GOVT OF INDIA

AERB SAFETY GUIDE

SURVEILLANCE OF ITEMS IMPORTANT TO SAFETY IN NUCLEAR POWER PLANTS

ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY GUIDE NO. AERB/SG/O-8

SURVEILLANCE OF ITEMS IMPORTANT TO SAFETY IN NUCLEAR POWER PLANTS

Issued In July 1999

This document is subject to review, after a period of one year from the date of issue, based on the feedback received

Atomic Energy Regulatory Board
Mumbai 400 094

FOREWORD

Safety of public, occupational workers and the protection of environment should be assured while activities for economic and social progress are pursued. These activities include the establishment and utilisation of nuclear facilities and use of radioactive sources. They have to be carried out in accordance with relevant provisions of the Atomic Energy Act 1962 (33 of 1962).

Assuring high safety standards has been of prime importance since the inception of nuclear power programme in the country. Recognising this aspect, the Government of India constituted Atomic Energy Regulatory Board (AERB) in November 1983 vide standing order No. 4772 notified in Gazette of India dated December 31, 1983. The Board has been entrusted with the responsibility to lay down safety standards and to frame rules and regulations in respect of regulatory and safety functions envisaged under the Atomic Energy Act of 1962. Under its programme of developing safety codes and guides, AERB has issued four codes of practice covering the following topics:

Safety in Nuclear Power Plant Siting
Safety in Nuclear Power Plant Design
Safety in Nuclear Power Plant Operation
Quality Assurance for Safety in Nuclear Power Plants

Safety guides are issued to describe and make available methods of implementing specific parts of the relevant codes of practice as acceptable to AERB. Methods and solutions other than those set out in the guides may be acceptable if they provide at least comparable assurance that the nuclear power plants can be operated without undue risk to the health and safety of the plant personnel, general public and environment.

The codes and safety guides may be revised as and when necessary in the light of experience as well as relevant developments in the field. The annexure, footnotes, bibliography are not considered an integral part of the document. They are included to provide information that might be helpful to the user.

The emphasis in the codes and guides is on protection of site personnel and public from undue radiological hazard. However, for aspects not covered in the codes and guides, applicable and acceptable national and international codes and standards shall be followed. Industrial safety shall be assured through good engineering practices and compliance with the Factories Act 1948 as amended in 1987 and the Atomic Energy(Factories) Rules, 1996.

This safety guide provides guidance on the aspects of surveillance of items important to safety in nuclear power plants.

The Safety Guide has been prepared by the staff of AERB and other professionals. In drafting this guide, they have used extensively the relevant documents of the International Atomic Energy Agency (IAEA) developed under the Nuclear Safety Standards(NUSS) programme, specially the IAEA Safety Guide on Surveillance of Items Important to Safety in Nuclear Power Plants
50-SG-08).

Experts have reviewed the guide and AERB Advisory Committees have vetted it before issue. AERB wishes to thank all individuals and organisations who reviewed the draft and finalised the guide. The list of persons, who have participated in the committee meetings, alongwith their affiliations is included for information.

(P.Rama Rao)
Chairman, AERB

DEFINITIONS

Acceptable Limits

Limits acceptable to Regulatory Body.

Accident Conditions[1]

Substantial deviations from Operational States[1] which could lead to release of unacceptable quantities of radioactive materials. They are more severe than anticipated operational occurrences and include Design Basis Accidents and severe accidents.

Anticipated Operational Occurrences[2]

All operational processes deviating from normal operation which may occur during the operating life of the plant and which in view of appropriate design provisions, neither cause any significant damage to Items Important to Safety nor lead to Accident Conditions.

Approval

A formal consent issued by the Regulatory Body to a proposal.

Atomic Energy Regulatory Board (AERB)

An authority designated by the Government of India to enforce the rules promulgated under the relevant Sections of the Atomic Energy Act 1962, for the control of radioactive substances (section 16), special provisions to safety (section 17) and administration of the Factories Act 1948 (section 23).

