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Construction for Nuclear Installations

DRAFT SPECIFIC SAFETY GUIDE XXX

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New Safety Guide

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CONTENTS

1. INTRODUCTION

BACKGROUND

1.1 The fundamental goal of construction is to correctly build an approved design. This Safety Guide provides an appropriate management process which focuses on the implementation of various aspects of construction activities. It provides specific guidance and recommendations to supplement and develop those contained in: 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]. 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 the construction of new nuclear installations and major design modifications[1]/refurbishments of existing nuclear installations. Nuclear installations vary greatly in type, size, potential radiation risks, utilization and other characteristics so that judgement has to be made on the degree of applicability to specific installations and sites.

[1] NS-G-2.3 " Modifications to Nuclear Power Plants" [4] provides guidance on controlling activities related to modifications at nuclear power plants and it deals with the intended modification of items, operational limits and conditions, procedures and software, and management systems and tools for the operation of nuclear power plants

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” [5], “Safety of Nuclear Power Plants: Commissioning and Operation” [6], “Safety of Research Reactors” [7], “Safety of Nuclear Fuel Cycle Facilities” [8] and “Predisposal Management of Radioactive Waste” [9]. For example, The Safety of Nuclear Power Plants: Design [5], Requirement 11, Provision for construction says “Items important to safety for a nuclear power plant shall be designed so that they can be manufactured, constructed, assembled, installed and erected in accordance with established practices that ensure the achievement of the design specifications and the required level of safety. This Safety Guide sets out how the objective of “achievement of the design specification and required level of safety” is ensured in practice.

1.3 In addition, the regulatory authorization described in “Governmental, Legal and Regulatory Framework for Safety” [10] 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 may have a potential impact on safety, even though there may be 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 the construction of nuclear installations, as currently

followed in Member States, which will enable construction to proceed with high quality, consistent with the design requirements as agreed by the regulatory body in issuing the authorization for construction.

SCOPE

1.5 This Safety Guide is applicable to the construction stage of a new nuclear installation and the major modification/refurbishments of an existing nuclear installation, including the process of manufacturing and assembling the components, carrying out of architectural and civil work, installation and maintenance of structures, systems and components, and performing the associated tests to demonstrate their acceptability. Neither the design nor commissioning stage is included in this Safety Guide, although 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 and assessment of construction methods and procedures and the identification of good practices for ensuring the quality of the construction to meet the design and safety intent;
- To assist the regulatory body in oversight and evaluation of the construction activities performed;

- To assist the licensee in providing specifications to a contractor, via contractual documentation;

- To assist the licensee in understanding the managerial aspects that should be considered when assessing contractors' qualifications and performance;

- To assist the licensee in its oversight of the whole supply chain in compliance with the licensee's quality and safety requirements.

- To assist stakeholders in understanding the roles and responsibilities of different types of contractors.

The contractors referred to above may be a construction organization, technical support organizations and/or consultants responsible for independent review and assessment and organizations responsible for third party inspections.

1.8 In this Safety Guide, it is considered that all relevant safety requirements must be complied with in accordance with all 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 provide guidance on security issues and should be taken into consideration during life cycle of the facility including site selection, design and construction.

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 systems 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 the process of manufacturing and assembling the components of a facility, the carrying out of civil and architectural works, the installation of structures, systems and components and the performance of associated tests [11]. The associated tests are those carried out to ensure that the structures, systems and components have been constructed, manufactured, and installed according to design specification. Guidance on these tests can be found in Annex of Ref. [12]. Due to differences in the construction schedule for each item, the commissioning and construction stages for the installation may occur concurrently. Hence it is difficult to define a precise ‘end of construction’ but the licensee must ensure that items have been installed, inspected and tested and obtain an authorization from the regulatory body before carrying out significant steps in the commissioning process. [13]

Construction organization

2.2 The ‘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. The construction organization may be part

of the licensee, or a contracted organization (Fig.1). If the licensee appoints 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. The licensee should retain prime responsibility for safety and the use of contractors does not allow this responsibility to be delegated [14]. The licensee, in order to meet this responsibility, should have an oversight process that covers the contractor's and subcontractor's management of activities and the activities themselves.

