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for protecting people and the environment

Conduct of Operations at Nuclear Power Plants

Safety Guide

No. NS-G-2.14

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International Atomic Energy Agency

CONDUCT OF OPERATIONS AT 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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CONDUCT OF OPERATIONS AT NUCLEAR POWER PLANTS

SAFETY GUIDE

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FOREWORD

by Mohamed ElBaradei
Director General

The IAEA's Statute authorizes the Agency to establish safety standards to protect health and minimize danger to life and property — standards which the IAEA must use in its own operations, and which a State can apply by means of its regulatory provisions for nuclear and radiation safety. A comprehensive body of safety standards under regular review, together with the IAEA's assistance in their application, has become a key element in a global safety regime.

In the mid-1990s, a major overhaul of the IAEA's safety standards programme was initiated, with a revised oversight committee structure and a systematic approach to updating the entire corpus of standards. The new standards that have resulted are of a high calibre and reflect best practices in Member States. With the assistance of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its safety standards.

Safety standards are only effective, however, if they are properly applied in practice. The IAEA's safety services — which range in scope from engineering safety, operational safety, and radiation, transport and waste safety to regulatory matters and safety culture in organizations — assist Member States in applying the standards and appraise their effectiveness. These safety services enable valuable insights to be shared and I continue to urge all Member States to make use of them.

Regulating nuclear and radiation safety is a national responsibility, and many Member States have decided to adopt the IAEA's safety standards for use in their national regulations. For the Contracting Parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by designers, manufacturers and operators around the world to enhance nuclear and radiation safety in power generation, medicine, industry, agriculture, research and education.

The IAEA takes seriously the enduring challenge for users and regulators everywhere: that of ensuring a high level of safety in the use of nuclear materials and radiation sources around the world. Their continuing utilization for the benefit of humankind must be managed in a safe manner, and the IAEA safety standards are designed to facilitate the achievement of that goal.

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.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide was prepared under the IAEA programme for establishing safety standards for nuclear power plants. It provides recommendations on fulfilling the requirements established in Section 5 of the Safety Requirements publication on Safety of Nuclear Power Plants: Operation [1].

1.2. To ensure safety, it is necessary that the management of a nuclear power plant recognizes that the personnel involved in operating the plant should be cognizant of the demands of safety, should respond effectively to these demands, and should continuously seek better ways to maintain and improve safety. This is particularly important as the nuclear industry faces increasing pressure for production in a competitive energy market. This recognition will help to ensure that operating policies for nuclear power plants that result in their safe operation are implemented and that adequate margins of safety are always maintained. The organization of the operations department, the management standards and administrative controls should be such that it is ensured to a high degree that policies and decisions for safety are implemented, that safety is continuously improved and that a strong safety culture is developed and promoted.

1.3. Regardless of the extent of automation of a plant, final decisions on operation and the resulting ultimate responsibilities for the operation rest with the personnel of the operations department of the plant. The operations personnel have a direct impact on plant operations and the associated systems and components.

OBJECTIVE

1.4. The objective of this publication is to provide States with recommendations to ensure that plant operations are conducted in a safe, effective, thorough and professional manner, in accordance with the requirements established in Ref. [1] and, where possible, best international practices. The recommendations of this Safety Guide provide further details on direct activities for operations, complementing Section 6 of the Safety Guide on The Operating Organization for Nuclear Power Plants [2].

SCOPE

1.5. The personnel of the operations department have a direct impact through the conduct of operations on the operation of the plant and its associated systems and components. This publication identifies the main responsibilities and operating practices of the operations department, which controls the safe operation of the plant.

1.6. This Safety Guide discusses the factors to be considered in (a) structuring the operations department of a nuclear power plant; (b) setting high standards of performance and making safety related decisions in an effective manner; (c) conducting control room activities in a thorough and professional manner; and (d) maintaining a nuclear power plant within the established operational limits and conditions.

STRUCTURE

1.7. Section 2 focuses on the organizational and administrative aspects of the operations department. Section 3 provides recommendations relating to the shift complement of operators and their duties. Section 4 provides recommendations on shift routines and on good operating practices. Section 5 provides recommendations for the control of plant equipment and of the plant status. Section 6 provides recommendations on the use and maintenance of facilities for operation and operator aids, and Section 7 provides recommendations on work control and authorization.

2. MANAGEMENT AND ORGANIZATION OF PLANT OPERATIONS

FUNCTIONS AND TASKS OF PLANT OPERATIONS

2.1. The management and organization of plant operations should be such as to ensure a high level of performance in operations. This should be achieved through the effective implementation and control of operations activities.

2.2. A clear understanding by operations personnel of their authorities, responsibilities, accountabilities and interfaces is essential for the proper functioning of a nuclear power plant. For operations personnel to achieve this understanding, the organizational structure of plant operations should be clearly defined and the administrative controls for implementing the structure should be formally documented.

2.3. While the structure of the operations department will vary depending on the specific plant or utility, it is normally composed of personnel who carry out shift work and additional support staff who are present during normal office hours. The following tasks, functions and responsibilities should be taken into consideration in determining the structure for the operations department:

— Planning the overall activities and work of the operations department in cooperation with other departments at the plant, to develop an integrated programme for plant operations;
— Human resources planning and staff development;
— Direct operation of the power plant by monitoring and controlling the plant systems in accordance with relevant rules, operating procedures, established operational limits and conditions and administrative procedures;
— Supervision of shift operations by the shift supervisor and periodic evaluation of shift operations by the operations management (i.e. the management of the operations department);
— Organization of supervision of refuelling and shutdown activities;
— Development of operating procedures and instructions and coordination of their preparation to ensure the safe and reliable operation of plant equipment and systems;
— Coordination of the development and implementation of programmes and policies to ensure that plant operations are carried out in a safe and reliable manner;
— Involvement in the development of surveillance programmes for structures, systems and components important to safety and coordination of their implementation;
— Development and implementation of work management processes to ensure that shift personnel are cognizant of the work in the plant and maintain the correct plant configuration;
— Maintenance of proper plant configuration by the correct handling of changes in the plant status resulting from maintenance, modifications and testing activities;

— Identification of deficiencies in equipment and in the plant to ensure that maintenance activities can be structured effectively;
— Support of outage activities through the involvement of knowledgeable plant operations personnel in schedule development, testing, special projects, alignment of systems[1], tracking of system operability and return to service of systems;
— Establishment and implementation of a system to prevent unauthorized access to, or interference for any reason with, structures, systems and components important to safety;
— Identification of training needs, involvement in the development of training programmes and in the monitoring of training sessions, and evaluation of training programmes;
— Verification of good housekeeping and material conditions in the areas of the plant for which the operations department is responsible;
— Establishment of operating goals and objectives that are in accordance with the overall goals and objectives for the plant;
— Reporting on, and participation in, the investigation of any abnormal event, including near misses and low level events, and deciding on measures to be taken to reduce the probability of a similar situation recurring as an actual plant event;
— Dissemination of information on operating experience to appropriate personnel so that operating crews and other operations staff are made aware of relevant in-house and external events in a timely manner;
— Production of operational reports for management and other groups and authorities as required.

2.4. The overall responsibility for establishing and implementing the operations programme and for managing the operations department should normally rest with the operations manager. The operations manager has responsibility for the day to day running of the operations department, which is responsible for the fulfilment of the tasks and functions specified in para. 2.3.

2.5. The operations department should be involved in prioritizing all work that may affect the safe operation of the plant and should be assigned the responsibility for overseeing the planning and scheduling of such work.

[1] The alignment of a system or equipment is the configuration of the system or equipment that is created by operating switches, valves or breakers to ensure the appropriate functioning of the system or equipment for a given purpose.

OPERATING POLICY

2.6. The operating policy should establish that safety has an overriding priority in all aspects of plant operations, including challenges resulting from production demands and project schedules. The policy should encourage a questioning attitude and a rigorous and prudent approach to all safety related activities. The defence in depth concept should be generally applied to all safety related activities.

2.7. Only authorized staff should be permitted to undertake plant operations that are critical to safety (Ref. [3] provides recommendations on the authorization of nuclear power plant personnel). The assignment to operate control room keys or equipment in the field should be specified in administrative procedures. Only personnel who are physically and mentally fit for operational duties should be allowed to perform activities for plant operation in the main control room or in the field.

2.8. Operations personnel should maintain the reactor and its supporting systems within the bounds of proper equipment alignments and approved operational limits and conditions. All operations affecting safety should be undertaken only in accordance with written procedures. The nuclear power plant should be maintained in a safe condition by deliberate control and monitoring to ensure that basic safety functions (such as controlling the power, cooling the nuclear fuel and confining radioactive material) are fulfilled.

2.9. The operating approaches and practices should ensure that doses due to exposure to ionizing radiation in the plant or due to any planned release of radioactive material from the plant are kept below prescribed dose limits in all operational states, and that they remain 'as low as reasonably achievable' (ALARA). Requirements for protection against exposure to ionizing radiation are established in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources [4].

HUMAN RESOURCES AND QUALIFICATION OF PERSONNEL

2.10. The operations manager should ensure that an adequate number of competent staff are available at all times to operate the plant safely in both normal and abnormal conditions. There should be sufficient numbers of operations staff to allow staff members to be periodically released to meet requirements for training and development. A long term succession plan for

staff should be put in place, supported by reviews of career development, associated action plans and recruitment plans. These reviews should aim to foster continuous improvement and learning.

2.11. The shift operator crews should be staffed in such a way that a sufficient number of authorized operators[2] and other staff are available for the reliable accomplishment of assigned tasks in normal and abnormal operating conditions, including fires and accident conditions of different types. Special attention should be paid to ensuring that staffing levels provide adequate redundancy and diversity of the competences needed in both normal and abnormal conditions.

2.12. During particularly busy periods, for example during reactor outages, line managers should ensure that sufficient staffing cover is provided to permit rest periods. Line managers should be particularly vigilant in noticing any signs of fatigue in staff.

