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No. 65

Application of Configuration Management in Nuclear Power Plants

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APPLICATION OF CONFIGURATION MANAGEMENT IN NUCLEAR POWER PLANTS

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FOREWORD

The IAEA has the statutory mandate to seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. However, it has become increasingly apparent that many Member States are facing the process of ageing operational nuclear power plants, which not only concerns the ageing of structures, systems and components (SSCs), but also the challenge of retaining core knowledge that can erode due to the ageing and attrition of staff.

The importance of having accurate knowledge of the design basis and deep technical awareness of the operational functionality of nuclear power plants has increasingly come into focus. In particular, there is awareness in the industry of the need for a long term staffing programme to ensure the adequate transfer of knowledge. It is important to establish and maintain, during the lifetime of the plant, the original design intentions and to comprehensively clarify any function of the plant design.

Consistent with this publication, the IAEA issued a technical document in 2003 on Configuration Management in Nuclear Power Plants (IAEA-TECDOC-1335). The present Safety Report highlights the safety aspects of configuration management and provides further guidance and examples on the functional areas of configuration management. The concept of configuration management is implemented in different ways in the nuclear industry. Some Member States have introduced a special organization part for handling configuration management, and others have introduced or incorporated the configuration management concept in their processes and procedures in a systematic way. This publication provides advice for a sound introduction of the configuration management concept, which will not be tied to any specific organizational model.

This report contains the latest experiences and lessons learned by Member States as presented at IAEA meetings on the application of configuration management in nuclear power plants. Furthermore, it includes examples of the challenges and good practices identified during IAEA operational and engineering safety review services between 2003 and 2009.

Supporting extracts from the IAEA safety standards have also been incorporated to strengthen the oversight of the overall set of requirements and guidance in the area of configuration management.

This report has been developed with the support of experts from regulatory, operating and engineering organizations. The IAEA thanks all the contributors to this report, especially R. Harris (USA). The IAEA officers responsible for this report were B. Hansson and C. Toth of the Division of Nuclear Installation Safety.

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CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

Configuration management is used to ensure consistency among design requirements, facility configuration documentation (FCD) and the physical plant. Plant configuration controls ensure that changes to the plant and systems are properly identified, screened, designed, evaluated implemented and recorded. Changes in plant configuration may result from maintenance, modifications, ageing of components and testing activities, operating experience and technical developments, as well as operational limits and conditions controls.

Inadequate configuration management can result in the loss of the ability to perform safety actions when needed. Not having the right information available at the right time and in the right format for engineering and operations staff can lead to human errors with potentially severe safety and economic consequences. In many cases, the effort required to respond to and correct these errors is considerably greater than the effort required to maintain plant configuration.

After several years of plant operation, modification and maintenance, plant management may not have a high degree of assurance that the FCD reflects actual plant status, nor that the cumulative effects of plant modifications have been considered sufficiently. In the absence of a configuration management programme, the physical plant, supporting documents and design basis may have diverged over time and no longer represent equilibrium.

A sound approach to configuration management relies on the need for an equilibrium between design requirements, the FCD and physical configuration in the plant. Configuration management principles should be integrated into processes for normal design, operation and maintenance activities of plants to provide assurance that documents are maintained to reflect the current configuration of structures, systems and components and that they conform to design requirements. It is important to see plant configuration management as a part of the management system that integrates activities in normally existing processes in a systematic and integrated way.

An important objective of the plant configuration management system is that accurate information, consistent with physical and operational characteristics of the plant, be available in a timely manner, for making safe, knowledgeable, and cost effective decisions, with confidence. To start and follow a chosen approach of configuration management is important for operating nuclear power plants. It is even more important when facing long term operation, and perhaps 60 years of operation. This will create a need for strengthening the availability of the design basis and design requirements.

In addition, many nuclear power plants, particularly older facilities, may still not have fully consolidated their design bases and other relevant documentation. The form of the actual design documentation depends on the design (engineering) technology used for initial planning of the plant. In addition, there may also be differences in documentation between plants, depending on whether the plant was designed by a single architect–engineer or by multiple designers and suppliers. Some plants that were designed as 'turn-key delivery' by the nuclear system supplier will likely not have all relevant design documents transferred to the plant owner or operator. Lack of complete design basis and configuration management poses a particular problem for these types of plants, because evolutionary safety and performance upgrades to the plant may not have been fully analysed and documented.

Also, in older facilities, some documentation containing very important safety or design basis information may be widely dispersed. Furthermore, the main design principles may not be fully documented and sometimes have been lost, although the functionality of the plant was approved. As such, the original design basis is not readily available for use by plant personnel.

An evaluation of past Incident Reporting System data indicates that a significant number of reported events have resulted from errors in the control and maintenance of the configuration of the physical facility, errors in the original design or design modifications, inadequate corrective actions, inadequate testing and documentation discrepancies. A review of results of IAEA Operational Safety Review Team (OSART) missions and follow-up reports also indicates that many findings are related to, or have their root cause in, configuration management deficiencies.

Good configuration management can contribute to financial and schedule-related benefits, such as more reliable and credible design documentation, elimination of duplicate databases, reduced operating and maintenance cost, and reduction of parts inventory.

This Safety Report has been developed to facilitate improvements in the activities affecting configuration management It provides information to organizations seeking to review their current approach to configuration management, and to identify and resolve shortfalls.

1.2. OBJECTIVE

The purpose of this publication is to provide fundamental knowledge about configuration management, to provide information on its application and to offer guidance for selecting the proper approach to configuration management, and establishing and maintaining an effective configuration management programme.

This Safety Report highlights the safety aspects of configuration management and provides guidance on how to address issues related to this topic. The publication is written primarily for operating organizations and technical support organizations (TSOs), but can also be used by regulatory bodies.

This publication also provides advice and good practices to support development and improvement of an existing configuration management programme, or establishment of such a programme if none exists, and it is not dependent on a particular organizational model. In addition, it may be used to facilitate training on the subject of configuration management.

1.3. STRUCTURE

Section 2 provides an overview of the principles and fundamentals of configuration management and includes a review of the key safety requirements and recommendations relating to configuration management as set out in the IAEA Safety Standards.

Section 3 addresses various technical categories of activities that may have an adverse effect on configuration management. Each subsection provides descriptions of typical problems.

Section 4 describes organizational and human factors issues related to configuration management that need to be considered. The human factors have deliberately been separated from the technical aspects in this publication because human errors can be the root cause of a large number of the failure modes and issues described in Section 3. Experience shows that human factors can be a significant source of challenges to configuration management.

Section 5 describes approaches for improving configuration management, through key performance indicators (KPIs) and metrics, applying information technology solutions to configuration management programmes in nuclear power plants, and the relationship of the regulator to those programme requirements and goals.

The appendix contains extracts from the IAEA Safety Standards to strengthen the oversight of the overall set of recommendations in the area of configuration management. Annex I contains an example of a configuration management assessment list. Annex II contains an example of configuration management performance indicators. Annex III describes a change process model.

2. FUNDAMENTALS OF CONFIGURATION MANAGEMENT

This publication assumes that the nuclear power plant has already knowingly or unknowingly employed some concept of configuration management to a certain extent. The exact degree to which the application of configuration management and its current status may depend on specific exposure to it and relative awareness of the plant management with respect to this type of management.

Configuration management is a managerial concept that provides technical and administrative direction to the development, production, support and plant life-cycle of an item for which an exact 'picture' of the configuration needs to be maintained. This discipline is applicable not only to plant equipment and components and their related documents, but also to supporting hardware, software, processed materials, services, and related technical documentation. Configuration management is an integral part of life-cycle management. A statement by a utility applying configuration management may illustrate the importance of such an approach:

> Contrary to popular belief, the cost of intervention resources is many times higher than that required to achieve and maintain information integrity.

The configuration management concept ensures that the construction, operation, maintenance and testing of the physical facility are in accordance with the design requirements as expressed in the design documentation, and to maintain this consistency, or *equilibrium*, throughout the operational life-cycle phase, particularly as changes are being made.

2.1. OVERVIEW OF CONFIGURATION MANAGEMENT

The fundamental concept of configuration management is to provide assurance to the owner, operator and regulator that a plant is designed, operated and maintained in accordance with the actual licensing and design basis, complying with the commitments for the safety of the public and protection of the environment.

2.1.1. The objective of configuration management

The concept of configuration management recognizes that there are three elements that need to be in equilibrium: design requirements, the FCD and physical configuration, as illustrated in Fig. 1.

Design requirements are technical requirements derived from standards, regulatory requirements and the design process, which impose limits on the final design including the consideration of margins and which are reflected in the design documentation.

Facility configuration documentation is the set of all the documents that contains *configuration information* defining how the plant is designed, how it is operated and how it is maintained. FCD is categorized as either:

— Design information.
— Operational configuration information, such as plant alignment and tag lists, surveillance procedures, equipment and component databases, etc.
— Other configuration information utilized for procurement, operation, maintenance and/or training activities.

Physical configuration applies to the installed and subsequently commissioned structures, systems and components (SSCs), and to the operational configuration of those items.

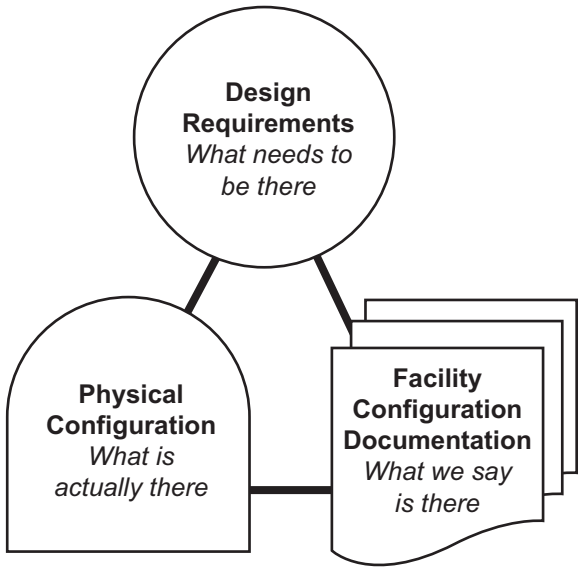


FIG. 1. Configuration management equilibrium model.

The configuration of a nuclear power plant is considered to be in *equilibrium* when:

— Elements conform — equilibrium is always maintained and is immediately restored when there are disruptions, whether caused by inadvertent action or intentional change. Conformance is assured when consistency is achieved among design requirements, the FCD and the physical configuration.
— All changes are authorized — People who generate design changes or manipulate the configuration of components are suitably qualified and experienced, and follow approved procedures, which are written so that limits imposed by the design are not exceeded (see Section 3, Ref. [4]).
— Conformance can be verified — all changes to the design and operational configuration are documented so that the relevant current and past configurations can be identified and distinguished from each other in terms of the engineering change or other configuration event responsible for the change, and determined to have been done correctly.

Achieving consistency between design requirements, physical configuration, plant operations, and the FCD offers many benefits, principal being the safety and efficiency of the nuclear power plant. Effective implementation of the elements and functions of an operational configuration management programme provides the tools and information necessary for integrating and coordinating activities to ensure that work is done correctly and safely the first time.

Since a major goal of configuration management is to protect the design basis, nuclear power plant programmes other than design and modification activities also need an effective configuration management concept to fulfil their objectives and requirements. By maintaining the basic relationships shown in Fig. 1, configuration management helps maintain nuclear power plant configuration documents.

2.1.2. Conformity disruption identification

Lack of conformance can be discovered or initiated between any two elements of the configuration management equilibrium diagram (Fig. 1) in one of three ways:

(1) A discrepancy is ***discovered as a collateral event*** to day to day activities. It is important that effective processes are established to ensure that such discrepancies are recognized, and that the culture of the organization encourages the identification and resolution of these discrepancies.
(2) A discrepancy is ***discovered through systematic review***, assessment, performance indicators, field walkdown and inspections intended to identify discrepancies.
(3) A discrepancy is produced pursuant to an ***intentional change*** in plant requirements, equipment and components, the plant design or operating documentation.

These discrepancies can arise from either permanent or temporary changes in the plant, for example:

(1) Discrepancies between design requirements and the FCD:
   — Errors in analysis;
   — Errors in licensing documents;
   — Operating procedures conflicts with design calculations;
   — Design changes such as power uprating create potential design basis changes.
(2) Discrepancies between physical configuration and the FCD:
   — Drawing/document and nuclear power plant discrepancies;
   — Components in the wrong position or alignment;
   — Maintenance errors that affect plant configuration;
   — Desired changes — modifications that cause manoeuvre, manipulation or realignment of plant components during installation or establishment/removal of barriers, interlocks or energized isolation.
(3) Discrepancies between physical configuration and design requirements:
   — Failure of SSCs to meet performance criteria as designed;
   — Equipment out of tolerance or fails surveillance;
   — Unexplained degradation in performance of SSCs.

2.1.3. Restoration of equilibrium

An imbalance in the configuration can lead to significant safety and operational problems. Therefore, identified configuration management disruptions must be resolved using existing, approved processes and procedures that are integral to design, operation and maintenance of plants. Existing processes and programmes may be evaluated using the configuration

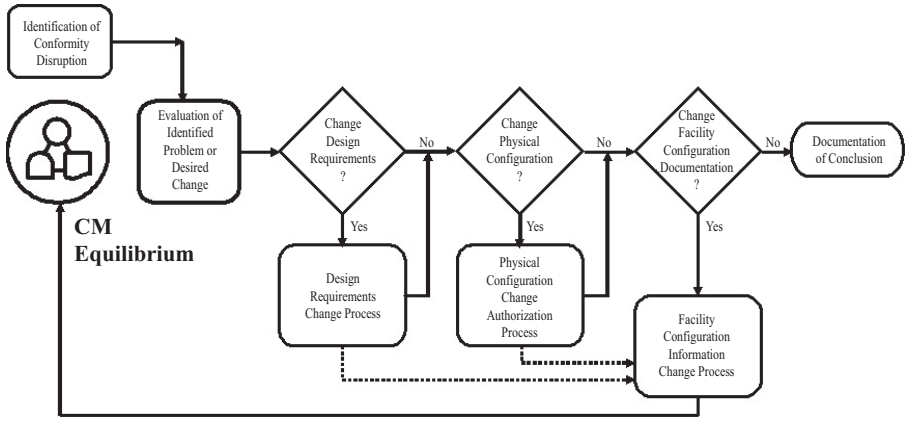


FIG. 2. Restoration of the configuration management equilibrium.

management process model described in Fig. 2 to ensure that all of the appropriate steps are accomplished to return to the equilibrium state.

2.1.3.1. Evaluation of identified problem or desired change

When an event at a nuclear power plant affecting configuration management equilibrium is identified, it must be resolved to either restore the original equilibrium, or changes must be made to either configuration management related processes and activities, or the plant, or both, in order to establish a new equilibrium. Such changes must take into account regulatory issues, cost–benefit and impact on other configuration management activities and other processes. If the chosen solution does not produce a successful outcome, the corrective process must be repeated for additional research or investigation.

2.1.3.2. Design requirement change processes

Following the identification and evaluation of an apparent discrepancy or a desired change in the configuration management equilibrium, the first step is to determine if the solution requires making a change to the design requirements. For example, if a discrepancy is discovered between a design drawing and an installed component (the most common configuration management event), and it is determined to not be a simple document omission, the design requirements contained in a system calculation may need to be re-checked to decide whether the drawing or the installed component is correct. Although it is infrequently encountered, the design requirements may need to be changed before addressing the other two elements of the configuration management equilibrium model (Fig. 1).

2.1.3.3. Physical configuration change authorization process

The next step is to determine if the solution requires making a change to the physical configuration. This may be either a design change that modifies one or more SSCs, or an operational configuration change such as the manipulation of a valve position or a switch (alignment or configuration control).

Existing processes may then be used to justify proposed changes to the physical configuration and to prepare or revise the documentation necessary to make the change, such as design documents, work instructions and operational procedures. Note that any changes to the physical configuration may also require changes to the FCD.

2.1.3.4. FCD change processes

The final step is to determine all affected FCD that needs to be modified to re-establish a state of configuration management equilibrium. Modify and issue all such FCD using existing processes. If changes to plant or documentation are required, approval may be needed from the regulator. Nuclear power plant controlled design documents should be cross-referenced to each other and to any affected SSCs to support this type of reconciliation.

2.1.3.5. Documentation of the conclusion

Based on the evaluation results, the configuration management restoration process at this point may be terminated. Documentation of the conclusion should include a description of why the configuration is acceptable.

2.2. FUNCTIONAL AREAS OF CONFIGURATION MANAGEMENT

The leadership provided by top nuclear power plant and owner/utility management is crucial in order to ensure an appropriate appreciation of the significance of configuration management at all organizational levels and throughout the organizations that carry out this management. In particular, the distinction and relationship between quality systems and configuration management should be understood by management.

The organization should develop a comprehensive description defining who is responsible for preparation and processing of documents and other configuration management related information. The description should include details of all interfaces and transfer of responsibilities throughout the process.

The relationship between the functional areas of configuration management and some common existing plant processes, with reference to the applicable sections in this report and related IAEA Safety Standards can be seen in Table 1.