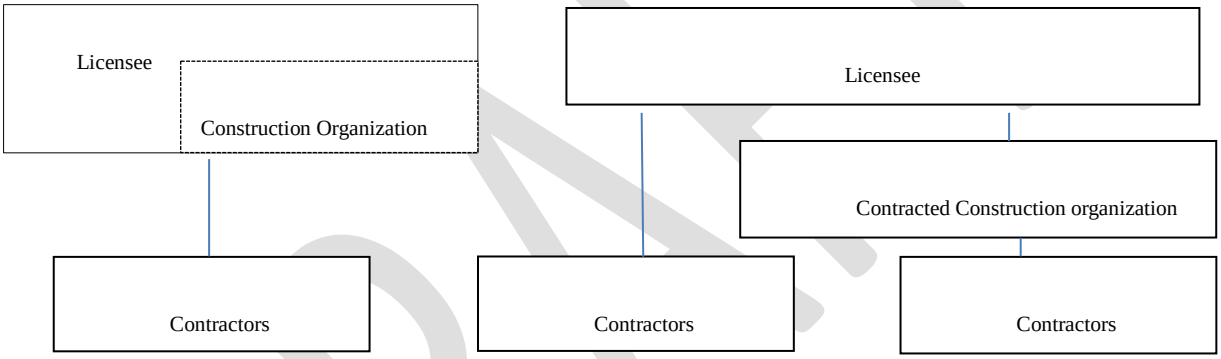

Figure 1

Contractor

2.3 The contractor is defined as any individual or organization who provides items or renders services in accordance with a contract or a procurement document. The term 'contractors' includes designers, architect engineers, manufacturers, producers, assemblers, installers, distributors, importers, suppliers, technical support organizations and any other consultants and their subcontractors or subsidiaries.

Design organization

2.4 The design organization is the organization responsible for preparation of the detailed design of the installation to be built.

PREREQUISITES FOR THE CONSTRUCTION OF NUCLEAR INSTALLATIONs

2.5 To achieve the highest level of safety in the construction of nuclear installations needs:

- a sound legal basis;
- an appropriate governmental infrastructure, including a regulatory body with well defined responsibilities, authority and functions;
- an established framework including necessary regulations and guides to ensure competent regulation during construction;
- a well resourced and technically competent licensee;
- well established safety culture in all involved parties;
- suitably qualified and experienced contractors ;
- and a technical support infrastructure for the regulatory body and licensee as required.

2.6 The relevant authorizations should be obtained before construction starts. If this is not done, the licensee bears the risk that structures, systems and components may fail to meet the necessary regulatory requirements. However, manufacturing of some long lead items may begin before construction authorization is given by the regulatory body. Such activity should be brought to the notice of the regulatory body. The licensee should verify that the design is of

the appropriate standard and sufficiently complete before construction starts. Any major safety issues should be resolved prior to construction when there is greater flexibility for design changes.

2.7 All applicable licences, permits and approvals required to initiate construction activities should be in place. Recommendations and guidance for the construction license processes and documentation required are provided in Ref. [13].

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

2.9 All efforts should be taken to ensure that an adequate level of safety culture is achieved by all parties. This includes licensee, regulatory body, contractors, and other stake holders.

2.10 A design schedule, including acceptance criteria and engineering work commensurate with the authorization process should be verified by the licensee prior to start construction so that late procurement does not adversely affect the construction process. Before construction starts, a readiness review should be carried out by the licensee or its construction organization to ensure adequate completion of design and the availability of engineering documents and to identify any areas where design is incomplete. Any major safety issues should be resolved prior to construction when there is greater flexibility for design changes [13]. The design organization should develop a forward action plan covering any remaining design and engineering work and the necessary resource requirements should

be agreed and monitored by the licensee as construction proceeds. Changes to the forward action plan should only be agreed if safety is not compromised by time and cost pressures resulting from late completion of design work. Design changes that may have an impact on safety should be minimized after construction starts and should be recorded in a well-defined process so that demonstration of safety of the as-built design is achievable.

2.11 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-a-kind technology[2]. Potential non-conformances and deviations should be minimized by early planning with adequate resources for qualification activities such as R&D activities or mock-up/full size verification tests. The requirements for design and construction should take into consideration decommissioning aspects as in Requirement 12 of reference 5.

2.12 The licensee should have in place emergency planning and emergency measures to ensure worker and public safety in the case of accident occurring at or affecting the construction site.