2.13. A comprehensive programme of continuing training and requalification for all operations personnel should be established. Additional briefing and, if necessary, training should be provided when an individual has been away from the plant for a significant period of time (e.g. owing to illness). Additional training or briefing may also be necessary for operations critical to safety or for infrequent operations, or for some routine operations that are carried out rarely owing to improved operational performance (e.g. startup of the plant). Changes to regulations and procedures, modifications to plant equipment and changes to the organizational structure should be addressed in continuing training. Special training should be provided on internal and external events relevant for the safety of the plant.

2.14. Support for the training department should be provided through the involvement of members of the operations department as subject matter experts in the analysis of training requirements and the development of training material and training tools, and also as part-time or occasional instructors.

[2] In some States, some positions of the shift operator crew are subject to a licensing process.

2.15. More detailed recommendations on the training and qualification of operations personnel for nuclear power plants, including a systematic approach to training, are provided in Ref. [3].

PERFORMANCE OBJECTIVES AND STANDARDS

2.16. Realistic, measurable and challenging goals and objectives for operation should be established by the operations department to support the goals and objectives of the organization. These goals and objectives should address areas where high standards of performance are expected. High standards of performance and the expectations of management should be reflected in the operating policy and procedures. Requirements and recommendations for the management of nuclear power plants are established in Refs [2, 5, 6], with one in preparation[3].

2.17. Performance objectives and associated criteria should be established and used to monitor routinely the performance of the plant and operations staff, and in particular their attitudes to safety and their responses to safety infringements and violations of operational limits and conditions or procedures (recommendations on operational limits and conditions are provided in Ref. [7]). The performance of operations staff should be appraised regularly and the results should be used for enhancing individual performance and preventing complacency.

2.18. The management of the operations department should be explicitly committed to safety and to established performance standards in plant operations. This commitment should be clearly communicated to the operations personnel and should be supported by the frequent presence of managers at the workplaces of personnel. Safety performance should be improved through leadership and coaching.

2.19. The operations managers and supervisors should, through consistent words and actions, develop a working environment that fosters adherence to the operating policy and reflects high standards of performance. The need for

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

conservative decision making, a questioning attitude and thoroughness in carrying out plant operating activities should be reinforced.

2.20. Periodic self-assessments should be carried out to reinforce high standards of performance and to identify areas for improvement. Corrective measures should be developed and implemented in a timely manner, on the basis of the results of the self-assessments and evaluations.

2.21. The operations management should support shift operations by ensuring that all necessary requirements for each shift position, such as qualification, job descriptions, training and licences, are sufficient to establish and maintain comfortable working conditions for each shift. Good and regular communication should be established between operations management and control room operators.

INTERFACES WITH OTHER PLANT GROUPS

2.22. The most senior manager of the plant, with the assistance of other managers both at the plant and outside the plant, should ensure that procedures are put in place to cover, in an unambiguous manner, the interfaces between the operations department and other groups in on-site organizations at the plant and in off-site organizations. The purpose of such procedures is to enable support to be provided, as necessary, to the operations department.

2.23. Adequate provisions should be established for providing prompt support to shift supervisors in normal working hours and outside normal working hours in the event of a problem arising in a particular field such as maintenance, reactor physics, radiation protection or water chemistry.

2.24. There should be effective interfaces between the plant shift crew (including control room and field operators), the technical support group and maintenance groups, including contractors. After completing work, the shift crew, technical support group and maintenance groups should ensure that structures, systems and components affected by the work are tested and returned to their original state or to a satisfactory operational state that complies with the operational limits and conditions. Operations staff should not tolerate equipment failures and defects and should urge the maintenance department to resolve such malfunctions within a reasonable time-frame.

2.25. Operations personnel should not normally interchange components or carry out maintenance. When something needs to be fixed, operations personnel should complete a written request for maintenance work and should allow maintenance personnel to complete the task in accordance with approved procedures. Maintenance personnel should be called in to carry out urgent maintenance when necessary.[4]

2.26. The interface between the operations department and the maintenance department should be established in particular for all aspects of outage activity, to ensure that risk from an outage is managed properly and the effectiveness of an outage is maximized. This should be achieved by means of thorough planning and scheduling, effective coordination and implementation and the timely return of systems and components to safe operational status (for the control of outages, see paras 7.18–7.20).

2.27. Effective coordination of the activities of the operations department with those of the plant chemistry department should be established to ensure proper chemistry control of the liquid and gas systems in the plant. In addition, operators should inform the personnel responsible for plant chemistry prior to commencing plant evolutions[5] that have the potential to affect plant chemistry or to require action from plant chemistry personnel. When problems relating to chemistry arise, operations personnel and plant chemistry personnel should work closely with one another to implement corrective action promptly (for chemistry control, see paras 5.44–5.47).

2.28. Good interfaces should be established between the operations department and the radiation protection department. Operators should inform radiation protection personnel prior to commencing plant evolutions that have the potential to affect radiation levels at the plant or to necessitate action from radiation protection personnel.

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[4] Operations personnel may do some minor repairs or replacements which they are competent to undertake, such as replacing light bulbs that indicate the status of equipment, replacing chart paper and ink cartridges, connecting portable sump pumps, adding oil to components and connecting steam generator sluice hoses. All such minor maintenance activities should be clearly listed in the job descriptions of the appropriate operations personnel.

[5] Plant evolution is the development or sequence of changes in the status of a system or equipment that is initiated by plant transients or by deliberate action of the operator.

2.29. The operations department should coordinate relevant activities with the organization responsible for security at the plant and for developing measures to reduce the vulnerability of the plant to malicious acts, to be able to utilize the synergies between safety and security.

3. SHIFT COMPLEMENT AND FUNCTIONS

SHIFT SUPERVISOR

3.1. The shift supervisor should manage plant operations on each shift and should be responsible for overall safety at the plant, protection and safety of personnel, coordination of plant activities and performance of the assigned shift. The responsibilities typically should include supervision of the shift personnel and direct control of plant operations in accordance with the operational limits and conditions and operating procedures. In addition, the responsibilities of the shift supervisor should normally be:

— To assume the authority of the plant manager during off-hours. The shift supervisor should be given the authority to resolve any problem that may affect the safe operation of the plant.
— To ensure that the shift is properly staffed and to request or initiate a call-out of personnel who are fit for duty, as required; to monitor the qualification and the physical and mental condition of the operations personnel on shift.
— To coordinate the activities of the operations, chemistry, radiation protection, maintenance and technical support groups to accomplish the operating objectives of the shift.
— To oversee closely activities that support complex and infrequently performed plant evolutions, such as plant heat-up, startup and shutdown, physical tests, cooldown and refuelling.
— To perform plant inspections to identify and correct problems involving the performance of personnel, policies and procedures, housekeeping, material conditions and hazards to personnel; to ensure that deficiencies are identified and corrective action is initiated.
— To initiate an assessment of the nature and extent of any unusual occurrence and subsequently to take the first steps necessary to minimize the consequences, to ensure the protection and safety of personnel and to

initiate the action required by the emergency plan; in an emergency, to act as the senior emergency coordinator until relieved by higher management authority.
— To initiate preparation of reports of abnormal events and reportable occurrences.
— To authorize temporary alterations and the use of jumpers and lifted leads and initiate appropriate engineering reviews of such items when required.
— To authorize the tagging of plant equipment and systems to ensure the radiation protection of personnel, the protection of equipment and the status control of the tagging boundary and all components within the boundary.
— To authorize the removal from service of systems and components for maintenance, testing and/or operational activities and their subsequent return to service.
— To authorize the issue of the associated permits to carry out work or to carry out tests on systems and components important to safety.
— To direct or assume the duties of a control room operator to ensure the safe operation of the plant if such action is considered necessary.
— To review the shift records for accuracy, completeness and trends and to maintain the shift supervisor's log.
— To oversee the qualification, requalification and training of shift personnel to ensure that they are properly trained to established standards and properly qualified to perform their assigned duties.

3.2. In multiunit power plants, where one shift supervisor may be responsible for all units, other persons, designated as unit supervisors, should be made responsible to the shift supervisor for the operation of each unit.

OPERATORS

3.3. Under the authority of the shift supervisor or the unit supervisor, the control room operators[6] are responsible for monitoring and control of the plant

[6] The common practice is to have one or two reactor operators (of whom one, usually, has the position of senior reactor operator) in the control room and several field operators who report to the reactor operator. In some States, in addition to the reactor operators in the control room, there is a turbine operator responsible for monitoring and control of turbine equipment and its associated systems. The turbine operator usually reports directly to the shift supervisor.

systems in accordance with the relevant operating instructions and procedures. Field operators are responsible for the control of operational activities outside the control room; such activities should be carried out under the general direction of the control room operators and in accordance with relevant operating instructions and procedures.

3.4. The number of operators on each shift and their responsibilities should be determined on the basis of the complexity of the plant, its level of automation and its organizational structure.

3.5. The main responsibilities of the control room operators are to operate the plant and the plant systems in accordance with the design intent and operating procedures and to maintain the reactor and other plant systems within the established operational limits and conditions. The control room operators' activities should cover, but are not limited to, the following items:

- Operation, control and monitoring of plant systems in accordance with relevant operating and administrative procedures;
- Reporting of anomalies or uncertainties in the plant state to the shift supervisor and documenting plant evolutions and significant events at the plant;
- Initiating and performing operating actions required by the normal, emergency and alarm procedures;
- Initiating a reactor trip if the automatic reactor trip fails or in other cases as stipulated in the operating instructions;
- Initiating actuation of the plant systems, in particular safety systems and safety related systems, in accordance with the operating instructions, if automatic initiation fails;
- Maintaining relevant documentation, including the operators' log.

3.6. The field operators who are assigned to control operational activities outside the control room should be made responsible for monitoring the performance and status of equipment in the field and for recognizing any deviations from normal conditions. They should also respond properly to plant conditions with the goal of preventing unanticipated transient operational states or at least mitigating their consequences.

