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MAINTENANCE
OF
NUCLEAR POWER PLANTS

A Safety Guide

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1. INTRODUCTION

1.1 GENERAL

1.1.1 Effective maintenance is essential to the safe operation of a nuclear power plant. Adequate maintenance activity assures that the level of reliability and effectiveness of all plant structures, systems and components having a bearing on safety remain in accordance with design assumptions and intent and that the safety status of the plant has not been adversely affected since the commencement of operation.

1.1.2 This guide provides detailed guidance on the provisions of the Code of Practice on Safety in Nuclear Power Plant Operation on the maintenance of structures, systems and components.

1.1.3 Maintenance of nuclear power plants requires special considerations because of the following:

- (1) Limitations due to the requirements for a minimum number of components to remain operable even when the plant is shut down
- (2) Difficulty of access to some plant items, even when the plant is shut down, due to radiological protection constraints
- (3) The potential radiological hazards to public and site personnel.

1.2 SCOPE

1.2.1 This guide covers the organizational and procedural aspects of maintenance but does not give detailed technical advice on the maintenance of particular plants.

1.2.2 This guide gives guidance on all those activities, both preventative and remedial, necessary to ensure that all safety-related structures, systems and components, having been correctly designed, installed and commissioned, are capable of performing their intended function.

1.2.3 This guide covers the organizational and administrative requirements for the establishment and implementation of a preventative maintenance schedule, repair of defective plant items, provision of maintenance facilities and equipment, the procurement of stores and spare parts, the selection and training of maintenance personnel, the review and control of plant modifications incidental to maintenance, and the requirements for the generation, collection and retention of maintenance records.

1.2.4 The maintenance activity shall be subject to quality assurance in all safety-related areas. Because quality assurance has been dealt with in detail in other safety guides, it has only been included in this guide in specific instances where emphasis was required.

1.2.5 Maintenance is considered to include functional and performance testing of plant, and in-service inspection, where these activities are necessary to validate other maintenance activities or to obtain assurance of the continuing capability of safety-related structures, systems and components to perform their intended function whether these activities are carried out by maintenance or other personnel. These two activities are, however, covered in other guides (SG-02, "In-service Inspection for Nuclear Power Plants", and SG-08, "Surveillance of Important Systems and Components in Nuclear Power Plants").

2. MAINTENANCE PROGRAMME

2.1 GENERAL

2.1.1 The Maintenance Programme covers all those preventative and remedial activities, both administrative and technical, necessary to perform the maintenance activity satisfactorily. The maintenance activity includes servicing, overhaul, repair and replacement of parts and, as appropriate, testing, calibration, inspection (including in-service inspection). It may also include modifications to structure, systems and components.

2.1.2 The Operating Organization is responsible for establishing a Maintenance Programme for preventative and remedial maintenance which will achieve the design objectives of performance throughout the operational life of the plant. The Operating Organization may delegate to other organizations the work of establishing and implementing the Maintenance Programme or any part thereof, but shall retain the overall responsibility for such work delegated.

2.1.3 The Operating Organization shall, however, ensure that an organization for maintenance is established which shall include all the administrative, technical and supervisory structures needed to employ and supervise on-site and off-site maintenance resources to implement satisfactorily the Maintenance Programme. Plant Management shall be responsible for on-site maintenance.

2.2 ESTABLISHMENT OF THE MAINTENANCE PROGRAMME

2.2.1 The development of the Maintenance Programme should be initiated sufficiently early in the design phase of a nuclear power plant since the design and the design objectives of the plant will have a strong influence on the Maintenance Programme. Similarly, the requirements of the Maintenance Programme should be reflected in the final design and construction details of the plant. This should be accomplished by the Operating Organization arranging for personnel with maintenance experience to consult regularly with the design organization.

2.2.2 The Maintenance Programme shall be established in such time that it can be implemented to the extent necessary to cope with the plant systems as they are put in operation or transferred to the responsibility of the Operating Organization, whichever comes first.

2.2.3 Responsibility for the maintenance of a plant item which is installed but awaiting completion of the system shall be established in writing by the Operating Organization. The Operating Organization should collect timely and sufficient information on the maintenance needs from designers, manufacturers, and from other operating organizations, and should ensure that good maintenance practices are being followed.

2.2.4 As early as possible during construction and pre-operational tests but not later than the commissioning stage of the plant, a site maintenance group of the type defined in sub-section 3.1.1 should already be established to perform plant maintenance.

2.3 PREVENTATIVE MAINTENANCE SCHEDULE

2.3.1 Preventative maintenance is the pre-planned routine testing, inspection, servicing and overhaul of structures, systems and components to detect incipient failures and to provide assurance of the continuing capability of the plant to perform its intended functions. These pre-planned activities shall be specified in a Preventative Maintenance Schedule.

2.3.2 Among the structures, systems and components which shall be included in the Preventative Maintenance Schedule are those which are considered to be safety-related. The Operating Organization should review, as appropriate, the lists of structures, systems and components in order to determine which items should be considered safety-related. Guidance on identification and classification of safety-related structures, systems and components is provided in the guide SG-D1, "Safety Functions and Component Classification for BWR, PWR and PTR".

Design basis and description documents, the safety report and regulatory requirements can also be used to identify items important to safety. Consideration should also be given to the requirements and recommendations of the guide SG-O3, "Operational Limits and Conditions for Nuclear Power Plants".

2.3.3 The frequency and extent of preventative maintenance of items included in the Preventative Maintenance Schedule should be established by considering the factors detailed in the guide SG-D1, supplier's recommendations and relevant experience of the Operating Organization. Assumptions made on the frequency of preventive maintenance, for justifying the reliability of the systems or plant items shall be incorporated in the Preventive Maintenance Schedule.

2.3.4 The Preventative Maintenance Schedule shall be reviewed as appropriate during the life of the plant as operations progress, experience is gained, and plant modifications are made.

2.4 DESIGN LIAISON

2.4.1 The aim of the close liaison between the operating and design organizations, mentioned in sub-section 2.2.1, should be to ensure that the final maintenance programme is based on a clear understanding of the design philosophy and plant detail, and that the plant is designed to minimize and facilitate maintenance, and to minimize radiation exposure to maintenance personnel.

