DS 441: Draft 1.2

January 2012

IAEA SAFETY STANDARDS

for protecting people and the environment

Status: For Member States consultations

Deadline: 30 June 2012

Construction for Nuclear Installations

DRAFT SAFETY GUIDE XXX

DS441

New Safety Guide

IAEA

International Atomic Energy Agency

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1 The fundamental goal of construction is to correctly build an approved design. In order to accomplish this, this Safety Guide provides an appropriate management process which focuses on various aspects of construction activities and supplements the requirements, recommendation and guidance provided by: The Management System for Facilities and Activities [1]; Application of the Management System for Facilities and Activities [2]; and, The Management System for Nuclear Installations [3], on implementation of construction activities in accordance with a management system. Appendix V of Ref. [3] provides some guidance on the specific processes to be developed for the construction stage.

1.2 This safety guide is broadly applicable to nuclear installations and is intended for application to both the construction of new nuclear installations and the modification of existing nuclear installations. Nuclear installations vary greatly in type, size, utilization and other characteristics so that judgement has to be exercised on the measure of the following recommendations' applicability to a specific installation.

1.3 To ensure that newly constructed structures, systems and components or nuclear installations can be commissioned and operated safely, it is necessary to fulfil the relevant requirements such as "Safety of Nuclear Power Plants: Design" [4], "Safety of Nuclear Power Plants: Commissioning and Operation" [5], "Safety of Research Reactors" [6] and "Safety of Nuclear Fuel Cycle Facilities" [7]. In addition, the regulatory authorization described in "Governmental, Legal and Regulatory Framework for Safety" [8] must be granted according to each country's regulatory framework. It is recognized that even if the design and

commissioning are fully compliant with all of the above requirements, a high level of safety can only be achieved when the construction is carried out with high quality and care, since commissioning cannot test all aspects of the design. Therefore all construction activities have a potential impact on safety, although no nuclear material may be present during the construction.

OBJECTIVE

1.4 The objective of this Safety Guide is to provide recommendations and guidance based on international good practices in construction of nuclear installations, as currently followed in Member States, which will enable construction to proceed with high quality, consistent with applicable codes, standards, and design requirements as part of the demonstration that the product can be commissioned and is capable of operating safely and reliably over its lifetime.

SCOPE

1.5 This Safety Guide is applicable to the construction stage of a new nuclear installation and the modification of an existing nuclear installation[1], including the process of manufacturing and assembling the components, carrying out of civil and architectural work, installation and maintenance of components and equipment, and performing the associated tests. Neither the design nor commissioning stage is included in this Safety Guide, although

[1] NS-G-2.3 "Modification to Nuclear Power Plants" [9] provides guidance on controlling activities relating to modifications at nuclear power plants and it deals with the intended modification of items, operational limits and conditions, procedures and software, and the management systems and tools for the operation of a nuclear power plant.

these stages may overlap with the construction stage. The specific definition of each stage may vary for each organization or country.

1.6 This Safety Guide identifies and explains safety significant construction management activities which should be considered, checked and reviewed for ensuring quality of a new or modified nuclear installation.

1.7 This Safety Guide may be applied to nuclear installations in the following ways:

- To support the development, implementation, assessment and improvement of the construction methods, procedures and techniques for ensuring the quality of the end product to meet the design and safety intent;
- To assist the regulatory body in oversight and evaluation of the construction activities performed;
- To assist licensee and construction organization in providing technical specifications to a contractor, via contractual documentation, that are pertinent to the supplied product;
- To assist licensee and construction organizations in understanding of the technical aspects that should be considered when assessing contractors' qualifications and performance.
- To assist stakeholders in understanding the roles and responsibilities of different types of contractors. These contractors may be technical support organizations or consultants carrying out independent review and assessment or third party inspections. (needs improvement)

1.8 In this Safety Guide, it is considered that all relevant safety requirements must be

complied with, in all applications of the graded approach.

1.9 While this Safety Guide focuses on achieving high quality during construction which is a prerequisite for a safe and reliable operation of nuclear installations, it is noted that security aspects should also be considered and evaluated during construction. The IAEA's Nuclear Security Series covers security issues at authorized installations.

STRUCTURE

1.10 Section 2 provides general considerations including definitions of terms used and prerequisites before the start of the construction. Section 3 provides guidance on the regulatory oversight of construction activities. Section 4 provides recommendations on management system for construction. Section 5 provides recommendations for the management of construction activities focusing on actual construction works on-site and at off-site locations.

2. GENERAL CONSIDERATIONS

USE OF TERMS

Construction

2.1 Construction is defined as the process of manufacturing and assembling the components of a facility, the carrying out of civil works, the installation of components and equipment and the performance of associated tests [10]. The associated tests are referred in this guide as pre-commissioning tests. Pre-commissioning tests are functional tests of individual subsystems of components and they are prerequisites for performing

pre-operational tests during commissioning [11].[2] Construction of the facility is considered to be finished when all items have been installed, tested (i.e. pre-commissioning tests have been conducted, but not any tests defined as part of commissioning) and, if necessary, transferred to a commissioning group. Because the construction schedule for each item will be different, the commissioning and the construction stages for the installation will overlap.

Construction organization

2.2 The 'construction organization' is either the licensee, or that part of the licensee or the contracted organization that is responsible for construction. This construction organization is the entity managing the construction activities such as civil and architectural works, manufacturing, assembly, installation and testing of items important to safety at the level of the installation. If the licensee is unable to fulfil this function, it may appoint a contractor or contractors to carry out specific functions for part or all of the installation. The responsibilities of the contractor(s) should be clearly defined and controlled by the licensee. In addition, the contractor's governance of activities and the activities themselves should be inspected by the licensee. The use of contractor(s) in no way replaces or reduces the responsibility of the licensee for safety.

Contractor

2.3 The contractor means to any individual or organization who provides items or renders services in accordance with a contract or a procurement document. The term 'contractors' includes designers, manufacturers, producers, assemblers, installers, distributors,

[2] In some cases, pre-commissioning tests may be part of a commissioning programme and may be performed by the group or organization responsible for commissioning. In this Safety Guide, pre-commissioning tests are considered part of the construction stage and are assumed to be performed by the construction organization.

importers, sellers, suppliers, subcontractors, technical support organizations, consultants and their subsidiaries.

PREREQUISITES FOR THE CONSTRUCTION OF NUCLEAR INSTALLATIONS

2.4 The construction should start only after the licensee has satisfied itself by means of verification that the main safety issues in the design have been resolved and that relevant authorizations have been issued. If the construction starts before the regulatory body has satisfied itself, by means of review and assessment, of the adequacy of the safety analysis submitted, and the adequacy of the proposed arrangements, procedures and quality assurance programmes for implementing the design throughout construction, the licensee bears the risk that the product may fail to meet necessary requirements.