3.7. Irrespective of the reactor type and organizational structure, at least one authorized reactor operator should be present at the controls in the main control room at all times while the reactor is in operation.

3.8. For core alterations for reactors that are refuelled in the off-load state, a reactor operator or other qualified person should be designated as the fuel handling supervisor. The responsibility of the fuel handling supervisor should be to supervise directly alterations to the core and the handling of fuel outside the core. The fuel handling supervisor should not be given any other concurrent duties while acting in this position, but should maintain an overview of the fuel handling process and should not act as an equipment operator.

SHIFT SAFETY ENGINEER OR TECHNICAL ADVISER

3.9. It is recognized as good practice that in some States a shift safety engineer or technical adviser is appointed to give advice or take over responsibilities in certain circumstances. The responsibilities, lines of authority and duration of duty of the shift safety engineer or technical adviser should be clearly established in writing.

3.10. The main functions of the shift safety engineer or technical adviser should be to evaluate the plant conditions and to provide technical expertise and analytical assistance to the shift supervisor for normal operation, abnormal occurrences and accident conditions. In transient operational states and emergency conditions, the technical adviser should analyse the adherence of critical plant parameters to those predicted in the safety analysis to verify that the plant is responding adequately.

SHIFT TECHNICAL SUPPORT PERSONNEL

3.11. The shift crew may include personnel for radiation protection, plant water chemistry and other categories of technical support for the direct operation of the plant. The number of personnel necessary for technical support on each shift should be determined on the basis of the organizational structure and the design characteristics of the plant. The functions, responsibilities and lines of reporting and accountability of such technical support personnel should be clearly specified in writing and should be understandable to all personnel involved.

4. SHIFT ROUTINES AND OPERATING PRACTICES

SHIFT ARRANGEMENTS

4.1. Shift staffing patterns and shift cycles and associated controls on hours worked should be put in place so as to minimize fatigue and to provide sufficient time for the training of shift personnel. Consideration should be given to undertaking safety sensitive operations during a part of the shift when staff are not heavily loaded and are at their most alert and supporting services are available.

4.2. Scheduled activities and other potential distractions should be managed to reduce simultaneous activities and to avoid overloading the control room operators so as to keep them focused on their responsibilities for ensuring safety. The number of concurrent plant evolutions affecting the control board indications should be limited so that the ability of operators to detect and respond to abnormal conditions is not impaired.

4.3. The management should ensure that distractions to the shift personnel are minimized to enable the crew to remain alert to any changes in plant conditions. Examples of distractions that should be minimized are excessive administrative burdens and excessive numbers of people allowed entry to the main control room. In particular, the need to minimize such burdens should be taken into account in shift arrangements for accidents and emergencies. This will facilitate maintaining the situational awareness of operators.

4.4. At the same time, the management should ensure the effective involvement of shift personnel to the extent necessary in the authorization and performance of all regular or special activities that affect plant operation. Such activities may be associated with surveillance testing, maintenance work, permanent and temporary modifications and special operating procedures for tests or particular plant evolutions.

4.5. Administrative controls should be established to allow the fitness for duty of shift personnel to be observed, verified and controlled. Elements of such administrative controls should include the identification of drug or alcohol abuse by personnel, monitoring of the psychological state of personnel, restrictions on excessive overtime and mandatory requirements for rests between shifts. Important elements of this programme are provisions to ensure active engagement and responsible attitudes on the part of the supervisors of

the corresponding crews. Supervisors should routinely evaluate their crew members as early as possible at the beginning of each shift or period of work.

4.6. Administrative procedures should be put in place to ensure that adequate and prompt support is provided to shift crews in off-normal staff working hours and that requirements on reporting do not place an excessive burden on the shift supervisor and do not affect the shift supervisor's ability to supervise the shift crew and the development of processes.

SHIFT OPERATIONS

4.7. While on duty, the shift crew should have as their primary responsibility the monitoring and control of all plant systems and components. On-shift operators should maintain the plant and its supporting systems within the boundaries of equipment alignments that have been analysed as well as within approved procedures and should restrict operations that could lead to a condition outside these boundaries.

4.8. The panels in the control room should be closely monitored. Operators should be required to check important parameters periodically (e.g. hourly), irrespective of whether these parameters are also recorded electronically. An analysis of trends should be carried out if the parameters demonstrate drifting. Supervisors should ensure that other duties (e.g. log keeping) that might distract the operators from the monitoring of panels are limited to short periods of time.

4.9. When a plant manoeuvre is carried out remotely by an operator in the control room, the operator should verify, by checking relevant indicators, that the manoeuvre has indeed been carried out correctly (e.g. if a valve is closed remotely to stop flow, then the operator should check not only that the indicators show the valve position as closed, but also that indicators show that the flow has indeed stopped).

4.10. Operating activities involving equipment and systems important to safety (e.g. equipment line-ups, positioning of components such as valves, switches and circuit breakers and removal of straps (jumpers)) should be independently verified, as appropriate.

4.11. During plant events and transient operational states, supervisors should ensure that parameters that are not expected to be affected by the event or the

transient operational state are not neglected by the responsible operators. For plants with multiunit control rooms, operators on units that are unaffected by the event or the transient operational state should continue to monitor their units routinely and should not allow themselves to become distracted.

4.12. Operators should consider the level of complexity of any activity and their own level of familiarity with the activity prior to performing it. In the case of complex or infrequently performed tasks, the shift supervisor should be involved in the decision to perform the activity and should ensure that an adequate pre-job briefing is conducted. If, after the pre-job briefing has been performed, the operator does not feel confident that the activity can be conducted safely and efficiently, the activity should not be commenced and, with the involvement of the operations management, other options should be sought.

SHIFT TURNOVER

4.13. Shift turnover should be carried out in accordance with a formal procedure. The procedure should identify the persons involved and their responsibilities, the locations, times and conduct of shift turnovers and the methods of reporting the plant status, and should include provisions for special circumstances such as abnormal plant status and unavailability of staff. The procedure should provide for a clear declaration of acceptance of duty from the incoming operator before the outgoing operator is released.

4.14. A shift turnover should not take place during important plant evolutions (e.g. an approach to criticality). The requirement to perform the shift turnover in stable plant conditions should be included in the plant procedures describing the turnover, together with provisions for regulating the process in the event of deviations in either plant conditions or the completeness of the crew.

4.15. Non-routine operating activities should be prohibited in the main control room during shift turnover. Access of non-shift personnel to the main control room during the shift turnover should be prohibited or minimized.

4.16. All important information about the plant status, the work in progress and the plant evolutions in the previous shift should be transferred and documented properly in the course of the shift turnover. This information should include a joint check of systems in which the incoming and outgoing operators walk down the control panels and jointly read checklists, log books,

records and messages to familiarize themselves adequately with the status of systems and equipment.

4.17. Shift briefings should be conducted in such a way as to ensure that the expectations and objectives of the shift supervisor are effectively communicated to, and understood by, all the staff under supervision. The level and number of shift briefings may vary depending on the composition of the shift crews. Briefings for control room staff should be conducted in the control room and should include the communication of information between relevant individual members of the two shift crews, and also between the two shift crews as a whole.

4.18. Incoming personnel should not assume operational duties unless they are physically and mentally fit for duty and until they and the outgoing shift crew are fully convinced that an appropriate transfer of information has taken place.

4.19. Arrangements should be put in place for dealing with a situation in which there are difficulties for the outgoing shift staff in leaving the site or for the incoming shift in arriving at the site. Such difficulties could arise owing to severe weather conditions, for example. Such arrangements should include preparedness for the use of all practicable means of transporting staff to and from the site, in particular the means for transporting staff of the incoming shift to the site. Rest facilities should be provided for the outgoing shift and all reasonable steps should be taken to ensure that the delayed outgoing shift undertakes only light duties, if they must stay on.

4.20. Shift personnel who expect to be late or who are unable to report for shift duty at the scheduled time should inform the shift supervisor as soon as possible. The shift supervisor should make the necessary arrangements for obtaining a replacement.

AVAILABILITY AND USE OF OPERATING PROCEDURES

4.21. The policy at the plant for the use of operating procedures by the operators should be clearly established and communicated. Operating procedures should be categorized according to the manner in which they are applied. Operating procedures that are applied continuously in a step by step manner, procedures that are used as references to confirm the correctness of actions and procedures for informational use should be clearly indicated

through the method of categorization of procedures. Recommendations for the development of plant operating procedures are provided in Ref. [7].

4.22. Procedures, drawings and any other documentation used by the operations staff in the main control room or anywhere else in the plant should be approved and authorized in accordance with the specified procedures. Such documentation should be controlled, regularly reviewed and updated promptly if updating is necessary, and it should be kept in good condition. Emergency operating procedures should be clearly distinguished from other operating procedures.

4.23. Special attention should be paid to ensuring that the procedures are compatible with the environment in which they are to be used. The procedures should be validated in the form in which they will be used in the field. Values prescribed in the procedures should be in the same units as those used on the associated instrumentation in the main control room and in other control rooms and on local control panels or equipment in the plant.

4.24. A controlled copy of all operations procedures should be available in the main control room for reference by operators. Controlled copies of selected procedures should be located at other working places where they are used or will be used in appropriate situations (for example in the emergency control room). Administrative controls should be put in place to ensure that only valid operating procedures are in use and that outdated procedures are not used by mistake. The plant procedures should be kept in such a way as to ensure their rapid retrieval. Operators should take special care when new procedures are introduced and used for the first time.

4.25. Alarm response procedures should be established for all alarm panels. These procedures should guide operators in verifying abnormal conditions or changes in plant status and should specify the appropriate subsequent action or procedures. Alarm response procedures should be available at the affected alarm panels and should be easily accessible to the operators who are responding to alarms (for the response to alarms, see paras 5.26–5.31).