2.4.2 The Operating Organization should arrange for reviews of the design by its staff experienced in maintenance, to check for design features which could be changed to improve maintainability, particularly in areas of radiological hazard. The staff should review:

- (1) Access to plant items
- (2) Adequacy of handling devices
- (3) Available space for withdrawal
- (4) Area available for in situ work
- (5) Interference with the operation and maintenance of other structures and systems
- (6) Provision for shielding and access control, both installed and temporary
- (7) Adequacy of the active maintenance shops and decontamination facilities, active drain facilities and ventilation in areas which may be used for temporary maintenance work
- (8) Electrical and mechanical isolation devices
- (9) Draining and venting facilities on active systems
- (10) Adequacy of stocks of spare parts.

The Operating Organization's previous experience or that of other Operating Organizations of maintenance of equipment and plant, should be a factor in the selection of plant items.

2.4.3 This close liaison should be maintained throughout the life of the nuclear power plant, in particular, to ensure the effective and timely assistance from the design organization when plant faults occur or modifications are required. For this purpose, the Operating Organization should arrange for the feedback of operating experience and reliability data to the design organization.

2.5 PLANNING OF MAINTENANCE ACTIVITIES

2.5.1 Because of the complexity of the nuclear power plant, activities of different units of Plant Management have interfaces of safety significance. In addition, the large number of special components to be maintained makes successful allocation of on-site and off-site resources for effective maintenance a major activity. Therefore, maintenance activity has to be planned in the context of overall planning of the activities of Plant Management. The Maintenance Group should, therefore, work in close consultation with other Groups of Plant Management. It is the usual practice for Plant Management to constitute a planning unit to co-ordinate all activities. However, the Maintenance Group should carry out its own scheduling of work within the overall plan.

Planning should also ensure availability of adequate maintenance personnel on call duty in order to provide for urgent remedial maintenance of items important to safety.

2.5.2 More complex planning is necessary for the timely completion of plant shutdown work, particularly where this involves off-load refuelling. Critical path analyses should be used for optimization processes.

2.5.3 The organization for maintenance will vary greatly in different Operating Organizations, depending on the Operating Organization's philosophy and practices for operation, but more significantly, on the type of reactor and mode of refuelling.

2.5.4 In plants designed for on-load refuelling, the refuelling activity is routine and continuing and will be performed usually by operating personnel. The organization for maintenance in this type of plant can have sufficient staff to deal effectively with a relatively even volume of maintenance with a minimum of assistance from off-site sources, subject to the Operating Organization's policy on the use of off-site resources.

2.5.5 In plants designed for off-load refuelling, the refuelling activity is periodic, occurring at intervals which usually vary from twelve to eighteen months depending on fuel, core design and load factors during the operating period. Due to the periodic nature of refuelling in the plant designed only for off-load refuelling, there will be a large accumulation of preventative, remedial and modification work scheduled for the refuelling shutdown. Since this accumulated work is all scheduled to be performed concurrently with the refuelling activity of limited duration, there will probably be large peaks in the demand for maintenance resources. The additional personnel requirements are due also to the necessity of meeting the radiological protection requirements without extending outage time. The organization for maintenance should be structured and staffed to respond effectively to these peak requirements. It is expected that, in this case, the on-site organization will require significant supplementary resources from off-site.

2.5.6 Advantage should be taken of any shut-down to undertake maintenance. This would also include refuelling shut-downs provided that the maintenance work does not interfere with refuelling activities.

2.5.7 Control room personnel shall be informed (e.g. by means of the permit to work procedure) of all maintenance work before it commences, any changes to the plant that it entails, and when the plant has been returned to the responsibility of the operator. Adequate communication should be maintained between the maintenance and control room operating personnel during the performance of the work.

3. ORGANIZATION AND RESPONSIBILITIES FOR MAINTENANCE

3.1 ORGANIZATIONAL STRUCTURE

3.1.1 The Plant Management shall establish a Maintenance Group on site to implement the Maintenance Programme. The responsibility for implementing the Maintenance Programme shall be delegated to an individual, usually designated as Maintenance Superintendent. Although the structure of the organization will vary in accordance with national practices and the Operating Organization's philosophy, there are common factors which will influence the choice of structure.

3.1.2 The organizational structure for maintenance will depend on the extent to which maintenance is implemented by the Maintenance Group, a central maintenance department of the Operating Organization, outside agencies, or contractors. These sources of maintenance personnel can be used successfully in combination, but in every case the Maintenance Superintendent shall retain primary responsibility for implementing the Maintenance Programme.

3.1.3 The Maintenance Group may be divided into Mechanical, Electrical, and Control and Instrumentation Sections. The organizational structure below the Section Heads will depend mainly upon which source or combination of sources of maintenance personnel are employed. Examples illustrating two different forms of organizational structures have been given in the guide SG-01, "Staffing of Nuclear Power Plants and Recruitment, Training and Authorization of Operating Personnel"; however, those examples are not the only possible alternatives for maintenance nor are they particularly recommended. The structure of the Maintenance Group, and its integration with off-site resources, is heavily dependent on such factors as type of plant, number of reactors on one site, local availability of suitable manpower, mode of operation of the reactors, regulations governing the employment of off-site labour. In all cases, the Plant Management shall ensure that sufficient numbers of adequately qualified personnel are available to implement the Maintenance Programme.

3.2 RESPONSIBILITIES

3.2.1 The responsibilities of the management and supervisory staff of the Maintenance Group shall be defined in writing by the Plant Management. Plant Management shall ensure that the Maintenance Group works in close co-ordination with such groups as operations, health physics, quality assurance, and planning.

