a skill with accuracy, proportion and exactness. Usually performed independent of original source.
- — Articulation: Combines one or more skills in sequence with harmony and consistency.
- — Naturalization: Completes one or more skills with ease and becomes automatic.

qualification. A formal statement that an individual possesses the education, training and experience required to meet specified job performance requirements. A formal statement of competence. The qualification may enable an individual to work independently, depending on local and national

policies. Also used to identify a process of formal confirmation that an individual (e.g. a trainee) meets qualification requirements. (See also competence.)

qualification programme. A structured series of assessed events, including education, experience and training, provided by management and training personnel for a trainee, with the aim of enabling the trainee to obtain a qualification. (See also qualification.)

reference facility. The specific nuclear facility from which a simulation of the facility's control room configuration, system control arrangements and design data are derived.

refresher training. Training that is used to reinforce previous training and/or sustain/regain previously acquired competence.

remedial training. Training designed, developed and implemented specifically to correct a trainee's demonstrated errors in, or inappropriate application of, knowledge, skills or attitudes.

responding. The second level in the affective domain. (See also affective domain.)

role play. A training method in which trainees and/or trainers act the parts and roles of any personnel or categories of personnel.

scenario. A series of simulator operations or functions (e.g. malfunctions) implemented in accordance with a lesson plan or guide for the purpose of familiarization, training or examination of control room operators.

self-study. Learning by a student alone without the presence of an instructor but normally using structured training materials. Self-study may be complemented by occasional or regular tutorial sessions in which an instructor answers queries, conducts an assessment or provides guidance for further self-study. In training practices, used to indicate both a training setting and a training method.

setting. The environment or location in which learning, instruction or training takes place, including classroom, laboratory, workshop, simulator, the actual workplace (i.e. during on the job training) and self-study. A decision on an appropriate setting to be used for a specific training session is made at the design phase of the systematic approach to training. (See also design phase.)

site access training. Obligatory training for all nuclear facility site personnel, including the facility employees and contractors, and unescorted visitors, before they are allowed to access the nuclear facility site.

skills. The physical and manipulative actions following the mental signal needed to perform an activity or task. A term often incorrectly applied to abilities. Together with attitudes and knowledge, skills provide the full requirements to undertake a given job or task to specified standards. Skills are sometimes termed "psychomotor" abilities. (See also psychomotor domain, attitudes and knowledge.)

soft skills. The practical application of attitudes in performing a task or undertaking a responsibility in a job position. Examples of soft skills are human interactions such as leadership, teamwork, communication, reinforcement, critiquing, assessing, coaching, observing, counselling, supervising and managing.

standard. (a) A document describing specified parameters that need to be complied with to meet identified criteria; the standard may be an internal organization document or one issued by a national or international authority such as the International Organization for Standardization (ISO).
(b) In training, standard is also used as an alternative term for criterion.

systematic approach to training (SAT). A training approach that provides a logical progression from the identification of the knowledge, skills and attitudes required to perform a job to the development and implementation of training to achieve these competencies, and subsequent evaluation of this training.

task analysis. The formal identification of the knowledge, skills and attitudes that are required to competently perform tasks associated with a particular job. (See also job analysis.)

task performance evaluation. A formal evaluation of task performance to determine a trainee's ability to independently perform a task. Task performance evaluation in some training practices is viewed as separate and distinct from on the job training. However, in some training practices, task performance evaluation is used both for evaluation of an incumbent's task performance and also a trainee's performance assessment in the actual job environment when job performance measures are used by the designated assessors for assessing a trainee performance. (See also job performance measure.)

terminal objective. In the training context, a statement of the purpose or goal of a particular training session, course or programme. A terminal objective is usually written in behavioural terms, stating the expected outcome in terms of performance, conditions and standards, supported by enabling objectives. Terminal objectives are usually directly related to specific tasks/competencies and reflect trainee performance requirements upon completion of a training programme. Terminal objectives are intended for long term retention and are reinforced through continuing training as needed. (See also condition, continuing training, enabling objective and standard.)