2.13 Security requirements should be identified by the licensee and taken into account in addition to safety considerations. Conflicting requirements identified by the licensee should be resolved in agreement with the authorities responsible for safety and security. Particular attention should be paid to security arrangements on sites with existing nuclear sites. Site

[2] Increased quality non-conformances and rework are expected when new methodologies are applied for the first time.

security procedures should describe the actions to be taken during the construction phase. The procedures should consider, detect and deter conditions that would otherwise impair site security. Security measures employed by the licensee should include: control of personnel, materials, and vehicles; random patrols/inspections; and screening (pre- employment screening and gate clearance) for access to secure and safety controlled areas. As a minimum, security measures within and around the site should include physical barriers, fencing, surveillance and monitoring capability, uniformed security personnel, communication capability, and personnel access control. Design documentation provided to contractors should be controlled to protect intellectual property rights and national security.

2.14 For sites with existing nuclear installations, 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. Each site should be analysed for site specific and construction methods related risks. Possible risks are caused by, but not limited to, dredging, quarrying, excavation, blasting, piling, dust, transportation and lifting and creation of connections between the existing facilities and the construction site. Preventive measures should be taken by the affected licensee(s) to manage the construction related risk. Further guidance on interaction with existing facilities is provided in paras. 5.58 – 5.50.

2.15 Construction processes and methods should consider internal and external hazards. Installations which handle, process or store potentially hazardous materials such as explosive,

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

flammable, corrosive, toxic or radioactive materials should be identified during the risk and threat assessment. The maximum amount of hazardous material present at any given time and the process in which it is used should be taken into consideration. The cumulative effects of such materials should also be considered. 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, see References 15 and 16 for more details. To ensure adequate mitigation of potential environmental effects and waste generation related to construction activities at the site, environmental monitoring and protective measures and waste minimization processes should be in place.

2.16 Necessary fire protection measures at the construction site should be available until the 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 For sites with existing nuclear installations, emergency preparedness should take into account the followings:

- The average and peak employment at the site throughout the construction or modification project;
- Training of construction site personnel;
- Appropriate provision of additional alarms to alert all personnel at the site taking

account of specific construction activities; and,

- The risks associated with the various phases of construction.

2.18 In addition, the following issues should be considered by the licensee and approved by the regulatory body, as appropriate, before on-site construction begins to ensure quality of the construction:

Infrastructure

- Location and transportation routes especially for large component transportation;

- All arrangements necessary to accommodate nuclear installation work force for the site;

- All infrastructure support systems should be in place including required electricity, gas and water supply;

Site capabilities

- Marking of site boundary within which the authorized facility will be constructed and operated;

- Procedures for protection or coverage after work completion and environmental qualification;

- Special construction processes and equipment where there is a specific nuclear safety issue; In other cases, normal construction processes and equipment can be used during the construction;

Management system and workers' safety

- Management system provisions related to on site construction activities;

- Work hazard analysis report;

- Construction safety management manual including radiation source handling;

- Plan for radiation safety of workers if relevant (for construction with existing installations); - Design reports of items important to safety identified in the construction authorization.

2.19 In cases where construction is being resumed on a suspended project special consideration should be given to factors that may affect continued construction. More detailed guidance can be found in Ref. [17] and [18].

2.20 Site preparation activities, such as ground investigation, may be carried out before a licence has been granted (see paragraph 3.11 of [13]). Arrangements should be put in place to ensure that, if the results of these activities are incorporated into the permanent works or can have an influence on them, they are planned, executed, monitored and documented to standards equivalent to activities carried out under the licence.

INTERACTIONS WITH STAKEHOLDERS

2.21 It is recognized as good practice that the interaction with stakeholders of all sorts is continued from the siting phase throughout the construction phase by both the regulatory body and licensee [19].

3. REGULATORY OVERSIGHT OF CONSTRUCTION ACTIVITIES

3.1 Four interrelated IAEA Safety Guides provide recommendations on satisfying the requirements in Ref. [9] 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 [20], regulatory review and assessment [21], regulatory inspection and enforcement [22], and documentation relating to the regulatory process [23]. In addition, the Safety Guide on Licensing Process for Nuclear Installations [13] provides details of the necessary documentation that is required for obtaining authorization for construction from the regulatory body. With respect to the involvement of external technical support during construction, the Safety Guide "External Expert Support for the Regulatory Body" [24] provides guidance. The recommendations in the current guide refer specifically to construction and are supplementary to, and should be read in conjunction with, the recommendations provided in documents quoted above.

3.2 Regulatory oversight should satisfy the 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 of its prime responsibility for ensuring safety.