TABLE 1. RELATIONSHIP BETWEEN THE FUNCTIONAL AREAS OF CONFIGURATION MANAGEMENT AND SOME COMMON EXISTING PLANT PROCESSES, WITH REFERENCE TO THE RELEVANT SECTIONS OF THIS REPORT AND THE IAEA SAFETY STANDARDS

Functional areas of configuration management	Common existing plant processes	IAEA Safety Standard reference number
Protect design basis (Section 3.1)	Safety committee/self-assessment/ PSR/safety analysis	Refs [3, 5, 6, 10, 11, 13]
Modify the plant (Section 3.2)	Design change process and documentation management	Refs [3, 7, 8–11, 14–16, 18]
Operate the plant (Section 3.3)	Operation inside safety envelope	Refs [3, 4, 8, 12–14, 16]
Maintain the plant (Section 3.4)	Maintenance procedures/ageing management	Ref. [13–17, 18]
Test the plant (Section 3.5)	Surveillance tests and in-service inspections/review physical status of the plant for conformance with design requirements.	Refs [3, 6, 8, 14, 17, 18]
Configuration management for other interacting areas	**Related activities (Scope)**	**IAEA Safety Standards reference number**
Human performance (Section 4)	Experience feedback/human errors/knowledge management/staff ageing/training	Refs [3, 6, 18]
Improving configuration management (Section 5)	Computerized tools	Refs [6, 8, 18]

2.3. SAFETY REQUIREMENTS RELATING TO CONFIGURATION MANAGEMENT

There is no specific IAEA Safety Standards Series publication providing direct recommendations on configuration management. This section summarizes some of the key principles and requirements relating to configuration management contained in the IAEA Safety Standards. More extracts from these and other IAEA Safety Standards are given in the Appendix.

The IAEA's Fundamental Safety Principles (SF-1) [1] establish the fundamental safety objective and ten safety principles, and briefly describe their intent and purpose.

The main principle for configuration management, 'Principle 1: Responsibility for Safety', states that "[T]he prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks". It is explained further: "Authorization to operate a facility or conduct an activity may be granted to an operating organization or to an individual, known as the licensee." (Ref. [1], Section 3, Principle 1, para. 3.4.)

In Ref. [1], 'Principle 3. Leadership and management of safety', it is stated that "Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks." This principle is explained further in paragraph 3.12:

> "Leadership in safety matters has to be demonstrated at the highest levels in an organization. Safety has to be achieved and maintained by means of an effective management system. This system has to integrate all elements of management so that requirements for safety are established and applied coherently with other requirements, including those for human performance, quality and security, and so that safety is not compromised by other requirements or demands. The management system also has to ensure the promotion of a safety culture, the regular assessment of safety performance and the application of lessons learned from experience." (Ref. [1], Section 3, Principle 3, 3.12.)

The following requirements relating to configuration management are established in the IAEA Safety Standards on the safety of nuclear power plants (Refs [2, 7, 12]):

— "The design process shall establish a set of requirements and limitations for safe operation, including:

(1) safety system settings;
(2) control system and procedural constraints on process variables and other important parameters;
(3) requirements for maintenance, testing and inspection of the plant to ensure that SSCs function as intended in the design, with the [as low as reasonably achievable (ALARA)] principle taken into consideration;
(4) clearly defined operational configurations, including operational restrictions in the event of safety system outages." (Ref. [7], para. 5.26.)

— "Compliance with the criterion shall be considered to have been achieved when each safety group has been shown to perform its safety function when the above analyses are applied, under the following conditions: … (2) the worst permissible configuration of safety systems performing the necessary safety function is assumed, with account taken of maintenance, testing, inspection and repair, and allowable equipment outage times." (Ref. [7], para. 5.37.)
— "The applicability of the analytical assumptions, methods and degree of conservatism used shall be verified. The safety analysis of the plant design shall be updated with regard to significant changes in plant configuration, operational experience, and advances in technical knowledge and understanding of physical phenomena, and shall be consistent with the current or 'as built' state." (Ref. [7], para. 5.72.)
— "The operating organization shall ensure that regular reviews of the operation of the plant are conducted, with the aim of ensuring: that an appropriate safety consciousness and safety culture prevail; that the provisions set forth for enhancing safety are observed; that documentation is up to date; and there are no indications of overconfidence or complacency." (Ref. [12], para. 2.13.)
— "The plant shall be adequately monitored and maintained in order to protect plant equipment, to support the testing phase and to continue to maintain consistency with the safety analysis report. Records of operations and maintenance shall be kept starting from the initial energization and operation of each plant system, and they shall be retained by the operating organization." (Ref. [12], para. 4.8.)
— "Operational limits and conditions shall be developed to ensure that the plant is operated in accordance with the design assumptions and intent." (Ref. [12], para. 5.1.)
— "The operating organization shall ensure that an appropriate surveillance programme is established and implemented to ensure compliance with the operational limits and conditions and that its results are evaluated and retained." (Ref. [12], para. 5.5.)

— "The maintenance, testing, surveillance and inspection of all plant structures, systems and components important to safety shall…remain in accordance with the assumptions and intent of the design throughout the service life of the plant." (Ref. [12], para. 6.2.)
— "The operating organization shall establish a procedure to ensure proper design, review, control and implementation of all permanent and temporary modifications. This procedure shall ensure that the requirements of the plant safety analysis report and applicable codes and standards are met." (Ref. 12], para. 7.4.)
— "Prior to putting the plant back into operation after modifications, all relevant documents necessary for the operation of the plant after the modifications (in particular the documents for shift operators) shall be updated and personnel shall be trained as appropriate." (Ref. [12], para. 7.7.)
— "The plant management shall establish a procedure for updating documents as soon as possible after modification, installation and testing. Responsibilities for the revision of all documents such as drawings, procedures, safety analysis report, operational limits and conditions, system description, training material including simulator, vendor equipment manuals and spare parts lists shall be clearly assigned." (Ref. [12], para. 7.8.)
— "A management system shall be established, implemented, assessed and continually improved. It shall be aligned with the goals of the organization and shall contribute to their achievement and enhance safety by:
— Bringing together in a coherent manner all the requirements for managing the organization;
— Describing the planned and systematic actions necessary to provide adequate confidence that all these requirements are satisfied;
— Ensuring that health, environmental, security, quality, and economic requirements are not considered separately from safety requirements, to help preclude their possible negative impact on safety." (Ref. [2], Chapter 2, para. 2.1.)

3. APPLICATIONS OF CONFIGURATION MANAGEMENT

This section addresses the various types of activities that can have a negative effect on configuration management. The following subsections discuss examples of issues that should be considered, and provide examples of good practices on how

to avoid or resolve these issues. The principles of configuration management are discussed below and in Section 2.1.3. Many plants have incorporated configuration management activities in their daily operational processes. The principles of configuration management can help to evaluate if these activities and processes are sufficiently effective to ensure equilibrium, as illustrated in Fig. 1.

Section 3.1, 'Protect the Design Basis', addresses the need for conformance between the design requirements and design documentation.

Section 3.2, 'Modify the Plant', addresses the need for conformance between the design configuration documentation and the physical configuration. Changes to the physical configuration may be made in accordance with design configuration documentation, which in turn is based on existing design requirements. If changes to design requirements are needed, these may be made in accordance with approved processes and procedures.

Section 3.3, 'Operate the Plant' addresses the need for conformance between operational configuration information and the physical configuration. Operational configuration information comprises operating procedures that permit manipulation of systems and components that are in service. This information is maintained within the existing design as defined by the design documentation.

Section 3.4, 'Maintain the Plant', addresses the need of conformance between the physical configuration and other documentation necessary for procurement, standby operation, maintenance and training activities, which are maintained within the existing design as defined by the design documentation.

Section 3.5, 'Test the Plant'," addresses the need for conformance between the physical configuration and the design requirements. Conformance discrepancies are typically experienced as the plant ages and components are unable to continue meeting the performance requirements assumed in their design.

Relevant recommendations contained in various IAEA Safety Guides applicable to configuration management aspects for each of the following section are set out in the appendix.

3.1. PROTECT THE DESIGN BASIS

The objective of this configuration management principle is to understand and maintain the design basis consistent with licensing basis. Typical causes for lack of conformance in the design configuration can include:

— Missing design information;
— New or revised design requirements not addressed by the plant;
— Errors in the original design;
— Misinterpretation of design requirements when designing changes.

The processes for the design configuration must include regular reviews with oversight groups such as a senior safety review committee capable of identifying threats to the design basis.

3.1.1. Revised or undocumented/implicit design basis

The design basis identifies and supports the reasons for which the design requirements are established and are, therefore, not typically subject to much change. However, through the process of safety reviews, which may impose more stringent design requirements, upgrading and modifications, elements of the design basis may be revised. Also, as discussed in Section 1.1, the main design principles may not have been well documented in the original plant design.

Sources of the new requirements may include:

(1) New requirements determined by periodic safety reviews (PSRs) concerning the plant technical parameters and plant operation;
(2) New environmental requirements established as a result of changes in on-site and off-site characteristics;
(3) New internal and external hazards;
(4) New technical solutions or modifications made to the systems of the plant that initiate new requirements for the connected system;
(5) New requirements resulting from lessons learned from incidents or events;
(6) Requirements originating from ageing of components and from lifetime management;
(7) New requirements from the preliminary plant decommissioning plan;
(8) Requirements from new operational limits or new operating regimes;
(9) Requirements from new nuclear safety standards issued by the nuclear regulatory authority relating to the safety aspects of the design;
(10) Requirements from the reconstitution of undocumented design bases.

Advice on avoiding configuration management issues or restoring equilibrium

Changes to the design of the plant should not be made unless their basis is understood. There should be a design authority identified by the nuclear power plant and/or the owner/utility to approve changes. Missing design information should be evaluated to determine which parts need to be regenerated; missing design information should be regenerated in order of priority, with the most critical to be restored first.

3.1.2. Cumulative effects of changes

The impact of previous modifications, including temporary modifications on current and future modifications should be considered. Temporary modifications in particular require a systems approach, to help ensure that the effects of any additional modifications are analysed together with existing open modifications. Typical issues in this area include:

— Increased floor loadings, electrical load, cable separation, heat loadings or radioactivity level from multiple, simultaneous modifications;
— Implementing new modifications while related modifications are still open, or completed but not yet formally closed;
— Implementing modifications without understanding the significance of previous modifications to support the system or related systems.

Advice on avoiding configuration management issues or restoring equilibrium

As part of the implementation of modifications, the plant design authority should adjust any deterministic safety analysis and probabilistic safety analysis (PSA), as appropriate, using the current plant configuration, updated codes and design inputs. When performing modifications, the plant design authority should review the design basis of all affected systems and examine the influence of modifications on the system's design basis, taking into account interfacing between the systems.

The operational and maintenance manuals should be updated appropriately to reflect the new configuration of the systems. The FSAR should also be updated as appropriate to reflect any changes. Updating should be carried out at the time the modifications are implemented. When updating the codes used to perform the deterministic safety analysis, updated inputs should be used to check the cumulative effect of modifications.

3.1.3. Facility decommissioning

Decommissioning presents special challenges to configuration management because the succession of new nuclear power plant configurations will create successive changes in the configuration management equilibrium, albeit in reverse. Typical challenges include:

— Modifying systems that are still required for the operating units;
— Delays in decommissioning that can deplete the knowledge base and the availability of suitably qualified and experienced persons;

— The fact that the safety functions of the design basis will change.
— Considering the design basis, safety functions and impact on other related or shared systems for components and systems as they are removed.

Advice on avoiding configuration management issues or restoring equilibrium

Prior to cessation of commercial operation and facility dismantlement, the design requirements are reviewed to determine which design and operational requirements may remain in place, at which point certain requirements can be abandoned or modified. A systematic plan for dismantling a nuclear power plant facility to be decommissioned should be established based on the timing of the remaining design and operational requirements. Each stage of dismantlement should be analysed to ensure that the plant will be in conformance with the remaining design and operational requirements.

In the systematic plan for dismantling, personnel deployment schedule should be integrated to assure that qualified and experienced people are available in every stage of decommissioning. Departing staff should transfer relevant knowledge to the dismantling organization.

Approved drawings should be modified following decommissioning, highlighting the redundant systems, in-service systems and components. Care should also be taken to recognize system dependencies between shared systems at multiple unit sites during facility decommissioning.

In some cases, facilities at multi-unit sites may share systems or there may be provision for cross-connecting mechanical systems such as service water, component cooling water and instrument air systems between units. There may be cross-connections provided for electrical distribution systems between facilities and for cross-connecting offsite sources of electrical power that may be tied together in the switchyard. It is important to identify such mechanical and electrical interfaces to assure that the dismantling of one unit does not adversely impact an adjacent operating unit and result in the operating unit not being in compliance with its design bases.

3.2. MODIFY THE PLANT

The change control process requires the design requirements be evaluated and revised as necessary, and that the FCD is also updated to identify changes to the physical configuration of the plant. FCD is the documentation that defines how the plant is designed, operated and maintained.

3.2.1. Conformance of the FCD to design requirements

This section addresses disruptions in the configuration management equilibrium between the design requirements and design documentation. These disruptions may be discovered through design reviews or they may occur when a change is made to the design requirements or the physical configuration. Discovery may occur through the modification process to ensure that all of the proper reviews are made.

Disruptions in the configuration management equilibrium between the design requirements and design documentation are typically caused by:

— New or revised design requirements;
— Inadequate original review;
— A desired change to the physical configuration that requires a change in design requirements.

The following issues may arise when the FCD is inconsistent with the design requirements:

— Lack of assurance that the facility continues to be in a configuration consistent with its design requirements and that is approved by the regulatory body;
— Lack of assurance that the SSCs will perform their specified safety functions;
— Lack of assurance that the accident analyses performed and potential offsite consequences of postulated accidents are still valid.

Advice on avoiding configuration management issues or restoring equilibrium

Suitably qualified and experienced persons should control and supervise changes to the configuration of the facility. Regulatory requirements may specify that design changes need to be verified by equally qualified independent personnel. In addition, many nuclear plants use independent review teams to evaluate the modifications in order to ensure a high level of quality and nuclear safety.

Control room drawings, plant normal and emergency operating procedures and other documentation relied on by the operators should be updated in a timely manner, preferably before the modified system is recommissioned. Critical drawings and documents may even have a nuclear power plant mandated time limit for issue, at least as an interim revision as-built document. Training tools and documents should also be updated in a reasonable time period, based on the

system's significance. Operators should be trained on modifications as appropriate prior to commissioning the modification. These modifications should be reviewed by all appropriate technical departments.

Nuclear power plant modifications that are designed or installed by contract organizations should be monitored by the facility, and design documentation prepared by the contractor should be turned over to the facility on completion of the design change. Prior to commissioning a new facility, it is important that all relevant design documentation be turned over to the nuclear plant or arrangements made for continued access to the information throughout the facility lifetime.

Facility modifications that are designed or installed by contract organizations present particular challenges to maintaining accurate FCD. When using contract organizations care should be taken to assure that they have a firm understanding of the existing facility design requirements prior to starting the design of the modification. For major facility modifications, consideration should be given to involving the design organization or architect-engineer firm that was responsible for the original facility design because it would be most knowledgeable of the design basis and will likely have the original design information and design documents such as calculations and detailed drawings. It is also important that the contractor's work is monitored by facility personnel with sufficient technical knowledge of the area and knowledge of the facility design requirements in the area being modified. It is imperative that after the modification is commissioned that all design documentation be provided to the facility and entered in their document control system. The nuclear plant must bear in mind that they are the design authority for all plant modifications, with final responsibility for plant safety and operation, regardless of utilizing outside vendors or contractors.

Care should be taken to properly coordinate simultaneous but separate modifications on an SSC that may be installed at different times or in a particular sequence. Separate but dependent modifications on an SSC may be in process at the same time. Typically, these modifications are intended to be installed sequentially, where the configuration of the first modification is intended to be the point of departure for the second modification. However, situations arise where modifications are being performed in parallel, by different individuals or different groups within the facility or company. Therefore, it is important to coordinate these modifications to ensure that they can be installed in the proper sequence and function properly. It may be appropriate for each facility or utility to have a single group responsible for the coordination of all facility modifications to ensure that they will be installed in the proper sequence, function properly and that transition effects are appropriately considered. When the nuclear plant performs multiple design changes to a given SSC

simultaneously, utilization of a technology solution for configuration management can assist greatly in the coordination and interface of the plant staff and external contractors involved.

Care should be taken that partially installed modifications meet design requirements at each stage of the installation. Large or complex modifications may be installed over several facility outages or plant shutdowns of suitable duration. It is important to ensure that, after each portion of the modification is commissioned, the facility configuration remains within the design envelope and in conformance with its design and licensing bases.

The software for digital control systems needs to be thoroughly verified and validated. Software relied upon to automatically operate or control systems or components may often be complex, and may be designated as a safety related system. It is therefore important that such software be thoroughly validated and verified to assure that unwanted automatic plant actions do not occur.

New design and analysis software needs to be benchmarked prior to use in safety related applications against analyses performed by codes previously accepted and approved by the regulatory authority, or approved by the regulatory authority as necessary. Use of software that has not been benchmarked or validated may produce incorrect results that can put the facility outside of its design envelope. It is important that software be benchmarked against known results to ensure accuracy and that any changes to the software be properly documented and controlled.

3.2.2. Conformance of physical configuration with design documentation

This section addresses disruptions in the configuration management equilibrium between the physical configuration and design documentation. These disruptions may be discovered through plant walkdowns or may occur when a change is desired to the physical configuration and accompanying changes to design documentation. This could be is accomplished through the modification process to assure that all of the proper reviews are completed.

Typical examples of discrepancy between design documentation and the physical configuration can include:

— Desired change to plant;
— Discrepancies between design drawings and as-built plant conditions;
— Unapproved modifications;
— Errors in installation of modifications:
— Poor post-modification testing procedures or execution;
— Out of date training material;
— Out of date simulators.