3.2.2 Because of the variety of organizational structures previously discussed, it is not practical in this Guide to define fully the responsibilities of the various managerial and supervisory positions. Regardless of the actual organization for maintenance, **the responsibilities normally include:**

- (1) For the Maintenance Superintendent - implementation of maintenance in accordance with the Quality Assurance Programme, the appropriate legislation and the policy of the Operating Organization and the guidelines issued by Plant Management; review and optimization of the Preventative Maintenance Schedule; administration of remedial maintenance activities including initiating the plant modifications where necessary; ensuring availability of adequate maintenance procedures; administration of maintenance personnel, including training and qualification; provision of tools and equipment; review and approval of records

- (2) For each Section Head (in the area of his responsibility) - implementation of maintenance in accordance with the Quality Assurance Programme and the instructions of the Maintenance Superintendent; specifications and inventory control of spares; preparation of maintenance procedures and updating of the same in the light of experience, e.g. radiation exposure work methods; provision of adequate supervision of the work, assistance in administration of maintenance personnel; planning and allocation of resources in accordance with the overall plan; reporting progress and results to the Maintenance Superintendent; review and approval of reports and records
- (3) For each Supervisor (in the area of work assigned to him) - allocation of resources to the various jobs in the daily work plan; observation of progress and quality of work; ensures that procedures are followed, generation, collation and processing of records; report of work status and progress.

It is the responsibility of all the above to take into account the need to minimize radiation doses to personnel resulting from maintenance activities.

3.3 SELECTION AND TRAINING OF MAINTENANCE PERSONNEL

3.3.1 Staffing for the Maintenance Group including selection of personnel shall be in accordance with the provisions of the guide SG-01, "Staffing of Nuclear Power Plants and Recruitment, Training and Authorization of Operating Personnel". The provisions in the following sub-sections 3.3.2, 3.3.3 and 3.3.4 also apply to outside personnel as appropriate to the type and duration of their job on site.

3.3.2 All maintenance personnel shall be given appropriate training in radiological protection safety rules, access control and emergency procedures, and they shall be qualified in these areas before being allowed to work in controlled areas. They shall also be appropriately trained and qualified in the Quality Assurance requirements which are applicable to their duties.

3.3.3 Selected maintenance supervisors and craftsmen should be given special training at manufacturer's works, during construction, fabrication, assembly and testing of safety-related items. Arrangements should be made for maintenance personnel to participate in maintenance, inspection and testing during the construction and commissioning stages.

3.3.4 Maintenance craftsmen shall have been trained and shall have initially demonstrated a satisfactory level of craft skill. Certain crafts, such as welding, require periodic re-qualification, and in these cases re-training may be necessary. They shall also be trained to have an understanding of the plant systems and equipment appropriate to their job. Each craftsman should be trained in several areas of the plant to provide flexibility in job allocation. This will not only result in more efficient use of manpower but will also enable variations between the radiation exposures of individuals to be minimized.

4. ADMINISTRATIVE CONTROLS

4.1 ADMINISTRATIVE PROCEDURES

In order to implement the Maintenance Programme and achieve the objective of safe reliable operation, the Plant Management shall establish a number of administrative controls. These controls will usually be in the form of administrative procedures which will also include all administrative controls and requirements for performing maintenance on the plant. The development, review and approval of administrative procedures shall be in accordance with the guide SG-QA5, "Quality Assurance during Operation of Nuclear Power Plants".

4.2 SCOPE OF PROCEDURES

4.2.1 Maintenance administrative procedures shall be sufficiently comprehensive to provide plant maintenance supervision with administrative guidance in all areas of the maintenance activity.

4.2.2 The following is a list of some of the administrative tasks and procedures applicable to the maintenance activity:

- (1) General Maintenance Work Criteria and Procedures
- (2) Generation and Control of Procedures
- (3) Review and Revision of Procedures
- (4) Work Order Authorization
- (5) Equipment Isolation Work Permit
- (6) Radiation Work Permit
- (7) Fire Hazard Control
- (8) Plant Modification Control
- (9) Training and Qualification of Maintenance Personnel
- (10) Material and Parts Control
- (11) Lubrication Control Plan and Schedule
- (12) Housekeeping and Cleanliness
- (13) Personnel Radiation Monitoring
- (14) Equipment Nomenclature and Location
- (15) Preventative Maintenance Schedule
- (16) Generation and Collection of Records
- (17) Retention of Records
- (18) Maintenance Instruction Preparation
- (19) Shutdown Work Planning.

4.2.3 In compiling the above procedures, account shall be taken of the interfaces between the maintenance activity and other functions such as plant operation and radiological protection. In particular, the following aspects shall be explicitly covered:

- (1) Delineation of lines of responsibility between those persons performing maintenance and the persons directly responsible for plant operation. For example, removal from and restoration to service of structures, systems and components shall be authorized by the designated persons in the operating shifts (normally the shift supervisor)
- (2) The establishment of a work permit system controlling the issuance and cancellation of appropriate documentation such as work authorizations, equipment isolation work permit, live testing authorizations, limitations of access, etc., by designated persons in the operating shift to the persons responsible for carrying out the work
- (3) The provision of a direct positive indication of the equipment which is not available for operation, including tagging where appropriate.
- (4) When work is to be undertaken in controlled areas, work planning and control requirements mentioned in SG-05 (Section 4.5.5) shall be complied with.

Reference should be made to Safety Guide SG-09 for further details of interface activities of maintenance and operation.

4.3 MAINTENANCE INSTRUCTIONS

4.3.1 The Operating Organization shall require Plant Management to prepare maintenance instructions to provide the detailed directions and controls required for performing maintenance. Plant Management should delegate the responsibility for the preparation of these instructions to the Maintenance Group. If persons outside the Maintenance Group prepare the instructions for routine maintenance activities, the instructions should be submitted for final approval to the Maintenance Group. The preparation of maintenance instructions shall be in accordance with the guide SG-QA5, "Quality Assurance during Operation of Nuclear Power Plants".

4.3.2 An administrative procedure shall describe the method, format and level of detail required in the maintenance instructions. A separate instruction should be provided for each individual maintenance job. A generic maintenance instruction may be used for simple, repetitive jobs of a common nature, such as valve packing or small valve replacement.