training aid. An artefact used to illustrate, clarify, exemplify or reinforce training such as printed materials, presentation slides, films, mock-ups, models, actual equipment, e-learning systems and simulators.

training committee. A panel of nuclear facility managers that collects and analyses nuclear facility performance information to evaluate the effectiveness of training; routinely meets to formulate suggestions needed to improve the effectiveness of training; and verifies that recurring training problems are identified and preventive measures are planned and implemented. Several training committees may be established at large nuclear facilities (e.g. a facility training committee and individual training committees to deal with the training of various job classifications). Experienced job incumbents and even employees who have recently completed training may be invited to take part in these training committees.

training needs analysis (TNA). A regular and systematic process used to evaluate potential training needs, to suggest and approve training solutions, and, where it is possible, to suggest other management initiatives to improve facility performance. (See also analysis phase and needs analysis.)

training objective. A statement of the expected performance of a trainee in terms of knowledge, skills and attitudes, on completion of a particular part of a training programme, to what standards and under what conditions.

training policy. A formal, written statement issued by senior management of an organization containing, at a minimum, the goals and scope of training. It may also address the organization and responsibilities

for its implementation and the methods of monitoring and controlling its effectiveness. (See also training procedures.)

training procedures. Written instructions that describe the philosophy, principles, management and organization of, and methodology and responsibilities involved in, preparing, administering, implementing and evaluating a training programme. Training procedures are based upon and consistent with training policy. (See also training policy.)

validity. (a) In training, the extent to which an item such as a task statement or qualification fulfils or represents the purpose for which it was intended. Validity is commonly used in evaluation.
(b) In tests, the degree to which an test measures what it purports to measure.

walkthrough. A method of oral assessment in the trainee's work area where the assessor and trainee 'walk through' or alongside the facility and the assessor asks the trainee questions relating to equipment or items of the facility relevant to the training objectives.

ABBREVIATIONS

ADDIE	analyse, design, develop, implement and evaluate
ALARA	as low as reasonably achievable
GET	general employee training
HEI	higher education institute
JCA	job competency analysis
JIT	just in time
JPM	job performance measure
JTA	job and task analysis
KSAs	knowledge, skills and attitudes
MCR	main control room
NPP	nuclear power plant
OJT	on the job training
SAT	systematic approach to training
SEG	simulator exercise guides
SME	subject matter expert
SQEP	suitably qualified and experienced personnel
TNA	training needs analysis

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Hernandez, M.A.	National Nuclear Safety and Safeguards Commission, Mexico
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Kolomiiets, V.	International Atomic Energy Agency
Kosheliev, V.	Intellectual Technology, Ukraine
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Lockwood, R.J.S.	HMS Sultan, United Kingdom
Luciani, A.	International Atomic Energy Agency
Markov, O.	South-Ukraine Nuclear Power Plant, Ukraine
McCall, K.	Emirates Nuclear Energy Corporation, United Arab Emirates
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Molloy, B.	International Atomic Energy Agency
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Nikonov, D.	International Atomic Energy Agency

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Tarren, P.	International Atomic Energy Agency
Templeton, R.	Ontario Power Generation, Canada
Van Sickle, M.	International Atomic Energy Agency
Zombori, P.	International Atomic Energy Agency

Technical Meetings

Uppsala, Sweden: 28 September–1 October 2010
Vienna, Austria: 17–20 October 2017

Technical Working Group Meetings

Vienna, Austria: 15–17 June 2010, 19–21 June 2012,
2–5 September 2014, 14–17 June 2016

Consultants Meetings

Vienna, Austria: 20–23 April 2009, 1–4 December 2009, 14–18 June 2010, 29 November–3 December 2010,
27 June–1 July 2011, 21–23 March 2017, 7–8 June 2017, 11–13 July 2017