3.3 The regulatory oversight during construction should focus on the management system of the licensee and its management of contractors/subcontractors as well as monitoring and direct observation 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.

3.4 Well in advance of the beginning of 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 program consistent with the construction program provided by the licensee as part of its application for construction authorization.

3.7 To properly implement an oversight program during construction, the communication between the licensee and the regulatory body and any other authorized bodies, as appropriate, should be formally defined and agreed 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 Prior to authorizing construction, the regulatory body should review and assess the arrangements, procedures and quality assurance programs for implementing or modifying the design.

3.9 During construction the regulatory body should review, assess and inspect as appropriate;

- proposed design changes, non-conformances or safety significant events as reported through the licensee's management system;

- on a systematic basis, the development of the design of the installation as demonstrated in the reports and safety documentation submitted by the applicant or licensee in accordance with an agreed program;

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

- the availability of the documents related to the detailed design to ensure that they are adequate and produced in a timely manner so that they can be properly incorporated into the facility construction program.

3.10 To gain assurance that the licensee has met the regulatory requirements and can move forward in the construction program, the regulatory body may 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 of safety significance are made;

- check construction organization preparedness for next stage.

If there are non-conformances, an action plan to correct deficiencies may be required by the regulatory body to allow progress beyond witness or hold points. The provision of timely information by the licensee to the regulatory body of all non-conformances is the key to the timely addressing of these issues.

3.11 The regulatory body should have in place provisions to receive and address any matters raised by other parties concerning the safety of construction.

3.12 The regulatory body should require appropriate corrective actions to be carried out by the licensee to correct and prevent the recurrence of safety significant events.

3.13 The regulatory body should make arrangements for analysis to be carried out to identify lessons to be learned from regulatory experience during construction and from the licensee's experiences during construction. Arrangements should be made for the dissemination of the lessons learned within the regulatory body and to authorized parties and other relevant stakeholders.

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 the future safety of nuclear installations, an integrated 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 A strong safety culture is important in all phases of the life cycle of a nuclear installation. In the construction stage, it implies characteristics and attitudes pursuing high quality construction to ensure safety in the future commissioning, operational and decommissioning phases. This involves an understanding that deviations from procedures and specifications, or lack of understanding of 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, managing the employment of temporary workers with various levels of skills, from various cultures and languages on some occasions, and of numerous contractors, and undertaking work influenced by weather conditions and external environments. In addition, construction activity necessarily involves managing change and people on a constant basis. These factors are known to be some of the prime challenges to safety culture. Conflicts between schedule, cost and safety goals should not adversely affect conservative decision-making and the maintenance of an open and questioning attitude.

4.4 Safety culture should be developed in all participating organizations and individuals taking into account their roles in term of safety significance. Construction programs and methodologies should be developed and implemented to help all interested parties involved in the construction project to strengthen the 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 Safety culture and its promotion should be considered as part of contractor evaluation. Evaluation should cover not only contractors' organizations but also their staff. The licensee should have adequate systems and procedures to monitor safety culture in contractors' organization and their staff throughout the construction process.

4.6 The licensee should ensure all contractors and subcontractors are fully aware of the safety significance of work that they have been contracted to do. 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 The licensee should have a process for workers to report non-conformances and safety concerns to the contractor management, construction organization, or itself. A good safety culture would encourage open reporting but some Member States have determined that it is good practice to include the capability of anonymous reporting. The workers should also be aware of the process for reporting safety concerns directly to the regulatory body.

APPLICATION OF A GRADED APPROACH

4.8 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 management system requirements, for example quality assurance.

4.9 In developing the graded 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 need for and extent of inspection and test plans and the necessary level of detail;

(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) The level of complexity;

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

(g) The risks associated with construction activities.

LICENSEE RESPONSIBILITIES

4.10 Reference [6] Safety of Nuclear Power Plants: Commissioning and Operation 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.

4.11 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.

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

4.13 During construction, the licensee should take the responsibility 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 for plant safety (Refs. [1][2][3]). The licensee should establish a construction supervision plan for the items important to safety which includes independent audits, product quality surveillance, witness and hold points, and 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(s);

[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,

[5] An 'intelligent customer' capability is the capability of the organization to have a clear understanding and knowledge of the product or service being supplied. The 'intelligent consumer' concept mainly relates to capability required of organization when using contractors or expert support.[24]

- Internal and external audits [2, 3] of 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 a technical and a management system perspective;

- Having a construction program 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. The regulatory body verifies the inspections, tests and verifications but this does not alleviate the licensee from the responsibility of performing them;

- Process for dealing with design changes, non-compliances and events;

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

- Ensuring that appropriate records relevant to safety are established and preserved, in particular appropriate records relevant to plant life and ageing management are preserved ;

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

- Transfer of documentation when moving from construction to commissioning.