2.5 The highest level of safety that can be achieved in the construction of nuclear installations requires: a sound legal basis; a well resourced and technically competent licensee; qualified and experienced vendors, manufacturers and construction organizations; an appropriate governmental infrastructure, including a regulatory body with well defined responsibilities and functions; and an appropriate technical support infrastructure for the regulatory body and licensee. The legal and governmental framework should be sufficiently implemented for proper regulation during construction.

2.6 All applicable licences, permits and approvals required to initiate construction activities should be in place. Recommendations and guidance for the construction license requirements are provided in “Licensing Process for Nuclear Installations” [12]. Before construction starts, a preliminary safety analysis report (or pre-construction safety analysis report that supports the application for authorization for siting and/or construction) should be available to describe the nuclear installation and its safety features with key design

characteristics and updated as appropriate. See Ref. [13] for more guidance on the safety analysis report.

2.7 The licensee should identify and understand jurisdictional boundaries and responsibilities where there is more than one regulatory body governing an area (i.e., national and provincial governance over occupational health and safety; pressure boundaries; protection of the environment).

2.8 All efforts should be taken to ensure that an adequate level of safety consciousness and the acceptance of personal responsibility for safety are achieved by all parties. This includes licensee, regulatory body, contractors, and other stake holders.

2.9 Adequate completion of design, including acceptance criteria, and engineering work commensurate with the authorization process should be verified prior to start of construction. Before construction begins, a forward action plan covering remaining design and engineering works and the necessary resource requirements should be developed and monitored as construction proceeds.. Care should be taken to ensure that the form of contract does not result in late completion of design work resulting in parties being placed under time and cost pressures that may affect quality and ultimately safety. Design changes and late completion of design works should be minimized after construction starts.

2.10 Development and qualification of well-defined methods of construction, transportation, inspection or testing that is relevant to safety should be done before commencement of the activities, especially for a first-of-kind technology. More quality non-conformance and re-works are expected when new methodologies are applied for the first time. Potential non-conformances and deviations should be minimized by early planning with adequate resource for qualification activities such as R&D activities or mock-up/full size

verification tests.

2.11 Security requirements should be identified and taken into account in addition to safety considerations. Conflicting requirements should be identified and resolved. According to those requirements, on-site arrangements should be implemented, including physical protection against sabotage in use and storage of items important to safety.

2.12 For sites with existing nuclear installations, emergency preparedness should take account the followings:

- The average and peak employment at the site throughout the construction or modification project;
- Training of construction site personnel;
- Provision of additional alarms all personnel at the site; and,
- The various phases of construction and commissioning with their inherent risks.

2.13 The regulatory body should ensure that the licensee(s)[3] carries out a risk and threat assessment to determine the possible risks of the construction site to the existing facilities and the effect of existing facilities on the construction site. These risks depend on the site and construction method which therefore should be analysed for each individual site. Possible risks are caused by, but not limited to, dredging, quarrying, excavation, blasting, piling, dust, transportation and lifting. Preventive measures should be taken to manage the construction related risk. Further guidance on interaction with existing facilities is provided in paras 5.42 – 5.44.

[3] In some cases multiple licensees on the same or nearby site may exist

2.14 Installations which handle, process or store potentially hazardous materials such as explosive, flammable, corrosive, toxic or radioactive materials should be identified. The maximum amount of hazardous material present at any given time and the process in which it is used should be taken into consideration. Pipelines for hazardous materials should be included in the category of items to be identified. Other sources to be considered are construction yards, mines and quarries which use and store explosives and which may cause the temporary damming of water courses, with possible subsequent flooding or collapse of ground at the site. For other potential sources of human induced external events, refer to paras 3.9 – 3.11 of Ref. [14] for more details.

2.15 Environmental monitoring and protection measures at the site should be in place to ensure adequate mitigation of potential environmental effects related to construction activities.

2.16 Necessary fire protection measures at the construction site should be available until final plant fire detection, protection, and suppression systems are installed and operational. Details of these measures should be included in the emergency planning arrangements.

2.17 The security measures that describe actions taken during construction should consider, detect, and deter conditions that would impair the capabilities of security- and items to perform their intended safety functions, where those conditions are not otherwise detected by engineering and performance barriers to ensure that items are installed and tested as designed. Security measures employed should consider control of personnel, material, and vehicles; random patrols/inspections as defined in site security procedures; and screening (pre-employment screening and gate clearance) for access to security and safety controlled areas. As a minimum, security measures within and around the site should include physical barriers, posting, surveillance and monitoring capability, uniformed security personnel,

communication capability, and control personnel access.

2.18 In addition, the following issues should be considered before on-site construction begins to ensure quality of the construction:

- Licensee's manual on site construction quality management;
- Design reports of items important to safety having reference to construction consent;
- Arrangements to accommodate specialized nuclear installation work force to the site (labour colony);
- Location and approach/exit roads especially for large component transportation;
- Work hazard analysis report;
- Construction safety management manual (radiation source handling and hazard);
- Marking of nuclear licensed site boundary;
- Plan for radiation safety of workers (for construction with existing installations);
- All infrastructure support systems should be in place including required electricity, gas and water supply, protection or coverage after work completion and environmental qualification.
- Construction processes and equipment such as cranes, scaffolding, temporary structures, portable equipment, and flammable equipment are all designed to withstand meteorological and hydrological hazards such as earthquakes, floods, fires, heavy rains, snow, ice, etc., during the construction.

2.19 In cases where construction is being resumed on a suspended project special

consideration should be given to factors that may influence continued construction. More detailed guidance can be found in Ref. [15] and [16].

2.20 Some activities, such as ground investigation, may be carried out before a licence has been granted. Arrangements should be put in place to ensure that, if the outputs of these activities are incorporated into the permanent works or can have an influence on them, any pre-licensing activities are planned, executed, monitored and documented to standards equivalent to activities carried out post-licensing.

3. REGULATORY OVERSIGHT OF CONSTRUCTION ACTIVITIES

3.1 Four interrelated IAEA Safety Guides provide recommendations on satisfying the requirements in Ref. [8] concerning particular responsibilities and functions of the regulatory body in the regulation of nuclear facilities. These four Safety Guides cover, respectively, the organization and staffing of the regulatory body [17], regulatory review and assessment [18], regulatory inspection and enforcement [19], and documentation relating to the regulatory process [20]. The following recommendations provide a means of meeting the requirements in Ref. [8] for the regulatory oversight of nuclear installations during construction. They are supplementary to, and should be read in conjunction with, the recommendations provided in Refs [12, 17-20].

3.2 The regulatory oversight during construction refers to monitoring and observing directly of construction work practices, items, and equipment. It also includes inspection and assessment of safety related construction activities through such methods as: discussions and interviews with relevant personnel; examination of procedures, records and documentation; and measurements and tests.

3.3 The regulatory oversight should satisfy regulatory body that the licensee is in compliance with the conditions set out, for example, in the authorization or regulations. In addition, the regulatory oversight should also take into account, as necessary, the activities of contractors of services and products to the licensee. The regulatory oversight should not relieve the licensee or contractor(s) of its responsibility for ensuring safety.