Advice on avoiding configuration management issues or restoring equilibrium

Plant design and configuration documentation should be updated in a timely manner following a design change.

Care should be taken when partially installing modifications so that control room drawings are systematically updated as appropriate to minimize safety concerns, especially if the modifications affect operator actions. If plant modifications that affect operator actions are to be installed over several operating shifts, it is recommended that the control room drawings and operating procedures be updated as appropriate and that the operators are briefed on the status of the modification at shift turnover. This should be done even if interim, letter series drawing revisions must be issued and delivered to the nuclear power plant main control room and other selected recipients (copyholders). These critical documents and recipients should be identified in the nuclear document control system.

As a part of the facility modification and design control process, it is essential that drawings and calculations be updated in timely manner. Verification that all pertinent documents are correctly updated and distributed is included in the closure process for the design change. As the current configuration is the departure point for future facility modifications, it is always important to have information that properly reflects the current plant configuration. Documents and design drawings controlled by a nuclear power plant should be cross-referenced with SSCs to facilitate identification of affected documents prior to commencing a design change. Beyond the safety benefits that accrue from having accurate information on plant configuration, there are also benefits gained through having a more efficient design process, where less time is spent verifying facility configuration before starting on a plant modification.

Design documentation, analyses, control room drawings, and operating and maintenance procedures should be updated to properly reflect equipment that has been decommissioned and abandoned in situ.

Equipment abandoned in situ (decommissioned, but not physically removed) should be reviewed for impact on SSCs that remain operational. Such abandoned equipment should be clearly tagged, and facility drawings and operating procedures updated to avoid operator confusion regarding availability of SSCs.

3.2.3. Uncontrolled temporary modifications and operator workarounds

Temporary modifications that are inappropriate for some operating conditions are sometimes inadvertently left in place. Lack of conformance in the design control process can result from uncontrolled temporary modifications or

operator workarounds. An operator workaround may also be one disregarding an instruction or step in an operating procedure because he/she knows that step is never used. Other examples could be a controller failure, which may be compensated for by manual operator action.

Advice on avoiding configuration management issues or restoring equilibrium

Temporary modifications and operator workarounds should be controlled through facility processes and evaluated by design engineering to ensure that design analyses and regulatory requirements are not violated.

Installation of temporary scaffolding or shielding as part of the facility modification should be analysed prior to installation because their presence may result in a nuclear power plant facility being outside its design envelope. Particular issues to note are seismic spatial interactions between temporary scaffolding and shielding, and safety related SSCs.

Temporary modifications (including defeat of interlocks, installation of jumpers and lifted leads) also may result in unexpected system performance and put the facility outside its design envelope. A record of temporary modifications should be maintained in the control room, and systems should be restored to their normal configuration as soon as possible. In any event, workarounds and jumpers should be utilized as little as possible and only after careful consideration of alternatives.

Prior to installing temporary modifications or implementing operator workarounds, they should be evaluated by appropriate engineering personnel to verify that they do not result in inconsistencies with the facility's design requirements and put the facility outside its design envelope. In addition, temporary modifications and operator workarounds need to be carefully controlled and periodically evaluated to determine if they are still necessary. If these are in place for long periods of time, this may be an indicator that a permanent facility modification is necessary. Some utilities have policies that temporary modifications and operator workarounds cannot be in place for more than one fuel cycle (or one year for facilities that refuel on-line), or some other specified time frame, in that reevaluation.

3.3. OPERATE THE PLANT

This section addresses the need for conformance between the operational configuration documentation and the physical configuration. Configuration management activities should be included in the operational processes.

Typical examples of lack of conformance between operational configuration documentation and the physical configuration can include components found in the wrong position and incorrect operational set points.

Some causes of these disruptions are:

— Failure to follow operating procedures;
— Errors in operating procedures;
— Wrong unit or wrong train operation;
— Human errors due to unevaluated workarounds, uncontrolled abandoned equipment and temporary modifications.

3.3.1. Commissioning

Commissioning of a new plant or modifications can present unforeseen challenges to CM as systems begin to interact. Dynamic testing of new SSCs may be the first time that interactions take place. It may be necessary to configure systems to facilitate dynamic testing; for example, the testing of a replacement turbine governor requires the reactor to be at power. In this instance, commissioning activities need to be closely coordinated with operators.

Advice on avoiding configuration management issues or restoring equilibrium

Commissioning documents may be made available in a step by step overview format. System operators can quickly assimilate the current operational configuration when information is presented in this way. Progression from one phase to the next may be conditional on evaluation of results, and if necessary, by the regulatory body. Commissioning activities are designed to commission the plant starting with individual components (‘bottom-up’ approach):

— Component calibration and function testing;
— System line-up checks (valve positions, power supplies, control switch selections, etc.);
— System commissioning and performance testing;
— Collation of commissioning test reports into usable documents, for example documents specifying performance curves.

A plant specific full scope simulator or interactive graphic simulator may be used to check the operational features of SSCs and validate procedures as part of the commissioning phase. An auditable overview of the system shall also be available to operators at every stage in commissioning to facilitate nuclear safety aspects. Electronic tools may be used to provide up to date status displays of systems.

3.3.2. Operation

The alignment of in-service equipment may not be consistent with approved design. Requests for maintenance or operational plant manoeuvres may result in misalignment of SSCs.

Advice on avoiding configuration management issues or restoring equilibrium

The operator has several tools available to help to maintain operational configuration control; use of some or all of them should be considered during planning, execution, supervision and critique of all operations.

Adopt a questioning attitude with regard to all plant manoeuvres. (See Section 4.5 for a more detailed discussion.)

Use 'stop–think–act–review', (STAR) or a similar technique.

Use clear communication techniques. Oral instructions to operators should be minimized. If oral instructions are required, then it is essential to ensure that verbal instructions are clearly understood. Three way communications and the phonetic alphabet should be used to ensure clear and concise oral communications.

Use conservative decision making when there is inadequate information or knowledge.

Apply good procedural adherence. Adequate procedures shall be available to perform all operating manoeuvres. Writer's guides should be used so that procedures are written in a consistent format and with accurate content. An electronic database facilitates use of the latest revision and associated links to other documentation.

Operator workarounds should be controlled; their number and duration should be minimized. Regular periodic review of all operator workarounds is undertaken to ensure an aggregated condition does not exist.

Pre-job briefing of the team and contingency plans should be formulated before significant operations take place. An 'expect to succeed but be prepared to fail' approach in the planning of tasks should be adopted.

Only suitably qualified and experienced persons should control and supervise changes in operational status of SSCs. The requirement for resorting to suitably qualified and experienced persons applies to all staff, for example, contractors during plant outages.

Conduct critiques (post-job briefing) of significant operating manoeuvres.

Use automated tools (risk monitors) to assist in the evaluation of risk associated with taking SSCs out of service.

Minimize the time that SSCs are unavailable even when allowed outage time is longer.

3.3.3. Outages

Major outages present many challenges to configuration management, some of which can jeopardize nuclear safety. In these operating modes, safety barriers can be seriously challenged as many of the safety systems may be unavailable, many activities are carried out in parallel and many subcontractors may be working on the plant.

All outage work should be carried out in accordance with the outage plan; however, there may be inevitable emergent work or modifications that may arise. Emergent work has the potential to upset equilibrium if the work is not controlled in the same manner as the original outage work scope.

Return to service of SSCs can be delayed by inadequate planning during critical or complex tasks where a high degree of planning and coordination is required.

Unexpected loss of supplies may occur during switching of essential electrical supply trains to essential equipment. Loss of instrumentation and control (I&C) supplies to a water head tank level controller can occur, resulting in loss of prime to an essential cooling system.

Advice on avoiding configuration management issues or restoring equilibrium

Maintaining the shutdown cooling capability is a key safety function during shutdown conditions. To help achieve this goal, configuration management is needed before, during and after the outage.

Ensure that the SSCs are out of service for the minimum time necessary within allowable limits to carry out the work programme and schedule details. In addition:

— Ensure that assigned staff are suitably qualified and experienced;
— Provide adequate work specifications;
— Conduct pre-job run-throughs or use mock-ups;
— Provide outage related training using a simulator facility;
— Conduct pre-outage briefings with all affected departments;
— Ensure spare parts availability;
— Use correct tools and equipment;
— Identify scaffolding and lagging support;
— Assess suitability of radiation protection.

Tag-out and alignment requirements should be specified, for example, a consistent procedure for locking and unlocking. Return to service and re-commissioning checks should be conducted, and the maintenance organization should ensure that, before the return of the SSCs to operations, all necessary work is completed and return to service quality plans are completed. Operators should verify proper alignment of all affected components before the system is returned to service. Nuclear power plant systems engineers can assist greatly in this area by carefully reviewing alignments based on their knowledge of the system.

Confidence hold points should be considered when releasing safety critical SSCs before allowing work to proceed. These confidence holds are built into the outage plans to maintain the availability of these systems for decay heat removal and low pressure safety injection until physical evidence of cooling capability has been assured. Gain confidence before releasing plant beyond the point of no return. These hold points may correspond to some extent with the mandated QC hold points in the procedure for the work. Nuclear power plant systems engineers can assist greatly in this area by witnessing and reviewing work confidence and QC hold points.

Area coordinators are the direct representatives of the outage manager and should be assigned to facilitate work in critical or complex areas of the plant. Coordination of work in congested areas or in cases where there is competition for cranes is especially valuable. The provision of lay-down areas for heavy equipment needs to be planned and adequately marked, in particular avoiding areas that may require emergency vehicle access.

Task coordinators should develop detailed plans to prepare and complete their particular activity by maintaining a log of significant events, hold-ups and problems, which will facilitate future outages.

Switching quality plans should be prepared to check that expected actions have occurred during the switching and that the correct operation of standby plant has occurred. Contingency plans should also be prepared to accommodate emergent work. The outage control team assesses all emergent work; normal review procedures are used where possible to determine critical path analysis and operational fit within the programme. For example, inspection plans for essential SSCs have a contingency plan to repair any anticipated defects (resources, specifications, spare parts, etc.). This type of contingency plan will ensure that SSC downtime is minimized.

3.4. MAINTAIN THE PLANT

This section addresses the need for conformity between the physical configuration of SSCs not in service and documentation necessary for procurement, standby operation, maintenance and training activities.

Maintenance activities are conducted on SSCs that are out of service. When the SSCs are returned to service, they should be in the condition and state expected by the design and operating organizations. Similarly, materials that are procured and stored in the warehouse should be maintained in the expected condition.

Training materials and the plant simulator should be consistent with the physical configuration of the plant in order to be useful for training.

Typical examples of disruptions between physical configuration and FCD for maintenance, training and procurement can include labelling errors, maintenance errors that affect plant configuration and foreign material or loose parts in a plant system.

Some causes of these discrepancies are:

(a) Failure to follow maintenance procedures;
(b) Errors in maintenance procedures;
(c) Installation of inferior spares from inadequate procurement quality assurance (vendor qualification, receipt inspections, functional testing);
(d) Improper filling out of work order material requests by the warehouse;
(e) Incompatible parts substitutions without proper evaluation;
(f) Failure to update training materials or the simulator(s) in response to a modification.

3.4.1. Routine maintenance activities

Routine maintenance activities can lead to human errors due to complacency and failure to follow procedures because the activities are routine. This can present challenges to configuration management when components are not returned to their desired condition or state for operation.

Challenges include:

— Insufficient knowledge about SSCs close to the work site and their importance for nuclear safety, for example, fire doors, steam relief passage ways and leak detection systems.

— Foreign material exclusion (FME) — low awareness of the importance of ensuring that tools or any other foreign materials or components from remaining inside or having the potential to enter into fluid systems following maintenance activities. FME is the second most common source of configuration management-related nuclear power plant events, after SSC document inconsistency.

Advice on avoiding configuration management issues or restoring equilibrium

Management of operational chemical products used in maintenance should be carefully reviewed to avoid unapproved chemical use in the plant.

Maintenance personnel should have knowledge about the safety significant functions of the SCC to be worked on, and other essential SCCs in the work area.

The maintenance staff should ensure that the work is performed on the correct component (correct nuclear power plant unit, correct plant system, correct equipment train, etc.), at the correct time and using the correct instructions. SSCs important to safety could be specially marked or signed in the plant, and should be identified in the maintenance management system. Pre-job briefings and post-job briefings should be used to avoid misunderstandings before and after work are completed.

Daily status report and briefings of operating personnel on maintenance activities should be conducted at the end of each day (some plants prefer to do this in the morning during normal operation and have both morning and afternoon briefings during outages). Risk assessments should be performed on system and implementation conditions.

Additionally, maintenance personnel should:

— Adopt a questioning attitude with regard to all plant manoeuvres (see Section 4.4.3 for a more detailed discussion).
— Use STAR (stop-think-act-review) or a similar technique. They should also use clear communication techniques. Oral instructions should be minimized. If oral instructions are required, then attention to ensuring that verbal instructions given are clearly understood is paramount. The use of three way communications, use of phonetic alphabet, etc., may achieve this.
— Use conservative decision making when there is inadequate information or knowledge. They should apply good procedure adherence practices, and adequate procedures should be available to perform all operating manoeuvres. Writing guides should be used so that procedures are written in a consistent format and with accurate content. An electronic database facilitates use of the latest revision and associated links to other documentation.

Standardized, correct component verification (CCV) equipment tags should be applied to components so that they can be positively identified prior to starting work to ensure work is not performed on the wrong component. CCV tags should contain equipment ID and attribute information identical to that contained on design drawings and documents describing the equipment and related SSCs involved.

3.4.2. Replacement of components, reconstructions and repair

Replacement of a component by an equivalent component is a recognized maintenance activity. In this context, an equivalent component is either one that is identical with the original component or one for which a safety assessment has previously been made, in accordance with the procedure for control of modifications, to confirm that it is considered to be an equivalent replacement for the original component.

Some typical challenges with repair and replacement of components include:

— Replacement of a component that is, through analysis, procurement or stock issue error, not identical to the original one;
— QA from the supplier may not be consistent with design requirements. The challenge is to recognize whether a component is equivalent to the original;
— Repair is not done in accordance with an approved and qualified method, documented in a procedure.

Advice on avoiding configuration management issues or restoring equilibrium

— Use methods that are qualified or belong to an accredited programme;
— Use an effective, documented process for evaluating replacements to confirm that the component is equivalent, through procurement engineering methodologies such as item equivalency evaluation (IEE) or manufacturer/vendor catalogue part number analyses;
— Use the original manufacturer to carry out repair work, in accordance with plant approved methods and procedures.

3.4.3. Procurement of spares (vendor QA, receipt inspection, supervision of vendors)

Some typical issues regarding procurement of spares include the following:

— The supplier may promise more than he or she is capable of or willing to deliver;

— The supplier may confuse or misclassify parts in terms of qualification or the ASME code;
— The supplier may modify components (or just change the part stock code) without informing the plant;
— It is sometimes difficult to get the original specification of requirements on components.

Advice on avoiding configuration management issues or restoring equilibrium:

— Develop partnership arrangements with suppliers and verify that they have acceptable processes for assuring quality and supervision during manufacturing of components;
— Adhere to well controlled manufacturing standards;
— Use agreed system for approving manufacturers according to country specific requirements.

3.4.4. Maintenance of spare parts

SSCs that are stored for extended periods of time may degrade while in storage. Vendors usually provide recommended storage requirements for the SSCs they supply. These may include environmental requirements such as for temperature and humidity. Vendors may also specify in-storage inspection and maintenance instructions for periodic lubrication or periodic shaft rotation for rotating mechanical or electrical equipment.

For equipment that is environmentally qualified, it is important to track the qualified life of such SSCs even during storage prior to installation in the facility, and discard or downgrade the items that have exceeded their ‘by-date’, or can no longer meet in-plant service life requirements. Environmentally qualified components may have special maintenance requirements specified by the manufacturer and may need to be maintained at specific intervals to replace items such as gaskets, and O-rings to maintain their ability to function in harsh environments.

Advice on avoiding configuration management issues or restoring equilibrium

Some plants buy spare parts especially for an upcoming outage, so that fresh materials are used:

— Storage of equipment should be controlled to meet or exceed vendor requirements;

— Create partnerships with manufacturers so that they will store special spare parts;.
— Establish an effective spare parts maintenance programme.

3.4.5. Foreign material exclusion (FME)

Some typical issues regarding FME include the following: SSCs can be made unavailable due to the ingress or non-removal of foreign material. There may not be any adequate procedures and precautions to prevent ingress of foreign material or to remove temporary blank plates or orifice plates. FME also applies to the exclusion of aggressive chemicals in systems, such as use of materials containing chlorides in stainless steel systems.

Advice on avoiding configuration management issues or restoring equilibrium

— Prevent foreign bodies in plant systems as a part of the planning phase of an outage. For example, blanking plates are made up prior to the outage to be available as soon as the containment, vessel, pipe, etc., has been exposed.
— Prevent loose materials by using adequate containers to store small items while maintenance work is in progress. Place suitable sheeting around the work area to act a second line of defence where work on or around gratings is required.
— Clear plastic should not be used as it can contribute to the likelihood of undetected foreign material.
— Independently inspect SSCs before closing.
— Monitor and record all tools and materials taken into and out of work areas.
— Comprehensively describe the process for the removal of temporary blanking plates in return to service procedures.
— An open reporting culture is encouraged if the FME boundary has been breached in order to facilitate prompt recovery of the foreign materials.
— Recommissioning following outages, if not properly planned and coordinated, can prolong the time that essential SSCs are unavailable.