Audit[3]

A documented activity performed to determine by investigation, examination and evaluation of objective evidence,the adequacy of, and adherence to, Codes, Standards, specifications, established procedures, instructions, administrative or operational programmes and other applicable documents and the effectiveness of their implementation.

---

1 Substantial deviation may be a major fuel failure, a Loss of Coolant Accident (LOCA) etc. Examples of Engineered Safety Features are: an Emergency Core Cooling System (ECCS), and containment.

2 Examples of Anticipated Operational Occurrences are loss of normal electric power and faults such as turbine trip, malfunction of individual items of control equipment and loss of power to main coolant pump.

3 The definitions refer to Quality Assurance activity as discussed in Quality Assurance Code and Guides.

Authorisation

See ' Regulatory Consent'.

Commencement of Operation[4]

The specific activity/activities in the commissioning phase of a Nuclear Power Plant towards first approach to criticality.

Commissioning[5]

The process during which structures, systems and components ofa facility, having been constructed, are made operational and verified to be in accordance with design specifications and to have met the performance criteria.

Competent Authority

An officer or authority appointed or approved by the Government by notification for the purposes of the Rules promulgated under the Atomic Energy Act 1962.

Construction[5]

The process of manufacturing, testing and assembling the components of a facility, the erection of civil works and structures and the installation of components and equipment.

Decommissioning[5]

The process by which a facility is finally taken out of operation in a manner that provides adequate protection to the health and safety of the workers, the public and of the environment.

Documentation[3]

Recorded or pictorial information describing, defining, specifying, reporting or certifying activities, requirements, procedures and results.

Emergency Situation

A situation which endangers or is likely to endanger safety of the NPP, site personnel or the environment and the public.

---

4 e.g. Fuel loading in case of Light Water Reactors and in case of Pressurised Heavy Water Reactors, heavy water addition with fuel already loaded.

5 The terms Siting, Construction, Commissioning, operation and Decommissioning are used to delineate the five major stages of the authorisation process. Several of the stages may coexist; e.g. Construction and commissioning, or Commissioning and Operation.

Examination[3]

An element of Inspection consisting of investigation of materials, components, supplies or services, to determine conformance with those specified requirements which can be determined by such investigation.

Inspection[3]

Quality Control actions which by means of examination, observation or measurement determine the conformance of materials, parts, components, systems, structures as well as processes and procedures with pre-determined quality requirements.

Items Important to Safety

The items which comprise:

(1) those structures, systems, equipment and components whose malfunction or failure could lead to undue radiological consequences at Plant or outside the Plant[6];

(2) those structures, systems and components which prevent Anticipated Operational Occurrences from leading to Accident Conditions;

(3) those features which are provided to mitigate the consequences of malfunction or failure of structures, systems or components.

Licensed Person

A person who has been licensed to hold certain Licensed Position of a NPP after due authorised procedure of certification by the AERB.

Licensed Position

A position, which can be held only by persons Certified by AERB or a body designated by it.e.g. Shift Charge Engineer, Assistant Shift Charge Engineer, Control Engineer, Assistant Shift Charge Engineer (Fuel Handling Unit) and Control Engineer (Fuel Handling Unit).

Normal Operation

Operation of a Plant or equipment within specified operational limits and conditions. In case of nuclear power plant this includes, start-up, power operation, shutting down, shutdown state, maintenance, testing and refuelling.

---

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

Nuclear Power Plant

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

Nuclear Safety

Protection of all persons from undue radiological hazards.

Objective Evidence

Term used in context of Quality Assurance, qualitative or quantitative information, record or statement of fact, pertaining to quality of an item or service, which is based on observation, measurement or test and which can be verified.

Operating Organisation[7]

The organisation so designated by responsible organisation and authorised by Regulatory Body to operate the facility.

Operating Personnel

Those members of Site Personnel who are involved in the operation of the NPP.