4.26. Administrative controls should be put in place to ensure that the operator prepares carefully for an activity by reviewing the procedure, in order to understand fully the procedural steps to be taken for correct performance of the activity or plant evolution. Special attention should be paid to independent checks and hold points in the procedure at which certain critical tasks are to be performed. When an operator is preparing for an activity, emergency or

off-normal procedures should be included in the planning in case conditions outside the normal operating conditions are encountered.

PRE-JOB BRIEFINGS

4.27. Pre-job briefings should be used as a means of avoiding personnel errors, difficulties in communication and misunderstandings. The operations shift crew should use pre-job briefings for all operations other than daily, routine shift activities. A procedure for pre-job briefings should be put in place that includes the following aspects:

- Conduct of a typical briefing, including required contents such as expected results;
- The concept of ALARA for radiation protection;
- Industrial safety and other precautions;
- Relevant operating experience;
- Identification of those whose attendance is required at the pre-job briefing;
- The responsibilities of the leader of the pre-job briefing;
- A checklist to assist the leader in the conduct of the briefing.

4.28. For frequent activities and testing, pre-job briefing checklists may be prepared in advance. By maintaining previously scripted pre-job briefing checklists, managers may be assured that important aspects will be discussed each time the work is performed. Such checklists should identify the purpose of the work and expectations, applicable procedures, potential hazards associated with the work, communication between partners, approximate time necessary to perform the work, possible disrupting factors, contingency action, plant evolutions to be avoided and factors to be monitored.

CONDUCT IN THE CONTROL ROOM

4.29. The management's expectations with regard to performance in the control room should be established and operators should be trained to meet these expectations. These expectations should be made clear and managers should ensure that all operators understand them. Managers should continuously monitor the performance of operators in fulfilling the management's expectations.

4.30. Operations managers should demonstrate and reinforce a conservative attitude to decision making[7] for activities that directly or indirectly affect the reactor core, the integrity of the fuel or the safety systems. Operators should be required to stop and seek advice from the shift supervisor or shift safety engineer when there is uncertainty or lack of clarity. Conservative decision making should be emphasized for instances where conditions outside the normal operating conditions are encountered. Operators should be able to reduce power or to trip the reactor without fear of blame when faced with unexpected or uncertain conditions. Hasty decisions and hurried acts should be avoided. When time does not allow a full understanding of the conditions to be gained before action, risks should be minimized and the plant should be placed in a 'known safe condition'[8].

4.31. Operators in the control room should maintain serious and attentive behaviour at all times. Operators should adhere strictly to plant policies with regard to the use of procedures, communication protocols, response to alarms and the use of methods in place to prevent or minimize human error. Operations management and supervisors should make themselves aware of the behaviour of operators in this regard and should ensure that high standards of performance are enforced at all times.

4.32. Controllers and items of equipment that are designed to operate in automatic mode should be routinely operated in this mode, with transfer to manual mode permitted only for a limited period when there is a need for special testing, plant evolutions or repair to the operating controls.

4.33. Operators should be particularly alert to plant indicators and signs of unexpected plant behaviour and should alert shift managers quickly to abnormalities. Operators should perform their activities in a manner that

[7] Conservative decision making in operational safety management means making decisions that maintain all levels of defence in depth at all times. In operational practice, a conservative approach means that decisions that take equipment out of service, alter plant line-ups, reschedule equipment testing or extend out of service time of equipment are evaluated for their effects on safety and that the final configuration meets the provisions of the safety analysis report and remains within established operational limits and conditions.

[8] A known safe condition for the plant means the operational status for which the main plant parameters (power level, coolant temperature, pressure, flow) are stabilized at the values prescribed in the procedures for normal operation and the reactor core is fully under the control of the operator.

avoids haste. If an operator makes a mistake, he or she should immediately report the error. The supervisor and operator should then proceed carefully to recover the situation. To encourage the reporting of errors, the supervisor should demonstrate a no-blame attitude to errors made by operators.

SHIFT ROUNDS

4.34. Rounds should be conducted regularly by the operators to identify actual and potential equipment problems and conditions that could affect the functioning of the equipment. The frequency of equipment inspections should be determined on the basis of the safety significance of the possible failure of the item of equipment, and it should be adjusted when operating conditions or maintenance conditions change. Particular attention should be given to remote areas of the plant and items of equipment that are difficult to access.

4.35. Personnel assigned the task of carrying out rounds should be made responsible for verifying that operating equipment and standby equipment operate within normal parameters. They should take note of equipment that is deteriorating and of factors affecting environmental conditions, such as water and oil leaks, burned out light bulbs and changes in building temperature or the cleanness of the air. Any problems noted with equipment should be promptly communicated to the control room personnel and corrective action should be initiated.

4.36. Factors that should typically be noted by shift personnel include:

— Deterioration in material conditions of any kind, corrosion, leakage from components, accumulation of boric acid, excessive vibration, unfamiliar noise, inadequate labelling, foreign bodies and deficiencies necessitating maintenance or other action;
— The operability and calibration status of measurement and recording devices and alarms on local panels throughout the plant, and their readiness for actuating or recording;
— The proper authorization for, and the condition and labelling of, temporary modifications in the field (e.g. the presence of blind flanges[9], temporary hoses, jumpers and lifted leads in the back panels);

[9] A blind flange is a piece of metal sheet mounted between two flanges to block flow.

— Indications of deviations from good housekeeping, for example the condition of components, sumps, thermal insulation and painting, obstructions, posting of signs and directions in rooms, posting of routes and lighting, and posting and status of doors;
— Deviations from the rules for working in safety related areas such as those relating to welding, the wearing of individual means of protection, radiation work permits or other matters of radiation safety or industrial safety;
— Deviations in fire protection, such as deterioration in fire protection systems and the status of fire doors, accumulations of materials posing fire hazards such as wood, paper or refuse and oil leakages, or industrial safety problems such as leakages of fire resistant hydraulic fluid[10], hazardous equipment and trip hazards;
— Deviations in other installed safety protection devices, such as flooding protection, seismic constraints and unsecured components that might be inadvertently moved.

4.37. Operators should assume that instrument readings are accurate unless proven otherwise. Ignoring an unusual reading can lead to abnormal conditions going undetected.

4.38. Operators should check other indications, if possible, when unexpected readings are observed. Prompt action should be taken to investigate the causes of abnormal or unexpected indications so that prompt corrective action can be undertaken.

4.39. To ensure best practice in identifying and reporting deviations, specific training should be provided to the shift personnel. In addition, supervisors should coach operations crews and individual operators in achieving a consistent standard in identifying and reporting plant deficiencies.

4.40. Adequate means should be used to log data from field operator rounds on log sheets and in computerized databases. Log sheets should specify the list of measurements and reference values necessary to assist the field operator in assessing any reading taken in the field.

[10] Fire resistant hydraulic fluid (such as Fyrquel®) is used in electrohydraulic control systems in nuclear power plants to reduce fire risk. Fire resistant hydraulic fluid is usually a toxic and environmentally hazardous material that should be handled with adequate safety precautions and controls.

4.41. The timely and proper conduct of operator rounds should be controlled by the control room staff. The control room staff should be aware of the activities performed by field operators and should stay in close communication with them at all times. The results of the rounds should be reported in a timely manner and the control room operators should review the log sheets periodically. An analysis of trends should be carried out when important parameters show drifts.

4.42. The shift supervisor and control room operators, when properly relieved or not on shift, should spend some time walking through the plant and observing field operators carrying out their activities. These observations should be appropriately documented and, when necessary, corrective actions should be developed, prioritized and tracked. Best practices include documenting minimum requirements as a basis for written field observations.

COMMUNICATIONS

4.43. Simple and clear lines of communication and reporting within the shift crew should be established. They should be such as to ensure that the control room shift staff retain full control over the plant. All activities that affect the status of systems and components important to safety should be authorized and controlled by the shift supervisor.

4.44. All verbal communications within the shift or between the shift crew and other groups should be clear and concise and the communication process should cover both the provision and the receipt of correct information. In all communications, the sender has the responsibility for ensuring that the information is fully understood.

4.45. In communications, the full description of any plant item should be given and the phonetic alphabet should be used where appropriate. To reduce the likelihood of error in verbal communication, both in the plant and in control rooms, training should be provided in the use of three way communications[11]

[11] The following three steps establish three way communication: (i) clear delivery of the message by the sender; (ii) acknowledgement by the receiver that the message is clearly understood; and (iii) confirmation of the acknowledgement by the sender. This final step is also the final command to proceed to the action stated in the message.

between the sender and recipient and this method should be used as widely as practicable, especially in abnormal situations.

4.46. Recipients of verbal instructions should proceed only when they fully understand the task to be undertaken. Where appropriate, they should check that the action that they have taken delivers the expected results.

4.47. When verbal or written instructions or orders are used in operational practice at a plant, administrative procedures should be put in place to ensure that the verbal or written orders do not diverge from the established procedures and do not compromise established operational limits and conditions.

4.48. Administrative controls should be established to specify the process of preparation, approval, authorization and distribution of shift orders that have an impact on the safety and reliability of the plant. Shift orders should be clearly written and should be marked with the date from which they are effective and the date on which they will expire, and they should be maintained in the control room. The duration of shift orders should be limited and it should be regularly checked whether they continue to be necessary.

SHIFT RECORDS AND LOG KEEPING

4.49. The shift crews should routinely monitor the conditions of systems and components and should record appropriately the plant status and parameters and all automatic or manual acts. Every change in the status of systems or components should be appropriately documented and should be communicated to the main control room in a timely manner.

4.50. Operational log books should be established for the key shift positions. They should contain a narrative of the plant status and of all events and should record the data that are necessary to maintain an accurate account of plant operation. Log books should typically contain information on:

— The processes and the general status of the plant at the time of shift turnover;
— Mode changes of the reactor and of major plant systems and equipment;
— Abnormal plant configurations and equipment and systems that are out of service;
— Surveillance and post-maintenance testing that has been carried out;

— Deviations that were identified and action that was taken for their resolution.

