

IAEA SAFETY STANDARDS SERIES

Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants

SAFETY GUIDE

No. NS-G-2.6



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MAINTENANCE, SURVEILLANCE AND IN-SERVICE INSPECTION IN NUCLEAR POWER PLANTS

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

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FOREWORD

by **Mohamed ElBaradei**
Director General

One of the statutory functions of the IAEA is to establish or adopt standards of safety for the protection of health, life and property in the development and application of nuclear energy for peaceful purposes, and to provide for the application of these standards to its own operations as well as to assisted operations and, at the request of the parties, to operations under any bilateral or multilateral arrangement, or, at the request of a State, to any of that State's activities in the field of nuclear energy.

The following bodies oversee the development of safety standards: the Commission on Safety Standards (CSS); the Nuclear Safety Standards Committee (NUSSC); the Radiation Safety Standards Committee (RASSC); the Transport Safety Standards Committee (TRANSSC); and the Waste Safety Standards Committee (WASSC). Member States are widely represented on these committees.

In order to ensure the broadest international consensus, safety standards are also submitted to all Member States for comment before approval by the IAEA Board of Governors (for Safety Fundamentals and Safety Requirements) or, on behalf of the Director General, by the Publications Committee (for Safety Guides).

The IAEA's safety standards are not legally binding on Member States but may be adopted by them, at their own discretion, for use in national regulations in respect of their own activities. The standards are binding on the IAEA in relation to its own operations and on States in relation to operations assisted by the IAEA. Any State wishing to enter into an agreement with the IAEA for its assistance in connection with the siting, design, construction, commissioning, operation or decommissioning of a nuclear facility or any other activities will be required to follow those parts of the safety standards that pertain to the activities to be covered by the agreement. However, it should be recalled that the final decisions and legal responsibilities in any licensing procedures rest with the States.

Although the safety standards establish an essential basis for safety, the incorporation of more detailed requirements, in accordance with national practice, may also be necessary. Moreover, there will generally be special aspects that need to be assessed on a case by case basis.

The physical protection of fissile and radioactive materials and of nuclear power plants as a whole is mentioned where appropriate but is not treated in detail; obligations of States in this respect should be addressed on the basis of the relevant instruments and publications developed under the auspices of the IAEA. Non-radiological aspects of industrial safety and environmental protection are also not explicitly considered; it is recognized that States should fulfil their international undertakings and obligations in relation to these.

The requirements and recommendations set forth in the IAEA safety standards might not be fully satisfied by some facilities built to earlier standards. Decisions on the way in which the safety standards are applied to such facilities will be taken by individual States.

The attention of States is drawn to the fact that the safety standards of the IAEA, while not legally binding, are developed with the aim of ensuring that the peaceful uses of nuclear energy and of radioactive materials are undertaken in a manner that enables States to meet their obligations under generally accepted principles of international law and rules such as those relating to environmental protection. According to one such general principle, the territory of a State must not be used in such a way as to cause damage in another State. States thus have an obligation of diligence and standard of care.

Civil nuclear activities conducted within the jurisdiction of States are, as any other activities, subject to obligations to which States may subscribe under international conventions, in addition to generally accepted principles of international law. States are expected to adopt within their national legal systems such legislation (including regulations) and other standards and measures as may be necessary to fulfil all of their international obligations effectively.

EDITORIAL NOTE

An appendix, when included, is considered to form an integral part of the standard and to have the same status as the main text. Annexes, footnotes and bibliographies, if included, are used to provide additional information or practical examples that might be helpful to the user.

The safety standards use the form 'shall' in making statements about requirements, responsibilities and obligations. Use of the form 'should' denotes recommendations of a desired option.

The English version of the text is the authoritative version.