Construction Manager

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

4.15 The construction manager should have access to the necessary resources to establish a construction organization which may include contracted staff or even comprise a fully contracted organization (see Fig. 1). If the construction organization is a fully contracted organization, the roles and responsibilities should be defined and documented and agreed by the licensee's construction manager. The management structure of the construction organization should define the level of responsibility for groups within it, including the responsibilities of all of its contractors.

CONSTRUCTION ORGANIZATION ACTIVITIES

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

(a) Controlling and monitoring contractors involved in safety significant issues both on-site and off-site, including manufacturing and assembling;

(b) Ensuring that the construction organization and contractors are established on 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, developing and maintaining guides about the use of standardized instructions and procedures and good

practices;

(d) Preparing safety related working procedures, including industrial, environmental and safety procedures, for 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 regard to quality and safety;

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

(g) Ensuring that work that it carries out and that carried out by its contractors is 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) Ensuring preservation of installed equipment, by 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 intrusion of foreign materials and contaminants;

(i) Carrying out the inspection for structures, systems and components to obtain relevant baseline data for comparative purposes during in-service inspection;

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

(k) Acquiring, installing or maintaining material samples for a long term monitoring and analysis program of ageing material;

(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

4.17 The following safety recommendations are provided in addition to those provided in paragraphs 5.43-5.60 of The Management System for Nuclear Installations [3] and Ref. [25]

Construction management

4.18 Construction management is a leadership function primarily concerned with the organization of processes, co-ordination of activities, and control of resources (human, informational and material) on a large scale and under many external constraints in order to correctly build an approved design.

4.19 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 or pumping and any other interruptions which may cause unexpected deterioration in work quality.

4.20 Construction management processes as well as construction work processes should be defined and documented. They should take due account of safety, security and environmental impact.

4.21 The licensee, construction organization and other contractors should have adequate organization, resources, experience, competence and procedures to manage the construction of a nuclear installation and maintain documentation to demonstrate them. Experience has shown that construction projects 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, etc.). These types of differences should be taken into account in developing the project management system and selecting project managers.

Requirements management[6]

4.22 A system should be established to ensure that applicable inputs such as legal,

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

regulatory and licensee requirements for ensuring safety and quality are correctly translated into specifications, drawings, procedures and instructions. The coherent application of the technical design requirements in separate project disciplines should be reviewed by competent personnel before start of construction. The requirements and changes thereto should be controlled, so that safety related activities and items important to safety are consistent with the applicable requirements.

4.23 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.

4.24 The regulatory body and the licensee in the country where the components will be used may 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 and accepted by all those within the supply chain. Any conflict or difference of opinion should be resolved during planning stage. Additional care should be taken where components for subcontracted equipment is further subcontracted down the supply chain to ensure competence and compliance with the original requirements.

4.25 The licensee 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. Excessive reliance should not be placed on just quoting codes and standards. Additional supervision

should be provided where the supply of components for subcontracted equipment is further subcontracted down the supply chain to ensure competence and compliance with the original requirements.

CONTROL OF DESIGN INFORMATION

4.26 Reference [5] Safety of Nuclear Power plants: Design states: The operating organization[7]shall establish a formal system for ensuring the continuing safety of plant design throughout the life time of nuclear power plant (requirement 3).The formal system for ensuring the continuing safety of the plant design shall include a formally designated entity responsible for the safety of plant design within the operating organization's management system…(paragraph 3.5)

Reference [6] 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" (paragraph 6.15).

Furthermore, Ref. [8] states in paragraphs 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

[7] The "operating organization" is frequently referred to as the "licensee" e.g. see Ref. [14]

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."

4.27 Arrangements for communication should be established between the design organization(s)[8] and construction organization, between the construction organization and its contractor(s) and the licensee where appropriate to deal with queries concerning the design.

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

4.29 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, security or decommissioning, its resolution should involve the design organization(s), licensee and regulatory body as appropriate.