Advice on avoiding configuration management issues or restoring equilibrium

— Form a recommissioning team to revalidate SSCs before releasing them for duty. The recommissioning team should have clear lines of accountability for this task.
— Groups or individuals should be assigned responsibility for systems review work to provide a state of readiness report prior to start-up consent being sought.

— Work packages should be checked to ensure that they have been closed out properly.
— Operators should be trained on the effects of plant modifications, including procedure revisions.
— Maintenance surveillance tests, post-modification testing and post-maintenance testing should be performed correctly.

3.5. TEST THE PLANT

The objective of this configuration management principle is to ensure that the performance of SSCs meets design requirements.

During design of a plant, the assumed or published performance of SSCs is documented in design documentation as allowable performance values, with appropriate margins to allow for plant ageing and other factors. During initial commissioning of a plant, the baseline performance is established through testing to confirm that the actual performance meets or exceeds the performance assumed in the design. Active SSCs usually require some form of maintenance intervention many times before the end of their service life. Passive SSCs such as pressure boundaries, cables and structures are subjected to ageing management programmes to monitor their ability to reach the end of their service life with adequate safety margin still remaining.

Disruptions between physical configuration and design requirements are typically represented by the failure of SSCs to meet their specified performance criteria as designed, equipment out of tolerance or unexpected degradation in performance of SSCs.

Some causes of these disruptions are:

— Inadequate performance testing programmes, including surveillance testing;
— Inadequate plant ageing programmes.

3.5.1. Surveillance and in-service inspections

The primary objective is to identify potential changes in material structure and function that would affect the ability of SSCs to meet their design requirements.

The purpose of surveillance and in-service inspections is to identify when measured parameters of SSCs begin to approach design limits in time to take remedial action. If the measured parameters are just within acceptable limits, it is important that any judgements made are based on expert analysis and earlier

experience. Many nuclear power plant surveillance and in-service inspection items are programmatic in nature, such as 'ASME XI, Motor Operated Valve, Primary Relief Valve', and other programmes that increase awareness of components or piping that may age and potentially fail prematurely based on operating experience and new knowledge from vendors.

Advice on avoiding configuration management issues or restoring equilibrium

— Use the knowledge and experience from previous surveillance tests and in-service inspections in decision making, for example, trending and comparison of results;
— Benchmark with other facilities to anticipate trends.

3.5.2. Ageing effects

Potential issues of configuration management related to fatigue could arise if the number of thermal transients experienced exceeds those assumed in the design analyses. A major reason for in-service inspection and surveillance programmes is intended to warn of excessive wear and ageing in time. Environmentally qualified equipment is monitored to ensure that it does not exceed its qualified life. Erosion and corrosion present challenges to the facility configuration and personnel safety. Issues associated with corrosion of the reactor vessel head have recently highlighted these challenges.

The effects of piping erosion and corrosion, including external corrosion, may not have been adequately accounted for in the original design. Piping wall thinning may exceed the design limit.

Advice on avoiding configuration management issues or restoring equilibrium

Mechanical fatigue is a design consideration that could go unrecognized and, consequently, uncontrolled by facility staff. The facility should monitor thermal transients or install instrumentation to monitor thermal cycles at critical locations to ensure that the cumulative usage factors specified in the design analysis, which provide the bases for the allowable stresses of primary coolant components, are not exceeded during plant operation.

Regular analysis of the transients should be performed to reflect real margins and to give a forecast for future periods of operation.

Equipment qualified to function in a harsh environment such as at conditions of extreme temperature, humidity and high radiation (environmental qualification) has a prescribed qualified life determined by the vendor. Exceeding the qualified life may result in the equipment not being able to perform its design

function (for example, dried out seals, gaskets or O-rings, loss of cables insulation or risk of non ductile failure). The qualified life of such equipment should be controlled and maintenance should be performed at prescribed intervals to assure conformance to the design requirements of the SSCs. A preventive maintenance programme or replacement programme based on a preventive maintenance approach should be implemented.

Programmes may be developed and implemented to identify SSCs that are susceptible to degradation by erosion and corrosion effects from both internal mechanisms and the external environment, and to check for initial indication and development of advanced corrosion/erosion.

A good erosion and corrosion programme identifies the piping that is susceptible to erosion and/or corrosion, mainly through pipe bend erosion and the Reynolds effect. Wall thickness should be measured periodically and tracked to detect any trend to wall thinning. Affected piping should be replaced well before the wall thickness approaches its design limit.

4. ORGANIZATIONAL AND HUMAN FACTOR IMPACTS ON CONFIGURATION MANAGEMENT

The human factors have been separated from the technical aspects in this report because human errors can be root causes to almost all issues described in Section 3.

The safety of every nuclear power plant relies on human activity. Power plants are operated and maintained by people other than the designers and original producers of the plant technology. Moreover, during long term power plant operation there is a potential risk that the original design organization and/or suppliers of components will disappear or change their delivery profile.

Hypothetically, if the plant SSCs are absolutely reliable and resistant to performance degradation effects, no maintenance would be needed. If there are no changes to regulatory requirements or identified improvements to plant design, the plant design documentation (and the plant itself) would remain unchanged during the plant lifetime. Even then the presence of humans needed to operate the plant equipment would offer challenges to the operational configuration.

In reality, plant maintenance and testing will be performed throughout the plant lifetime to monitor and trend plant performance. Changes to the operational configuration will be needed to operate the plant and changes to the plant design

configuration will be needed to accommodate the evolving technology, economic conditions, regulatory requirements and plant safety improvements. Humans will perform these activities and there will be additional challenges to configuration management due to such factors as:

— Varying levels of experience and training of personnel;
— Human error due to social, psychological, ergonomic or environmental factors;
— Human errors due to insufficient information both about the plant design basis and the actual status of SSCs;
— Inconsistencies in adherence to plant safety culture;
— Loss of knowledge and experience through retirement and transfers.

This section addresses some of these issues. Each subsection first states the potential issue and then provides advice on avoiding or addressing the issue. Relevant recommendations contained in Ref. [18] applicable to configuration management aspects for each following section are set out in the appendix.

4.1. IMPACT OF KNOWLEDGE MANAGEMENT ON CONFIGURATION MANAGEMENT

An objective of configuration management is to document the design and operational configuration in the FCD, but much of the information needed to design, operate and maintain a nuclear power plant is undocumented. This is known as ‘tacit knowledge’ and has also been referred to as ‘hidden knowledge’ or ‘tribal knowledge’. As personnel retire or transfer to other jobs, this undocumented knowledge can be diluted or lost. This is relevant not only for the staff of the nuclear power plant, but also for the architect-engineer, the designers of the power plant’s systems, and suppliers of components (not only main components such as the reactor vessel, turbine generator, reactor coolant pumps, etc.). During the lifetime of the nuclear power plant, many suppliers may go out of business or change delivery profile, deliver new technology (e.g. I&C) or no longer have specialists who are familiar with the originally supplied technology. Therefore, the transfer of knowledge from supplier to operator or to its long term TSO, including ‘know-why’ is needed. Also, architect-engineer organizations lose specialists who are familiar with the design basis. Therefore, design basis knowledge at the appropriate level in written form must become a nuclear power plant’s ‘property’ and be properly interpreted in the modification approval process by experienced senior engineers to avoid misinterpretation.

4.1.1. Transfer of knowledge

Issue

A new engineer replaces another one who has spent many years in the same position and finds a full cupboard of files and records. Even if they have been correctly sorted, it is very difficult for the new engineer to find data that have originated many years ago.

Advice on avoiding configuration management issues or addressing issue

The utility can obtain supporting information for design from the original system designer.

Use electronic databases and information technology management systems, entering all information necessary for sorting and analysis. A good system is one that can be used correctly both by people entering information and by people using the information.

To capture undocumented information:

— Identify key competencies and information;
— Identify the holders or owners of valuable undocumented knowledge and motivate them to share or document it;
— Establish pre-retirement programmes where an experienced expert is given time with another employee or employees to transfer undocumented knowledge;
— Build a culture of trust and collaboration;
— Decide whether useful information needs to be controlled;
— Decide how to organize the data and where to store it;
— Build systems and populate with data;
— Train people on how to find information;
— Use new operators to walkdown systems and confirm as-built plant configuration as part of their initial training;
— Refer to documents from which information is taken in order to give an easy possibility to check that it has not been modified by a new revision;
— Implement an effective document control system so that everyone has access to the same information;
— Use an efficient archive centre where all design documentation from design bases to detailed documents, including justifications, is stored, easily accessible by the information management system and correctly protected against fire, flooding and earthquakes.

4.1.2. Transfer of technical and organizational knowledge ('know-why')

Issue

Plant design changes are implemented without documentation of the basis for selecting a particular design from several available options.

A core knowledge of design basis information might not be available at the plant, especially if the plant has been supported from the beginning of its operation by the original vendors, architect-engineer, etc. Therefore, the technical knowledge of the staff might be limited.

Advice on avoiding or addressing configuration management issues

— For any design changes, describe the different options considered and the reason(s) why other options were rejected.
— In each modification file, describe the historic context including the originating event(s) and describe the analysis of alternative solutions studied, with advantages and disadvantages of each proposed solution.
— Due to social or commercial developments in the area of nuclear power, the original engineering support may be weak and/or its quality may change. In such cases, the early establishment of plant engineering or external TSO is necessary, to save and maintain design basis information. The existence of the internal (utility) or external (TSO) design authority with the capability of the original architect-engineer is essential during the entire plant lifetime.

4.1.3. Staff's personal databases and experience

Frequently, some people use their own notes, schemes and remarks to facilitate their job performance. Instrumentation and control experts or other specialists need more detailed information or documents with a structure or contents that are different from ordinary plant documentation. Some people are willing to maintain their indispensability and image, and therefore have a tendency to keep some core information only for themselves.

Information that is documented only in personal databases may be lost if nothing is done to transfer it to an accessible database.

Advice on avoiding configuration management issues or restoring equilibrium

— Enforce the QA and safety culture principles to write procedures on necessary activities.
— Use post-job briefing practices to capture and document job knowledge.

— Support team spirit among staff.
— Create joint teams consisting of both experienced and young engineers for complex projects such as reconstruction or periodic safety reviews.
— Transfer to official or enterprise technology databases all the information that could be useful in the future and periodically check that this procedure has been followed. This makes the data available to the plant or owner/utility.
— Use mentoring to transfer tacit knowledge from experienced personnel to less experienced personnel.
— Organize a debriefing of undocumented knowledge of people leaving their position (including retirement). Asking a sample of newcomers for their expectations helps to build the debriefing procedure.
— Establish joint teams consisting of experienced people and young engineers to solve some problems or to develop new projects. Retired engineers in particular may have strong motivation to support their former company.
— The design authority, as the owner of the design basis, should identify and capture sources of volatile knowledge and develop ways to systematically retain critical undocumented knowledge.

4.2. IMPACT OF COMMON HUMAN ERRORS ON CONFIGURATION MANAGEMENT

Human error is usually blamed for failures in operational configuration where a component is moved to the wrong position or when is manipulated on the wrong system, wrong unit or wrong train. Root cause evaluation of such human errors usually uncovered a process shortcoming or a process barrier that can be enhanced. Below are some examples of good practices to prevent such line-up errors.

In the case of maintenance or testing of the safety systems, personnel designate the affected equipment as non-operating, e.g. de-energize the pumps or valves or change the position of valves. It is necessary to set all equipment to the correct operational position after work is finished. A key management system needs to be established for handling and controlling all keys for hand operated valves in safety related systems. Position indicators with alarms for wrong positions of hand operated valves, which are not controlled by the above-mentioned key management system, are installed in safety related systems.

A formal process should be used for implementing standard working packages for periodic preventive maintenance activities, whether paper or task management system based. A checklist should be added to the shift logbook to

ensure that the required information transfer between shift groups is recorded. Both shift supervisors should sign this checklist.

FME — Foreign objects and material are a major source of configuration management discrepancies and can be nearly always traced to human factors. Procedures should be established, FME supervisors selected and checkpoints set up at major work locations in the plant. Training should be conducted and awareness of FME increased for all maintenance and plant personnel.

Special checklists should be created for all personnel involved in the preparation of the safety system. For example, checklists can be used by the field operator to check the actual valve position, by the electrical foreman to energize or de-energize equipment, by an I&C foreman to set actuating systems and by the reactor operator for the successful test of the whole system. The checklist can be completed after every test or system tie-in and is also the certificate of system preparedness.

For startup of the power plant after an outage, detailed checklists can be implemented into the startup procedures. The operability of every system can be checked and/or verified by system checks and/or individual tests. In general, the time when a safety related system is operable depends on the actual plant conditions (e.g. some systems are operable before starting heating-up of the reactor coolant system; other systems or trains before increasing system temperature above a certain limit). Before starting to go critical, tests should be performed to confirm that all systems are operable.

After maintenance activities on safety related systems, system checks and functional tests should be performed to verify operability. For the functional tests, existing test procedures (e.g. for periodic testing) are used. All system checks and tests should be specified during the planning phase of the working package.

4.2.1. Impact of long term routine work

Issue

Repeated performance of the same task could become routine and lead to procedure non-conformance and errors.

Loss of motivation to learn and update knowledge may be the result of the ageing of staff and/or monotonous work.

Advice on avoiding or addressing configuration management issues

— Use job rotation and career moves to increase the number of people who can perform a task.

— Introduce ‘ergonomic and fitness for duty’ training in human resources management in order to allow managers to use methods adapted to detect potential risks of monotonous and routine work.
— Implement QA tools and methods to ensure correct performance of the activity, both manual (maintenance, operation, line-up setting) and intellectual (calculations, justification of data, etc.).

4.2.2. Organizational and personnel changes

Issue

The need to change the organization or to replace retired colleagues may lead to inappropriate personnel changes. Major organizational changes and staff reduction programmes may lead to some important configuration information being lost due to the lack of evaluation on where the knowledge is before the changes and after.

Advice on avoiding or addressing issues

— Use personnel policies that allow increased reward for technical capability or special knowledge, rather than promoting staff to management positions.
— Very carefully implement changes to the existing organization, taking into account the accommodation of people into the functional system. Also, it is very important to recognize key competencies in their area of responsibility in order to avoid affecting plant performance or safety.
— Key knowledge centres have to be recognized before the major organizational changes or staff reduction programmes. Knowledge transfer should be controlled during the changes and checked after completed changes.

4.3. IMPACT OF INFORMATION MANAGEMENT SYSTEMS ON CONFIGURATION MANAGEMENT

4.3.1. Information system and document control system

Issues

— Inefficiency, with potential risk of errors, may be caused by a lack of rapid access to correct information;
— Loss of documents can lead to loss of knowledge;

— People may use incorrect information if its access is more convenient than the correct information;
— Unauthorized drawings can lead to errors in their interpretation;
— Errors in drawing updates or poor visibility after many revisions can lead to design, operating and maintenance mistakes;
— Document inconsistencies may result if all documents affected by a modification are not identified;
— Inadequate control of software changes can result in loss or inappropriate use of data.

Advice on avoiding or addressing issues

— Protect all data (hard copy or electronic version) is essential to avoid the risk of loss or damage of configuration management information.
— Keep paper documentation in good condition to avoid misinterpretation.
— Maintain a functional computerized information system is important, even if the plant age makes it impractical to automate all documentation.
— Ensure that information systems allow easy access, without the need for specialized computer knowledge. Testing information systems on a sample of the different potential users helps to identify the necessary simplifications.
— Use computer based task management systems, since they are useful tools to support operating and maintenance processes in the power plant. They also help to ensure that these processes are performed and continuously controlled in accordance with procedures.
— Use a task monitoring system that integrates all tasks and corrective actions important for the safe and reliable operation of the plant into one application. It is essential that all stakeholders have access to the system. The application owner monitors the system and provides monthly status reports to the plant management.
— Elaborate a system of documentation control dealing with all these aspects.
— Reconstitute only one part of a drawing/diagram when possible to reduce CADD or drawing drafting burden and limit the need for document verification to a minimum.
— Take the opportunity of reconstitution to verify the consistency with the physical state or other parts of the design,
— Perform walkdowns to verify consistency with the physical state of installation before and after modifications.

Issue

Consistency of documentation, especially drawings, diagrams, parts lists, and equipment lists, can be improved with electronic documents.

Advice on avoiding issues or restoring equilibrium

— Use fully computerized document control systems for the design of new plants, being aware that there are limits for some contractors.
— Use electronic tools for modifications of already computerized documents so that all the document revisions can be tracked and accessed.
— Use electronic tools when upgrading documentation. This can also allow consistency verifications to be more easily carried out.

4.3.2. Management of data

Issue

Using wrong data (not correctly introduced, or not updated) can lead to safety events. For example, when starting a procedure modification study, a set point value for a steam generator discharge valves was copied manually from a database. An engineer participating in the study recalled that this set point had been changed three years before. However, a QA system did not exist at that time in that plant, and the common reaction was, "Everybody knows that."

Advice on avoiding or addressing issues

— Have procedures to include updating of data each time one is modified.
— Develop the safety culture of all involved staff.
— Use a computerized data system and update the data each time it is modified, either permanently or temporarily. Use designations to distinguish temporary modifications.