CONTENTS

1.	INTRODUCTION	1
	Background (1.1–1.2)	1
	Objective (1.3)	1
	Scope (1.4–1.7)	1
	Structure (1.8)	2
2.	MAINTENANCE, SURVEILLANCE AND IN-SERVICE INSPECTION AND THEIR INTERRELATIONSHIP	2
	Maintenance (2.1–2.10)	2
	Surveillance (2.11–2.12)	5
	In-service inspection (2.13–2.15)	5
	Interrelationship between maintenance, surveillance and in-service inspection (2.16–2.17)	6
3.	FUNCTIONS, RESPONSIBILITIES AND INTERFACES	7
	The operating organization (3.1–3.3)	7
	The regulatory body (3.4–3.5)	7
	Contractors (3.6–3.9)	8
	Other bodies, including designers and manufacturers (3.10–3.11)	9
	Interface control (3.12)	9
4.	ORGANIZATIONAL ASPECTS	10
	General provisions (4.1–4.9)	10
	Organizational structure (4.10–4.16)	11
	Planning and safety management (4.17–4.24)	13
	Administrative procedures (4.25–4.28)	14
	Quality assurance (4.29)	16
	Training and qualification of personnel (4.30–4.38)	16

Surveillance of safety systems (9.15–9.17)	50
Surveillance of other items (9.18)	51
Frequency and extent of surveillance (9.19–9.30)	52
Surveillance methods (9.31–9.37)	55
Functional tests (9.38–9.44)	56
Documentation and records of surveillance (9.45–9.46)	58
 10. ADDITIONAL CONSIDERATIONS SPECIFIC TO IN-SERVICE INSPECTION	 59
In-service inspection programme (10.1–10.3)	59
Extent of in-service inspection (10.4–10.7)	59
Inspection schedules (10.8–10.10)	60
Pressure and leakage testing (10.11–10.15)	61
Methods and techniques (10.16–10.20)	62
Equipment (10.21–10.23)	63
Qualification of in-service inspection systems (10.24–10.34)	63
Evaluation of results of in-service inspections (10.35–10.44)	65
Documentation and records of in-service inspections (10.45–10.47)	66
 REFERENCES	 68
GLOSSARY	69
CONTRIBUTORS TO DRAFTING AND REVIEW	73
BODIES FOR THE ENDORSEMENT OF SAFETY STANDARDS	74

1. INTRODUCTION

BACKGROUND

1.1. Effective maintenance, surveillance and in-service inspection (MS&I) are essential for the safe operation of a nuclear power plant. They ensure not only that the levels of reliability and availability of all plant structures, systems and components (SSCs) that have a bearing on safety remain in accordance with the assumptions and intent of the design, but also that the safety of the plant is not adversely affected after the commencement of operation.

1.2. This Safety Guide supplements Section 6 of the Safety Requirements publication on the Safety of Nuclear Power Plants: Operation [1], which relates to the maintenance, surveillance and in-service inspection of SSCs important to safety. It provides recommendations on the basis of international experience of measures for fulfilling the safety requirements for MS&I. This publication supersedes the following three earlier IAEA Safety Guides: In-service Inspection for Nuclear Power Plants, Safety Series No. 50-SG-O2 (1980), Maintenance of Nuclear Power Plants, Safety Series No. 50-SG-O7 (1990), and Surveillance of Items Important to Safety in Nuclear Power Plants, Safety Series No. 50-SG-O8 (1990).

OBJECTIVE

1.3. The objective of this Safety Guide is to provide recommendations and guidance for MS&I activities to ensure that SSCs important to safety are available to perform their functions in accordance with the assumptions and intent of the design.

SCOPE

1.4. This Safety Guide covers the organizational and procedural aspects of MS&I. However, it does not give detailed technical advice in relation to particular items of plant equipment, nor does it cover inspections made for and/or by the regulatory body.

1.5. This Safety Guide provides recommendations and guidance for preventive and remedial measures, including testing, surveillance and in-service inspection, that are necessary to ensure that all SSCs important to safety are capable of performing as intended.