4.3.3 Normally, maintenance instructions shall be written and approved prior to actual use. Exceptionally, where no maintenance instruction is available for a particular job, with proper review and approval by Plant Management the instruction may be written concurrent with the job progress if appropriate supervision is provided and the draft of the instruction is reviewed and approved upon job completion and before the equipment is returned to normal service.

4.3.3 In the process of preparing a maintenance instruction, reference documents should be consulted for determining technical contents. These documents should include appropriate drawings, codes, standards, instruction books and manuals provided by the design organization, construction organization, equipment supplier and the Operating Organization.

4.3.5 The information in the instruction should be presented in a logical, step-by-step order. The level of detail should be such that the individual responsible for the work can follow the instruction without further direction or supervision.

4.3.6 The content and format for a typical maintenance instruction should be generally in accordance with the guide SG-QA5 and shall be suitably adapted to the specialized needs of the maintenance activity as follows:

(1) Instruction Identification

This should be numbers, letters or combinations of each which identify each unique instruction as one in the maintenance series. It shall be used to identify uniquely the instruction in all programmes, plans and records.

(2) Title

This should be a concise description of the subject of the instruction.

(3) Purpose

This should be a brief statement of the scope of job controlled by the instruction.

(4) Prerequisites

This section shall include all special conditions of the plant, system or equipment status required prior to commencement of work. Any special training or mock-up practice should be noted.

(5) Limiting Conditions

This section shall include any limiting conditions of operation imposed on the plant as a result of execution of the job, such as load reduction, operation of standby equipment or safety systems. For example, when a system is undergoing maintenance, it shall be considered unavailable for safety purposes unless it can be demonstrated that the ability of the system to perform its safety function has not been diminished.

(6) Special Precautions

This section shall include any special safety instructions, such as special radiological protective measures, securing or removing loose items, material control and environmental conditioning.

(7) Special Tools and Equipment

This section shall list all special tools, rigging and equipment required to perform the job.

(8) References

This section should list the applicable sections of reference documents which may need to be consulted, such as base line data, drawings, prints, instruction books, manuals, photographs, mock-ups, etc.

(9) Instruction Text

This section shall contain the step-by-step sequential listing of the work details required to perform the work and shall identify any changes for radiological conditions as work progresses. At selected steps, the craftsman may be required to sign his name or initials indicating satisfactory completion of the preceding step or steps, either in the instruction or on an attached check sheet.

(10) Inspection Witness Points

At selected points in the instruction, inspection witness points shall be provided for the quality control verification of an event by a competent person. Work may not proceed past this point until the inspection has been made and documented.

(11) Return to Service

This section describes the actions and checks required to return the equipment or system to an operational condition once certified by the person responsible that the job is complete. Where appropriate, acceptance criteria shall be specified including correct reinstatement and correct procedural compliance as well as system operability, e.g. value line up

(12) Operational Testing

This section shall describe any post-maintenance operational testing required to prove that the equipment is functioning in the intended manner.

Items (11) and (12) are operating functions and may be included in the Maintenance Instruction or in a special interfacing Operating Instruction.

4.3.7 The format of maintenance instructions may vary depending on the purpose of the document and the practices of the Operating Organization.

5. MAINTENANCE FACILITIES

5.1 WORKSHOP FACILITIES

5.1.1 The Operating Organization shall provide adequate workshop facilities with sufficient space and equipment to perform the maintenance activity effectively, taking account of availability and intended use of off-site facilities and the need to deal with radioactive plant items. On-site workshops should in any case be provided for mechanical, electrical, control and instrumentation equipment.

5.1.2 Each of the workshops should include the following:

- (1) Office area (if not already provided elsewhere), including facilities for the processing and storage of records and procedures
- (2) Fitting and overhaul area with suitable work benches for disassembly, repair and reassembly of plant items which are intended to be dealt with in the workshop
- (3) Secure storage facilities for special tools and testing equipment required for maintenance.

5.1.3 Additional facilities recommended to be available in the on-site workshops or off-site should include:

- (1) Mechanical Shop
 - (i) Space and equipment for welding, sheet metal and plate fabrication, pipefitting and handling of heavy equipment and material
 - (ii) Machine tools such as lathes, milling machines, shapers, pedestal drills, grinders and presses
 - (iii) Clean room with lapping, polishing and surface checking equipment

- (2) Electrical Shop
 - (i) Test benches with the appropriate power supplies connected
 - (ii) Motor test facility
 - (iii) High voltage test area with controlled access
 - (iv) Instrument and relay testing and calibration facilities
 - (v) Small capacity coil rewind facility
- (3) Control and Instrumentation Shop
 - (i) Test benches with the necessary electrical, pneumatic and hydraulic supplies and test equipment
 - (ii) Instrument calibration facility
 - (iii) Facility for safe fault finding on energized equipment.

5.2 FACILITIES FOR MAINTENANCE ON RADIOACTIVE PARTS

5.2.1 It may be impracticable or impossible to decontaminate plant items sufficiently to allow them to be maintained in the general workshops. In this case and for the maintenance of irradiated items, special maintenance facilities shall be provided to minimize doses to individuals and to prevent the spread of contamination. This may be accomplished by the provision of specific maintenance facilities for particular single plant items and the provision of a workshop for radioactive parts, located within the controlled area, for work on plant items which can be brought to it.

5.2.2 Plant Management may occasionally find it necessary to supplement the above permanent arrangements by the erection of a **temporary** facility around a plant item or a machine tool.

5.2.3 Whichever facility is being provided, the following are features which shall be included:

- (1) Access control and change facilities
- (2) Ventilation system with filtered discharge
- (3) Facilities for dealing with liquid radioactive wastes
- (4) Facilities for solid radioactive waste storage and disposal
- (5) Radiological monitoring and protective equipment
- (6) Shielding and remote handling equipment as necessary
- (7) Segregated storage facilities for both conforming and non-conforming active items
- (8) Limited decontamination facilities.

5.3 DECONTAMINATION FACILITIES

5.3.1 Facilities shall be provided by the Operating Organization for the purpose of removing radioactive contamination from plant items, tools and equipment prior to maintenance or other disposition.