3.4 Well in advance of the beginning of the construction, the regulatory body should schedule resources to ensure a consistent and responsive oversight, according to the progress of the construction activities. Inspectors should be suitably qualified, trained and experienced in order that their competencies are consistent with the planned construction activities.

3.5 The regulatory body should develop requirements or guidelines governing its oversight of construction activities according to a graded approach. This extends to contractors manufacturing and assembling items important to safety.

3.6 The regulatory body should implement an oversight programme consistent with the construction programme provided by the licensee.

3.7 To properly implement an oversight programme during construction, the communication between the licensee and regulatory body and any other authorized bodies as appropriate should be formally defined before construction begins. The communication should be performed on a regular basis and include detailed scheduling information such that the regulatory body can plan to inspect specific construction activities and review relevant documentation.

3.8 During construction, the regulatory body should review and assess:

- how proposed arrangements, procedures and quality assurance programmes for

implementing or modifying the design is carried out under a proper management system;

- on a systematic basis, the development of the remaining design of the nuclear installation as demonstrated in the safety documentation submitted by the applicant or licensee;

- the progress of research and development programmes relating to demonstration of the design, if applicable;

- the availability of the documents related to the detailed design for the construction organization so that it has enough time to prepare and manage the construction properly; how these design issues are incorporated into the licensee's construction programme.

3.9 To gain assurance that the licensee has met the regulatory requirements and can move forward in the construction programme, the regulatory body should make use of hold points or witness points such as excavation to rock head/formation level, first concrete, major safety significant equipment installation, fuel on site, entering commissioning, or following a major deviation from the requirements. These should be identified and communicated to the licensee as early as possible to allow consideration in planning and scheduling activities. The hold or witness points should be carefully selected to:

- enable observability or testability especially before irreversible steps are made;

- check construction organization preparedness for next stage.

If there are non-conformances, an action plan may be needed to correct deficiencies to allow progress beyond witness or hold points.

3.10 The regulatory body should have in place a system to allow them to receive and address any matters raised by other parties concerning the safety of construction.

3.11 The regulatory body should make arrangements for analysis to be carried out to identify lessons to be learned from construction experience and regulatory experience and for the dissemination of the lessons learned and for their use by authorized parties, the regulatory body and other relevant authorities. The regulatory body should require appropriate corrective actions to be carried out to prevent the recurrence of safety significant events.

4. MANAGEMENT SYSTEM FOR THE CONSTRUCTION OF NUCLEAR INSTALLATIONS

4.1 The following recommendations provide a means of meeting the requirements in Ref. [1] for the construction of nuclear installations. They are supplementary to, and should be read in conjunction with, the recommendations provided in Ref. [2] and Ref. [3]. Since construction work has significant impact on future safety of nuclear installation, a successful management system during construction ensures that safety matters are not dealt with in isolation but are considered within the context of all construction activities.

SAFETY CULTURE

4.2 Safety culture is important in all phases of nuclear installation life cycle. In the construction stage, it implies characteristics and attitudes pursuing high quality construction to ensure safety in the commissioning, operational and decommissioning phases. This involves an understanding that deviations from procedures and specifications, or failure to understand the safety significance of structures, systems and components may have unforeseen consequences in the future.

4.3 A construction process involves challenges such as planning and execution under time and budget pressures, temporary workers with various levels of skills, numerous contractors and works influenced by weather conditions and external environments. In addition, construction activity necessarily involves change on a constant basis. These factors are known to be some of the prime conditions that can induce poor safety culture. Goal conflicts between schedule, cost and safety should not adversely affect conservative decision-making and the maintenance of a questioning attitude. Application of safety culture attributes should be implemented in all participating organizations and individuals.

4.4 Construction programmes and methodologies should be developed and implemented to help all interested parties involved in the construction project strengthen safety culture particularly in organizations less familiar with nuclear safety requirements. A system to train personnel who have transferred to or are employed on nuclear projects from other industries should be established to make them aware of the additional issues associated with nuclear safety.

4.5 The licensee should have adequate control and oversight of the supply chain and have robust systems and procedures in place to monitor this.

4.6 The licensee should ensure all contractors and subcontractors in the supply chain or involved in surveillance activities are fully aware of the safety significance of what they have been contracted to supply. This safety awareness should be ensured for all tasks including common construction works such as anchoring or cable sheathing since contractors may not have experience of working for the nuclear industry. The licensee should encourage them to demonstrate a questioning attitude if any aspect of the work specified seems unusual or is not fully understood, or if any situation occurs during the course of the supply that could affect the quality of the finished component or service.

4.7 Safety culture and its promotion should be considered as part of contractor evaluation and monitored during the construction stage.. Monitoring and evaluation should cover not only contractors' organizations but also staff.

4.8 To support the safety culture principles, there should be a process for reporting safety concerns directly to management and the regulatory body. This process should include the capability of anonymously reporting a non-conformance or concern.

APPLICATION OF GRADED APPROACH

4.9 A graded approach based on the relative importance to safety of each item, service or process should be used during all construction activities. The graded approach should reflect a planned and recognized difference in the application of specific quality assurance requirements.

4.10 The grading process should determine the extent of the application of the management system requirements to the construction activities.

4.11 In developing the grading approach, the following should also be considered:

(a) The qualification of special construction processes such as welding or non-destructive testing and the qualification of the personnel that will carry them out;

(b) The necessary level of detail and the need for inspection and test plans;

(c) The safety significance of equipment, materials, procedures, records and other documents;

(d) The level of in-process controls and the need for hold or witness points;

(e) Level of complexity;

(f) First-of-a-kind activity.

LICENSEE RESPONSIBILITIES

4.12 Reference [5] states:

"During construction and commissioning, the plant shall be monitored, preserved and maintained so as to protect plant equipment, to support the testing stage and to maintain consistency with the safety analysis report" (para. 6.14).

This requirement is implicitly applicable to the licensee for the construction of nuclear installations.

4.13 The licensee has responsibility for the nuclear installation being built in accordance with all legal and regulatory requirements[4]. The licensee may contract construction but retains the primary responsibility for safety, quality and security.

4.14 The licensee should develop and maintain its capability to control all activities for which the license has been granted.

4.15 The licensee should take the responsibility during construction for all activities that could affect safety of the installation regardless of location. This includes:

- Developing and implementing a management system covering construction activities to assure the required quality. The licensee should establish a construction

[4] Where multiple jurisdictions and requirements exist, requirements or standards may not be aligned in all cases. In this case, all *applicable* legal and regulatory requirements should be met,

supervision plan for the items important to safety which includes audits, product quality surveillance, witness/hold points, and field walk downs;

- Defining and retaining its core capability to be an "intelligent customer"[5] in its oversight and contracting processes;

- Taking and maintaining ownership of the safety case especially for the information provided by contractor(s) or design/construction organization;

- Internal and external audits on the management system of contractors based on the graded approach. The licensee should perform surveillances to verify that the contractors' activities are in compliance with all relevant safety requirements from both technical and management system perspective;

- Having a construction programme with hold points in the construction processes, where approval may be required (possibly by the regulator) prior to continuing to the next stage;

- Inspections, tests and verification of items important to safety, which the regulator verifies but does not substitute for.