1.6. This Safety Guide covers measures for fulfilling the organizational and administrative requirements for: establishing and implementing schedules for preventive and predictive maintenance, repairing defective plant items, selecting and training personnel, providing related facilities and equipment, procuring stores and spare parts, and generating, collecting and retaining maintenance records for establishing and implementing an adequate feedback system for information on maintenance.

1.7. MS&I should be subject to quality assurance in relation to all aspects important to safety. Quality assurance has been dealt with in detail in other IAEA safety standards [2] and is covered here only in specific instances, for emphasis.

STRUCTURE

1.8. In Section 2, a concept of MS&I is presented and the interrelationship between maintenance, surveillance and inspection is discussed. Section 3 concerns the functions and responsibilities of different organizations involved in MS&I activities. Section 4 provides recommendations and guidance on such organizational aspects as organizational structure, planning and safety management, administrative control, quality assurance, and training and qualification of personnel. Sections 5 and 6 cover the implementation of an MS&I programme, analysis of results and feedback of experience. Section 7 highlights the areas that need to be given special consideration in relation to the MS&I programme. Finally, Sections 8 to 10 address additional items that are specific to MS&I.

2. MAINTENANCE, SURVEILLANCE AND IN-SERVICE INSPECTION AND THEIR INTERRELATIONSHIP

MAINTENANCE

2.1. The maintenance programme for a nuclear power plant should cover all preventive and remedial measures, both administrative and technical, that are necessary to detect and mitigate degradation of a functioning SSC or to restore to an acceptable level the performance of design functions of a failed SSC. The purpose of maintenance activity is also to enhance the reliability of equipment. The range of maintenance activities includes servicing, overhaul, repair and replacement of parts, and often, as appropriate, testing, calibration and inspection.

Types of maintenance

2.2. While there are various conceptual approaches to maintenance, the relevant activities may be divided into preventive and corrective maintenance. A considerable part of all maintenance activity is performed while the plant is shut down; however, maintenance may be planned and executed under power operation provided that adequate defence in depth is maintained. For definitions of different types of maintenance, see the Glossary.

2.3. Preventive maintenance should include periodic, predictive and planned maintenance activities performed prior to failure of an SSC so as to maintain its service life by controlling degradation or preventing its failure.

- (a) Periodic maintenance activities should be accomplished on a routine basis and may include any combination of external inspections, alignments or calibrations, internal inspections, overhauls, and replacements of components or equipment.
- (b) Predictive maintenance should involve continuous or periodic monitoring and diagnosis in order to predict equipment failure. Not all equipment conditions and failure modes can be monitored, however; predictive maintenance should therefore be selectively applied where appropriate. Predictive techniques may include condition monitoring, reliability centred maintenance and similar techniques.
- (c) Planned maintenance activities should be performed prior to unacceptable degradation or equipment failure and may be initiated on the basis of results of predictive or periodic maintenance, vendor recommendations or experience.

2.4. Corrective maintenance includes actions that, by means of repair, overhaul or replacement, restore the capability of a failed SSC to perform its defined function within the acceptance criteria.

Systems approach to maintenance

2.5. A systems approach to maintenance of safety relevant SSCs should include the following elements:

- (a) A systematic evaluation of the functions and objectives of SSCs, to determine the necessary maintenance activities and the related requirements;
- (b) A focus on long term maintenance objectives, establishing a proactive as opposed to reactive maintenance programme;
- (c) A reliability centred approach to maintenance;

- (d) Maintenance planning and scheduling that is derived from overall programme objectives.

Optimization of maintenance

2.6. A systematic approach to evaluation should be taken to establish which maintenance tasks are to be performed, on which SSCs, and at what intervals, in order to optimize the use of resources allocated for maintenance and to ensure the availability of the plant. This approach can be used in establishing a preventive maintenance programme and for optimization of the ongoing maintenance programme. The aim of optimization is to use condition monitoring to determine where unnecessary maintenance work and failures induced by errors in maintenance can be avoided. If a probabilistic safety assessment has been performed, its results may be used for this purpose.