These facilities should include the following features:

- (1) Access control and change facilities
- (2) Ventilation with filtered discharge
- (3) Facilities for dealing with liquid radioactive wastes
- (4) Facilities for solid radioactive waste storage and disposal
- (5) Radiological monitoring and protective equipment
- (6) Decontamination tanks and special equipment to deal with the largest plant item likely to require decontamination
- (7) Adequate supplies of electrical power, steam, hot water, and compressed air and approved chemical decontamination agents
- (8) Other decontamination systems such as glass blasting or ultrasonic techniques.

5.3.2 Care should be taken when establishing the size and capacity of the decontamination facilities since experience in operating plants has shown that these facilities are frequently inadequate.

5.4 SPECIAL FACILITIES

5.4.1 Mock-ups

In some cases there are advantages to the maintenance activity in designing and constructing simulations, mock-ups or models of particular sections of the plant, either full size or reduced, in areas remote from the section of the plant concerned. In particular, such facilities are recommended for:

- (1) Rehearsals of work to be carried out in high radiation areas or on highly contaminated plant items, particularly for personnel not familiar with the plant or for an unusual or specialized job
- (2) Planning procedures to avoid errors and reduce exposures
- (3) Gaining experience of using tools and protective equipment in simulated working conditions
- (4) Developing and improving tools and equipment
- (5) Training and qualifying personnel for selected work.

5.4.2 Special Equipment and Tools

In addition to the special equipment essential to the maintenance activity, Plant Management shall provide special equipment where this can result in significant reductions in radiation exposure or improvements in safety.

Examples of special equipment which have proved necessary or desirable are:

- (1) Remote handling manipulators and remotely operated special purpose tools
- (2) Automatic welding and cutting equipment

- (3) Remotely operated non-destructive testing equipment
- (4) Automatic in-situ valve seat lapping machine
- (5) Remote viewing equipment such as mirrors, binoculars, telescopes, periscopes, boroscopes, fibrosopes, closed circuit television and remotely operated cameras
- (6) Communication systems such as direct line telephones, radio and communication equipment for use when respiratory protection is being worn.
- (7) Special containers for contaminated items
- (8) Shielded containers and portable shielding
- (9) Radiological protection clothing and equipment
- (10) Material and equipment for the control and containment of radioactive contamination. Examples are plastic sheeting and tents, paper floor covering, suction cleaners and floor cleaning equipment.

5.4.3 Photographic and Video Records

During the construction of the plant, the Operating Organization should ensure that comprehensive photographic and as appropriate, video records are compiled, particularly of those parts of the plant which will eventually be inaccessible or subject to high radiation dose rates.

These records of the as-built conditions should show identification bench marks and be comprehensively catalogued with descriptive captions. This will ensure ease of comparison with similar photographs and tapes taken during subsequent inspections or maintenance work and will enable work planning and personnel familiarization to be undertaken prior to the start of maintenance work.

5.5 LIFTING AND HANDLING FACILITIES

5.5.1 The Operating Organization shall ensure that adequate facilities, space and clear access are provided in the design of the plant for all plant items which are likely to require removal and transport.

5.5.2 Plant Management shall provide suitable portable lifting and transport facilities. In the selection and use of these facilities, due account shall be taken of the radiological consequences of failure. Examples of precautions taken include regular examination and maintenance of lifting equipment, periodic testing and special inspections prior to major lifting and rigging operations, and clear indication of lifting capacity.

5.5.3 Special consideration should be given to the use of mobile lifting and transport facilities as a possible means of making substantial reduction in exposure of personnel (e.g. filter removing equipment).

6. REPLACEMENTS AND REPAIRS

6.1 REMEDIAL MAINTENANCE

6.1.1 The Maintenance Group should be capable, with the assistance of outside agencies if necessary, of restoring the plant to its normal operational capability by remedial maintenance such as replacement or repair of defective plant items.

6.1.2 The need for remedial maintenance may arise from failures during plant operation which come to the attention of the operations personnel. For these circumstances, Plant Management shall set down in appropriate procedures such as the Works Order Authorization and the Equipment Isolation Work Permit Procedures how such failures are to be reported to the Maintenance Group and how plant items are to be withdrawn from service for remedial maintenance. These procedures should require the operating personnel to assign priority to remedial work based on its importance to safety and taking into account the prescribed operational limits and conditions.

When the need for remedial maintenance is found during preventative maintenance of the plant, the Maintenance Group shall initiate remedial maintenance in accordance with the administrative procedures referred to above.

6.2 REPLACEMENT OF DEFECTIVE ITEMS

6.2.1 When the remedial maintenance can be most conveniently undertaken by the substitution of the defective plant item by a proven identical spare item, it shall be done in accordance with the established procedures such as the Work Order Authorization. A defective plant item not suitable for subsequent repair shall be disposed of by a documented process to avoid re-use. Minor defective components should not be allowed to accumulate in work areas.

6.2.2 Following completion of the replacement of the defective item, suitable functional or performance tests shall be carried out in conjunction with the operating personnel and the tests documented and results recorded. The plant item shall be returned to service or standby duty in accordance with established procedures such as the Equipment Isolation Work Permit.

6.3 REPAIR OF DEFECTIVE ITEMS

6.3.1 The repair of defective items, whether removed from the plant or not, shall be undertaken in accordance with established procedures such as the Equipment Isolation Work Permit and Work Order Authorization as necessary.

6.3.2 When the repairs of plant items consist of more than a mere replacement of parts and components by identical spares, consideration shall be given to whether the repair will make sufficient change to require the application of the Plant Modification Control Procedure described in Section 7.

6.3.3 If repairs are made to the plant in situ, post-maintenance testing and return to service control shall be applied as described in sub-section 6.2.2.

6.3.4 Plant items repaired but not intended for immediate re-installation shall be subjected to appropriate post-repair inspection and testing to ensure, as far as possible, full return to serviceability. If such testing cannot be completed in the workshop, cautionary labels or tags shall be applied to the plant item to warn that testing needs to be completed before re-use. When these post-repair processes have been completed, the item should be returned to stores through the normal receiving channel.