4.4. IMPACT OF SAFETY CULTURE ON CONFIGURATION MANAGEMENT

Without an appropriate safety culture, there is a great risk that the actions will not be performed correctly. A strong safety culture is crucial to promoting a configuration management environment. The safety culture is based on a combination of norms, values, and standards of acceptable behaviour. These are

aimed at maintaining a self-disciplined approach to the enhancement of configuration management beyond legislative and regulatory requirements. Paragraph 2.36 of Ref. [18] provides a detailed list of important attributes for a strong safety culture.

In order to ensure effectiveness of the configuration management process, it is recommended that a safety culture be evaluated according to an appropriate model. Section 6.4 of Ref. [16] provides such a model.

4.4.1. Verification that all activities are performed in due time

Issue

The primary objective is to avoid human error due to factors such as routine work, time pressure, distractive environment or first time evolutions.

If operational or training documentation is not updated in due time, errors could result in equipment damage, personnel injury or regulatory violation.

Advice on avoiding or addressing issues

Review and verification is introduced in procedures using the relevant and necessary steps at different levels:

(a) Self-assessment;
(b) Peer check;
(c) Verification by supervisor;
(d) Independent review by external organization;
(e) Involvement by the regulatory body, if required;
(f) Verification is necessary at all levels:
    - Design versus design basis;
    - Physical state versus design;
    - Operating/maintenance procedures versus design;
    - Training material (including simulator) versus physical state.

4.4.2. Self-checking

Issue

Self-checking is the primary method for verifying that an action was performed appropriately.

Advice on avoiding issues or restoring configuration management equilibrium

— Each action, whatever the subject is checked by the person responsible for the action.
— The following practices have been successfully used.
  • Implement a behaviour safety programme, for example, a job observation process by peers. Observers are expected to carry out 1–2 job observations each month using a standard check sheet and give feedback to identify any unsafe behaviour.
  • Raise awareness using a performance observation programme — an established process for monitoring work performance.
  • Develop a STAR (stop–think–act–review) concept.
  • Use clear communication techniques.
  • Use self-evaluations to identify strengths and weaknesses.

4.4.3. Questioning attitude

Issue

Lack of a questioning attitude could lead to:

— Not considering better ways or solutions;
— Not taking into account the evolution of knowledge, including the potential danger of what was admitted as good;
— Performing wrong actions;
— Not evaluating all the aspects of an action, especially as far as modifications are concerned, including the affect on all documentation, data and other information.

Advice on avoiding or addressing issues

— As part of safety culture, insist on the need for a questioning attitude.
— Introduce a questioning attitude for all engineering activities, including modification analysis, design and maintenance.
— Assess the effectiveness of safety culture when carrying out configuration management audits.
— Observe the actions of other units, plants, companies and contractors. Adopt good practices and learn from operating experience.
— Collaborate with partners and customers (internal or external).
— Collaborate with other teams and participate in working groups set up to evaluate the good practices of others.

5. IMPROVING CONFIGURATION MANAGEMENT

There is no prescriptive formula for improving configuration management. Each facility will have a different configuration management situation, and implementation or improvement plans will therefore differ in the overall concept as well as in the details. Several Member States have incorporated configuration management activities in their normal processes, and therefore there is a need to review the strengths of activities to assure that the equilibrium is in conformance, as well as checking the level of integration.

Relevant activities from the listing below should be incorporated into the implemented configuration management approach. After a review, appropriate improvements can be implemented. In starting the improvement process, the first step is to check the current situation of configuration management and to establish an adequate process to perform these functions. Prior to performing a configuration management assessment, it is helpful to identify activities important to configuration management in order to ensure that all relevant areas are addressed and to summarize the results. An example of a list of such activities from the USA is provided in Annex I.

Although the approaches to configuration management will be different depending on existing management systems and processes in the facility, some common characteristics and practices can be adopted in order to strengthen the chosen approach:

— Programme planning.

  To effectively achieve configuration management objectives, a plan can be developed or updated as a basis for more detailed improvement planning. The processes and personnel of the organization must address the linkage between design requirements, operation processes and maintenance requirements, and related information sources. This plan has to be reviewed periodically and, in particular, revised as a basis for the improvement process.

— Physical configuration scope criteria.

  The facility SSC to be included in the managed configuration must be identified. The scope of the SSC included in configuration management is based on the functions provided by the SSC, and the corresponding list has to be issued to the organization and maintained current.

— Facility configuration documentation scope criteria.

The FCD to be included in the managed configuration has to be identified. The scope is based on the SSC associated with the relevant documentation and the information needed to support the facility mission.

— Concepts and terminology.

Configuration management concepts, terminology and definitions, e.g. based on those provided in this Safety Report, should be established, maintained, improved and incorporated into existing administrative control procedures and management systems.

— Procedures.

An action plan and appropriate implementing and improving procedures should be issued that will support the configuration management criteria and intended practices.

— Assessments.

An assessment, for example by audits, has to be performed before acceptance of a configuration programme (or its revision) to ensure that the status of the facility complies with the design requirements and that the physical status of the facility is accurately reflected by the current configuration documents. Furthermore, the configuration management programme effectiveness has to be assessed and continuously improved based on the results of the assessments. Efforts should be made to take advantage of Operational Safety Assessment Review Team (OSART–IAEA) data, World Association of Nuclear Operators and other non-governmental organization (NGO) review missions to gain assessment experience outside of owner/utility or State regulator audits.

— Configuration management training.

Training programmes have to include modules on CM addressing CM concepts, terminology, procedures, practices and job specific competencies associated with configuration management to maintain knowledge and support improvement. Workers need to understand how their actions can impact station configuration management.

These practices may be adopted individually, but the most effective approach is to pursue a range of practices suitable to the needs of an organization to support development of a progressive configuration management environment.

For improving configuration management, a combination of a top down and bottom up approach is reasonable to take into account existing documentation and control systems, and to improve each system and its interfaces with other systems.

A comprehensive description of organizational responsibilities based on the principles of configuration management should be developed and integrated into policies and procedures. The description shall include details of all interfaces and transfer of responsibilities for the preparation and processing of documents and other configuration management related information.

It is important that the effectiveness of configuration management is measured through periodic assessments. For that purpose different types of assessment procedures are applicable. Examples for the assessment of the configuration management process are given below given.

Although the operating organization has the responsibility to establish and improve a proper configuration management, the regulator can encourage this activity providing guidance for implementation, improvement and review of the system regularly, among others, within periodic safety reviews. This supports plant internal reviews such as self-assessment or evaluation of performance indicators.

5.1. EVALUATING CONFIGURATION MANAGEMENT

5.1.1. Assessment of the configuration management process

Ideally, an assessment should include all three elements of the configuration management equilibrium diagram correlations (Fig. 1), together with a confirmation of the design requirements and the effectiveness of processes that return the plant to a state of equilibrium. For example, when comparing the actual physical configuration of an SSC against the design drawings (FCD), it is necessary at the same time to evaluate whether the design conforms to the design requirements and whether the performance meets the design requirements.

Programmatic assessments (design requirements)

The adequacy of processes and procedures to achieve the configuration management objectives (equilibrium) may be focused on all programmes that affect a particular SSC (‘vertical slice’), or focus on a single programme and its

effect on all SSCs (‘horizontal slice’). A technical review of design requirements and design bases adequacy should first be performed.

Example of possible methods

— Multiprofessional review teams of experienced engineers;
— Reviews and assessments of OSART, the World Association of Nuclear Operators (WANO) and the Institute of Nuclear Power Operations (INPO);
— Recalculation of the deterministic analysis;
— Regular update process of the final safety analysis report (FSAR);
— Periodic safety review.

Example of good practices

— Re-establish the design bases and design requirements for SSCs first if the design bases are not currently documented.

FCD assessment follow-up (between design requirements and FCD)

If systematic checks of FCD reveal discrepancies, appropriate corrective actions are developed to re-establish agreement between the design requirements and the FCD. Corrective actions include technical evaluations to determine whether the design requirements or the FCD need to be changed.

Example of possible methods

— Multi-professional review teams of experienced engineers;
— Systems engineer and Independent Safety Engineering Group (ISEG) review or reports;
— Use of fixed information structures for collecting the design requirements (templates).

Example of good practices

— Review of all FCD;
— Using computer based systems for preserving FCD.

Physical configuration assessment follow-up (between FCD and physical configuration status)

If walkdowns reveal substantive discrepancies, appropriate corrective actions are developed to re-establish agreement between the physical configuration and the FCD. Corrective actions include technical evaluations to determine whether the physical configuration or the FCD needs to be changed.

Example of possible methods

— Systematic walkdowns with a fixed schedule;
— Operating (normal) walkdowns — motivate people to observe the equipment and focus on correlation between physical configuration status and FCD;
— Checking of the actual equipment parameters.

Example of good practices

— Review of all facility piping and wiring with emphasis on correct marking of all equipment;
— On-line parameter monitoring by the experts to provide independent review of actual equipment status.

Periodic equipment performance monitoring (between design requirements and physical configuration)

Configuration managed SSCs are monitored periodically to verify that they are still capable of meeting their design requirements.

Example of possible methods

— Surveillance tests — evaluate the equipment status based on actual technical performance parameters;
— Checking of all real equipment parameters;
— Review and measure dimensions of constructions and position of any equipment.

Example of good practices

— Evaluate the results of the surveillance tests of equipment and take immediate corrective actions in the case of unsatisfactory results.

Use state of the art surveying techniques to verify the as-built configuration.

5.1.2. Self-assessments

The objective of configuration management self-assessments is to support identification of FCD needs and to measure how effectively configuration management objectives are established and maintained. Assessments are conducted at all stages of the facility life cycle in a systematic way whenever a potential significant issue related to configuration management is identified.

Assessments most often compare the elements of the configuration management equilibrium diagram (Fig. 1) to check the degree of compliance. For example, plant walkdowns examine the degree of compliance between design documentation and physical configuration, or calculations are reviewed to determine the degree of compliance between design documentation and design requirements. These assessments may focus on all programmes that affect a particular SSC (vertical slice), or focus on a single programme and its effect on all SSCs (horizontal slice). IAEA Safety Series No. NS-G-1.2 [5] provides guidance for assessment of the as-built design against the design requirements.

Self-assessments that examine processes that have an impact on configuration management including processes implemented in the plant are possible.

5.1.3. Performance indicators related to configuration management

Each plant should have a set of indicators to anticipate, address and resolve problems regarding configuration management performance. Many utilities select performance indicators that they have traditionally measured, which also align with configuration management principles.

To satisfy the full requirements of configuration management, it is important to measure the effectiveness of the process to identify the weak areas before they become unmanageable. The plant impact of configuration management non-conformances needs to be assessed and a prioritized improvement plan and strategies developed to re-establish the equilibrium.

The performance indicators (PIs) given below are good examples of indicators to track and trend the behaviour of plant configuration management:

— Number of undocumented plant changes (e.g. hand-made changes to documentation without an official procedure change form or proper approval are considered to be undocumented changes);
— Number and timeliness of temporary modifications installed, identifying those related to safety;

— Backlog of plant permanent modifications, identifying those related to safety;
— Backlog of pending documents (like the FSAR, procedures, etc.) to be revised or issued as a result of a plant modification already installed, either temporary modifications or permanent modifications;
— Number of technical specifications or alterations, pending action on issuance;
— Number of plant drawings not updated or waiting for revision;
— Tracking and trending of the number of events related to configuration management, whether significant or not;
— Tracking of number of differences between the facility configuration documentation and physical configuration (for example, incorrectly positioned valves; unlocked valves that should be locked in a set position, procedure errors, margin issues, errors in set points and labelling errors);
— Tracking of the backlog in procedures, mainly those related to safety, pending revision;
— Number of 'vetoed' alarms (i.e. removed from service) due to any reason other than an approved permanent modification;
— Number of engineering open items related to configuration management.

As in any other management process, to be successful, once the indicators have been selected, the following rules are recommended:

— For all of the configuration management performance indicators given above, clear and tangible goals should be established, based on self-assessment and benchmarking of the top performance plants.
— Configuration management performance indicators should be tracked and trended in regular intervals (e.g. monthly or quarterly).
— Goals and results of the performance indicators should be communicated to plant personnel at all levels.

Annex II provides information on the Configuration Management Benchmarking Group (CBMG) with regard to relevant performance indicators based on practices in the USA.

5.2. COMPUTERIZED TOOLS

Computer systems may provide access to key information from anywhere in the plant. In order to carry out their daily tasks and assignments, workers need to access reliable and available information and documents in real time and close

to their work station. Some plants have implemented a computer system that allows all workers in the plant to have access to any information from anywhere in the plant.

Reliable configuration management programmes typically rely on computerized tools such as:

— Databases for storage of design basis and plant configuration data;
— Software and databases supporting administrative procedures of configuration management;
— Software for design basis reconstitution and safety assessment.

The software used for the configuration management process must support and comply with the modification process. Some excerpts from IAEA safety standards publications applicable to the configuration management aspects of computerized tools are given in the Appendix.

The following information and documents should be made available on the local network system:

— Information about the structure of the documentation system of the plant;
— Catalogue and map to access plant documents;
— Information about the validation of the documents (list of new documents, modified or cancelled documents and list of documents which are available in electronic form);
— Working documents, including procedures in compliance with QA rules;
— Event reports;
— Decisions of the safety and regulatory authorities;
— List and access to normative documents (IAEA publications, national standards, etc.);
— Department commitment plans (contracts);
— Performance indicators and goals for the unit and all departments;
— Monthly reports on progress to achieving the goals;
— Technical information pertaining to the state of units in operation and/or units in outage;
— Meeting agendas, minutes and decisions made;
— Follow-up of commitments;
— Temporary operating instructions including writing review, electronic signature approval and issue;
— Policy document describing a high level of operational and quality communication for all workers.

5.3. REGULATORY ACTIVITIES

Although the operating organization has the responsibility to establish and improve a proper CM in order to run the plant safely, the regulator can encourage this activity providing guidance for implementation, improvement and review of the CM system.

The regulator may require that the licensee ensure that a management system is implemented to manage, control, evaluate and develop the facility's activities, and that the management system is designed in such a way that the requirements important to safety are met. Moreover, the management system has to be kept up to date. The application of the system and its effectiveness have to be assessed systematically and periodically, e.g. by an external audit, specific peer reviews or, on a longer term, within periodic safety reviews.

Since one principle of configuration management is to modify the plant, it is necessary to categorize modifications related to physical configuration by its safety significance. This categorization has to follow an established procedure. The procedure can be prescribed by the regulator or proposed by the operating organization and finally approved by the regulator. One example of such a categorization is provided in Ref. [11].

The required documentation of the modifications to be elaborated and — depending on the safety significance — to be submitted to the regulator must also be determined by the regulator.

The required documentation for modifications may be based on their safety significance. For modifications with a high impact on safety, the level of documentation may also be determined by the regulator.

The regulator should establish clear requirements to be verified during the modification process including the documentation updates, even in cases of modifications having no impact on safety.

5.4. STARTING A CONFIGURATION MANAGEMENT PROGRAMME FOR A NUCLEAR POWER PLANT

If a nuclear power plant or utility/owner has not considered or implemented a formal configuration management programme, the steps given below should be followed. The recommendations of this report may then be applied subsequently to the new plant configuration management programme to achieve the safety and operating benefits of comprehensive configuration management and design basis maintenance programmes.

The configuration management programme should start with the plant and/or management of the utility/owner making a commitment to the regulator

and owners. This comes in the form of a 'plant programme for configuration management', typically created as an addendum to the nuclear power plant 'quality assurance plan and programme' documents in a manner similar to other plant programmes for quality systems, procurement, design control, etc. This configuration management programme document should be approved by the plant's quality manager, the design authority (normally the plant engineering director or chief engineer), plant director, and other key plant and/or utility/owner management. The configuration management plant programme describes, in general terms, the authority, mandate, organization, procedures, management elements and execution plan for establishment and maintenance of plant configuration management.

Once the configuration management programme is established for the nuclear power plant or utility/owner, one or more high level (administrative or programme level) procedures should be written to implement the plant programme. This is the time that a position for the configuration management manager, and (optionally) a support organization for configuration management can be established. The configuration management manager is responsible for oversight of the programme and for interaction with other plant organizations to review business functions and processes in terms of configuration management, including design engineering, operations, maintenance, QA, procurement, document and quality records control, IT, etc. The configuration management manager also reviews new, revised and existing plant procedures and instructions for the impact of the configuration management programme, and makes recommendations to the plant and/or utility/owner management for issues related to configuration management and design basis maintenance, as well as interaction with national regulators, international organizations such as the IAEA and WANO, and external contractors and vendors doing business with the plant. The configuration management manager should be an individual who is respected, credible and well regarded at the plant to facilitate effective organizational interaction and advisement of diverse plant organizations and functions.

Once established, the configuration management manager, together with appropriate plant staff and management, should review and recommend enhancements for implementation of the configuration management and design basis procedures and requirements for each plant discipline and work activity. A review of the plant activities and elements associated with the traditional configuration management 'triangle' will aid in the identification, review and improvement of plant procedures. This review centres around those plant organizations whose responsibilities fall under:

— Design basis: Engineering design change processes and design basis maintenance and/or reconstitution.
— Physical configuration: Nuclear power plant equipment list and related components, parts and their design and manufacturer specifications.
— Document and quality records inventory: Document/records management, controlled plant documents, the design basis document (DBD) library and other documents related to safe plant operation.

This review of nuclear power plant processes and procedures in the context of configuration management will likely result in revisions to existing working level procedures, as well as to potential new procedures if it is intended to fully implement the configuration management programme and design basis maintenance throughout all plant processes and activities at the practical level. This includes procedures such as the master equipment list, engineering design change control, document control, quality records management, maintenance and work orders, procurement, spares inventory and catalogue, operations and physical plant control, quality assurance and action tracking programmes.