2.7. The operating organization should monitor the performance or condition of SSCs against the goals it has set so as to provide reasonable assurance that the SSCs are capable of performing their intended functions. Such goals should be commensurate with safety and, where practicable, industry-wide operating experience should be taken into account. When the performance or condition of an SSC does not meet the established goals, appropriate corrective action should be taken.

2.8. An adequate condition monitoring programme should be established in support of optimization of the maintenance programme. Such a monitoring programme should be based on the following assumptions as a minimum:

- that the monitored parameters are appropriate indicators for the condition of the SSCs,
- that acceptance criteria are available,
- that all potential failure modes are addressed,
- that the behaviour of the potential failure is traceable and predictable.

2.9. The scope of the condition monitoring programme should include, but is not limited to:

- SSCs which ensure safe operations or whose failure could challenge a safety function;
- SSCs which are relied on to remain functional following a design basis accident to ensure the continued performance of safety functions, or whose failure could prevent safety related SSCs from performing their safety related functions;

- SSCs which are used in plant emergency operating procedures (EOPs) or are relied on to mitigate the consequences of transients or beyond design basis accidents.

For more information on condition monitoring see Safety Guide Q13 in Ref. [2].

2.10. Changes deriving from the optimization of maintenance should be analysed to assess the effects of the changed maintenance approach on system availability and the overall risks to the plant in all operating and shutdown states. A periodic review of the optimization process should incorporate operating experience, including new failure modes and data. In the optimization process, due attention should be paid to maintaining the required reliability of the SSCs and adequate safety margins.

SURVEILLANCE

2.11. The objectives of the surveillance programme are: to maintain and improve equipment availability, to confirm compliance with operational limits and conditions, and to detect and correct any abnormal condition before it can give rise to significant consequences for safety. The abnormal conditions which are of relevance to the surveillance programme include not only deficiencies in SSCs and software performance, procedural errors and human errors, but also trends within the accepted limits, an analysis of which may indicate that the plant is deviating from the design intent.

2.12. The operating organization should establish a surveillance programme to verify that the SSCs important to safety are ready to operate at all times and are able to perform their safety functions as intended in the design. Such a surveillance programme will also help to detect trends in ageing so that a plan for mitigating the effects of ageing can be prepared and implemented.

IN-SERVICE INSPECTION

2.13. Over the plant's operating lifetime, the operating organization should examine SSCs for possible deterioration so as to determine whether they are acceptable for continued safe operation or whether remedial measures should be taken. Emphasis should be placed on examination of the pressure boundaries of the primary and secondary coolant systems, because of their importance to safety and the potentially severe consequences of their failure.

2.14. Baseline data should be collected for future reference. These data are normally collected in the pre-service inspection carried out before the start of plant operation; they give information on initial conditions which supplements manufacturing and construction data in providing a basis for comparison with the data from subsequent examinations. In the pre-service inspection the same methods, techniques and types of equipment should be used as those which are planned to be used for in-service inspections. Whenever an SSC has been repaired or replaced, a pre-service inspection should be performed before putting it into operation.

2.15. When new inspection methods are introduced, a comparison with the previous methods should be made. Such a comparison will provide a revised baseline for future inspections.

INTERRELATIONSHIP BETWEEN MAINTENANCE, SURVEILLANCE AND IN-SERVICE INSPECTION

2.16. Maintenance, surveillance and in-service inspection have a common objective, which is to ensure that the plant is operated in accordance with the design assumptions and intent, and within the operational limits and conditions. Maintenance, for example, should always be followed by a series of tests. Results of surveillance or in-service inspection should be compared with the acceptance criteria. If the results fall outside the acceptance criteria, corrective actions should be initiated. Such actions should include corrective maintenance measures such as adjustment, repair or replacement of defective items to prevent recurrence. These activities should be planned and co-ordinated effectively. A common database should be established in order to share relevant data and evaluations of results among the organizations that are involved in the planning and implementation of MS&I activities.