4.51. The policy for logging of activities and for collection and archiving of the operators' records should be such as to ensure that the necessary information can be located easily and can be accessed in a reliable manner if subsequent evaluation is necessary. Logs should be legible and entries should be made in a narrative manner so that they can be easily read and understood.

4.52. Special attention should be paid to establishing and communicating clear and understandable rules about the quality and content of the operators' records and to providing operators with the appropriate log books, control sheets and checklists for their work.

4.53. Feedback of information from operational experience should be used to optimize the amount of data or records available as necessary for later analysis. (Detailed recommendations on the feedback of operational experience are provided in Ref. [8].)

4.54. To aid in the reconstruction of events, as much significant information as possible should be logged in emergencies and in abnormal or unexpected events. However, log keeping should not take precedence over the control and monitoring of the plant.

4.55. Administrative controls should be established to document compliance with the plant's technical specifications. This applies, in particular, to entries into action statements in the plant's technical specifications for events where deviations from the established operational limits and conditions occur.

4.56. Every entry into an action statement should be recorded in the appropriate shift documentation (logs, status sheets, checklists, etc.). These records should include the conditions for which the entry into the action statement took place, the date and time of entry and the date and time of expiry of the action statement, and the action taken to return the plant to normal operating conditions.

4.57. Shift management should be made aware of all entries into action statements and should ensure that appropriate action is taken within the allowed time to correct or mitigate any possible undesired consequences of making entries into the action statement. Information on limiting conditions

should be provided daily to the operations and plant management to ensure that the required action has been taken.

4.58. To allow the timely elimination of any deficiencies in logging, shift supervisors and operators should regularly review the log books of those working under them. The reviewers should ensure that records are accurate and appropriate and should request members of staff who demonstrate deficiencies in logging to improve their performance. In addition, reviews of control room logs should be performed regularly by managers who are not part of the shift crews.

5. CONTROL OF EQUIPMENT AND PLANT STATUS

LABELLING OF PLANT EQUIPMENT

5.1. A consistent labelling system for the plant should be established, implemented and continuously maintained throughout the lifetime of the plant. It should be ensured that the system is well known by the staff. The system should permit the unambiguous identification of every individual component in the plant. In addition to the labelling of plant components, labelling of the doors and compartments of the plant should be regarded as part of the same system.

5.2. The labelling standards used should be such as to ensure that the labels are suitable for the environmental conditions in the location in which they are to be mounted and that the equipment can be unambiguously identified. The format and placement of labels should allow the operators to identify the component quickly and easily and should prevent the easy or inadvertent removal or misplacement of labels.

5.3. The plant management should ensure that all valves, switches, breakers and components are labelled using the same labelling nomenclature as that prescribed in current design documents. Furthermore, operations procedures and documents should also reflect the same nomenclature. When discrepancies are found, they should be reported and corrected in accordance with the established procedure. To assist in the management of the labelling

programme, the number of discrepancies awaiting correction should be tracked and monitored.

5.4. Particular consideration should be given to the arrangement in the labelling system for the identification by operators of missing or necessary labelling and the process to ensure that the corresponding corrective action has been taken in a timely manner.

SYSTEM ALIGNMENT

5.5. For each plant system, the valve, switch and breaker alignment should be documented. Prior to the initial operation of a system, a complete alignment check should be carried out. Clear guidance should be established in advance for conditions that may necessitate equipment and system alignment, including conditions in plant startup, major outages and mode changes.

5.6. Specific measures should be developed and maintained to prevent unauthorized access to systems and equipment important to safety. These measures should include controlled access to certain rooms or compartments and an effective key control system or other measures to prevent an unauthorized change in the position of, or an unauthorized intervention affecting, certain important safety valves, transmitters, breakers or other specified equipment. This access control system should not prevent shift operators from effectively controlling the readiness of the safety systems and should allow them to carry out prompt and timely operation of the equipment in normal and abnormal plant conditions.

5.7. The parts of a system that may be affected by a modification should be considered before initial operation and a check of the alignment in those parts of the system should be performed. If the valve, switch or breaker alignment in those parts of the system is found to be incorrect, a full adjustment of the alignment for the system should be performed.

5.8. Valves, switches and breakers that are not in their proper position for current operations can pose a significant threat to safe operation. On a periodic basis (e.g. monthly), the number of items found to be out of position or to have been operated improperly should be tracked and reported and an evaluation of the severity of the discrepancy and its probable cause should be made. Such periodic tracking will permit unwanted trends to be identified and controlled.

RELEASE OF EQUIPMENT FROM AND RETURN OF EQUIPMENT TO SERVICE

5.9. The operations management should implement appropriate controls to verify that a thorough review is conducted by the shift supervisor before equipment is removed from service. This review should cover, as a minimum, items such as redundant electrical power supplies to emergency and essential electrical buses, the reliability of the electrical grid, and normal and alternative paths for make-up coolant water to the reactor vessel and make-up water to the spent fuel storage pools. The review should also include the effects of temporary modifications on the availability of the system and the capability of the modified system to fulfil its intended safety functions. The shift supervisor should consider the combined impact of all modifications on the systems and components. In conducting this review, the shift supervisor should be supported by appropriate competent staff.

5.10. Clear communication should be established and written guidance should be provided for the case of a simultaneous unavailability of more than one train of any safety system or supporting system that may result in a high risk (the single failure criterion should be taken into consideration). Appropriate information should be posted in the centre for control of maintenance work and the control room, and the train(s) that remain operable should be in the plan of the day.

5.11. Compensatory measures should be implemented as necessary for on-line maintenance or for other activities that necessitate the removal of equipment from service. The operations manager and operations personnel should ensure that compensatory action is established and clearly specified and that only approved compensatory action is implemented. Examples of such compensatory measures are the use of alternative power sources, the provision of temporary equipment or the implementation of temporary modifications.

5.12. Before equipment is released from service, consideration should be given to testing the redundant trains or single components that remain in service. The need for additional testing to verify availability should be evaluated on the basis of the number of redundancies, the importance to safety of each redundant train or component and the interval since the last test. Operations personnel should evaluate the results of such tests before commencing the process of tagging. Before initiating the tagging process for trains or components, the shift supervisor should conduct a pre-job briefing, which should also cover the status of the plant and non-related components or trains.

Additionally, procedures should be established to provide for warning barriers and signs located in the plant close to such redundant systems to alert operators and workers to their special protected status.

5.13. Backup plans should be developed to restore equipment to service if redundant or backup equipment becomes unavailable or if problems arise during the performance of work.

5.14. In testing the functions of a system before returning it to service, operations personnel should consider broadly the operability and intended function of the entire system and should not merely focus on the operability of individual components. Operations personnel engaged in reviewing post-maintenance testing should be trained in the functionality and operability requirements on the system.

5.15. The risk associated with on-line work activities should be evaluated on the basis of a safety analysis of the plant, including, as appropriate, consideration of single failures and a risk informed approach on the basis of a 'living' probabilistic safety assessment specific to the plant.

5.16. The amount of time that items important to safety are unavailable to perform their design functions should be tracked on a periodic basis (e.g. monthly, quarterly or yearly). The reasons for periods of unavailability (e.g. breakages or planned maintenance) should also be monitored to permit long term equipment problems or work inefficiencies to be identified.

SURVEILLANCE OF EQUIPMENT STATUS

5.17. Reference [1] requires the plant to maintain a surveillance programme for items important to safety. Recommendations on meeting the requirements for such a programme are provided in Ref. [9]. The programme should ensure that items important to safety continue to perform in accordance with their intended design functions. The surveillance programme should cover monitoring, checks and calibration, testing and inspections and should be complementary to the plant's in-service inspection programme. Surveillance test results should be reviewed for long term trends that may indicate any deterioration.

5.18. Initiation of a surveillance test should be subject to prior authorization by the shift supervisor and the results of the test should be reported to the

operations staff in a timely manner. The shift supervisor should review any observed malfunctions to verify continued compliance with the operational limits and conditions. Any deviations discovered in the course of surveillance tests should be evaluated against the success criteria for the surveillance test.

5.19. Departments other than the operations department may be assigned responsibilities by management to develop individual surveillance test procedures, specify the appropriate frequency of testing, complete some of the testing and identify acceptance criteria. The operations department should retain responsibility for the scheduling and accomplishment of tests that involve equipment operation, for the review of completed test reports to ensure the test's completeness and for verification that the test results meet the approved acceptance criteria.

5.20. Surveillance activities should be scheduled to eliminate the potential for common mode failures. For example, if one single crew were to complete the testing of all redundant trains of a system, the crew might cause a common mode failure by making the same mistake on all of the redundant trains.

CONTROL OF REACTIVITY RELATED OPERATIONS

5.21. The operations management should be involved in the planning, evaluation and conduct of all operations affecting the fuel while the fuel is under its supervision (i.e. not only during operation of the reactor). The level of involvement of the operations management should correspond to the degree of responsibility that the operations department has for the safe operation of the plant and to the degree of responsibility assigned to shift personnel under the supervision of the shift supervisor. Further recommendations on operations relating to reactivity are provided in Ref. [10].

5.22. Decisions on operations that may result in manipulations of reactivity should be such that the reactor is maintained within established core operational limits. Operation within operational limits for the core provides the basis for safety in anticipated transient operational states. The importance of maintaining margins to core operational limits should be highlighted as part of the management's expectations for operating within established limits.

5.23. Reactivity manipulations should be made in a deliberate, carefully controlled manner, and should include appropriate time intervals between reactivity changes, during which the reactor is monitored to verify that the

desired response has been obtained. Planned reactivity changes should only be performed in accordance with written operating instructions and the explicit permission of the shift supervisor. The supervisor should monitor the reactivity and the plant evolution and the reactor operator should be free from other duties and free from distractions while planned reactivity changes are carried out.