- Reporting safety significant non-compliances and events as required by the regulatory body;

- Ensuring that appropriate records relevant to safety are preserved;

[5] An 'intelligent customer' is which the organization has clear understanding and knowledge of the product or service being supplied.

- Preparing the commissioning programme, taking into account tests performed during construction;

- Ensuring that appropriate records relevant to plant life and ageing management are preserved;

- Transfer of documentation when moving from construction to commissioning.

4.16 The licensee should formally appoint an individual from its own organization as the construction manager to be responsible for construction activities.[6] The construction manager has the responsibility to ensure that the construction meets all relevant safety requirements.

Construction organization

4.17 The construction manager should have access to the necessary resources to establish a construction organization which may be or include contracted staff. The role and responsibilities of the construction organization should be defined and documented. The management structure of the construction organization should define the level of responsibility for groups within it, including the responsibilities among contractors.

4.18 The principal activities of the personnel in the construction organization should include, as a minimum:

(a) Controlling and supervising contractors both on-site and off-site;

(b) Ensuring that the construction organization and contractors are established on

[6] The individual formally appointed to be responsible for construction activities may be the head of the construction organization.

the site in a controlled manner in allocated areas and are provided, where appropriate, with the necessary site services, information and instructions with regard to the applicable nuclear and industrial safety requirements;

(c) Identification of generic construction activities, develop and maintain guides about the use of standardized instructions and procedures and best practices;

(d) Preparing safety related working procedures, including industrial safety procedures, to issue to the personnel of both the construction organization and the contractors, and establishing that both the construction organization and the contractors' industrial safety arrangements on the construction site comply with the applicable requirements;

(e) Monitoring the nuclear and industrial safety policies and activities of all personnel to ensure compliance with statutory and regulatory requirements with regards to quality and safety;

(f) Planning and monitoring the progression of work to fulfil the construction programme, including, where appropriate, coordinating the activities of contractors responsible for constructing interfacing structures, systems and components;

(g) Ensuring that work by construction organization and contractors is carried out in accordance with procedures, specifications and drawings, that safety and quality requirements are specified and implemented and that inspections and tests, including those at the suppliers' facilities, are appropriate and in accordance with inspection and test plans and associated surveillance schedules;

(h) Carrying out maintenance of equipment as required, ensuring proper care of equipment that could deteriorate during construction, such as dehumidification of electrical equipment and preservation of critical surfaces that could rust; and carrying out adequate housekeeping activities to protect open equipment against foreign materials intrusion and contaminants;

(i) Carrying out the first inspection for systems or components and obtaining relevant baseline data for comparative purposes in in-service inspection;

(j) Arranging the controlled handover of completed work and records from one group to another or to the construction organization;

(k) Acquiring, installing or maintaining material sample for a long term material ageing monitoring and analyses;

(l) Through auditing of procedures and surveillance of work activities, ensuring that adequate documentation is being produced to demonstrate such things as due diligence, compliance and corrective actions.

PROJECT MANAGEMENT

4.19 The following safety recommendations are provided in addition to those provided in Ref. [3] paras 5.43-5.60.

Construction management

4.20 Construction management is a leadership function primarily concerned with the organization, co-ordination and control of large human, equipment and material undertakings, with many constraints.

4.21 Construction management processes as well as construction work processes should be defined and documented. They should take due account of safety.

4.22 The licensee, construction organization and other contractors should have adequate organization, resources, experience, competence and procedures to manage a nuclear installation construction project and maintain documentation to demonstrate them. Experience has shown that a construction project can involve the use of temporary workers with various skills, multi-layered and multi-national contractors with various languages, cultures, legal and regulatory backgrounds, and different conventions for measurements (units, measurement methodologies, measurement equipment/devices, uncertainty, etc.). These differences should be taken into account in developing the project management and selecting project managers.

Requirements management[7]

4.23 A system should be established to ensure that applicable inputs such as legal, regulatory and licensee requirements for ensuring safety and quality are correctly translated into specifications, drawings, procedures and instructions. The requirements and changes thereto should be controlled, so that safety related activities and items important to safety are consistent with the applicable requirements.

4.24 Compliance with all relevant safety requirements including implementation of safety culture and quality management should be ensured for all relevant parties, including contractors from the point of awarding contracts to the work completion. Ref. [2] provides recommendations on procurement requirements.

[7] The word 'requirements' in the phrase 'requirements management' refers specifically to the requirements not only from applicable law, regulations, or the IAEA Safety Fundaments/ Requirements, but also from contractual agreements, applicable codes and standards, and any other source which the licensee must conform to.

4.25 The regulatory body and the licensee in the country where the components will be used might each impose specific requirements that differ from the specification that would be normal for the country in which the component is manufactured or assembled. The licensee should ensure that the relevant requirements are known and understood by all those within the supply chain.

4.26 The licensees should ensure that all information supplied by the design organization is sufficiently clear and explicit to convey all the relevant requirements to the contractors chosen to construct and, where appropriate, test and commission items important to safety. Reliance should not be placed on just quoting codes and standards.

Traceability

4.27 Traceability of items important to safety from initial design through construction and then to commissioning is an important aspect of ensuring safety. The licensee should ensure that processes are in place and should collect and store such records as required by itself and the regulatory body. The aspects of this traceability include:

(a) As built drawings;

(b) Manufacturing and assembling details;

(c) Inspection reports;

(d) On-site traceability including marking and tagging;

(e) Construction and test records (to be used as baseline data).

The construction organization should be responsible for ensuring that the traceability records required by the licensee are provided to them..

4.28 The level of traceability for items important to safety should extend through all equipment, materials, procedures, records, and other documents to ensure that the items are constructed to the appropriate quality level for their safety classifications.

4.29 Comprehensive photographic and, where appropriate, video records and computer simulations should be compiled, particularly in areas that will later be eventually inaccessible or will be subject to intense radiation. This information will facilitate the planning of work in these areas during commissioning, operation and decommissoning. These visual construction records of as-built conditions should show identification marks and should be comprehensively catalogued with descriptive captions. This will ensure that visual records made during subsequent inspections or maintenance work can be easily compared, and will help in any work preparation.

INTERFACE MANAGEMENT

4.30 Interface arrangements should be identified and agreed between the licensee, construction organization (if appropriate), design organization, contractors and other organizational units performing the work. The interface arrangements should be specified in management system documentation and should be included in procurement documents as appropriate.

4.31 The construction organization should establish and implement a method to maintain an adequate and timely communication to link on-site and off-site construction activities. This communication should also involve the design organization as appropriate.

4.32 The construction organization should define processes for identifying and resolving conflicts and misunderstandings between contractors, for instance concerning conflicts with construction schedules, activities, tools, work spaces.