4.30 Comprehensive photographic and, where appropriate, video records and computer simulations should be compiled, particularly in areas that will later be inaccessible or will be

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

subject to intense radiation. This information will facilitate the planning of work in these areas during commissioning, operation and decommissioning. 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.

Traceability

4.31 Traceability of items important to safety from initial design through construction and then to commissioning and future life time phases is necessary for 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);

(f) Design calculations;

(g) Design change and non-conformances documentation.

(h) Equipment qualification details

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

4.32 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.

INTERFACE MANAGEMENT

4.33 Interface arrangements should be identified and agreed between the licensee, construction organization (if not within the licensee), the 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.

4.34 The construction organization should establish and implement a suitable communications plan to link on-site and off-site construction activities in an adequate and timely manner. This should also include the design organization and licensee as appropriate.

4.35 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, etc.

TRANSFER OF RESPONSIBILITY

Transfers during construction

4.36 Appropriate rules and procedures should be established and documented by the

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

4.37 When items important to safety and working areas are to be transferred between groups within the construction organization or contractors, both concerned parties 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 to by both parties along with any identified deficiencies.

4.38 After transfer, any remaining work or corrective actions by the previous party should only be done with appropriate authorization by the new party.

Transfers to commissioning

4.39 The licensee should ensure provisions are established and implemented 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) Tests to ensure that the structures, systems and components have been constructed, manufactured, and installed according to design specification

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) Any outstanding work should be agreed, planned and scheduled.

(e) Termination points identifying the boundaries of transferred systems and equipment, or transferred parts of systems and equipment, should be clearly identified in transfer documentation with associated required configuration (open/close).

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

(g) Transfer of responsibilities should be recorded.

(h) Approved as-built plans should be established and transferred together with adequate and precise plant configuration details.

(i) All structures, system and components transferred should be marked/tagged in accordance with the documentation.

(j) All temporary devices should be identified.

4.40 To enable adequate maintenance and aging management once the installation is in operation:

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

(b) All other relevant information should be copied to the licensee.

CONSTRUCTION RESOURCES

Provision of construction resources

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

4.42 Resources should be estimated, planned and secured for the construction of items important to safety consistent with the project schedule, particularly for the long lead items.

Training of licensee's staff

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

CONTROL AND SUPERVISION OF CONTRACTORS

Evaluation and selection of contractors

4.44 The licensee should be notified of the proposed contractors for supply or manufacture of items important to safety, or to provide safety significant services. Depending on the agreement between the licensee and the construction organization, the licensee's

approval may be needed.

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

Contractor oversight

4.46 Where contracted services are an integral part of construction, there are specific challenges (see para. 4.3) to contractor oversight to ensure safety during all life cycle phases. The use of contracted services tends to be increased by: an insufficient availability of nuclear expertise within the licensee; the expansion of the international supply chain; a first-of-a-kind project; and, in turn-key projects. These create challenges related to: the retention of expertise; the effective management of the interfaces between the licensees; the construction organization and its contractors; and the oversight of contractor manufacturing quality in the context of greater multinational diversity and international supply chains.

4.47 The extent of oversight of the contractor's activities by the licensee and/or the construction organization 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 other stakeholders.

4.48 Before initiating any activity following the award of subcontract(s), the contractor(s) should demonstrate to the construction organization, and to the licensee if required by the licensee, 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’ items meets the safety and quality requirements;

(e) The management system including adequate safety culture and oversight and

supervision arrangement.

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

(f) Housekeeping;

(g) Site security;

(h) Site training.

The arrangements that the contractor(s) will make to satisfy these requirements 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 and regulatory body, should be utilized to confirm all these issues.

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

4.50 The construction organization should organize regular meetings with contractors and subcontractors to review and ensure implementation of the construction organization requirements.

4.51 Each contractor should implement regular tool-box meetings to discuss work process, schedule, deviations, and any other important aspects of work relevant to safety and quality.

MEASUREMENT, ASSESSMENT AND IMPROVEMENT

Assessment of management system

4.52 Project management processes and their performance should be periodically assessed by the licensee or, where appropriate, by the construction organization. An assessment of progress 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 work.

4.53 Independent assessment programs should be established and implemented to address project management competence [2].

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 by the licensee 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 them. The system should include the investigation of the non-conformances and why they arose with the aim of preventing recurrences. In addition, this system should incorporate the regulatory approval process for handling any non-conformance of safety significance.

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

4.56 The licensee should maintain records of the corrective and preventive actions taken to resolve non-conformances. The effectiveness of the process should be monitored.