7. MODIFICATIONS INCIDENTAL TO MAINTENANCE

7.1 GENERAL

Modifications may be necessary to rectify component failures discovered during maintenance, to repair components following failures in operation, to reduce the frequency of faults, to improve maintainability or to incorporate a non-identical replacement plant item. Modifications may include physical changes, changing of set points, and changes to procedures.

7.2 REVIEW

7.2.1 The Operating Organization shall make arrangements for an independent review of proposed modifications to safety-related plant items which result from maintenance activities. These arrangements shall include an appropriate directive which requires the Plant Management to categorize modifications as minor or major so that those judged to be major can be submitted to an independent assessment by suitable qualified persons. The directive shall include criteria for making this judgment. For example, modifications which, if incorrectly conceived or inadequately executed, could increase the probability or severity of a radiological hazard, shall be considered major.

7.2.2 Notwithstanding these general criteria, the Operating Organization should specify those plant items and systems (such as primary coolant boundary, emergency electrical supplies, reactor protection equipment) which are considered to be of such significance to safety that no modifications to them can be judged minor.

7.2.3 The above mentioned directive should allow for the rapid review and assessment of proposed modifications required to be undertaken urgently; but such emergency actions shall not reduce the levels of safety. In these circumstances, formal documentation of the assessment process may be completed in retrospect without undue delay.

7.2.4 A suitable procedure such as the Plant Modification Control Procedure, issued by the Plant Management, should clearly allocate the responsibility for co-ordinating plant modifications, for implementing the on-site categorization and review process, for liaison with the independent assessment process, for the administrative controls relating to the implementation and documentation of approved modifications, and dissemination of information to specified bodies.

7.3 SUBMISSION OF PROPOSALS

7.3.1 Proposals for major modifications submitted by Plant Management to the independent assessment process shall comply with requirements specified by the Operating Organization in the above mentioned directive.

The amount of information required will depend on the extent and complexity of the modification, but as a general guide, submissions should include the following as necessary:

- (1) Design description and reason for modification
- (2) Safety analysis
- (3) Sketches, drawings and materials list
- (4) Specifications requirements for parts and materials
- (5) Applicable codes, standards and safety report section
- (6) Fabrication, installation and test methods
- (7) Adverse environmental or operating conditions
- (8) Quality assurance requirements.

7.3.2 The proposal shall assess the effect of the modification on radiological hazard during implementation of the modification, the subsequent commissioning, testing, maintenance, operation and decommissioning of the modified plant. This assessment shall consider the effect of the modified item of plant and its associated system, on physically adjacent systems and plant items, and interconnected systems (such as power supplies).

7.3.3 The proposal should demonstrate that the modification is designed to the original system specification or that the system specification used is better.

7.3.4 When so required, the proposed modification shall be submitted to the Regulatory Body for approval before implementation.

7.4 IMPLEMENTATION AND DOCUMENTATION

7.4.1 Reviews and assessments shall be appropriately documented, and only those modifications which have successfully gone through the appropriate processes shall be approved for implementation. Implementation of modifications shall be subject to usual maintenance administrative procedures together with any special requirements generated by reviews and assessments.

7.4.2 The above mentioned directive shall place responsibility on the Plant Management to record approval and implementation of modifications, to amend records of plant design, to update drawings, procedures and instructions as necessary and to ensure that affected spare parts in stores are appropriately dealt with either by an appropriate modification or disposal and replacement. These requirements should be implemented by suitable steps in such procedures as the Plant Modification Control Procedure.

8. STORES

8.1 ORGANIZATION

8.1.1 The Operating Organization shall establish suitable organizational units to procure, receive, store and issue materials, spare plant items and components for use with safety-related systems. The unit receiving, storing and issuing such items on site should be responsible to the Plant Management. The procurement unit may be responsible to Plant Management or located elsewhere to serve a number of power plants; in the latter case, the Operating Organization shall ensure that there are written procedures to control the interface between the off-site procurement units and Plant Management. These procedures shall clearly define who has the authority for specifying the technical and quality assurance requirements and for selection of suppliers. When that authority is vested off-site, the procedures should require consultation with and approval by the Plant Management. Whatever the organizational structure, provision should be made for Plant Management to identify safety-related items and the procurement unit to respond by appropriate Quality Assurance activities.

8.1.2 The unit for receipt, storage and issue of safety-related items shall have its responsibilities defined in writing by the Plant Management. A satisfactory arrangement would be for personnel in charge of the stores to be responsible to the head of on-site procurement unit who also should be the officer administrating the interface with the off-site procurement unit. If Plant Management considers allocating this responsibility to an Administration group, suitable procedures will be necessary to ensure that this Group responds to the requirements of the Maintenance Group.

8.1.3 The Maintenance Group is responsible for ensuring it has adequate spares, tools and resources to achieve its objectives; it establishes stock levels and authorizes spares issue and use.

8.2 PROCUREMENT

8.2.1 Arrangements should be made by the Operating Organization to procure appropriate quantities of spare plant items and components for safety-related systems at the same time as the installed plant items are purchased. These spares shall be subject to the same technical and quality assurance requirements as the equivalent installed plant item, with additional requirements necessary to ensure adequate protection during long-term storage.

8.2.2 The quantities of initial spare plant items and components to be purchased in this way should be approved by the Plant Management after consultation with the vendor and taking account of relevant maintenance experience available to the Operating Organization. Factors which should be considered are the number and importance of major plant items subject to serious failures; the special nature of the manufacturing process precluding subsequent manufacture of the plant item; the uncertainties in the future supply of parts and components currently available; anticipated delivery times; the estimated duration of repairs to a plant item compared with the unavailability time of the item permitted by the operational limits and conditions, the shelf life of the component.

8.2.3 Procurement of plant spares,

materials parts and components shall be in accordance with the provision of the guide SG-QA3, "Quality Assurance in the Procurement of Items and Services for Nuclear Power Plants". Deviations from the original technical specification, however minor, should not be permitted until the change has been referred to the Plant Management for consideration under the established procedure related to plant modifications described in Section 7 and such changes circulated to all interested units.