2.17. Testing consists of post-maintenance testing, surveillance testing and in-service inspection testing. The purpose of the tests is to confirm that the SSCs continue to meet the design intent. In this Safety Guide, testing is dealt with separately for maintenance, surveillance and in-service inspection, as appropriate. Further guidance on testing can be found in Safety Guide Q4 in Ref. [2].

3. FUNCTIONS, RESPONSIBILITIES AND INTERFACES

THE OPERATING ORGANIZATION

3.1. The operating organization is required to prepare and implement a programme of MS&I for those SSCs which are important to safety. This programme is required to be in place prior to fuel loading, and full details of it are required to be made available to the regulatory body. The operational limits and conditions as well as any other applicable regulatory requirements are required to be taken into account in the programme and are required to be re-evaluated as necessary in the light of experience [1]. Recent scientific and technological advances should also be taken into consideration.

3.2. 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.

3.3. The operating organization should periodically evaluate the performance of SSCs as well as condition monitoring activities and their associated goals, and activities in relation to MS&I. It should thereby take into account and, where practicable, contribute to industry-wide operating experience. Adjustments should be made where necessary to ensure that the objective of preventing failures of SSCs by means of maintenance or detecting them through testing, surveillance and in-service inspection is appropriately balanced against the objective of minimizing the unavailability of those SSCs due to monitoring or MS&I. In performing these activities, an assessment of all the plant equipment that is out of service should be made and the overall effect of this unavailability on the performance of safety functions should be determined and taken into account.

THE REGULATORY BODY

3.4. The extent of the regulatory body's involvement in MS&I activities at nuclear power plants will depend on the practices in the State concerned. In general, the regulatory body's main concern will be to ensure that all such activities are properly conducted, particularly for SSCs important to safety. In most cases, the regulatory body may be involved in the following activities as a minimum:

- establishing rules and conditions to ensure the appropriateness of the MS&I for SSCs important to safety (for example, in terms of rules and guidelines for the contents of the MS&I programme, requirements for reviewing the maintenance

programme in the light of new approaches or requirements for equipment qualification);

- approving those parts of the MS&I programme that are related to operational limits and conditions, and the changes thereto;
- monitoring compliance with the MS&I programme and the related quality assurance programme (for example, by requiring the operating organization to report on the extent of its compliance with the MS&I programme, or by sample inspections of MS&I records);
- selectively monitoring and assessing the results of the MS&I programme (including functional tests, non-destructive tests, preventive maintenance and surveillance of systems);
- observing selected MS&I activities through its representatives;
- assessing selected MS&I procedures and checklists;
- considering proposals for new approaches to MS&I activities (such as reliability centred maintenance, condition based maintenance or new methods of non-destructive testing);
- monitoring to verify that appropriate actions are taken if unsafe or potentially unsafe conditions are detected.

3.5. Descriptions of all new approaches to MS&I that may result in significant changes to the approved MS&I strategies should be submitted by the operating organization to the regulatory body, together with the appropriate documentation, for thorough consideration. Examples of such new approaches are the optimization of maintenance, the use of new in-service inspection techniques and methods, or the use of new functional tests and cancellation of the functional tests previously used.

CONTRACTORS

3.6. The operating organization may delegate to other organizations the work of implementing the MS&I programme or any part thereof, but it is required to retain overall responsibility for such delegated work [1].

3.7. The operating organization should ensure that an effective organization is established for MS&I, which should perform all the administrative, technical and supervisory functions necessary in mobilizing and supervising on-site and off-site MS&I resources. The management at the plant is required to remain responsible for all tasks undertaken on its behalf [1].

3.8. Contractors should be subject to the same standards as plant staff, particularly in the areas of professional competence, adherence to procedures and evaluation of

performance. Suitable steps should be taken to ensure that contractors conform to the technical standards and the safety culture of the operating organization.