TRANSFER OF RESPONSIBILITY

Transfers during construction

4.33 Appropriate rules and procedures should be established and documented by the construction organization to control and coordinate the handover of completed works from one supplier to another in order to maintain the integrity of the completed works. Access control for items important to safety and working areas should also be written and implemented for the transfer. The rules and procedures should be approved by the licensee for use in the project.

4.34 When items important to safety and working areas are to be transferred between groups within the construction organization, both groups concerned should make a joint check of the transferred items and the associated documents together at the location in consideration. Configuration of the items and working areas should be agreed by both groups.

4.35 After transfer, further work or corrective actions by the previous group should only be done with appropriate authorization by the new group.

Transfers to commissioning

4.36 The licensee should ensure provisions are made to control and coordinate the handover from construction to commissioning. These provisions should include the following activities:

(a) Documentation relating to the items to be transferred should be reviewed by the construction organization and the receiving party for completeness and accuracy.

(b) Pre-commissioning inspection and pre-commissioning functional tests should

be carried out and the results recorded.

(c) Any remaining non-conformances or incomplete items should be identified and assessed to ensure that there is no safety implication during commissioning activities.

(d) Termination points identifying the boundaries of transferred systems and equipment, or transferred parts of systems and equipment, should be clearly identified in transfer documentation.

(e) An inspection of transferred items and associated records and documents should be conducted.

(f) Transfer of responsibilities should be recorded.

(g) The level of technical detail in transfer documentation should be sufficient to allow the recipient to identify parts and order replacements for maintenance.

(h) All relevant information should be copied to the plant operators and other parties who will be responsible for ageing management at a later time.

CONSTRUCTION RESOURCES

Provision of construction resources

4.37 The licensee and construction organization should ensure that suitably qualified and experienced people are available as required by the construction programme. Processes should be in place to ensure continuous qualification of the workers.

4.38 Resources should be estimated, planned and secured for the construction of items important to safety, particularly for the long lead items.

Training of human resources

4.39 Licensee personnel who will be involved in commissioning, operating and maintaining nuclear installations should be involved during the construction, so that they undergo hands-on training to gain special expertise in operation, maintenance and technical support.

CONTROL AND SUPERVISION OF CONTRACTORS

Evaluation and selection of contractors

4.40 Depending on each regulatory or contractual case, the construction organization is usually responsible for contracting activities for construction. As a minimum, the licensee should be notified of the contractors chosen to supply or manufacture items important to safety, or to provide safety significant service. Depending on the agreement between the licensee and the construction organization, licensee's approval may be needed.

4.41 The graded approach should be applied to the development of criteria for the evaluation and selection of contractors and suppliers providing materials, products and service.

Contractor oversight

4.42 Where contracted services are an integral part of construction, contractor oversight challenges are similar in scale and safety importance as those for operating installations. The use of contracted services tends to be increased by: a lower availability of nuclear expertise; the expansion of the international supply chain; the first-of-a-kind project; and, turn-key projects. These create challenges related to the retention of expertise, the effective management of the interfaces between the licensees and contractors, and the oversight of

contactor manufacturing quality in the context of greater multinational diversity.

4.43 The extent of oversight of the contractor's activities by the licensee and/or the construction organisation should be proportionate and based on the graded approach. The choice will depend on:

- Safety and security significance of the item or service;
- The experience of the licensee and the contractor in relation to the products or services being procured;
- The presence of any first-of-a-kind features;
- Complexity of the work or service;
- Necessary expertise to carry out the work or service;The extent of evidence available that the appropriate quality can be demonstrated;
- Utilization of independent third party inspections;
- Legal and regulatory requirements.

The licensee should be notified of the results of the oversight performed by the construction organization on safety related matters and, if necessary, be able to present the results to the stakeholders.

4.44 Before initiating any activity following the award of subcontract(s), the contractor(s) should demonstrate to the construction organization that the contractor(s) is fully aware of all relevant requirements for the activities. The specific safety requirements should be identified and the requirements should include:

(a) Applicable safety requirements for the item to be manufactured or built;

(b) Interface arrangements;

(c) Methods of communication;

(d) Documents and information to be submitted, including non-conformance reports and evidence that the as-built item meets the safety and quality requirements;

(e) The management system including oversight and supervision.

In addition, if the contractor(s) is working on the site, additional requirements include:

(f) Housekeeping;

(g) Site security;

(h) Site training.

In addition, the arrangements that the contractor(s) will make to satisfy these requirements and demonstrate its appreciation of safety culture should be finalized and agreed before any contractor's activity starts. The licensee should be notified of these arrangements and approve as appropriate (particularly if the construction organization is not the licensee). An initial kick-off meeting with the attendance of all parties, including the licensee, should be utilized to confirm all these issues.

4.45 The construction organization should be informed of all the subcontractors used by the contractor. Any new subcontractors appointed after this agreement should be made known to the construction organization before relevant work begins.

4.46 The construction organization should frequently organize regular meetings with

contractors and subcontractors to review and ensure implementation of the construction organization requirements.

4.47 Contractors should ensure that each contractor organizes daily tool-box meetings where work process, schedule, any deviation, and any other important aspects of work that is relevant to safety and quality should be discussed and confirmed.

CONTROL OF DESIGN INFORMATION

4.48 Reference [5] states:

> "During construction and commissioning, a comparison shall be carried out between the as built plant and its design parameters. A comprehensive process shall be established to address non-conformities in design, manufacturing, construction and operation. Resolutions to correct differences from the initial design and non-conformities shall be documented" (para. 6.15).

Furthermore, Ref. [7] states in paras 7.6 and 7.7 that:

> "The operating organization shall specify a formal procedure for design changes such that those made to the facility during construction are accurately recorded and their impacts are assessed.
>
> "'As built' drawings of the facility shall be provided to the operating organization. Following construction of the facility, the operating organization shall review the as built drawings to confirm that, as far as can be assessed, the design intent has been met and the safety functions specified will be fulfilled. The operating organization shall, as required, seek agreement by the regulatory body to proceed to the commissioning stage."

These requirements are also implicitly applicable to the licensee for the construction of nuclear installations.

4.49 The licensee should control the drawings, design codes and documentation which describe the basis for licensing the construction, commissioning and operation of the nuclear installation in order to maintain design configuration control.

4.50 Arrangements for communication should be established between the design organization(s)[8] and construction organization and between construction organization and its contractor(s) to deal with queries on the design.

4.51 A process should be established to address change proposals from the contractor(s) with regard to the design. If the proposal has an implication for safety, its resolution should involve the design organization(s), licensee and regulatory body as appropriate.

MEASUREMENT, ASSESSMENT AND IMPROVEMENT

Assessment of management system

4.52 Project management processes and their performance should be periodically assessed. Progress assessment should also be done to provide early diagnosis of performance, planning, or resource problems. Early remedies, adjusting human resource, revising the schedule, renegotiation of contracts should be considered to avoid compromising the quality of the product.

4.53 Independent assessment programmes should be established and implemented, and address project management competence.

[8]There may be a design supply chain in parallel to the construction supply.