As mentioned in this section, the configuration management manager and programme will also require the development and implementation of management tools, such as key performance indicators (KPIs), to assess the effectiveness of programme implementation. In addition, one or more IT solutions will be needed to manage not only raw data for plant operation and engineering processes that support configuration management, but also those plant business processes and activities that use configuration management data and information. In addition, reviews, internal self-assessments, and formal audits should be conducted periodically, not only to assess the general quality and effectiveness of the plant configuration management programme, but as an aid in the identification of new processes, procedures, management tools and other improvements that may be made.

The establishment of a plant configuration management programme assumes that the following infrastructure and facilities, at a minimum, are in place and are operating:

— Complete, verified and documented design basis document library;
— Established engineering design change process controlling changes to equipment, controlled documents, components, parts, bills of material, etc.
— Document control system with revisions driven by engineering design change process.
— The creation of a master equipment list, its maintenance and validation process.

— Work management system controlling and providing history for scheduled maintenance, surveillance, predictive maintenance events, replacement spares, and component failure data.

6. CONCLUSIONS

The concept of configuration management is implemented in different ways in the nuclear industry. It is important to start and follow a chosen approach of configuration management for operating nuclear power plants.

For new plants, a configuration management process may be set up as early as possible (at the design stage). For existing plants, the configuration management process may be evaluated and systematically improved to achieve the desired characteristics described in this Safety Report.

For all plants, the following aspects should be emphasized in a high level policy document:

— The design bases and requirements for the plant should be established, documented and maintained. They should be actively maintained throughout the life of the plant.
— The scope of configuration information be identified and the information checked throughout the plant life.
— An effective change control process is essential, and should be established to maintain consistency among the physical configuration, the design requirements and the FCD contained in various information systems.
— When feasible, participation of the original designer in both the establishment of design requirements and the change process should be facilitated. Provision should be made to maintain a continuity of personnel knowledge and skills (design, maintenance and operation).
— The effectiveness and efficiency of configuration management processes should be assessed at all stages of the life of the plant.

Specific training in configuration management objectives and processes should be provided to all personnel to ensure that they can carry out their work effectively.

Appendix

EXTRACTS FROM IAEA SAFETY STANDARDS

This appendix contains extracts from selected IAEA Safety Standards publications that apply to configuration management. They are listed in order of the section in Sections 3, 4 and 5 to which they apply. References [1, 2] establish the fundamental safety principles and safety requirements.

A.1. APPLICATION OF CONFIGURATION MANAGEMENT (SECTION 3)

A.1.1. Configuration management aspects of design configuration (Section 3.1)

— "Adequate design information, including information on the design basis, should be available to provide for the safe operation and maintenance of the plant and to facilitate plant modifications." (Ref. [6], para. 4.11)
— "In general, adequate documentation of the design basis and of probabilistic safety assessment (PSA) is needed for a PSR." (Ref. [6], para. 3.5)
— "A PSR should ensure that all significant documentation relating to the original design basis has been obtained, securely stored and updated to reflect all the modifications made to the plant and procedures since its commissioning. This is of particular importance for plants that have undergone many modifications over their lifetime and those for which record keeping has been less than satisfactory. Recommendations on meeting the requirements for document control are presented in Safety Guide Q3 on Document Control and Records." (Ref. [6], para. 4.13)
— "The factors to be considered in determining the structure of the operating organization and its staffing requirements for a nuclear power programme should include… (1) the need to ensure that structures, systems and components important to safety remain in accordance with the design assumptions and intent;… (5) the necessity for design, construction, operation and modifications to be thoroughly analysed and reviewed with the aim of ensuring safety." (Ref. [3], para. 2.9)
— "The safety analysis should establish the conditions and limitations for safe operation. This would include items such as:

- Safety limits for reactor protection and control and other engineered safety systems;
- Operational limits and reference settings for the control system;
- Procedural constraints for operational control of processes;
- Identification of the allowable operating configurations." (Ref. [5], para. 4.54)

— "In addition to the design requirements that are established for the purpose of ensuring subcriticality, an analysis should be undertaken for all operational states and in conditions during and following design basis accidents to demonstrate that a critical configuration will not be formed." (Ref. [10], para. 5.9)

— "The (core) design should include an analysis of fuel storage facilities which demonstrates that the entire system can always be maintained in a sub critical condition under all possible (normal and abnormal) configurations." (Ref. [10], para. 4.4)

— "The PSA should set out to determine all significant contributors to risk from the plant and should evaluate the extent to which the design of the overall system configuration is well balanced, there are no risk outliers and the design meets basic probabilistic targets." (Ref. [5], para. 4.20)

— "The PSA should be used during the lifetime of the plant to provide an input into the decision making process. During the operating lifetime of a nuclear power plant, modifications are often made to the design of safety systems or to the way the plant is operated, as for instance a change in plant configuration during maintenance and testing. These modifications could have an impact on the level of risk of the plant". (Ref. [5], para. 4.212)

— "As a consequence of plant operations, burnup and refuelling, the core reactivity changes. This necessitates movements or changes in the configuration of the reactivity control devices that affect the power distribution." (Ref. [13], para. 2.5)

A.1.2. Configuration management aspects of revised or undocumented design basis (Section 3.1.1)

— "The PSR should be conducted typically every ten years and its duration should not exceed three years…. (In general, adequate documentation of the design basis and of probabilistic safety assessment (PSA) is needed for a PSR. If such documentation is not readily available and a major effort would be necessary to obtain it, consideration should be given to obtaining it by means of projects separate from the PSR.)." (Ref. [6], para. 3.5)

A.1.3. Configuration management aspects of cumulative effects of changes (Section 3.1.2)

— "Particular care should be taken and procedures should be put in place to avoid two or more potentially conflicting modifications being designed and undertaken coincidentally on the same part of the plant or on interrelated parts of the plant. This means that master drawings, safety analysis reports and procedures should be subject to rigorous controls. Design requests should be routed through the controlling organization and they should track any proposal that affects part of the plant or plant processes until it is fully implemented or formally abandoned. There should be a way of advising others at the plant who may wish to modify the plant or plant processes of the need to coordinate the activities." (Ref. [11], para. 4.29)

A.1.4. Configuration management aspects of engineering change control (Section 3.2)

— "The detailed design of modifications should specify requirements for construction, installation, commissioning, equipment qualification, testing, including test acceptance criteria, and maintenance during operation." (Ref. [11], para. 4.17)
— "Attention should be paid to the interrelationships between modifications. In addition, when modifications are made to structures, systems and components and process software, the relevant operating instructions and procedures should be modified accordingly." (Ref. [11], para. 4.27)
— "A procedure to ensure the proper design, review, control and implementation of all permanent and temporary modifications. This procedure should ensure that the plant's design basis is maintained, limits and conditions are observed, and applicable codes and standards are met." (Ref. [3], para. 6.72)
— Before a modification is put into operation, the following should be ensured:
  • "All the documentation affected by the plant modification, such as the safety analysis report, operational limits and conditions, drawings, operating and emergency procedures, periodic maintenance and testing procedures, and equipment indexes (commonly used for system operation, tagouts and maintenance) have been updated and are available. Documents should not be released for use until the modification has been completed.

- The as-built configuration of modified systems has been verified and the design basis document has been updated.
- Personnel have been trained on the modifications.
- Records for design, commissioning, quality assurance, testing and installation have been reviewed for completeness and accuracy." (Ref. [11], para. 7.16)

— "Putting modifications into operation should be under the control of the management and should be conducted in accordance with the procedures governing the entire modification process. Putting modifications into the operational state is the final stage of the modification process." (Ref. [11], para. 7.14)

— "To ensure reliable configuration control after implementation of the modification, the status of other design modifications should also be reviewed, because a modification may have been based on the assumption that an earlier proposed modification had already been implemented." (Ref. [11], para. 7.15)

— "The completion of the modification should include a check that all temporary connections, procedures and arrangements used in making the modification have been removed or cancelled and that the plant has been returned to full operational status." (Ref. [11], para. 7.17)

— "Arrangements should be made for the verification and validation of any changes to procedures, operational limits and conditions and process software, and this should be done in the commissioning phase." (Ref. [11], para. 7.10)

— "The ability to operate the modified plant safely should be verified through a testing programme which…, should be aimed at demonstrating that modifications meet their design specifications." (Ref. [11], para. 7.8)

— "Tests should be planned as part of the initial design of the modification. Acceptance tests should include specific acceptance criteria based on performance criteria and testing requirements specified as part of the modification process." (Ref. [11], para. 7.9)

— "…retraining specifically describes training…required because of a major modification to the existing plant or to plant operation, the installation of a new plant or a change of job." (Ref. [15], para. 4.22)

— "There may be cases where a change in the training programme (or modification of the plant reference simulator) would be appropriate before modification of the plant or of a plant procedure in order to provide adequate training for operations personnel. Training programmes should be reviewed and training needs determined for any plant modifications or changes." (Ref. [15], para. 5.38)

— "A system should be established which routinely provides information to the training unit on proposed plant modifications or changes in plant procedures, so as to allow for an appropriate follow-up action. This is particularly important in relation to simulator training. The time needed to modify simulator hardware and software can be significant; hence, an effective system should be in place for the transfer of information on approved proposals and details of the subsequent implementation, if timely training is to be provided." (Ref. [15], para. 5.39)
— "Consideration should be given to the need to revise procedures, training and provisions for plant simulators as part of the implementation of the modification. Revised procedures and training may include operating procedures for normal operation, emergency operating procedures, maintenance procedures and testing procedures. These supporting actions will need close communication and coordination among the staff for design, engineering, operation, maintenance and training to ensure that all necessary supporting actions have been effectively completed in order to ensure safe operation with the effected modification." (Ref. [11], para. 4.28)

A.1.5. Configuration management aspects of conformance of FCD to design requirements (Section 3.2.1)

— "Throughout the design process, from conception to operation, in any iteration, control should be exercised over any proposed modification, so that the configuration of the design is being managed." (Ref. [9], para. 7.5)
— "Requests for modification should be evaluated on the basis of their impact on plant safety and reliability, plant operation and performance, personnel safety and the fulfilment of regulatory requirements. Considerations should include the need for training upgrades and associated hardware." (Ref. [3], para. 6.73)
— "The modifications should, whenever possible, minimize the deviations from the characteristics and intent of the design. When such deviations are inevitable, they should be evaluated against the safety requirements for design…and should be shown to be acceptable. It should be ensured that, once established, the corrected design requirements are justified and maintained and made available to all parties (operators, contractors, regulators) involved in the implementation of the modification." (Ref. [11], para. 4.16)

— "Modifications relating to plant configuration should conform to the provisions set forth in the safety requirements for design …and the associated Safety Guides. In particular, the capability of performing all safety functions shall not be degraded." (Ref. [11], para. 4.18)

A.1.6. Configuration management aspects of temporary modifications (Section 3.2.3)

— "Implementation of MS&I often calls for a temporary change in the plant configuration required for normal operating conditions. In such cases the risks associated with a particular plant configuration should be assessed and the conditions for safe implementation specified prior to the performance of MS&I." (Ref. [14], para. 4.24)
— "Any necessary precautions and restraints on operation with temporary configurations or conditions should be clearly specified to all relevant personnel, and training should be carried out if necessary." (Ref. [14], para. 4.29)
— "Temporary changes to procedures should be properly controlled and should be subject to appropriate review and approval. Such temporary changes should be promptly incorporated into permanent revisions where appropriate, in order to limit the number of temporary procedures and their durations." (Ref. [14], para. 4.28)
— "The factors to be taken into account in developing administrative controls and procedures applicable to MS&I should include…control of the plant configuration." (Ref. [14], para. 4.26)
— "Completion of any MS&I activity should include a verification that all temporary connections, procedures and arrangements that were necessary for its implementation have been removed or cancelled and the plant has been returned to fully operational status." (Ref. [14], para. 5.30)

A.1.7. Configuration management aspects of operational configuration control (Section 3.3)

— "The operating organization should provide for the development of operating instructions and procedures that…are in accordance with design assumptions and intent." (Ref. [3], para. 6.26)
— "A records administration and documentation system should be established to ensure the appropriate keeping of all documents relevant to the safe and reliable operation of the plant, including design documents, commissioning documents, and documents relating to the operational history of the plant as well as general and specific procedures." (Ref. [3], para. 6.76)

— "An important element of safety culture is that employees should have confidence in procedures and use them correctly." (Ref. [16], para. 7.1.2.3)
— "Control room operating personnel are directly responsible for safe operation of the plant, including its continued configuration control." (Ref. [14], para. 4.9)
— "There should be strict control of core discharge, reload, shuffle or on-load refuelling, and all core alterations should comply with predicted configurations. Throughout such changes, core reactivity should be monitored to prevent an inadvertent criticality and all fuel movements should be in accordance with detailed, approved procedures. Intermediate fuel patterns should be no more reactive than the most reactive configuration considered and approved in the design … There should be a method of checking that fuel movements would not be in conflict with each other, and it should be possible to track back the actual fuel movements made if necessary." (Ref. [13], para. 2.43)
— "Checks should be performed after a reload to provide assurance that the core has been correctly constituted. In addition, physics tests should be performed before or during start-up after each reload to verify the constitution and characteristics of the core, and control rod reactivity worths and boron worths throughout their operating range." (Ref. [13], para. 2.52)
— "For off-load refuelled reactors, prerequisites for ensuring that a critical configuration is not formed during fuel loading." (Ref. [13], para. 4.18)
— "Typical records important to core management and handling of fuel and core components should include…" (Ref. [13], para. 9.3)

A.1.8. Configuration management aspects of operations (Section 3.3.2)

— "Methods of configuration management should be used when modifying Operational Limits and Conditions (OLCs) or OPs to ensure that other documents remain consistent with the modified OLCs and OPs. In particular, there should be a mechanism to track from the safety analysis through the OLCs to the implementing procedures, in order to aid configuration control and to avoid the accidental deletion or retention of an OLC or its accidental application." (Ref. [4], para. 10.4)
— "All plant modifications should be reviewed to determine whether they necessitate modifications to the OLCs." (Ref. [4], para. 3.13)

— "When it is necessary to modify OLCs on a temporary basis, for example to perform physics tests on a new core, particular care should be taken to ensure that the effects of the change are analysed, and the modified state, although temporary, necessitates at least the same level of assessment and approval as a permanent modification." (Ref. [4], para. 3.14)
— "The OPs should be periodically reviewed to ensure that they remain fit for their purpose and if necessary the procedures should be modified, verified, validated and approved, as required." (Ref. [4], para. 8.7)

A.1.9. Configuration management aspects of outages (Section 3.3.3)

— "In view of the number and diversity of activities carried out during the shutdown period, the plant management should pay special attention to the plant configuration." (Ref. [14], para. 7.3).
— "Particular attention should be paid to assessing core conditions following startup, on-load refuelling and shutdown to ensure that: Reactivity and control rod configurations are correct…" (Ref. [13], para. 2.18).