3.9. Activities performed by contractors and other personnel who are not permanent employees of the plant should be controlled by means of established management systems. These systems should cover the training and qualification of contractor personnel, radiation protection, familiarity with and adherence to procedures, understanding of plant systems, and applicable administrative procedures for both normal operation and emergency conditions. Contractor personnel should be made aware of their responsibilities in relation to the safety of the plant and the equipment they maintain. However, this shall not diminish the prime responsibility of the operating organization for plant safety and for ensuring that the contractors' work is of the required quality and that they are accountable through appropriate channels [1].

OTHER BODIES, INCLUDING DESIGNERS AND MANUFACTURERS

3.10. A close relationship should exist between the operating organization and the design or manufacturing organizations, so as to ensure that the MS&I programme is based on a clear understanding of the design philosophy and/or the manufacturing technology and technical details of the plant, and that the plant is designed to facilitate and optimize MS&I. Design and manufacturing organizations can also contribute effectively to the training of staff of the operating organization.

3.11. The operating organization should have long term access to organizations that have appropriate competence in design and engineering. Special commercial arrangements may be necessary to ensure continuity of access to these resources over the long term. A close relationship should be maintained between the operating organization and the design or manufacturing organization throughout the plant's operating lifetime. It is essential that, when plant faults occur or modifications are required, effective and timely assistance from the design or manufacturing organization is ensured. For this purpose, the operating organization should arrange for feedback of operating experience and reliability data to the design or manufacturing organization.

INTERFACE CONTROL

3.12. For all MS&I activities, a good interface control system should be in place. There should be a clear understanding of the division of responsibilities between all organizational units participating in MS&I activities (see also paras 5.23–5.26). In particular, the interface between the operating organization and contractors should be

clearly specified, with clear arrangements for the maintenance of configuration control to ensure plant safety during and after the contracted work. For further guidance on interfaces, see Annex II of Safety Guide Q1 and Safety Guide Q13 in Ref. [2].

4. ORGANIZATIONAL ASPECTS

GENERAL PROVISIONS

4.1. Before fuel loading, the operating organization should prepare an MS&I programme with the purpose of preserving the functionality and reliability of SSCs or restoring them as they degrade. Usually such a programme will consist of separate activities in MS&I intended to provide assurance that the plant's safety status remains consistent with the design assumptions and intent and is not adversely affected after the commencement of operation.

4.2. Since the design and the design objectives of a nuclear power plant will have a strong influence on the MS&I programme, development of this programme should be initiated appropriately early in the design phase. The requirements of the MS&I programme should be taken into account in the final design and construction details and in the safety analysis report for the plant. To this end, the operating organization should arrange for experienced personnel to consult regularly with the design organization.

4.3. The MS&I programme 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 (see Ref. [2]).

4.4. The goals, objectives and priorities of the MS&I programme should be defined so as to be consistent with the policies and objectives at the plant. Appropriate operational safety performance indicators should be established and used to monitor and enhance the quality of MS&I. Senior management should encourage effective and high quality performance of MS&I. Results and feedback from the performance of MS&I should be used in accountability reviews and in establishing goals and objectives for subsequent planning periods.

4.5. The frequency of MS&I for individual SSCs should be determined on the basis of:

- their relative importance to safety,
- the required reliability,
- the assessed potential for degradation in operation and ageing characteristics,
- operating experience,
- manufacturers' recommendations.

4.6. The organization and the number and qualifications of personnel should be adequate for the purposes of operation of the plant, the outage work to be performed by the plant's staff, and supervision of the work of contractors if these are used.

4.7. Following any abnormal event, the operating organization is required to revalidate the safety functions and the structural and functional integrity of any SSCs that may have been challenged by the event. Necessary corrective actions are required to include maintenance, surveillance and in-service inspection, as appropriate [1].