Non-conformance and corrective actions

4.54 A system which collects all identified non-conformances, records and processes them should be implemented. Everyone engaged in construction should be made aware that they are expected to identify and report non-conformances. This system should define non-conformance and specify the roles and responsibilities of the licensee, construction organization and contractors for reporting and correcting non-conformances. In addition, this system should incorporate the regulatory approval process for handling any non-conformance.

4.55 Non-conformances of safety significance should be treated as events by the licensee, and resolved via a corrective action programme in a graded manner. The process of determining the safety significance and the corrective actions of the non-conformance should include appropriate experts including the design organization(s), if necessary.

4.56 Actions that are determined for corrective actions should be assessed in relation to their safety significance to the construction programme and dealt with at the appropriate management level.

4.57 Records of the corrective actions taken to resolve non-conformances should be maintained. The effectiveness of the process to implement corrective actions and to prevent similar non-conformances should be monitored.

4.58 Due to the challenging nature of construction projects such as tight schedules, new technology or limited availability of resources, corrective actions to non-conformances may require long time and may stay as pending issue even after handovers from one party to another. These pending non-conformances should be tracked to completion. A comprehensive tracking system should be managed to ensure that these non-conformances are resolved as soon as possible and records maintained and that the relevant parties are informed.

Construction experience feedback

4.59 Construction experience and best practices not only from specific nuclear installations but also from nuclear and non-nuclear construction should be collected and lessons learned implemented for the enhancement of quality and safety. Criteria should be established for reporting of construction related experience and measures put in place to ensure the dissemination of this information to the relevant parties. Mechanisms to enable sharing of construction experience in a systematic and timely manner should be put in place.

4.60 The licensee should be pro-active in sharing safety relevant experiences internationally.

5. MANAGEMENT OF CONSTRUCTION PROCESSES

GENERAL CONSIDERATIONS

Planning, scheduling and work sequence

5.1 Construction activities should be planned. The plan should specify, for instance:

- The activities to be performed in manageable units. Complex activities such as verification and validation for digital I&C system or environmental and seismic qualification of items important to safety should be planned carefully;
- The planned sequential order(taking into account pre-requisites) and duration of these activities;
- The resources allocated for each activity.

5.2 The construction schedule should be managed continuously by the construction organization during the construction and communicated by the construction manager to

relevant parties. The construction programme should be fully integrated with a procurement programme highlighting long lead in items. The regulatory bodies involved should be given regular and timely updates of the construction schedule.

5.3 The planning, scheduling and work sequence should include hold and witness points as necessary. Some may be specified by the licensee and regulatory body.

5.4 The construction planning, scheduling and work sequence should include requirements for off-site manufacturing and assembling under an adequate quality assurance programme.

5.5 The examination of specifications, documents and drawings, and plans and schedules should identify which on-site manufacturing, assembling, installation, and inspection and testing activities should be performed.

5.6 The construction organization should confirm the adequacy of construction methods with reference to the principal designer[9] where necessary. There should be regular meetings at which the contractor's methods are discussed with the design team. There is the potential for the contractor's methods to undermine design assumptions. Conversely, early contractor involvement can assist the designer in the appreciation of the contractor's preferred method of construction and thus improve constructability.

5.7 Construction sequencing should ensure prior construction work (such as embedded items in walls or ground) will not be adversely affected by later construction works. Special

[9] Principal designer (or design authority) refers to the organization responsible for establishing the design requirements and ensuring that design output documents accurately reflect the design basis. The principal designer is responsible for design control and ultimate technical adequacy of the design process.

consideration should be given to the form of cast-in items and plant fixings. Post-drilling of concrete for the installation of plant fixings may be unacceptable and undermine safety.

Procurement specifications

5.8 Procurement specifications should be developed with sufficient lead time to ensure that items important to safety will be provided in such a way that they can ensure the achievement of the design specifications and required level of safety. More information regarding the preparation of procurement requirements is provided in Ref. [2].

5.9 The procurement specifications relevant to items important to safety should emphasize the safety requirements including implementation of safety culture and quality management.

5.10 The safety classification of items important to safety should be included in the procurement specifications so that the supplier can determine the necessary codes and standards (including inspection requirements), where these have not been specified by the designer.

5.11 As part of procurement document for items important to safety, there should be the requirement for an end of manufacturing (or assembly if appropriate) report. This should include:

- Compliance certificate;
- Inspection and test results;
- Non-conformance reports;
- Procurement records;
- Storage, installation and test instructions;

- Operation and maintenance manuals;
- Operating conditions and limits;
- Personnel training requirements;
- As-built drawings;
- Bill of materials with a list of the raw materials, sub-components, components, parts and the quantities of each.

5.12 Special attention should be paid to the procurement of commercial grade component or product that is proposed to be a part of any safety function. The suitability of the product or component should be verified as described in Ref. [3] paras 5.35-5.37.

Prerequisites for construction works

5.13 Design documentation should be completed with sufficient time in advance to assure quality of instructions, procedures and drawings and to make appropriate preparation for the work.

5.14 Contractors should obtain the approval of the licensee and/or construction organization before beginning work and ensure they have the relevant information including work schedule, instructions with drawings and compatible consumables.

5.15 The licensee should have in place emergency planning and emergency measures to ensure worker and public safety in the case of an on-site or external event that may occur during construction.

5.16 The documentation to be used for construction activities should be up to date, including latest design information, drawings and work procedures. These documents should also be consistent with licensing basis.

5.17 The construction organization should have in place contingency plans for on-site critical construction activities, including measures to cope with electric power outage, loss of water supply, disruption of concrete batching and any other interruptions which may cause unexpected deterioration in work quality.

Work and environmental conditions

5.18 Construction work and environmental condition should be monitored to protect safety significant mechanical, electrical & control equipment, and structures from internal and external damage or contamination.

5.19 The environmental conditions such as temperature, pressure, humidity, dust, dirt, airborne salt, wind, and electromagnetic conditions during construction work including manufacturing, assembly and transportation should be specified and periodically monitored to confirm that conditions are within allowable limits. Limits need only be developed for conditions applicable to a given work location and given work activities.

Cleanliness and Foreign Material Control

5.20 When procuring items for installation, it should be ensured by the licensee or construction organization that the requirements for cleanliness are included in the procurement documentation so that the items arrive on the site at an acceptable standard of cleanliness.

5.21 The construction organization should put in place measures and controls necessary to protect items important to safety from internal and external contamination by dirt, dust and foreign material. Those measures include:

(a) Methods and techniques for control of the site area, individual structures and systems, the facilities, and the material and equipment being incorporated into

the installation;

(b) Methods for the control of environmental conditions;

(c) The control of access of workers. Where clean zones are used to achieve this control, they should be clearly marked, and procedures or instructions should be issued to regulate their usage and maintenance;

(d) Determination and control of allowable chemicals and consumables;

(e) Contingency plans.