8.2.4 It should be the responsibility of the purchasing unit to ensure that materials and items are obtained only from suppliers who are approved in accordance with the requirements of the guide SG-QA3.

8.2.5 The routine re-ordering of material and plant items already held in store should be automatically initiated according to written procedures when a pre-determined lower limit of stock-holding is reached. This limit should be based on the expected or known rate of use and the anticipated delivery time or shelf-life. The purchasing unit shall ensure by documented reviews at the time of re-ordering that the technical and quality assurance requirements have been updated as appropriate and incorporated in the routinely generated procurement documentation.

8.2.6 Procurement of maintenance items not held in store should be initiated by the Maintenance Group. It should be the responsibility of this Group to ensure, in accordance with an established procedure that the technical and quality assurance requirements are correctly established and specified to the purchasing unit. It should be the responsibility of the purchasing unit to ensure that these technical and quality assurance requirements are then incorporated into the procurement documents without change.

8.3 RECEIPT

8.3.1 The Operating Organization shall provide adequate facilities to receive on site all materials, spare parts and components for safety-related items. The facilities for receipt should include equipment for the safe and convenient handling of items and sufficient space with appropriate environmental conditions for proper receipt inspection. Provision should be included for a separate and secure quarantine area for the temporary retention of stores not cleared for final storage or issue.

8.3.2 The Plant Management shall allocate in writing the responsibility for the receipt of all stores on site and should issue a special procedure to control the receipt and acceptance process. This procedure should include a visual external inspection for transit damage or deterioration and verification of correct packaging and identification. Items found to be incomplete, incorrect or having inadequate documentation should not be accepted for final storage. The above mentioned procedure shall include a requirement to label or tag such items until the non-conformance is resolved. More detailed guidance on receipt inspections is given in Sections 7, 9 and 10 of the guide SG-043, "Quality Assurance for the Procurement of Items and Services for Nuclear Power Plants".

8.3.3 Satisfactory completion of the receipt procedure should include generation of appropriate records and the physical disposition of the item to storage or immediate issue.

8.4 STORAGE

8.4.1 The Operating Organization shall ensure that storage facilities have adequate space and provision for the secure retention of stores in environmental conditions designed to prevent loss of quality through external effects or deterioration. Access and installed handling equipment shall be adequate for the type and size of items to be stored.

8.4.2 The Plant Management shall make administrative arrangements to ensure that the storage facility is operated in a manner which preserves the correct environmental conditions, guards against fire hazard and prevents unauthorized access to stored items. The stored items should be arranged so that, with suitable handling equipment if necessary, regular examination of all stored items may be conveniently accomplished.

8.4.3 The administrative arrangements should include written procedures allocating responsibility for the regular examination of stored items and audit of the administration of the store to detect deterioration, unauthorized or unrecorded use of stored items. Particular attention should be paid to the retention of original identification of items during storage.

8.4.4 The Plant Management should include in the procedure relevant to modifications, steps to initiate, control and record the modification of spare plant items when this is necessary because of modification to the equivalent installed plant items or for other reasons.

8.4.5 If the packaging of items incorporates protection against deterioration in storage and it is found necessary to invalidate that protection, for example to modify or inspect the item, then the protective function shall be restored or deterioration prevented by some other equivalent means.

8.5 ISSUE

8.5.1 The facilities for storage shall include provision for the convenient and orderly issue of stores. These normally take the form of a counter or barrier through which the issue of stores can take place without invalidating the arrangements for security and correct environmental conditions of the stored items.

8.5.2 Stored items shall only be issued by authorized persons in response to written orders presented by persons having authority to receive the stored items. Appropriate records should be generated to document the ultimate disposition of issued items to facilitate traceability. The issuing procedure shall require return to the stores of excess or unused items, which shall be processed through the normal receipt channel.

8.5.3 Unless the organizational arrangements include full shift staffing of the store, the procedures should permit the emergency issue of urgently required stored items on the authority of and under the control of the shift supervisor, in a manner compatible with the normal issuing process.

9. RECORDS

9.1 GENERATION AND COLLECTION OF RECORDS

9.1.1 Appropriate arrangements shall be made for the orderly collection of records and the production of reports relative to the maintenance activity. Records and reports are required to provide objective evidence that the Maintenance Programme is being implemented in all respects with the Quality Assurance Programme. In addition, records of maintenance, such as equipment history cards, and the results are a necessary input to the continuing review of maintenance effectiveness which should be the responsibility of the Maintenance Group. A particular use of maintenance records is the generation of data for reliability studies.

9.1.2 Both purposes can be served by suitable arrangements to generate and collect the same records, but the controlled copy used for the quality assurance function shall be processed in accordance with the recommendations of guide SG-QA2, "Quality Assurance Records System for Nuclear Power Plants".

9.1.3 The maintenance instructions should be designed to facilitate the convenient generation of records and, in general, records shall include identification of the maintenance and operational personnel concerned and the certification by supervisors or inspectors as appropriate.

9.1.4 A classification system which identifies the plant item and system is desirable so that data retrieved for feedback to the appropriate bodies and provision of component reliability data is facilitated.

9.2 RETENTION OF RECORDS

9.2.1 The Maintenance Organization should be required by an administrative procedure to select those records which form a meaningful plant history and to retain them for the life of the plant. Other records having only a transitory value should be retained until they cease to serve the purpose for which they were originally intended or are replaced by later records. An important factor in the selection of records to be retained is the importance of collecting reliability data.

9.2.2 The retention of records required for quality assurance purposes shall be in accordance with the guide SG-QA2, "Quality Assurance Records System for Nuclear Power Plants".

9.2.3 The record should consist of originals, hard copies, microfilms or computer storage. In all cases, the ease of retrievability, commensurate with the likely need for consultation and review, and the need to guard against accidental loss shall be factors considered when establishing storage facilities.

10. SURVEILLANCE, REVIEW AND AUDIT OF MAINTENANCE PROGRAMME IMPLEMENTATION

10.1 GENERAL

The Operating Organization shall establish a programme of surveillance, review and audit of the maintenance activity in order to provide assurance that the Maintenance Programme has been implemented in accordance with the design intent; with regulatory codes and requirements; and with the Operating Organization's own procedures and policies. Reference should be made to the guide SG-QA5, "Quality Assurance During Operation of Nuclear Power Plants".