A.1.10. Configuration management aspects of SSCs not in service and applicable to standby operation, maintenance, procurement and training activities (Section 3.4)

— "For all MS&I activities, a good interface control system should be in place…with clear arrangements for the maintenance of configuration control to ensure plant safety during and after the contracted work." (Ref. [14], para. 3.12)
— "Preventive maintenance should be of such a frequency and extent as to ensure that the levels of reliability and functionality of the plant's SSCs important to safety remain in accordance with the design assumptions and intent." (Ref. [14], para. 8.4)
— "A procedure should be in place for the periodic review and timely modification and updating of training facilities and materials, to ensure that they accurately reflect all modifications and changes made to the plant." (Ref. [15], para. 6.7)
— "It has long been recognized that poor housekeeping standards are an indicator of behaviours and attitudes, which are not likely to be conducive to the development of a sound safety culture. Other indicators are a lack of attention to alarms or non-repair of malfunctioning equipment, overdue maintenance work or poor information recording and archiving systems." (Ref. [16], para. 7.1.4)

— "The principal elements of any fresh fuel handling programme should include receipt, transfer, inspection and storage of nuclear fuel." (Ref. [13], para. 3.2)
— "Physical and/or administrative measures should be taken to ensure that fuel is handled and stored only in authorized locations in order to prevent a critical configuration from arising." (Ref. [13], para. 3.23)
— "Adequate and specified storage sites should be used for the storage of irradiated fuel. Procedures should be used to ensure that the irradiated fuel is only stored in fully assessed configurations, and fuel storage analyses should consider, for example, new fuel designs, extended burn-ups and storage configurations for new fuel." (Ref. [13], para. 5.10)

A.1.11. Configuration management aspects of the maintenance of spare parts (Section 3.4.4)

— "The operating organization should arrange to purchase appropriate quantities of spare items …. These spares should, as a minimum, meet the same technical standards and quality assurance requirements as the equivalent installed plant items, but with additional provisions for ensuring adequate protection during long term storage." (Ref. [14], para. 8.24)
— "The maintenance group should be responsible for ensuring that adequate spare parts and components, tools and resources for achieving its objectives are available. It should also be responsible for establishing stock levels and authorizing the issue and use of spare items and components." (Ref. [14], para. 8.23)

A.1.12. Configuration management aspects of re-commissioning and pre-startup reviews (Section 3.4.6)

— "All safety related SSCs which were changed from their normal states should be returned to normal operational states. Their configuration should be verified by authorized personnel in accordance with prescribed procedures before the system is returned to operation." (Ref. [14], para. 5.31)
— "Before returning to an operational state, it is important to ensure that: appropriate post-maintenance testing has been carried out … — the configuration of affected systems is verified; all relevant records are reviewed for completeness and accuracy." (Ref. [14], para. 5.28)

— "The work control system should be used to ensure that … the plant is returned to service only upon completion of a documented check of its configuration and, where appropriate, of a functional test." (Ref. [14], para. 5.17)
— "The content and format of a typical procedure should be in accordance with the provisions established for quality assurance. The content should therefore typically include the following: … (k) Return to service: the actions and checks necessary for returning the equipment or system to an operational condition after the person responsible has certified that the task is completed. Where appropriate, independent checking and acceptance criteria should be specified. These criteria should include correct reinstatement and correct compliance with procedures as well as confirmation of system operability (for example, confirmation of valve line-up)." (Ref. [14], para. 5.9)
— "Any necessary precautions and restraints on operation with temporary configurations or conditions should be clearly specified to all relevant personnel, and training should be carried out if necessary." (Ref. [14], para. 5.29)

A.1.13. Configuration management aspects of plant design validation (Section 3.5)

— "The plant is tested, pursuant to prescribed specifications, to demonstrate that design and construction requirements have been met and that the plant can be operated in accordance with the operational limits and conditions, and design assumptions and intent." (Ref. [3], para. 3.19)
— "Maintenance, surveillance and in-service inspection (MS&I). have a common objective, which is to ensure that the plant is operated in accordance with the design assumptions and intent." (Ref. [14], para. 2.16)
— "The surveillance programme should ensure that items important to safety continue to perform in accordance with the original design assumptions and intent …The programme should include requirements for evaluation and review to detect in a timely manner degradation and ageing of structures, systems and components that could lead to unsafe conditions." (Ref. [3], para. 6.42)
— "The operating organization should ensure that MS&I for SSCs important to safety are of such a standard and frequency as to ensure that the level of reliability and functionality of the SSCs remains in accordance with the design assumptions and intent throughout the plant's operating lifetime." (Ref. [14], para. 3.2)

— "The MS&I programme and intent should be fully integrated with activities for plant operation and modification. The programme should be routinely reviewed and updated as necessary to take into account on-site and off-site operating experience, modifications to the plant or its operating regime, plant ageing, and methods, both deterministic and probabilistic, for the assessment and evaluation of safety. Documentation, procedures and records deriving from the MS&I programme should be managed in accordance with extant arrangements for quality assurance." (Ref. [14], para. 4.3)

A.1.14. Configuration management aspects of surveillance and in-service inspections (Section 3.5.1)

— "A plant walkdown of installed equipment should be performed to identify for qualified equipment any differences from the qualified configuration (abnormal conditions such as missing or loose bolts and covers, exposed wiring or damaged flexible conduits)." (Ref. [6], para. 4.20)
— "In preparing and reviewing the surveillance programme, special attention should be paid to ensuring that, whenever surveillance tests are carried out, control of the plant configuration is maintained and sufficient redundant equipment remains operable, even when the plant is shut down, to ensure that no operational limits and conditions are violated." (Ref. [14], para. 9.9)

A.1.15. Configuration management aspects of ageing effects (Section 3.5.2)

— "Having determined the current condition of the SSCs important to safety, each SSC should then be assessed against its design basis to confirm that ageing has not significantly undermined the design basis assumptions." (Ref. [6], para. 4.16)
— "The objective of the [ageing] review is to determine whether ageing in a nuclear power plant is being effectively managed so that required safety functions are maintained, and whether an effective ageing management programme is in place for future plant operation." (Ref. [6], para. 4.21)
— "All SSCs of nuclear power plants are subject to some form of physical changes caused by ageing which could eventually impair their safety function and service lifetime." (Ref. [6], para. 4.22)
— "A comprehensive understanding of an SSC, its ageing degradation and the effects of this degradation on the SSC's ability to perform its design functions is the basis and a prerequisite for a systematic ageing management process." (Ref. [17], para. 2.1)

— "Data collection and records management programme(s). Provide information for screening plant SSCs and for ageing management evaluations. Ideally, a records management system provides integrated, 'one stop' access to all information on plant SSCs." (Ref. [17], para. 2.3)
— "Data on operating experience should be collected and retained for use as input for the management of plant ageing, for the evaluation of residual plant life and for probabilistic safety assessment and periodic safety review." (Ref. [3], para. 6.70)
— "Managing the safety aspects of nuclear power plant ageing requires implementation of effective programmes for the timely detection and mitigation of ageing degradation of plant structures, systems and components important to safety, so as to ensure their integrity and functional capability throughout the plant's service life." (Ref. [3], para. 6.77)
— "The programme to manage the ageing process should contain, but is not limited to, such elements as:
  • Identification of the degradation processes that could adversely affect plant safety;
  • Identification of components that are susceptible to ageing degradation that could affect plant safety;
  • Adequate and current methods for the detection of ageing problems;
  • Appropriate records to enable the ageing process to be tracked;
  • A methodology for corrective action in order to mitigate and/or remove ageing effects; and
  • Changes to the maintenance, testing, surveillance and in-service inspection programme to reflect the analysis of ageing test results." (Ref. [3], para. 6.78)

A.2. ORGANIZATIONAL AND HUMAN FACTOR IMPACTS ON CONFIGURATION MANAGEMENT (SECTION 4)

A.2.1. Impact of knowledge management on configuration management (Section 4.1)

— "The information and knowledge of the organization shall be managed as a resource." (Ref. [18], para. 4.2)

A.2.2. Transfer of knowledge (Section 4.1.1)

— "Training should address the knowledge of concepts, including safety culture. It should also address the enhancement of skills and the reinforcement of good practices by applying lessons learned from experience." (Ref. [18], para. 4.13)

A.2.3. Impact of common human errors on configuration management (Section 4.2)

— "To support the achievement of the organization's objectives and the development of individuals, the following should be considered in planning for education and training:
- Safety and regulatory requirements;
- The experience of individuals;
- Tacit knowledge and explicit knowledge;
- Leadership and management skills;
- Planning and improvement tools;
- Team building;
- Adult learning styles and techniques;
- Decision making techniques;
- Problem solving techniques;
- Communication skills;
- Cultural diversity;
- The organizational culture;
- The needs and expectations of interested parties;
- Creativity and innovation." (Ref. [18], para. 4.10)

A.2.4. Organizational and personnel changes (Section 4.2.2)

— "For changes for which it is judged that potentially significant effects on safety could arise, assessments should be carried out to ensure that the following factors are considered:
- The final organizational structure should be fully adequate in terms of safety. In particular, it should be ensured that adequate provision has been made to maintain a sufficient number of trained, competent individuals in all areas critical to safety. It should also be ensured that any new processes introduced are documented with clear and well understood roles, responsibilities and interfaces. All retraining needs should be identified

by carrying out a training needs analysis of each of the new roles. The retraining of key individuals should be planned. These issues are especially important if individuals from outside the organization are to be used for work that was previously carried out internally, or if their roles are to be otherwise substantially extended.

- The transitional arrangements should be fully adequate in terms of safety. Sufficient personnel with knowledge and expertise that are critical to safety should be maintained until training programmes are complete. Organizational changes should be made in such a way as to maintain clarity about roles, responsibilities and interfaces. Any significant departures from preplanned transitional arrangements should be subject to further review." (Ref. [18], para. 5.60)

A.2.5. Information system and document control system (Section 4.3.1)

— "A document control process should be established to provide for the preparation, review, approval, issuing, distribution, revision and validation (where appropriate) of documents essential to the management, performance and assessment of work. An electronic document management system can be used to aid in document control and management." (Ref. [18], para. 5.24)

— "The responsibilities of each participating organization or individual should be defined in the document control process." (Ref. [18], para. 5.25)

— "The types of document to be controlled should include, but should not be limited to: documents that define the management system; safety requirements; work instructions; assessment reports; drawings; data files; specifications; computer codes; purchase orders and related documents; and supplier documents." (Ref. [18], para. 5.26)

— "The types of document to be controlled should include, but should not be limited to: documents that define the management system; safety requirements; work instructions; assessment reports; drawings; data files; specifications; computer codes; purchase orders and related documents; and "An effective electronic document management system (EDMS) will build on and utilize the controls applied for and the experience gained with the paper document management system." (Ref. [18], Annex I–1)

— "An EDMS consists of the computer hardware, software and databases that allow for the integrated preparation, input, distribution, storage, location and retrieval of electronic documents, whether initially created electronically or produced from paper documents." (Ref. [18], Annex I–2)

A.2.6. Management of data (Section 4.3.2)

— "Data should be converted to information for the continual development of an organization's knowledge, and senior management should treat information as a fundamental resource that is essential for making factually based decisions and stimulating innovation. To manage information and knowledge, senior management:
  - Should identify the organization's information needs;
  - Should identify and access internal and external sources of information;
  - Should convert information to knowledge of use to the organization;
  - Should use the data, information and knowledge to set and meet the organization's strategies and objectives;
  - Should ensure appropriate security and confidentiality;
  - Should evaluate the benefits derived from the use of the information in order to improve the management of information and knowledge;
  - Should ensure the preservation of organizational knowledge and capture tacit knowledge for appropriate conversion to explicit knowledge." (Ref. [18], para. 4.4).

A.2.7. Impact of safety culture on configuration management (Section 4.4)

— "Senior management should have an understanding of the key characteristics and attributes that support a strong safety culture and should provide the means to ensure that this understanding is shared by all individuals. Senior management should provide guiding principles and should reinforce behavioural patterns that promote the continual development of a strong safety culture." (Ref. [18], para. 2.34.)

— "A strong safety culture has the following important attributes:
  - Safety is a clearly recognized value: ….
  - Leadership for safety is clear:
  - Accountability for safety is clear:
  - Safety is integrated into all activities:
  - Safety is learning driven: …."

  (Ref. [18], para. 2.36.) (Sub-attributes are listed in this paragraph.):

— "Any individual who finds products or processes that do not meet specified requirements, or who observes abnormal behaviour, should be obliged to report the matter formally using the appropriate process." (Ref. [18] para. 6.59)

— "Senior management and management at all other levels in the organization shall carry out self-assessment to evaluate the performance of work and the improvement of the safety culture." (Ref. [18], para. 6.2)
— "Any individual who finds products or processes that do not meet specified requirements, or who observes abnormal behaviour, should be obliged to report the matter formally using the appropriate process." (Ref. [18], para. 6.59).

A.2.8. Verification that all activities are performed in due time (Section 4.4.1)

— "Potential non-conformances that could detract from the organization's performance shall be identified. This shall be done: by using feedback from other organizations, both internal and external; through the use of technical advances and research; through the sharing of knowledge and experience; and through the use of techniques that identify best practices" (Ref. [18], para. 6.16.)

A.2.9. Self-checking (Section 4.4.2)

— "Independent assessments shall be conducted regularly on behalf of senior management:
  • To evaluate the effectiveness of processes in meeting and fulfilling goals, strategies, plans and objectives;
  • To determine the adequacy of work performance and leadership;
  • To evaluate the organization's safety culture;
  • To monitor product quality;
  • To identify opportunities for improvement." (Ref. [18], para. 6.3)

A.3. IMPROVING CONFIGURATION MANAGEMENT (SECTION 5)

A.3.1. Evaluating configuration management (Section 5.1)

A.3.1.1. Self-assessments (Section 5.1.2)

— "Various methods of self-assessment may be used. Examples of self-assessment techniques include the following:
  • Workspace inspections or observations and routine communications with individuals, including informal interviews, to determine whether expectations are understood;

- Coaching or observation programmes in which weaknesses in performance are documented for further action;
- Review, analysis and trending of important performance and safety data;
- Reviews of new corrective action reports by senior management;—Reviews of important data on process performance;
- Benchmarking to identify opportunities for improvements in performance;
- Periodic reviews of performance by senior management, such as management review meetings in which managers provide a summary of key performance weaknesses or strengths in areas for which they are responsible." (Ref. [18], para. 6.19)

A.3.1.2. Performance indicators related to configuration management (Section 5.1.3)

— "Performance indicators should be developed for each process to measure whether or not performance is satisfactory. Performance indicators should have particular emphasis on safety and should be monitored so that changes can be recorded and trends can be determined." (Ref. [18], para. 5.32)
— "Trends in performance indicators should be analysed to identify both beneficial and adverse factors. Beneficial factors should be used to encourage improvement. The causes of adverse factors should be determined and eliminated." (Ref. [18], para. 5.33)

A.3.2. Configuration management aspects of computerized tools (Section 5.2)

— "The organization's quality assurance programme should extend into the software development process and should also cover CM and change control after the software is delivered." (Ref. [8], para. 3.30)
— "A development plan should define a set of development activities and the essential characteristics of each activity. Other aspects of the project which should be planned are quality assurance, verification and validation, configuration management, and commissioning and installation." (Ref. [8], para. 4.2)
— "Configuration management is an extension of the development plan and quality assurance programme description, and is of sufficient importance that it is described separately." (Ref. [8], para. 4.19)
— "All items of software development, such as compilers, development tools, configuration files and operating systems, should be under configuration management control." (Ref. [8], para. 4.20)

— "The elaboration of the computer system requirements is based on the results of high level plant design…Safety analyses, for example accident analyses, transient analyses or plant safety analyses…" (Ref. [8], para. 5.2)
— "Documents describing processes and techniques should be subject to configuration management that should be distinct from the configuration management of the computer system documents." (Ref. [8], para. 10.4)

REFERENCES

[1] EUROPEAN ATOMIC ENERGY COMMUNITY, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).

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

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, The Operating Organization for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.4, IAEA, Vienna (2001).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.2, IAEA, Vienna (2000).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment and Verification for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.2, IAEA, Vienna (2002).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.10, IAEA, Vienna (2001).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. NS-R-1, IAEA, Vienna (2000).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Software for Computer Based Systems Important to Safety in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.1, IAEA, Vienna (2000).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Instrumentation and Control Systems Important to Safety in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.3, IAEA, Vienna (2002)

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Design of Fuel Handling and Storage Systems for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.4, IAEA, Vienna (2002).

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

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Operation, IAEA Safety Standards Series No. NS-R-2, IAEA, Vienna (2000).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Core Management and Fuel Handling for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.5, IAEA, Vienna (2002).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.6, IAEA, Vienna (2002).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.8, IAEA, Vienna (2001).
[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Developing Safety Culture in Nuclear Activities, Practical Suggestions to Assist Progress, Safety Reports Series No. 11, IAEA, Vienna (1998).
[17] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA, Implementation and Review of a Nuclear Power Plant Ageing Management Programme, Safety Reports Series No. 15, IAEA, Vienna (1999).
[18] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA, Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

Annex I

EXAMPLE OF A CONFIGURATION MANAGEMENT ASSESSMENT LIST

This annex provides an example of a configuration management assessment list as applied in the USA. The list identifies some key attributes important to an effective configuration management programme and can be used to guide assessments of an organization's configuration management.

I–1. PROGRAMME MANAGEMENT

I–1.1. Programme planning

A policy or directive that proclaims top management support for configuration management objectives, defines key roles and responsibilities, provides criteria for the scope and establishes key terminology and definitions is available to station personnel.

The plan recognizes and addresses the methods by which the design requirements are translated into operating and maintenance instructions, and other related facility configuration documentation.

The plan includes a mechanism for initiation of review and appropriate disposition of weaknesses discovered during assessments. Actions to address such weaknesses are commensurate with the significance of the assessment findings.

The programme plan is reviewed periodically and revised as needed.

I–1.2. Physical configuration scope

The scope of SSCs included in the programme is identified and available to station personnel.

I–1.3. Facility configuration documentation scope

The FCD to be included in the programme is identified.

The FCD scope is based on the category of the SSC associated with the information and the use of the information to support the facility's mission.

I–1.4. Concepts and terminology

Standard configuration management concepts, terminology and definitions are established, maintained, and incorporated into procedures and training.

I–1.5. Interfaces

Controls are established for identifying and maintaining effective organization, process and programme interfaces, including the control of vendor activities and information.

Interface controls include clear definition and assignment of key roles and responsibilities, including responsibilities for control of design documents.

I–1.6. Configuration control information system (CCIS)

Information systems enable identification, storage, control and retrieval of configuration management information and status tracking.

I–1.7. Implementation

Appropriate configuration management procedures are issued and training is provided to all station personnel.

I–2. DESIGN REQUIREMENTS

I–2.1. Establishment of design requirements

Design requirements for SSCs included in the configuration management processes are formally established, documented and maintained.

I–2.2. System and process boundaries

The boundaries for each system and process are established and identifiable via appropriately controlled documentation and/or information system.

I–2.3. Specific equipment list

The specific SSCs included in the programme scope are identified on the basis of the physical configuration scope criteria and incorporated into the CCIS.

I–2.4. Assignment of SSC classes

Each SSC is assigned a classification (used as the basis for the degree of control placed on all associated activities) based on the most important type of design requirements applicable to it.

I–2.5. Basis

The basis for design requirements is identified, correlated with the design requirements, documented, and maintained to the extent and level appropriate to the facility's mission, life cycle stage and other relevant factors.

I–2.6. Communication of design requirements

New and/or revised design requirements are identified by the design authority and clearly communicated to facility engineering, operation, maintenance and procurement personnel.

I–3. INFORMATION CONTROL

I–3.1. Identification

The types and sources of configuration management information are determined, and responsible persons assigned as owners of each of these sources of information.

Information source owners establish priorities for information revision and access.