5.22 Specific requirements and cleaning methods should be implemented for systems such as hydraulic, instrument control, and lubrication lines and systems where interior surfaces are generally not accessible for visual inspection.

5.23 Specific procedure should be developed and implemented for cleaning by flushing or rinsing. The procedure should include:

- Checking of actual circulating flow path to satisfy specified requirements with regards to location, position, and status of all components;
- Tagging of critical components to prevent inadvertent actuation;
- Inspection of the interior of all accessible components and piping for cleanness;
- Isolation or protection of any components such as demineralizers, filters, instruments and any other components which may be damaged by cleaning; and
- Sealing of the openings of the cleaned system(s).

Receipt, handling, transport, storage, preservation and maintenance

Control of items and consumables

5.24 Items and consumables should be controlled through packaging, shipping, handling, receipt and storage at any location, including off-site manufacturing facilities, to prevent their abuse, misuse, damage, deterioration or loss of identification. Items and consumables that could represent a security threat if misused should be controlled according to the level of possible risk.

Handling

5.25 The use of items such as special cartons, containers, protective devices, cranes, hoists, manipulators and transport vehicles should be considered where handling operations are of a nature likely to cause damage to the items important to safety. Operators and handlers of all such items should be competent. Equipment for handling items should be used and maintained in accordance with national regulations and standards. Handling devices should be included in the scope of the supervision performed by the construction organization to ensure safety and security of the handled items.

Transportation

5.26 All transportation routes both off- and on-sites should be planned with appropriate protection measures for items important to safety. For transportation of large or heavy components, all roadways and bridges on the routes are appropriately assessed to ensure that transport is possible without causing hazards or damage to the items and anything on the routes.

Storage

5.27 Storage should be provided as specified by the designers and manufacturers to protect items important to safety prior to their installation and use. This may require segregation of some items.

5.28 Storage areas should be established with account taken of aspects such as:

(a) Cleanliness and housekeeping practices;

(b) Requirements for fire protection;

(c) Protective requirements relating to coatings, preservatives, covers and sleeves;

(d) Prevention of physical damage;

(e) Environmental control (such as control of temperature and humidity);

(f) Preventive maintenance;

(g) Security;

(h) Physical and chemical characteristics of items;

(i) Radiation protection from any sources and their appropriate markings.

5.29 Inspections should be performed by the construction organization as necessary to ensure that the specified conditions are maintained and that any non-conformances are dealt with. These inspections may need to be continued in the commissioning and operation stages in which case handover arrangements should be established.

5.30 Items important to safety and their components should be clearly identifiable by using appropriate marks. Marking materials should be compatible with material preservation.

On-site physical protections against unauthorized removal in use and storage of items important to safety should be implemented.

Preservation of products

5.31 Before installation of any items important to safety, they should be inspected against the requirements and if necessary remedial action taken.

5.32 Acceptable limits on the environmental and operational conditions to which equipment may be exposed after installation should be specified by designers and manufacturers. The construction organization should monitor and control the environmental conditions of items important to safety after installation to protect them against other work that is being carried out.

5.33 When a temporary structure or support is used, attention should be paid to ensure the required quality of the items important to safety affected by it.

5.34 During the on-site or off-site pre-commissioning tests, the relevant items important to safety should be isolated or protected to avoid inadvertent actions.

Maintenance

5.35 During the entire construction phase, the licensee should ensure that the items important to safety are kept under an appropriate preventive or corrective maintenance plan to maintain their functionality as required by the design. This should be continued until operational maintenance programmes are initiated.

Verification and test of construction activities

5.36 The licensee and construction organization should develop a process to verify the completion of construction activities. This verification should be formally documented to

confirm the items important to safety have been constructed to the specified requirements and comply with the acceptance criteria. A typical verification record should include:

(a) Identification of the structure, system or component;

(b) Description of the checks carried out and how the results were verified;

(c) The date and time of the check;

(d) Any special tools or calibrated equipment used;

(e) Test results and comparison with acceptance criteria;

(f) A list of deficiencies and outstanding items or work and their resolution results;

(g) Confirmation that specified documentation and records are available and complete;

(h) Confirmation by relevant parties that the check has been carried out.

5.37 Whenever relevant, test and verification should be performed by a qualified third party.

5.38 The test plan, acceptance criteria and results should be documented such that they can be independently assessed. The adequacy of tests (contents, results and timing) should be justified and the test coverage analysed against the specified requirements.

5.39 Any use of radioactive sealed sources and devices during such activities as radiographic examinations, gauging (density, thickness, moisture, etc.) or material analysis should consider protection of workers and sensitive items in the area as required by the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (the Basic Safety Standards or BSS) [21].

MANUFACTURING AND ASSEMBLING

5.40 The quality assurance programme for manufacturing and assembling activities should provide for the review of procurement documents for the item to be manufactured or assembled to determine what regulations, codes, standards and other requirements are applicable during manufacture and assembly. Regulatory, design and other requirements set forth in these documents should be included, as appropriate, in manufacturing drawings, specifications, inspection and test plans, procedures and work instructions.

5.41 During the planning phase for manufacture and assembling, consideration should be given to such factors as:

(a) Understanding the manufacturing implications of the design;

(b) The procurement of critical path and long term delivery items;

(c) The amount of manufacturing such as forming, heat treating, partial machining or fabricating of subassemblies, to be carried out;

(d) Clean conditions and other environmental controls to meet requirements and to achieve required quality. These controls may include dust-free or inert atmospheres, humidity controls, temperature controls, and control of the chemical composition of water;

(e) The assembly of the equipment;

(f) Handling, storing, packaging and delivery requirements;

(g) The application of new techniques in manufacturing, assembling, inspection and testing;

(h) The need for inspections and tests specified by the designers and regulatory bodies, and those deemed necessary by the manufacturer to control quality and to ensure the process has been followed;

(i) The need to develop, qualify and control any new manufacturing or assembling processes;

(j) Processes which are complex or sensitive, or which require extensive set-up, special equipment or special training;

(k) Compatibility of cleaning methods and material with the items being cleaned.

5.42 The licensee should ensure that manufacturer's quality assurance programme includes the identification and control of processes which are required to be carried out by qualified personnel or which require continuous monitoring and control of process parameters. These processes are those where the results cannot be fully verified by subsequent inspection and testing of the item and where, for example, processing non-conformances may become apparent only after the item is in use or operation.

5.43 Where special equipment such as tooling, jigs, fixtures, unique inspection gauges, computers and computer software are required to aid the manufacturing or assembling process, these should be properly qualified or validated for use as required, and their application known to those carrying out the activity.

5.44 The licensee and construction organization should establish and implement requirements and procedures for the verification of quality of manufacturing and/or assembly (including materials and procedures) of items important to safety as mentioned in paras 5.32-5.35.

5.45 Technological expertise of the manufacturer and assembler should be verified by the licensee, not only through final acceptance tests but also by checking that proven state-of-the-art technology is used. Augmented monitoring and inspections, if needed, should verify that new manufacturing techniques and new types of equipment meet relevant design requirements.