4.8. In planned shutdowns the opportunity should be taken to undertake MS&I activities. In the event of an unplanned shutdown, it should be considered whether it would be useful to undertake MS&I. Refuelling activities should be taken into account in relevant MS&I schedules. Suitable schedules for MS&I should be readily available for unplanned as well as planned shutdowns.

4.9. Control room operating personnel are directly responsible for safe operation of the plant, including its continued configuration control. They should be informed (by means of a work permit procedure, for example) of all MS&I work before it is commenced, of any changes to the plant that this work entails, and of the return of plant systems to the control of the operator. During the performance of such work, adequate communication should be maintained between the relevant personnel and control room operating personnel.

ORGANIZATIONAL STRUCTURE

4.10. The organization for MS&I will vary greatly between different operating organizations, depending on:

- the operating organization's concepts and practices for operation,
- the type of reactor,
- the refuelling mode,
- the frequency of periodic shutdown.

4.11. The ultimate responsibility for preparing and executing an adequate MS&I programme rests with the operating organization. For every aspect of the MS&I programme, the operating organization should assign the authority and responsibilities, both within its own organizational structure and to other organizations, and should specify lines of communication. It should make available to the plant management sufficient resources in terms of personnel and equipment to implement the appropriate programmes satisfactorily. It should ensure the timely conduct of work activities, their documentation and reporting, and the evaluation of results. Any deviation from the established frequency and extent of the relevant activities should be justified, reviewed and reported to the regulatory body as appropriate.

4.12. The plant management should establish a group on the site to implement the MS&I programme. This group may be divided into mechanical, electrical, and control and instrumentation sections. The detailed organizational structure will depend mainly on which source of personnel, or combination of sources, is employed: the group itself, the operating organization, outside agencies or contractors. The structure of the group and its integration with off-site resources will depend heavily on such factors as the type of plant, the number of reactors on the site, the availability of suitable staff locally, the mode of operation of the reactors, and regulations governing the employment of off-site labour. In all cases, the plant management should ensure that sufficient numbers of adequately qualified personnel are available to implement the programme.

4.13. There are some common factors that will influence the choice of organizational structure of the MS&I group. The organizational structure will depend on whether, and the extent to which, MS&I is implemented by the group, by a central department of the operating organization, by outside agencies or by contractors. These sources of personnel can be successfully used in combination. In each case, however, the plant management is required to retain primary responsibility for implementing the MS&I programme [1].

4.14. In plants designed for on-load refuelling, refuelling activities are routine and continuous and will usually be performed by operating personnel. Subject to the operating organization's policy on the use of off-site resources, the organization for MS&I in plants of this type should be based on the concept of having a sufficient number of staff to deal effectively with a relatively steady flow of MS&I work with a minimum of assistance necessary from off-site sources.

4.15. It is common at many plants to undertake a large amount of MS&I work during refuelling outages or other outages lasting for periods of several weeks or more. Much MS&I work can be accomplished only during this period. This inevitably leads to large

peaks in demand for MS&I resources. To be able to respond effectively to these peak demands, the organization for MS&I should be well structured and adequately staffed, and the on-site organization will require significant supplementary resources to be provided from off-site sources.

4.16. Independent verification that the MS&I programme is being implemented in compliance with the requirements for quality assurance should be carried out by persons from the operating organization who are not directly involved in these activities. For further guidance on provisions for quality assurance, see the relevant Safety Guides in Ref. [2].

PLANNING AND SAFETY MANAGEMENT

4.17. Activities for MS&I should be planned in the context of the overall management of the plant. It is usual practice for the management of the operating organization to establish a planning team to co-ordinate all MS&I activities.

4.18. In planning activities for MS&I, consideration should be given to potential human failures in the performance of such activities. Particular emphasis should be placed on establishing the best work procedure, providing suitable job aids and using sound principles of human engineering design wherever practicable, to ensure that the potential for errors is minimized at all times.