I–3.2. Categorization

Sources of facility configuration documentation are categorized by the responsible entity to communicate relative validity, update frequency and level of detail to potential users of the information.

I–3.3. Storage

Facility configuration documentation is appropriately stored and protected.

I–3.4. Control and tracking

Control and tracking systems make users aware of whether the information is historical, current (as-built) or pending (as-designed).

Data needed for control and tracking such as the information title, revision level, current status, information custodian, pending changes and storage location is readily available to all persons who have a need to know.

A graded approach to updating information sources is established.

I–3.5. Retrieval

Facility configuration documentation is retrievable in a timely manner.

I–3.6. Minimization

Redundant FCD is minimized or eliminated.

I–3.7. Operational configuration information status control

Appropriate method(s) are available to facility operators that enable them to be aware of the current operational configuration and relate it to the configuration presumed by the design bases.

I–4. CHANGE CONTROL

I–4.1. Identification

All mechanisms that can lead to a temporary or permanent change in the design requirements, physical configuration or FCD are identified as configuration management related change mechanisms.

I–4.2. Review of planned changes

Each specific proposed change is reviewed for:

— Consistency with or impact on design basis or requirements;
— Regulatory approval requirements;
— SSC function impacts;
— Configuration information impact and update time frames;
— Safety, environmental and mission impacts;

— Appropriate post-implementation acceptance criteria;
— Design changes that are evaluated and approved by the design authority prior to implementation.

I–4.3. Implementation of planned changes

Each change is implemented as approved using procedures and processes that produce predictable results.

Appropriate status controls are available to provide relevant status information throughout the implementation process.

Provision is made for change requests initiated during the implementation process.

Appropriate technical and management reviews and approvals of change requests are performed.

The change process generates accurate as-built information.

Post-implementation testing is conducted as appropriate to validate that the change meets the acceptance criteria, thus ensuring compliance with the design requirements.

I–4.4. Documentation of changes

Each change is documented and that documentation includes a description of the change, as well as an account of the technical reviews and management approvals.

Documentation reflecting change requests, as-built information, and post-implementation test results is included.

Change impacts on documentation are identified, available to users of the documents, and tracked to completion of updates.

Facility configuration documentation affected by the change, directly or indirectly, is revised.

The timelines of documentation updates is commensurate with the significance of the change (considering the SSC scope criteria) and the use of the documentation.

I–4.5. Inadvertent change prevention

Work control and maintenance processes, including post-maintenance testing, ensure the physical plant is restored to the approved configuration.

Materials processes, including procurement, commercial dedications, receiving, storage and issue, ensure correct material is available and used in maintenance and modification activities.

Procedures for design and configuration changes, material procurement and issue, work control, testing, and document/programme update are linked adequately to ensure discrepancies are not introduced.

I–5. ASSESSMENTS

I–5.1. Programmatic assessments

The adequacy of processes and procedures to achieve the objectives of configuration management is assessed using both vertical and horizontal slice assessments.

I–5.2. Physical configuration assessment follow-up

If walkdowns reveal substantive discrepancies (either in number or type), appropriate corrective actions are developed to re-establish agreement between the physical configuration and the facility configuration documentation.

Corrective actions include technical evaluations to determine whether the physical configuration or the configuration information needs to be changed.

I–5.3. Periodic equipment performance monitoring

Configuration managed structures; systems and components are monitored periodically to verify that they are still capable of meeting their design requirements.

I–5.4. Performance measures

The health of the configuration management programme is monitored by measurement of status and backlogs of configuration changes and document/programme updates.

I–6. TRAINING

I–6.1. Training content

Overview configuration management training explains the configuration management objectives and how the facility is achieving the criteria of this standard.

I–6.2. Specialized training

More detailed and task specific training is provided as appropriate for people who are directly involved in programme management, establishing and maintaining design requirements, information or change control tracking, assessments or implementing design requirements during facility operation or maintenance.

I–6.3. Simulator

Change processes ensure that changes made to the plant are reflected in the simulator hardware, software and training plans.

Annex II

CONFIGURATION MANAGEMENT PERFORMANCE INDICATORS OF THE CONFIGURATION MANAGEMENT BENCHMARKING GROUP

This annex sets out configuration management performance indicators of a benchmarking group and is based on practice in the USA.

ASSUMPTIONS

(1) Configuration management is understood to include all plant personnel and processes — not just engineering;
(2) These performance indicators (PIs) are independent of any specific utility/plant process or resource base;
(3) Measurement techniques/methods probably do not exist for some indicators at this time;
(4) The configuration management equilibrium restoration diagram is adopted and used by the Nuclear Energy Institute and INPO;
(5) All configuration managementproblems/discrepancies are reported in condition reports (CRs);
(6) Either CR cause or event codes, and their assignments, allow binning and tracking of configuration management related information, or someone familiar with configuration managementwill evaluate them for the period.

DEFINITIONS/NOTES

(1) Configuration management. The process of identifying and documenting the characteristics of a facility's SSCs (including computer systems and software), and of ensuring that consistency is maintained between the design requirements, physical configuration and facility configuration documentation.
(2) In addition to configuration managementself-assessments performed by the engineering department, other departments and process checks should be considered. For example, operations clearance tag audits, chemistry sampling, audits of temporary modification times, etc. Problems found during these assessments would be reported on CRs.

(3) Condition reports. This is a commonly used problem reporting mechanism. Some facilities call them problem reports (PRs), or problem evaluation reports (PERs). CRs may cover the gamut of configuration problems, from an oil leak in someone's car in the plant parking lot to a pump's failure to meet rated output to an unexpected flux change in the core. It may also be appropriate to record and monitor the number of 'repeat' occurrences of CRs by category. It would also be advisable to identify 'legacy' issues so as not to distort the significance of current problems. Facilities are encouraged to review their existing event coding scheme to determine if they can be used effectively to evaluate configuration management issues.

(4) Change requests are typically a uniform requesting mechanism to get items into a review cycle for scoping, validity determination, action assignment, etc. Some facilities call them action requests (ARs), engineering change requests (ECRs), or engineering service orders (ESOs).

(5) Cumulative effects of pending or temporary changes to the design basis calculations, e.g. piping stress calculations, heat load calculations, service water heat load calculations, containment heat load calculations, electrical load calculations, etc. should be considered as a leading indicator to potential design requirements problems. Tracking of incremental changes is advised so that individual changes that do not erode design/safety margin will not collectively present a problem.

(6) Field change requests (FCRs). This is a mechanism for identifying in-process changes for physical configuration modifications after authorization is received. The term could also apply to physical configuration package revisions. Avoidable FCRs and physical configuration package revisions are those that should not have occurred with adequate prior planning or design development. Tracking the number, percentage and age of FCRs and/or physical configuration package changes may be an informative measure.

(7) Physical configuration changes include items/processes in addition to traditional modifications or engineering changes. For example, physical configuration changes apply to operations valve and equipment line-ups, chemistry changes, computer hardware/software changes, nuclear fuel/core changes, etc.

(8) Facility configuration documentation needs to include documents/databases outside of engineering. For example, operations/chemistry/maintenance procedures or training materials that include structure, system, or component design/licence basis information.

A Overall configuration management programme effectiveness

Definition	Composite score for configuration management related leading and lagging indicators.
How the indicator is determined	— For leading indicators — develop customer survey; — For lagging indicators — composite of results from all areas.

B Configuration management awareness and training

Definition	No. of CRs or other plant indicators indicating in-adequacies in CM awareness or training.
How the indicator is determined	Review of CRs or other indicators (either all, a percentage sample, or CR database word search).

C Configuration management self-assessment

Definition	No. of CRs written as result of CM self-assessments.
How the indicator is determined	Review of CRs (either all, a percentage, sample or CR database word search).

PROCESS: EVALUATE IDENTIFIED PROBLEM OR DESIRED CHANGE

A Effectiveness of identification process for configuration management related CRs

Definition	— No. and percentage of configuration management related CRs to total CRs per period; — No. and percentage of configuration management related CRs considered valid.
How the indicator is determined	Review of CRs (either all, a percentage sample or CR database word search.

B Timeliness of identification for configuration management related CRs

Definition	— Time from initiation of CR to assignment of action to resolve; — No. of open configuration management related CRs; — Time from initiation of request to assignment of action to resolve; — No. of open configuration management related desired changes.
How the indicator is determined	Review of CRs (either all, a percentage sample or CR database word search).

C Cost performance for evaluation process

Definition	Work hours to evaluate configuration management related CRs.
How the indicator is determined	Data extracted from facility time keeping records.

A Effectiveness of design requirements change process

Definition	No. of CRs written specifically against design requirements change process.
How the indicator is determined	Review of CRs (either all, % sample or CR database word search).

B Timeliness of design requirements change process

Definition	— Time from assignment of action as a design requirement change to closure; — No. of outstanding changes in the design requirement change process.
How the indicator is determined	From work tracking system, from initiation to closeout (excludes regulator time).

C Cost performance for design requirement change process

Definition	Work hours to process design requirement changes.
How the indicator is determined	From data extracted from facility time keeping records.

PROCESS: PHYSICAL CONFIGURATION CHANGE AUTHORIZATION PROCESSES

A Effectiveness of physical change authorization processes

Definition	— No. of CRs written specifically against physical change processes; — Score on physical configuration change package review; — No. of avoidable FCRs.
How the indicator is determined	Review of CRs (either all, a percentage sample or CR database word search.

B Timeliness of physical change

Definition	— Time from assignment of action as a physical change to closure; — No. of outstanding changes in the physical configuration change processes.
How the indicator is determined	From work tracking system.

C Cost performance for physical changes

Definition	Work hours to develop physical configuration changes.
How the indicator is determined	From data extracted from facility time keeping records.

PROCESS: FACILITY CONFIGURATION DOCUMENTATION CHANGE PROCESS

A Effectiveness of FCD change process

Definition	— No. of CRs written specifically against the FCD change process; — No. of CRs written against problems or discrepancies with the FCD.
How the indicator is determined	Review of CRs (either all, percentage sample, or CR database word search).

B Timeliness of FCD change process

Definition	— Time from assignment of action as an FCD change to closure; — No. of open items (or backlog) in the FCD change process; — No. of physical changes completed, but paperwork still outstanding.
How the indicator is determined	From work tracking system.

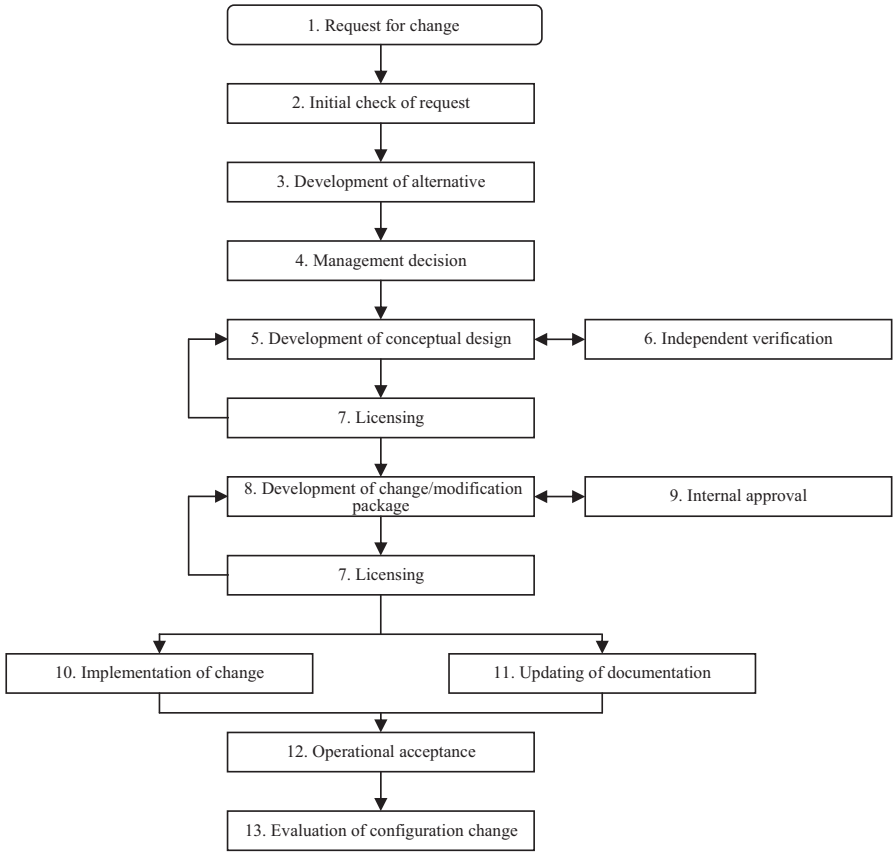
C Cost performance of FCD change process

Definition:	Work hours to process FCD changes.
How the indicator is determined	From data extracted from facility time keeping records.

Annex III

REFERENCE CHANGE PROCESS

This annex describes a change process in use at the Dukovany and Temelin nuclear power plants in the Czech Republic. The major steps in a change process are shown in the following flow chart and are described below.



(1) **Request for change.** May be initiated by employees, subcontractors or plant managers. The source of the request may be:
— The identified safety issue;
— The modernization programme;
— Operational issues;
— Maintenance and in service inspection;
— Changes of standards;
— A regulatory request.

(2) **Initial check of request.** The request should follow procedure for preparation. It should be in written form and should contain adequate information and supporting documentation by several departments.

(3) **Development of alternative solutions.** Modification engineer performs root cause analysis, prepares alternative solutions of the request, evaluates the impact of each solution to safety, costs, time schedule, etc. One of the proposed solutions can be to keep status quo.

(4) **Management decision.** Responsible manager or committee decides which solution should be implemented.

(5) **Development of conceptual design.** Modification engineers or TSO develop conceptual design for chosen solution.

(6) **An independent verification.** Carried out by internal departments or TSO. They give condition for implementation of change. It is particularly intended to assess the potential impact of change to plant safety. This should be approved by the design authority.

(7) **Licensing.** Depending on the impact of planned change to plant safety and in accordance with national licensing regulations, the relevant licensing procedure should be placed.

(8) **Development of change/modification package.** It could be developed by modification engineers or TSO.

(9) **Internal approval.** Responsible departments in utility including the design authority should review if the conditions given in step 6 are met. Adequate resources should be allocated and proper time schedule should be established.

(10) **Implementation of change.** During this stage the following should be done: fabrication, installation, inspection, testing, personnel training, and changes in the full scope simulator.

(11) **Updating of documentation.** Design documentation and procedures should be updated. It is recommended to prepare it before the change is put into operation or immediately afterwards.

(12) Operational acceptance

(13) **Evaluation of configuration change.** This is useful for feedback from the configuration management process, checking that the change met proposed target.

This reference change process can be modified according to classification of the proposed modification. A screening on the proposed modifications may suggest the most appropriate process to be followed. For changes with no safety impact, even the licensing steps could be omitted.

DEFINITIONS

The following definitions are applicable in this publication only.

configuration management equilibrium. The state represented by configuration management equilibrium diagram (Fig. 1) that demonstrates conformance of three elements: design requirements, facility configuration documentation and physical configuration; can be confirmed by audits or assessments

configuration management. The process of identifying and documenting the characteristics of a facility's structures, systems and components (SSCs) (including computer systems and software), and of ensuring that consistency is maintained between the design requirements, physical configuration and facility configuration documentation.

commissioning. The process during which systems and components of facilities and activities, having been constructed, modified or maintained; are made operational and are verified to be in accordance with the design and to have meet the performance criteria. Commissioning may include both non-nuclear and nuclear tests.

design authority. The design organization with appropriate knowledge of the design basis that is responsible for establishing the design requirements and ensuring that design documentation (document and/or data) appropriately and accurately reflect the design. The design authority is responsible for design control and the technical adequacy of the design process throughout the lifetime of the nuclear facility.

design basis. The high level functional requirements, interfaces and expectations of a facility, structure, system or component that are based on regulatory requirements or facility analyses. Individual bases are contained in design documentation and may be reflected in any combination of criteria, codes, standards, specifications, computations or analyses identifying pertinent constraints, qualifications or limitations. The design basis identifies and supports *why* a design requirement is established.

design documentation. The subset of facility configuration documentation that includes the documentation of design requirements information and the design basis information.

design requirements. Technical requirements derived from the design process and reflected in design documentation (documents and/or data) that defines the form, fit and function (including capabilities, capacities, physical sizes and dimensions, limits and set points, etc.) specified by the design authority for a structure, system or component of the facility. Each Design requirements has a basis, documented or not.

facility configuration documentation (FCD). Recorded information that describes, specifies reports, certifies, or provides data or results regarding the design requirements or design basis, or pertains to other information attributes associated with the facility and its SSCs. This information may be contained in original hard media (mylar, etc.), paper copies, electronic media and any other sources of information used to make sound technical decisions regarding design, procurement, construction, modification, operation, maintenance and decommissioning of the facility. It includes current information, pending information and records. The scope of facility configuration documentation to be controlled is defined and the level of control is determined using a graded approach.

operational configuration information. Recorded information that describes the acceptable configuration of facility SSCs, when variable configuration conditions may exist, based on operational needs. This information may be recorded as a specific state, such as a valve or switch position, or as a step in an operating procedure for performing a particular task or evolution.

operator workaround. An operator workaround may take the form of an operator disregarding an instruction or step in an operating procedure because he knows that step is never used. Others examples could be due to a controller failure which may be compensated for by manual operator action.

physical configuration. The actual physical location, arrangement and material condition of SSCs within a facility including electronic hardware and software performing a facility function.

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