5.46 All items important to safety should be inspected and tested by the manufacturers

against safety and design requirements and also applicable codes and standards. The level of traceability for individual component or batch identification should be highlighted in the inspection and test plan for items important to safety.

5.47 If appropriate, before transporting to the site, pre-assembly and match-marking of the components should be done to ensure proper re-assembly at the site.

5.48 The procurement of item may start long before the construction licence is issued. Regardless of the time of procurement, the licensee should ensure procured items important to safety achieve the design specification and required level of safety.

ON-SITE CONSTRUCTION PROCESSES

Receipt

5.49 If appropriate, items that arrive at the construction site should be visually inspected before unloading to verify that there is no damage and rejected if necessary.

5.50 After items have been received, an inspection should be carried out by the construction organization to ensure that the relevant specifications are fulfilled, prior to acceptance and use in construction, such as that:

(a) The item is configured correctly;

(b) Identification and marking are adequate;

(c) Manufacturing and assembly documentation is available as required;

(d) The inspection record and/or certificate should be traceable to the inspected item for acceptance confirmation;

(e) Protective covers and seals are intact;

(f) Coatings and preservatives have not been damaged;

(g) No physical damage has been sustained;

(h) Cleanliness meets applicable codes and standards and design requirements;

(i) Inert gas blankets and the condition of desiccants, where relevant, have not been compromised;

(j) Non-conformances identified by receipt inspections are recorded;

(k) Necessary tests of hardware characteristics have been performed;

(l) Storage should be controlled to prevent inadvertent installation or use.

Effect on and from existing facilities

5.51 A construction site may already have operating facilities on-site, with the possibility of interdependent safety or support systems. Other critical facilities may also be present such as those for spent fuel storage in fuel pools or dry cask storage. Research reactor sites may already have associated laboratories, isotope production facilities and hot cells. Assessment of safety and security during construction should be performed and take into account all hazards from, or to, nearby site facilities and any interdependence of their safety systems. For instance, the consequences of potential contamination from a construction site to operating units should be assessed and its contamination should be monitored, if necessary. All other potential risks should also be assessed (digging, excavation, spurious fall of cranes, collapsing of items, use of explosives, etc.). Such consideration should also include consequence assessment of environmental discharges that are cumulative for all facilities on a site.

5.52 The responsibilities of the construction organization and of the existing operation organization should be defined before the start of construction activities at the site. Close communication between the construction organization and the existing operation organization should be established. The licensee should ensure that the ability of the existing operating organization to maintain safe operation of the existing facility will not be affected by construction activities.

5.53 For installations adjacent to each other or those that share common buildings or services, the following boundaries should be put in place: radiological protection, physical, system, security, access boundaries and cleanliness. In utilizing resources of existing nuclear installations such as water, electric power, fire protection, emergency medical services and security, clear interfaces should be defined and understood by the construction organization so as not to jeopardize operating installations. Emergency plans should take full account of the presence of other parties in the area.

On-site manufacturing and assembling

5.54 The construction organization should ensure that on-site manufacture and assembly of items important to safety are capable of producing an acceptable product which meets safety and design requirements and also applicable codes and standards.

5.55 On-site manufacturing and assembling should be located such that these activities will not affect adjacent items important to safety or activities that may affect items important to safety.

5.56 Temporary devices used during the manufacturing, installation, inspection, testing should be controlled and documented.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Nuclear Installations, IAEA Safety Standards Series No. GS-G-3.5, IAEA, Vienna (2009).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR 2/1, IAEA, Vienna (in preparation). [DS414; submitted for approval by Commission on Safety Standards meeting May 2011]

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Commissioning and Operation, IAEA Safety Standards Series No. SSR-2/2, IAEA, Vienna (2011).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Research Reactors, IAEA Safety Standards Series No. NS-R-4, IAEA, Vienna (2005).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. NS-R-5, IAEA, Vienna (2008).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GS-R Part 1, IAEA, Vienna (2010).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Modifications to Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.3, IAEA, Vienna (2001).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Glossary, Terminology Use in Nuclear Safety and Radiation Protection, 2007 Edition, IAEA, Vienna (2007).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Commissioning for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.9, IAEA, Vienna (2003).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Licensing Process for Nuclear Installations, IAEA Safety Standards Series No. SSG-12, IAEA, Vienna (2011).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Format and Content of the Safety Analysis Report for Nuclear Power Plants, IAEA Safety Standards Series No. GS-G-4.1, IAEA, Vienna (2004).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, External Human Induced Events in Site Evaluation for Nuclear Power Plants, Safety Standards Series No. NS-G-3.1, IAEA, Vienna (2002).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Management of Delayed Nuclear Power Plant Projects, IAEA TECDOC-1110, IAEA, Vienna (1999).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Restarting Delayed Nuclear Power Plant Projects, IAEA Nuclear Energy Series No. NP-T-3.4, IAEA, Vienna (2008).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Organization and Staffing of the Regulatory Body for Nuclear Facilities, Safety Standards Series No. GS-G-1.1, IAEA, Vienna (2002).

[18] INTERNATIONALATOMIC ENERGYAGENCY, Review and Assessment of Nuclear Facilities by the Regulatory Body, Safety Standards Series No. GS-G-1.2, IAEA, Vienna(2002).

[19] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulatory Inspection of Nuclear Facilities and Enforcement by the Regulatory Body, Safety Standards Series No. GS-G-1.3, IAEA, Vienna (2002).

[20] INTERNATIONAL ATOMIC ENERGY AGENCY, Documentation for Use in Regulating Nuclear Facilities, Safety Standards Series No. GS-G-1.4, IAEA, Vienna (2002).

[21] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANISATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).

CONTRIBUTORS TO DRAFTING AND REVIEW

Artayet, A	U.S. Nuclear Regulatory Commission, United States of America
Chen, L. H.	China Nuclear Power Engineering Co., Ltd., China
Frye, T.	U.S. Nuclear Regulatory Commission, United States of America
Fujii, S	Mitsubishi Heavy Industries, Ltd., Japan
Ghosh, S. K.	Atomic Energy Regulatory Board, India
Gibson, S.	Health and Safety Executive, United Kingdom
Inoue, Y.	International Atomic Energy Agency
Iwasawa, K.	Toshiba Corporation, Japan
Johnson, G.	International Atomic Energy Agency
Lu, Q.	China Nuclear Power Engineering Co., Ltd., China
Maciejewski, J.	Institute of Nuclear Power Operations, United States of America
Maeng, S.	Korea Hydro & Nuclear Power Co., Korea
Nevalainen, J.	Finnish Radiation and Nuclear Safety Authority (STUK), Finland
Prinja, N. K.	AMEC, United Kingdom
Riou, P.	Areva NP, France
Segaud, M.	Autorité de Sûreté Nucléaire (ASN), France
Vaughan, G.	Health and Safety Executive, United Kingdom

Virolainen, T. Finnish Radiation and Nuclear Safety Authority (STUK), Finland