5.24. Any planned major changes to the reactor power or to any other operations relating to reactivity should be initiated only after a pre-job briefing on the expected effects of the change. Prior to any major change being made, any conflicts in procedures should be resolved and possible distractions from work or contingency action should be discussed.

5.25. Self-assessment and error prevention techniques, such as the stop, think, act, review (remembered as the mnemonic STAR) methodology and peer checking, should be used during reactivity manipulations. Effective and appropriate control should be established over other activities that could affect reactivity or the removal of residual heat and which are performed by other plant personnel such as chemistry technicians or instrumentation and control technicians.

CONTROL OF ALARMS

5.26. Operators should respond promptly to alarm conditions, in accordance with alarm response procedures, to avoid undesired situations or emergencies and to mitigate the consequences of an accident. Unexpected alarms should be clearly announced and should be logged. All alarms should be treated as correct and valid unless proven otherwise on the basis of the assessment of other plant indications. Alarms that are spurious or that occur frequently should be discussed and reported to the operations management for timely corrective action.

5.27. Information on the status of alarms on the control boards or the panels in the plant should be made available to the shift personnel. Such information should cover alarms that have been totally disabled, alarms with disabled individual inputs, computerized alarms that have been taken out of service and alarms with temporarily changed set points. Tools or aids should be developed to enhance the operator's awareness of the alarm status.

5.28. Inoperable alarms, irrespective of whether they were rendered inoperable through failure or deliberate suppression, should be tracked and their number should be minimized. Their status should be clearly determined and should be made known to the staff who operate the systems or components that are affected. A procedure should be developed that describes the process by which alarms are removed from service and returned to service.

5.29. Alternative means of indication should be available to operators to permit them to verify the compliance of the affected systems or components with technical specifications and to monitor equipment parameters for abnormal conditions that could be masked by deficient or altered alarms.

5.30. Whenever an alarm is acknowledged, even if it is expected, a scan of all the unit's annunciator panels should be performed to ensure that no other alarms occurring simultaneously go unnoticed.

5.31. In the case of abnormal operational occurrences or other situations that result in the occurrence of multiple alarms, a detailed alarm analysis to identify alarms that are unexpected or inconsistent with the known plant problem should be performed once the plant has been stabilized. During the implementation of an emergency operating procedure, the assessment of safety functions should be given a higher priority than assessment of the alarm status.

RECOVERY FROM ABNORMAL SITUATIONS

5.32. Control room operators should notify their shift supervisor of any unexpected or abnormal situations. The shift supervisor should determine whether the plant status warrants the notification of off-site personnel or regulatory bodies. The shift supervisor should be authorized to activate the emergency plan if necessary.

5.33. If the plant does not respond as expected in an abnormal situation or an accident, all efforts should be directed by the shift personnel to putting the plant into a safe and stable status.

5.34. Following a reactor scram or other major transient operational state, a thorough investigation of its causes and consequences should be carried out prior to restarting or resuming operation at full power. This investigation should determine the direct cause of the trip and further investigations should be made to determine the root cause to prevent recurrence of the event in the

future. Restart conditions and criteria and authorities for making decisions should be established and adhered to.

5.35. After each actuation of a reactor trip, the control room staff should verify, in accordance with an approved procedure, the status of the plant to ensure that the plant has reacted as intended and that its status is safe in order to detect any detrimental effects of the reactor trip.

5.36. Restarting the plant should be allowed only after independent verification of the safety status of the plant and identification of the cause of the reactor trip. A senior operations manager or shift safety engineer or shift technical adviser should carry out the independent verification with the assistance of the shift supervisor. The shift supervisor should never be given authority to take the decision to restart the reactor after a reactor trip has occurred.

TEMPORARY MODIFICATIONS

5.37. Temporary modifications in the operation of a plant should be managed in accordance with the recommendations provided in Ref. [11]. The operations personnel have basic responsibilities with respect to temporary modifications and these are discussed in the following paragraphs.

5.38. Operations personnel should participate in evaluations and reviews of temporary modifications prior to their implementation. Reviews should verify that temporary modifications will not cause approved operational limits to be exceeded and are appropriate for the current plant configuration. After other necessary approvals have been obtained, temporary modifications should be made subject to the approval of authorized operations personnel prior to their implementation. The shift supervisor should be given the authority to veto any temporary modification or test according to a personal assessment.

5.39. A time limit should be specified for the duration of temporary modifications. After this time period, the temporary modification should be reviewed for its applicability, safety and necessity in the current plant conditions. After the review, an approval process similar to the initial approval process should be carried out if the temporary modification is to remain in effect.

5.40. Tagging should be used to designate clearly that the modification in the field is approved for use. A tagging programme should be maintained by operations personnel. Each approved modification should be assigned a unique number.

5.41. Control room operators should maintain a listing of the temporary modifications that have been made. The listing should identify each modification by its number and should include copies of the description of the modification made and of its reviews and approvals.

5.42. Operations personnel should review periodically all temporary modifications for their continued applicability and proper implementation.

5.43. All operators should be trained to look for unapproved temporary modifications in the course of their rounds and tours of the plant. The training should include how to identify unauthorized temporary modifications as well as the action to be taken if such a modification is found.

CONTROL OF PLANT CHEMISTRY

5.44. An adequate programme to monitor plant chemistry should be established to maintain parameters for the plant chemistry within the established limits and to minimize the ingress of chemical impurities. Operations personnel should be capable of correctly interpreting the chemistry parameters being monitored and taking timely corrective action if necessary.

5.45. The specific responsibilities of operators with respect to chemistry control should be clearly defined and should be communicated to the operations personnel. Operators should have expertise in the recognition of conditions that do not meet the specifications for the plant chemistry and adverse trends associated with the inadequate maintenance of chemistry regimes. They should also be trained in the use of proper corrective measures to deal with problems of plant chemistry. Operators should report to the chemistry department any adverse trends in chemistry parameters and the corrective action taken. The chemistry department should analyse the data and advise the operators on any further corrective action to be taken.

5.46. Control of oil, grease and chemical waste should be undertaken by operations personnel to prevent the ingress of such matter into the radwaste

system and to minimize operational problems that might adversely affect the quality of make-up water.

5.47. If water treatment equipment such as clarifiers, charcoal filters and demineralizers is operated or monitored by operations personnel (and not by personnel of the chemistry department), they should be knowledgeable about, and trained in, its use.

HANDLING OF EQUIPMENT DEFICIENCIES

5.48. A process should be put in place to specify the expectations of management and the responsibilities for the identification and documentation of deficiencies, equipment failures and other defects. Deficiencies that are identified should be recorded and prioritized by the shift supervisor or the operations manager to ensure that issues are resolved in a timely manner, in compliance with operational limits and conditions or technical specifications and in such a way that the impact of any such deficiencies on safety is minimized.

5.49. All deviations in the status of the plant or its systems and equipment should be reported and evaluated properly and in a timely manner. A system for documenting such deviations that includes evaluation of their impact on the operability of the plant, system or item of equipment should be clearly established. A system should be put in place to control the total number of deficiencies at the plant for which operator action is required, to ensure that operating crews are not overly burdened and to ensure that safety is not significantly affected by the cumulative effect of such deficiencies.

5.50. Deficiencies in equipment should be clearly identified to make them readily apparent to the operations personnel who conduct plant rounds and make observations. A system of tagging for deficiencies and/or cautions should be implemented to mark problems with equipment. Deficiencies that are identified should be assessed for their safety significance and should be prioritized for their correction.

5.51. A compensatory measure taken by an operator to operate a deficient item of equipment or its associated system is known as a workaround. As workarounds may distract the operator from the intended operation of the plant, the plant should establish a policy that provides for the identification and tracking of such workarounds. The policy should include the requirement to

assign a high priority to the correction of deficiencies that give rise to the need for workarounds. Where applicable, workarounds should be treated as temporary modifications.

5.52. Deficiencies and workarounds should be periodically reviewed for their aggregate impact on the performance of the shift personnel. Any necessary compensatory measures should be undertaken, including the deployment of additional operational human resources to compensate for the increased use of workarounds.

6. OPERATIONS EQUIPMENT AND OPERATOR AIDS

CONDITION OF CONTROL ROOMS AND PANELS

6.1. The equipment used by operations staff should be adequate to support the safe and reliable operation of the plant in all operating conditions and should be well maintained. Overall plant cleanness, good lighting and good environmental conditions are important attributes of the operation of a plant and efforts should be made to maintain these.

6.2. The main (or unit) control room is the central coordination point for unit operation. Where the design of the plant foresees additional or local control rooms dedicated to the control of processes that could affect plant conditions, clear lines of communication should be developed to ensure an adequate level of information transfer to and from operators in the main control room.

6.3. The lighting, noise level and temperature in the control room should provide suitable conditions for work and communications. Consideration should be given to administrative measures to minimize unnecessary distractions for the control room staff by notifications, telephone calls or requests for information. Administrative arrangements should be established to exclude unnecessary personnel from the control room.

6.4. Management should establish rules and processes to ensure normal working conditions for control room operators. Consideration should be given to the following:

— Conversations not relating to plant operations and their support should be minimized;
— Discussions not relating directly to the operation of equipment should be conducted in subdued tones;
— Telephone calls to and from the control room should be limited in subject matter to topics relating to current plant operations;
— The use of public address systems at the plant should be closely controlled by personnel in the main control room and should usually be limited to conveying information on the status of the plant;
— Communications by hand-held radio between field operators and operators in the main control room should be short and concise. For instance, radios should be used for the initial call-up and the call should then be switched to telephones where possible;
— The use of radio receivers, computers and other electronic devices for purposes relating to anything other than plant operations (e.g. for entertainment) should be limited or prohibited.

6.5. The habitability of the control room should be maintained in good condition. All dusting and cleaning of control consoles, instrument panels and computer consoles should be performed by shift operations personnel or under their close supervision and only approved materials and techniques should be used. Necessary replacements of light bulbs and repairs to ventilation systems should receive high priority.