4.57 Due to the challenging nature of construction projects (such as tight schedules, new technology or limited availability of resources), actions to correct non-conformances may require extended time scales for resolution and may remain as pending issues even after handover from one party to another. Implementation of preventive actions should not be delayed unnecessarily if the corrective actions require an extended time period. These pending non-conformances and preventive actions should be tracked to completion by the licensee. Records should be maintained and relevant parties informed.

Construction experience feedback

4.58 Construction experience and examples of a good practice, not only from specific nuclear installations but also from nuclear and non-nuclear construction, should be collected by the licensee and any lessons learned disseminated for the enhancement of quality and safety in the industry. Criteria should be established for reporting of construction related experience and measures put in place at the industry level 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.

4.59 The licensee should be pro-active in sharing safety relevant experiences nationally and internationally.

5. MANAGEMENT OF CONSTRUCTION ACTIVITIES

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 to relevant parties. The construction program should be fully integrated with a procurement program highlighting long lead items. In the case where procurement of lead items starts before the construction licence is issued, and possibly the construction organization is not yet in place, the licensee should ensure that procured items important to safety achieve the design specification and required level of safety. 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/or witness points as necessary. These may be specified by the licensee and/or the regulatory body.

5.4 The construction planning, scheduling and work sequence should include requirements for off-site manufacturing and assembling under an adequate management system including a quality assurance program. All contractors should have a quality assurance

program which should be consistent with that of the licensee.

5.5 Specifications, documents, drawings, and plans and schedules should identify which manufacturing, assembling, installation, inspection and testing activities should be performed on site and adequate provisions to be made to carry them out.

5.6 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.

5.7 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.

5.8 The designer should ensure that the design can be constructed using established processes [see [4] Requirement11]. The construction organization should confirm the adequacy of construction methods with reference to the design organization where necessary. Early contractor involvement can influence design options at the appropriate stage by taking into account contractors' construction methods. There should be regular meetings at which the contractor's methods are discussed with the design team as there is a potential for the contractor's methods to undermine design assumptions. Assessment of construction risk and mitigation by suitable choices in design is a statutory requirement in some Member States.

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

should be done only in exceptional case after due considerations.

Procurement specifications

5.10 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].

5.11 The procurement specifications relevant to items important to safety should emphasize the safety requirements relevant to technical characteristics, safety culture and quality management.

5.12 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. If the supplier determines codes and standards, the designer/licensee should formally agree to them.Any change in the safety classification should be notified to the supplier and the impact on already manufactured equipment should be assessed.

5.13 Procurement document for items important to safety should specify 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, test and preservation 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.

5.14 Special attention should be paid to the procurement of commercial grade components or products that are proposed to be a part of any safety function. The suitability of the products or components should be verified as described in paragraphs 5.35 – 5.37 of [3].

MANUFACTURING AND ASSEMBLING

5.15 The licensee's management system, covering the quality assurance program 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.

5.16 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) 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;

(d) The assembly of the equipment;

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

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

(g) Equipment qualification and associated type tests;

(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.

5.17 The licensee should ensure that each manufacturer's management system includes the identification and control of processes where the results cannot be fully verified by subsequent inspection and testing and processing non-conformances may become apparent

only after the item is in use or operation.

5.18 Special equipment, such as tooling, jigs, fixtures, unique inspection gauges, computers and computer software used in the manufacturing or assembling process should be properly qualified or validated.. The personnel using the equipment should be trained and be aware of any limitations in its use.

5.19 The licensee and the 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.

5.20 The technological expertise of the contractors should be verified by the licensee and/or construction organization, before procurement specification has been specified. Augmented monitoring and inspections, if needed, should verify that new manufacturing techniques and new types of equipment meet relevant design requirements.

5.21 All items important to safety should be inspected and tested by the manufacturers according to the requirements in the procurements' specifications. The traceability of individual items important for safety or the identification of batches of such items, as appropriate, should be highlighted in the inspection and test plan.

5.22 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.

Prerequisites for construction works

5.23 Where the final design is not available at the start of construction work, the forward action plan should ensure that the outstanding design documentation is completed with

sufficient time in advance to assure quality of instructions, procedures and drawings and to make appropriate preparation for the work.

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

Work and environmental conditions

5.25 Construction work and environmental conditions should be monitored by the construction organization to protect safety significant mechanical, electrical, instrumentation and control equipment, and structures from internal and external damage or contamination.