4.19. In planning activities for MS&I that involve the removal from service of SSCs important to safety, it should be ensured that operational limits and conditions and any other applicable regulatory requirements are always met. If tasks for MS&I are discovered to be incompatible with existing operational limits and conditions, then, after invoking the plant modification procedure, either a temporary waiver of or a permanent change to the operational limits and conditions should be effected (see also Ref. [3]).

4.20. As a general rule, MS&I activities should be staggered in cases where there are redundant trains or several trains of similar design. This makes it possible to analyse performance data before proceeding with subsequent tests, and to make adjustments for the subsequent tests if any problems are found.

4.21. Factors important to safety, such as the ageing of safety significant components, as well as maintenance history and operating experience should be taken into account in the long term planning.

4.22. The elimination of plant defects should be tracked to completion, and records should be kept of the work performed. These records should be accessible whenever needed for review.

4.23. Procedures and work related documents should specify preconditions and provide clear instructions for the work to be done, and should be used to ensure that work is performed in accordance with the strategy, policies and programmes of the plant. The procedures and work related documents should be technically accurate, properly validated, verified and authorized, and they should be periodically reviewed. Human factors and the ALARA principle (to keep radiation doses as low as reasonably achievable) should be considered in the preparation of work instructions.

4.24. 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. The conditions for safe implementation of MS&I should be part of the operational limits and conditions.

ADMINISTRATIVE PROCEDURES

4.25. In order to implement the MS&I programme and to achieve the objective of safe and reliable operation, the operating organization should ensure that administrative controls are established. These controls will usually take the form of administrative procedures, which will include all administrative controls and requirements for carrying out activities at the plant. Methods should be established in the MS&I programme for identifying the need for any work, for implementing the work identified as necessary and for reporting on that work. Administrative procedures and controls should be established to guide personnel in the entire process.

4.26. The factors to be taken into account in developing administrative controls and procedures applicable to MS&I should include, but are not limited to, the following:

- the generation of adequate written work procedures;
- the use of work order authorizations;
- the use of work permits in connection with equipment isolation;
- radiation protection of personnel;
- control of the plant configuration;
- calibration of tools and equipment;
- industrial safety controls;
- fire hazard controls;

- general risk assessment;
- the use of interlocks and keys;
- training and qualification of personnel;
- control of materials, products and spare parts;
- a control plan and programme for lubrication;
- housekeeping and cleanliness;
- nomenclature, location and labelling of equipment;
- a preventive maintenance programme;
- generation and collection of records;
- retention of records;
- planning for work during shutdowns.

4.27. In developing these administrative controls and procedures, account should be taken of the interfaces between each activity and other activities such as maintenance on other systems or components, plant operation and radiation protection. In particular, the following aspects should be explicitly covered:

- (a) The delineation of responsibilities between those persons performing MS&I and those directly responsible for plant operation. This should not be taken as diminishing or delegating prime responsibility for safety, which rests with the personnel in charge of operations (for example, the shift supervisor).
- (b) Ensuring that the operating personnel have adequate information about the plant status at all times during MS&I activities.
- (c) Establishment of a work permit system controlling the issuing and cancellation of appropriate documentation such as work authorizations, equipment isolation work permits, live testing authorizations and limitations to access. This includes the designation of persons in the operating shift who are authorized to issue such permits to those responsible for carrying out MS&I work.
- (d) Provision of a direct positive indication of equipment that is not available for the operational state. This includes tagging, where appropriate, and any steps to be taken to prevent unintentional return to service. The tagging should not hide or obscure any indication device.
- (e) Ensuring that, after MS&I, the SSCs are inspected for their intended operational state and, where necessary, are tested by authorized persons before being formally declared functional and fully reinstated for normal operation.

In addition, a mechanism should be implemented which enables users to feed back suggestions for the improvement of procedures.

4.28. Temporary changes to procedures should be properly controlled and should be subject to appropriate review and approval. Such temporary changes should be