6.6. The alternative control room used for reactor control in certain unusual circumstances, and any associated panels, should be kept free of obstructions and non-essential material that could hinder the immediate use of the alternative room or control panels if the need arises. Operators should periodically verify on their rounds that the alternative control room or panels, including the associated communication and alarm systems, are in the proper state of operational readiness. Other operational panels outside the control room, including local instrumentation and control panels, should be similarly maintained and it should be checked that they remain free of obstructions.

6.7. The control room desk and panels as well as any local control panels should clearly display the availability of systems and equipment. The system for designating defective systems and equipment should provide for the clear indication and proper labelling of defective items.

6.8. Goals and limits should be established for the availability of control board instrumentation and controls. These goals should include the timeliness

of repairs as well as the number of instruments that are unavailable. The unavailability of instruments and controls should be reported, in due time, in accordance with their importance to safety[12], to the operations management and plant management to raise the awareness of plant managers regarding these conditions.

6.9. Instrument displays and annunciators should be clearly readable and understandable to the operator and should be kept clear of obstructions. The layout of workplaces should allow for adequate control and oversight of the documents and tools to be used and should provide enough space for the proper placement and use of procedures in the main control room and in in-plant working areas.

6.10. In normal plant operation, the number of lit annunciators in the control rooms and on local control panels elsewhere in the plant should be minimized to the extent practicable to allow operators to recognize better any deviation in the status of the plant and its equipment. Only those annunciators that are necessary to support the provision of information on the plant status should be lit. The system of identification of the annunciators should allow the easy differentiation of their importance.

COMMUNICATION EQUIPMENT

6.11. Reliable communication equipment should be available to support activities in the control room and in the plant for all modes of operation. The types and numbers of devices used should allow for quick and effective audible communication with all plant workers involved in important communications, particularly communication with and within the shift crew.

6.12. The use of communication devices should be thoroughly assessed, both in terms of the possible adverse effects on plant equipment of electromagnetic interference from portable radios or cellular phones and in terms of the ability to communicate in the expected conditions of noise and vibration. It should be taken into consideration that the use of cellular phones might affect, in particular, the operation of digital control equipment. Measures should be

[12] The importance to safety of a certain item depends on the plant design and can be derived from probabilistic or deterministic analysis.

taken to mark the areas in the plant where special rules of communication apply.

6.13. The adequacy of the communication system should be periodically evaluated with regard to all requirements for the notification of an emergency. Public address systems and other emergency notification devices should be regularly inspected and should be maintained in good condition and be capable of alerting personnel when necessary. In addition, a system should be put in place for the regular testing of and verification of the operability of communication devices.

6.14. The rules of access to, and use of, the communication system should be clearly established and should be well understood by all plant staff to ensure that unnecessary use of the public address system for paging announcements to personnel does not detract from the impact of important notifications.

OPERATOR AIDS AND SUPPORTING TOOLS

6.15. Operator aids[13] may be used to supplement, but should not be used in lieu of, approved procedures or procedural changes. Operator aids should also not be used in lieu of danger tags or caution tags. A clear operating policy to minimize the use of, and reliance on, operator aids should be developed and, where appropriate, operator aids should be made permanent features at the plant or should be incorporated into procedures.

6.16. An administrative control system should be established at the plant to provide instructions on how to administer and control an effective programme for operator aids. The administrative control system for operator aids should cover, as a minimum, the following:

— The types of operator aid that may be in use at the plant;
— The competent authority for reviewing and approving operator aids prior to their use;
— Verification that operator aids include the latest valid information.

[13] Operator aids include sketches, handwritten notes, curves and graphs, instructions, copies of procedures, prints, drawings, information tags and other information sources that are used by operators to assist them in performing their assigned duties.

6.17. The system for controlling operator aids should prevent the use of unauthorized operator aids or other materials such as unauthorized instructions or labels of any kind on equipment, local control panels in the plant, boards and measurement devices in the work areas. Operator aids should be placed in close proximity to where they are expected to be used and posted operator aids should not obscure instruments or controls.

6.18. The system for controlling operator aids should ensure that operator aids include correct information that has been reviewed and approved by the relevant competent authority. In addition, all operator aids should be reviewed periodically to determine whether they are still necessary, whether the information in them needs to be changed or updated, or whether they should be permanently incorporated as features or procedures at the plant.

6.19. If the rules of operation foresee the use of additional devices (e.g. measuring devices) or tools (e.g. ladders), arrangements should be put in place to ensure that only properly tested or calibrated and authorized tools are used. In addition, operators should be provided with adequate tools (portable torches, personal protective equipment, etc.) to be able to observe equipment effectively in normal operation and in emergencies.

HOUSEKEEPING AND MATERIAL CONDITIONS

6.20. Plant housekeeping[14] should maintain good conditions for operation in all working areas. Working areas should be kept up to standard, well lit, clean of lubricants, chemicals or other leakage and free of debris; the intrusion of foreign objects should be prevented and an environment should be created in which all deviations from normal conditions are easily identifiable (such as small leaks, corrosion spots, loose parts, unauthorized temporary modifications and damaged insulation). The effects of the intrusion of foreign objects or the long term effects of environmental conditions (i.e. temperature effects or corrosion effects or other degradations in the plant that may affect the long term reliability of plant equipment or structures) should be evaluated as part of the plant housekeeping programme.

[14] Housekeeping concerns the degree to which the plant is safely accessible and operable, and unnecessary parts or equipment either are not present or are properly located.

6.21. Administrative procedures should be put in place to establish and communicate clearly the roles and responsibilities for plant housekeeping in normal operating conditions, post-maintenance conditions and outage conditions. For all areas of the plant, it should be made clear who bears the responsibility for ensuring that an area is kept clean, tidy and secure. Operations personnel should periodically monitor housekeeping and material conditions[15] in all areas of the plant and should initiate corrective action when problems are identified.

6.22. Means of radiation protection, industrial safety, emergency first aid and fire protection should be adequately distributed in the plant, well marked and available to support all modes of plant operation. Plant evacuation routes should be well lit and clearly marked and should not be obstructed by material or equipment of any kind.

6.23. All plant equipment should be made easily accessible to field operators. In the provision of access to the equipment, account should be taken of potential concerns for industrial safety such as tripping hazards. Adequate means (e.g. the use of remote controls, platforms or permanent stairs) should be foreseen to enable the operator to control without undue effort items of equipment that have limited access by design. Gauges used in the field should be suitably placed for ease of observation without the need for special additional efforts by field operators. This applies both to the identification of the gauge itself and to the taking of readings from the gauge. When necessary, additional platforms or other means of access should be provided.

6.24. Areas in the plant and systems and their associated components should be clearly and accurately marked, allowing the operator to identify easily the equipment and its status. Examples of such systems are isolations, positions of motor operated and manually operated valves, trains of protection systems and the electrical supply to different systems.

6.25. Temporary tags, such as those marking deficiencies, temporary modifications or temporary warnings, are important sources of information for operators in supervising the work areas. Their proper use should be governed by a policy that is consistent with the overall labelling policy at the plant (see paras 5.1–5.4). The temporary tagging system adopted should provide for easy

[15] The material condition concerns the degree to which structures and systems and equipment are kept in a well maintained state.

checking of compliance with the rules for authorization and validity, thus allowing the operator to distinguish between new and old deficiencies and at the same time to control the proper use of the tagging system (for recommendations on the tagging routine, see paras 7.21–7.32).

6.26. Management should give due consideration to any disused equipment and to the detrimental effects of such items on the behaviour of operators and the overall material condition of the plant. Plant policy should provide for the removal of all disused equipment from areas where operational equipment important to safety is located. When it is the practice at the plant to accept the retention of such equipment in work areas, the item of equipment should be clearly marked and should be covered by the plant housekeeping programme. Attention should be paid to such an item of equipment to avoid its condition affecting safety at the plant and the ability of the staff to maintain the required operational conditions.

7. WORK CONTROL AND AUTHORIZATION

WORK CONTROL PROCEDURES

7.1. The work control process required by Ref. [1] should include suitable and sufficient assessments of the risks to health and safety arising from particular activities. The purpose of risk assessment is to verify the acceptability of the proposed activity and to determine the appropriate control measures necessary to ensure that risks are kept ALARA. The results of the risk assessment should be incorporated into the work procedures or control documentation associated with the activity, for example the documentation for the system for issuing work permits.

7.2. The comprehensive work control system should cover any authorizations, permits and certificates necessary for ensuring safety in the work area and for preventing work activities from having undue effects on safety. The following specific matters should be considered:

— Compliance with established operational limits and conditions;
— Authorizations for work orders;
— The equipment isolation process, including work permits and tagging;

— Permits for radiation work;
— Precautions for industrial safety;
— Draining, refilling and venting of process systems;
— Drainage facilities and ventilation of workplaces;
— Control of fire hazards;
— Electrical and mechanical isolation of equipment;
— Control of plant modifications.

7.3. Recommendations on the authorizations, permits and certificates referred to in para. 7.2 are provided in Ref. [9]. Reference [12], in particular paras 3.39–3.47, provides recommendations on permits for radiation work.

7.4. The work control process should ensure adequate interfaces between all work groups. Operations personnel should assist the maintenance department in the planning and execution of work on plant systems and components to ensure that the reliability and availability of equipment are optimized. By doing this, operations personnel will be better able to assess the risk when equipment is inoperable and the period of unavailability of important items of equipment due to maintenance will be reduced.

7.5. The work control process should be used to ensure that operations personnel, in particular the operators in the main control room, are aware of and have approved the work in the plant and are maintaining correct control of the plant configuration. The process should further be used to ensure that operations personnel are aware of all the expected effects of the work performed, including alarms and changes to the functioning of systems.

7.6. The work control process should be used to ensure that plant equipment is released from service only upon the authorization of designated operations personnel and in compliance with the operational limits and conditions (see paras 5.9–5.16). Responsibilities and authorities relating to the isolation of equipment, post-maintenance testing and restoration of systems to service should be clearly defined in the procedures for the authorization of work.