5.26 The licensee should specify the allowable environmental conditions, such as temperature, pressure, humidity, rain, snow, dust, dirt, airborne salt, wind, and electromagnetic conditions during construction work including manufacturing, assembly and transportation. The construction organization should periodically monitor the conditions to confirm that conditions they are within allowable limits. Such limits need only be developed for conditions applicable to the specific work location and work activity.

Cleanliness and Foreign Material Control and Exclusion

5.27 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 with an acceptable standard of cleanliness.

5.28 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. These 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 personnel. 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 if the protection measures and control fail.

5.29 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.

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

- Checking of the actual flow paths to satisfy specified requirements with regards to location, position, and status of all components;

- Tagging and locking as appropriate 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;
- Sealing of the openings of the cleaned system(s); and
- Checking installation and subsequent removal of temporary devices (for example, temporary caps in piping)

Receipt, handling, transport, storage, preservation and maintenance

Control of items and consumables

5.31 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 risk.

Handling

5.32 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

5.33 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 aspects of the routes should be appropriately assessed to ensure that transport is possible without causing hazards, damage or injury to people, the items and anything else on the routes.

Storage

5.34 Suitable storage should be provided as specified by the designers and manufacturers to protect items important to safety prior to their installation and use.

5.35 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; and

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

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

5.37 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 protection against unauthorized removal in use and storage of items important to safety should be implemented by the construction organization.

5.38 Before installation of any items important to safety, the construction organization or contractor should inspect them against the specified requirements and if necessary take remedial action.

Preservation of installed items

5.39 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.

5.40 The contractor or the construction organization needs to ensure that the use of temporary structures does not adversely affect items important to safety.

5.41 During the on-site or off-site tests, the other items important to safety should be

isolated or protected to avoid inadvertent actions.

Maintenance

5.42 During the entire construction phase, the licensee and/or the construction organization 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 into commissioning until operational maintenance programs are initiated.

Verification and test of construction activities

5.43 The licensee and construction organization should develop and agree a process to verify the completion of construction activities and transfer of completed work. The test plan and acceptance criteria should be documented by the construction organization such that they can be independently assessed. The results of the tests (coverage, contents, results and timing) should be analyzed against the specified acceptance criteria. Test and verification should be performed by a qualified independent party for items important to safety. 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, including those detailed in the licensing documentation.

5.44 A typical verification record should include:

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

(b) Description of how the results were verified;

(c) The date and time of verification;

(d) Name and organization of the verifier;

(e) Any special tools or calibrated equipment used;

(f) Test results and comparison with acceptance criteria;

(g) A list of remaining deficiencies and the plan for their resolution;

(h) A list of outstanding items of work and the forward action plan;

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

5.45 Any use of radioactive sealed sources and radiation devices during such activities as radiographic examinations, gauging (density, thickness, moisture, etc.) or material analysis should consider protection of workers 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) Ref. [26] and sensitive items in the area

ON-SITE CONSTRUCTION PROCESSES

Receipt

On receipt at the construction site, an initial check should be carried out to ensure that the items are as ordered and suffered no obvious damage during transport.

5.46 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 or detected during manufacturing but to be corrected on site are recorded;

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

(l) Storage has been controlled to prevent inadvertent installation or use.

Effect on and from existing facilities

5.47 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. An assessment of safety and security during construction should be performed by the appropriate licensee(s) 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 as well as from operating site to construction site should be assessed and its contamination should be monitored, if necessary. All other potential risks should also be assessed (digging, excavation, accidental fall of cranes, collapsing of items, use of explosives, etc.). Such consideration should also include impact assessment of environmental discharges that are cumulative for all facilities on a site.

5.48 The responsibilities of the relevant licensee(s) and the construction organization for safety and security should be agreed before the start of construction activities at the site. Close communication and cooperation between the parties should be established. All steps should be taken to ensure that the existing facility can be operated safely and securely during construction activities.

5.49 For installations adjacent to each other or those that share common buildings or services, the following boundaries should be identified: radiological protection, physical, system, security, access boundaries and clean zones. 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. Procedures shall be put in place to ensure that the licensee of existing facilities endorses a change of status for those common buildings or services before implementation by the construction organization

On-site manufacturing and assembling

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

5.51 Waste materials and remaining consumables used or generated on site during construction work should be removed by the contractors after the work is complete.

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