10.2 SURVEILLANCE

Verification inspections of maintenance activities shall be performed by appropriately qualified individuals other than those who performed the activities. The inspector may be a member of the same organizational unit, and a supervisor may serve as the inspector if he did not personally participate in the work. Inspections may be unannounced and should include direct observation of the specific maintenance activity as well as examination of the documentation. Results and findings of these inspections shall be transmitted to the appropriate maintenance supervision for information, and for corrective action if required.

10.3 REVIEW

10.3.1 The Operating Organization shall establish a programme for review of the maintenance activity. The responsibility for this review programme shall be assigned by the Operating Organization.

10.3.2 It is suggested that the impartiality of the Maintenance Review be achieved by utilizing the various department heads in Plant Management. Additional expertise may be obtained by utilizing off-site personnel.

10.3.3 The review programme should examine the maintenance activity for features such as:

- (1) Adequacy of the preventative maintenance schedule and its implementation
- (2) Response to remedial maintenance requirements
- (3) Satisfactory control of radiation doses
- (4) Effective use of resources
- (5) Level of training and experience
- (6) Adherence to quality assurance requirements.

10.3.4 Reports of findings of the review programme should be made periodically and should be sent to the Maintenance Group, Plant Management and selected members of the Operating Organization.

10.4 AUDIT

10.4.1 The Operating Organization shall establish an audit programme for the maintenance activity. These audits shall be performed by qualified personnel who have no direct responsibility for maintenance. These audits will determine whether or not the maintenance activity is being conducted in compliance with regulatory requirements and the Operating Organization's Quality Assurance Programme.

10.4.2 Audits should be performed at specified intervals by qualified audit teams and should cover all areas of the maintenance activity affecting safety. Audit details shall be in accordance with the recommendations contained in the guide SG-QA10, "Quality Assurance Auditing for Nuclear Power Plants". The audit reports should be sent to Plant Management and selected members of the Operating Organization for action or information, as appropriate.

Personnel in the Maintenance Group should occasionally be assigned to audit teams auditing other areas of plant activity. This experience will enhance the individual's understanding of quality assurance requirements in his own activity.

DEFINITIONS

The following definitions are intended for use in the NUSS Programme and may not necessarily conform to definitions adopted elsewhere for international use. They have been selected from those included in the approved Codes of Practice published under the NUSS Programme.

Audit

A documented activity performed to determine by investigation, examination and evaluation of Objective Evidence the adequacy of, and adherence to, established procedures, instructions, specifications, codes, standards, administrative or operational programmes and other applicable documents, and the effectiveness of implementation.

Commencement of Operation

The beginning of initial fuel loading.

Commissioning⁴

The process during which plant components and systems, having been constructed, are made operational and verified to be in accordance with design assumptions and to have met the performance criteria; it includes both non-nuclear and nuclear tests.

Construction⁴

The process of manufacturing and assembling the components of a Nuclear Power Plant, the erection of civil works and structures, the installation of components and equipment, and the performance of associated tests.

Decommissioning⁴

The process by which a Nuclear Power Plant is finally taken out of Operation,

⁴ The terms Siting, Construction, Commissioning, Operation and Decommissioning are used to delineate the five major stages of the licensing process. Several of the stages may coexist; for example, Construction and Commissioning, or Commissioning and Operation.

Items Important to Safety

The items which comprise:

- (1) those structures, systems, and components whose malfunction or failure could lead to undue radiation exposure of the Site Personnel or members of the public;²
- (2) those structures, systems and components which prevent Anticipated Operational Occurrences from leading to Accident Conditions;
- (3) those features which are provided to mitigate the consequences of malfunction or failure of structures, systems or components.

Nuclear Power Plant

A thermal neutron reactor or reactors together with all structures, systems and components necessary for Safety and for the production of power, i.e. heat or electricity.

Operating Organization

The organization authorized by the Regulatory Body to operate the plant.

Operation (see Footnote 4)

All activities performed to achieve, in a safe manner, the purpose for which the plant was constructed, including maintenance, refuelling, in-service inspection and other associated activities.

Plant Management

The members of Site Personnel who have been delegated responsibility and authority by the Operating Organization for directing the Operation of the plant.

Qualified Person

A person who, having complied with specific requirements and met certain conditions, has been officially designated to discharge specified duties and responsibilities.

Quality Assurance

Planned and systematic actions necessary to provide adequate confidence that an item or facility will perform satisfactorily in service.

² This includes successive barriers set up against the release of radioactivity from nuclear facilities.

Regulatory Body

A national authority or a system of authorities designated by a Member State, assisted by technical and other advisory bodies, and having the legal authority for conducting the licensing process, for issuing Licences and thereby for regulating nuclear power plant Siting, Construction, Commissioning, Operation and Decommissioning or specific aspects thereof.³

Safety

Protection of all persons from undue radiological hazard.

Safety Report

A document provided by the Applicant or Licensee to the Regulatory Body containing information concerning the Nuclear Power Plant, its design, accident analysis and provisions to minimize the risk to the public and to the Site Personnel.

Siting (see Footnote 4)

The process of selecting a suitable Site for a Nuclear Power Plant, including appropriate assessment and definition of the related design bases.

³ This national authority could be either the government itself, or one or more departments of the government, or a body or bodies specially vested with appropriate legal authority.

LIST OF PARTICIPANTS

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Date of meeting: 3 to 14 July 1978

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Moore, R.H.

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IAEA Staff Member

Wright, H.A.

Scientific Secretary (Operation)

(b) TECHNICAL REVIEW COMMITTEE (TRC) - OPERATION

Dates of meetings: 27 November to 1 December 1978; 24 to 28 September 1979

Chairman

A. Bertini Italy

Members and alternates participating in the meeting

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Date of meeting : 10 to 14 December 1979

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Clement, B.)	France
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Iansiti, E.	Scientific Secretary (SAG)