7.7. Non-routine work (e.g. erection of scaffolding, installation of temporary lead shielding) carried out in the vicinity of structures, systems and components and equipment important to safety should also be made subject to authorization by the operations management. Cleaning and painting in the plant and any work outside the plant (e.g. construction, excavation or dredging near the coolant water intake) that may affect safety should also only be

performed with the authorization of the operations management. Shift personnel should be notified of the commencement of such work activities.

7.8. Provisions should be established at plants that have multiple units to ensure that major changes to work in progress in one unit do not affect the safe operation of other units.

7.9. Work orders that are not fulfilled within the planned time period may be given a formal extension on the basis of a reassessment by the shift supervisor on duty. The planned time period for the work order should be extended only if reassessment provides evidence that out of service equipment has no adverse impact on the safe operation of the plant or on compliance with technical specifications. Efforts should be made to minimize the number of extended work orders. The causes of deviations from the planned schedule should be subject to a thorough analysis to identify any necessary amendments to the system covering the planning and performance of work.

WORK PLANNING AND SCHEDULING

7.10. Planning of work on plant systems and equipment important to safety should be well coordinated to ensure that the plant remains in a safe condition at all times and in accordance with the operational limits and conditions. Scheduling and planning should be applied to prioritize the work so as to minimize the risk to safety. Where a 'living' probabilistic safety assessment is available, it should be used in optimizing work planning in operations and in shutdown and outage conditions to minimize the overall risk at the plant. Operations personnel should be encouraged to challenge assumptions and to give adherence to the schedule under pressure a lower priority than ensuring safety when confronted with unanticipated situations.

7.11. Sufficient resources should be provided for operations to guide and assist in the planning and scheduling of major work sequences. The operations management should be actively involved in the process of planning and scheduling work. Additional support should be provided to operations staff for outages and other periods of high workload.

7.12. Work to be undertaken in controlled areas where it is possible that radiation levels or contamination levels may be significant should be planned so that doses are kept ALARA. The radiation protection group should take part in the planning of any activities that might entail significant doses to

workers and should advise on the conditions under which work may be undertaken in controlled areas and contamination zones [12].

7.13. The shift supervisor and the shift personnel should be made familiar with the details of the schedule for maintenance work. Unscheduled work should be refused except under unusual circumstances and maintenance staff should be made accountable for working in accordance with the approved schedule.

7.14. The operations personnel should review plans for post-maintenance testing. This review can be conducted when maintenance is being planned and scheduled and should be repeated by control room personnel prior to the testing.

CONTROL OF SPECIAL TESTS AND NON-ROUTINE ACTIVITIES

7.15. Operations personnel should adequately control special tests[16] and non-routine activities that have no previously defined procedures. Such non-routine activities and special tests should be performed in accordance with a formal process that includes step by step procedures in the same manner as required for routine tests. Provision should be made to ensure that the plant is brought back to normal operating conditions as soon as the test is completed.

7.16. The procedure for a special test or non-routine activity should clearly specify any special precautions that should be observed, possible risks that should be analysed and action that should be taken if a problem arises in the course of the test. The procedure for a special test should include requirements to instruct personnel involved in the test, specifically operations personnel, on the risks of the test prior to carrying it out. The operations staff should discuss the criteria for halting tests or plant evolutions when unexpected situations arise. Recommendations on the performance of tests are provided in Ref. [9].

7.17. The operations manager should maintain oversight and awareness of the plant status during special tests or infrequent plant evolutions. The regulatory body should be informed beforehand of any special tests that are to be conducted.

[16] A special test in this context is any test that is not included in the surveillance programme or which is not performed frequently.

CONTROL OF OUTAGES

7.18. The operations department should be involved in all aspects of activities in outages to ensure that the risks in outages are managed properly and the effectiveness of outages is optimized by thorough planning and scheduling, effective coordination and implementation and the timely return of systems and components to operational status.

7.19. Operations personnel who are formally so authorized should be involved in the coordination of outage activities to ensure that the proper configuration of the plant is maintained and that the plant status is known and is communicated to each incoming shift.

7.20. Special attention should be paid to redundant power sources, core cooling systems, the capability to ensure the integrity of the containment, cooling of the spent fuel pool, fuel handling activities and the interdependence of systems important to safety and auxiliary systems. Control should be maintained over the systems and redundant systems that are necessary to maintain the plant in a safe shutdown state.

ROUTINES FOR ISOLATION OF EQUIPMENT

7.21. Guidance for the isolation and tagging processes should be established to ensure the protection of personnel and equipment and status control of the tagging boundary and all components within the boundary. A training programme for the tagging and isolation processes should be established and all staff involved in the tagging and isolation of equipment should be trained and regularly retrained.

7.22. Suitable arrangements should be made for locking, tagging or otherwise securing isolation points to ensure safety. Locking devices for breakers and switches should be adequate to prevent the inadvertent startup or incorrect positioning of equipment. Out of service systems and components should be identified by means of appropriate signs and tags, both in the plant and in the control room. If it is impossible to de-energize all equipment or components within an isolation boundary, the management should ensure that the supervisor and the work group fully understand which equipment is energized and where it is located.

7.23. The rules for carrying out electrical and mechanical isolations and issuing radiation work permits should be published and adhered to. A qualified person from the operations department should verify the isolation procedures and checklists. Tags should be periodically reviewed for their accuracy and continued applicability.

7.24. Provisions should be put in place for the authorization of work under voltage on non-isolated equipment and of the procedures for such work. Lifted leads and jumpers should be controlled and tagged.

7.25. In multiple unit plants, arrangements should be put in place to prevent human error resulting in the isolation of equipment in the wrong unit.

7.26. Tags used for the protection of personnel or equipment should be unambiguously identifiable and should be different in appearance from other plant tags. All plant personnel should understand the meaning of the tags used for the protection of personnel or equipment. Miniature tags should be used if a full sized tag could obscure switches, indicators or other controls or informational devices.

7.27. In addition, caution tags should be used to identify short term conditions specific to a tagged component. Such caution tags should be used in situations in which a system or component is functional but where some precaution or information is temporarily necessary prior to operation.

7.28. Tags should be prepared by individuals who are qualified in the tagging process and aware of the scope of the work to be performed. The scope of the work should be described in sufficient detail by the organization responsible for the performance of the job. Prepared tags should be reviewed independently for their accuracy and adequacy. Either the person preparing the tags or the person reviewing them should be the formally authorized operator for the affected unit. Tags indicating the status of equipment important to safety should be approved by the shift supervisor or the control room operator who supervises the affected unit.

7.29. Tags should be placed by operators or other qualified individuals who are knowledgeable of the components and systems being tagged. For components that require independent or concurrent verification, a second qualified person should verify the position of tags and components. Such a second verification should be supplementary to that performed by the worker or supervisor prior to the commencement of a job. It should be verified that the voltage has been

removed. The worker or supervisor should only begin the job after verification that all tags are in place and that the system or component has been isolated.

7.30. A record of all active tagging requests and the positions of all tagged components should be made available to the control room operators to allow them to determine readily how the tagging will affect operations. Requests for tags to be placed in the plant should be reviewed periodically by management to verify the need for each request.

7.31. The removal of tags should be subject to authorization by the shift supervisor or another responsible person in the operations department. Authorization for the removal of tags should be subject to approval by all groups working within the isolation boundaries. The individual who authorizes the removal of tags should ensure that the final position of the components and the sequence in which they are to be installed have been correctly specified. In addition, the alignment of other, untagged components inside the isolation boundary should be determined at this point and it should be verified that they comply with normal alignment requirements.

7.32. Written guidance covering the temporary removal of isolation tags should be established as necessary and should be clearly communicated. It should be specified when the temporary removal of tags is appropriate. The roles and responsibilities of individuals involved in the temporary removal of tags should be specified. Tags that are temporarily removed and replaced should be controlled in a similar manner to those that are placed or removed normally. All instances of the removal and replacement of tags should be subject to approval, review, documentation and verification.

INDUSTRIAL SAFETY

7.33. The tagging procedures should also refer to the applicable industrial safety requirements. Industrial safety precautions for taking components and equipment out of service, switching off breakers in the electrical cabinets or switchyard, draining a system and bringing back into service a system or component should be specified. In the case of hazardous materials such as hot water, steam, chemicals, gases under pressure or radioactive material, procedures should be clearly written and communicated to specify the manner in which such hazardous materials are to be treated to avoid any harmful impacts on the components, on the staff who deal with such materials or who work in the surrounding area, or on the environment.

7.34. The shift supervisor and the operations manager should conduct periodic walkdowns in the plant to observe the tagging process and the process for bringing equipment back into service, and in particular the process for filling and venting a drained system or component in a manner that ensures the industrial safety of field operators. If supervisors detect any non-compliance with the relevant industrial safety standards, it should be corrected immediately and communicated in accordance with established procedure for the feedback of operational experience.

7.35. Field operators should be trained and periodically retrained on the industrial safety standards relating to their tasks. These standards should be included in a training manual and should be communicated to the personnel and their supervisors. If control room personnel are involved in tasks similar to those of the field operators, they should be trained appropriately. A strict rule should be established that only trained personnel are allowed to perform tasks for which industrial safety is relevant.

7.36. The operations manager should also analyse industrial safety related events in the operations department so as to be aware of the direct and root causes of such events. The operations manager should analyse trends in the occurrence of industrial accidents relating to poor industrial safety in the operations department and should take action to reduce the number of events relating to industrial safety.

7.37. Guidelines should be written for the use of personal industrial safety equipment, on the basis of existence of actual or potential industrial safety hazards. Requirements should be specified for the use of equipment such as hard hats, safety glasses, safety belts, hearing protection, appropriate footwear, protective equipment and clothing for working on energized equipment or with hazardous chemicals. Requirements for the routine use of industrial safety equipment should be clearly posted at the locations where they apply and should specify the industrial safety requirements in effect at that location.

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