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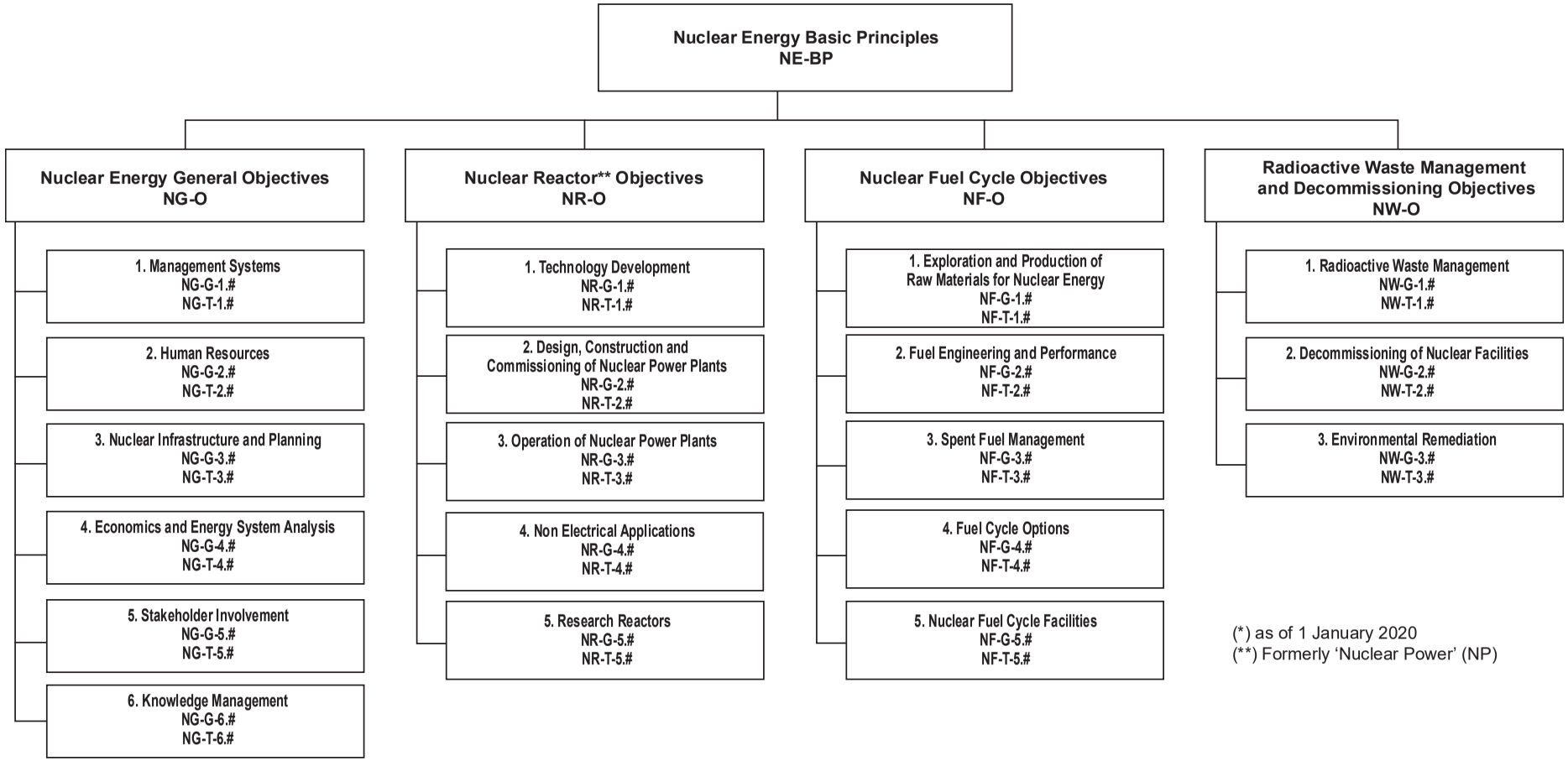

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BP: Basic Principles
O: Objectives
G: Guides and Methodologies
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Examples

NG-G-3.1: Nuclear Energy General (**NG**), Guides and Methodologies (**G**), Nuclear Infrastructure and Planning (topic **3**), **#1**
NR-T-5.4: Nuclear Reactors (**NR**)*, Technical Report (**T**), Research Reactors (topic **5**), **#4**
NF-T-3.6: Nuclear Fuel (**NF**), Technical Report (**T**), Spent Fuel Management (topic **3**), **#6**
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