Operation[5]

All activities following commissioning and before decommissioning performed to achieve in a safe manner the purpose for which an installation was constructed, including maintenance.

Operational Limits and Conditions (OLC)
(See also technical specification)

Limits on plant parameters and a set of rules on the functional capability and the performance level of equipment and personnel, approved by the Regulatory Body, for the safe operation of the facility.

Operational Records

Documents such as instrument charts, certificates, log books, computer print outs and magnetic tapes, made to keep objective history of the NPP operation.

Operational States

The states defined under Normal Operation and Anticipated Operational Occurrences.

---

7 Organisation structure and not individual names.

Plant Management

The members of Site Personnel who have been officially delegated responsibility and authority by the Operating Organisation for directing the operation of the plant.

Prescribed Limits

Limits established or accepted by Regulatory Body for specific activities or circumstances that must not be exceeded.

Qualified Person

A person who having complied with specific requirement and met certain conditions, has been officially designated to discharge specific duties and responsibilities. [For example, Reactor Physicist, Station Chemist, and Maintenance Person of a Nuclear Power Plant are qualified persons]

Quality Assurance

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

Records

Documents which furnish objective evidence of the quality of items and activities affecting quality. It also includes logging of events and other measurements.

Regulatory Consent

It is a written permission issued by the Regulatory Body to perform the specified activities related to the facility. The types of consent are 'Licence', 'Authorisation', 'Registration', and 'Approval', and will apply depending upon the category of the facility, the particular activity and radiation sources involved.

Reliability

It is the probability that a structure, system, component or facility will perform its intended (specified) function satisfactorily for a specified period under specified conditions.

Responsible Organisation[8]

The organisation having overall responsibility for siting, design, construction, commissioning, operation and decommissioning of a facility.

---

8 In the present context the Nuclear Power Corporation of India Limited (NPCIL) is the Responsible Organisation for Nuclear Power Plants in India.

Regulatory Body

See 'Atomic Energy Regulatory Board'

Safety

See 'Nuclear Safety'.

Safety Limits

Limits upon process variables within which the operation of the facility has been shown to be safe.

Safety Report

A document provided by the applicant or licensee to the Regulatory Body containing information concerning the facility, its design, accident analysis and provisions to minimise the risk to the public and to the site personnel.

Safety Critical systems (Safety Systems)

Systems important to safety, provided to assure, under anticipated operational occurrences and accident conditions, the safe shutdown of the reactor (Shutdown System) and the heat removal from the core (Emergency Core Cooling System), and containment of any released reactivity (Containment Isolation System).

Severe Accidents

Nuclear Power Plant conditions beyond those of the Design Basis Accidents causing significant core degradation.

Site

The area containing the facility defined by a boundary and under effective control of facility management.

Site Personnel

All persons working on the site, either permanently or temporarily.

Siting

The process of selecting a suitable site for a facility including appropriate assessment and definition of the related design bases.

Specification

A written statement of requirements to be satisfied by a product, a service, a material or process indicating the procedure by means of which it may be determined whether specified requirements are satisfied.

Surveillance[9]

All planned activities namely monitoring, verifying, checking including in-service inspection, functional testing, calibration and performance testing performed to ensure compliance with specifications established in a facility.

Technical Specifications for Operation

A document submitted on behalf of or by the responsible organisation covering operational limits and conditions, surveillance and administrative control requirements for the safe operation of the facility and approved by Regulatory Body.

Testing

The determination or verification of the capability of an item to meet specified requirements by subjecting the item to set of physical, chemical, environmental or operational conditions.

Ultimate Heat Sink

The atmosphere or a body of water or the ground water to any or all of which the residual heat is transferred during normal operation, anticipated operational occurrences or accident conditions.

---

9 This includes activities performed to assure that provisions made in the design for safe operation of the NPP continue to exist during life of the plant.

CONTENTS

1. INTRODUCTION

1.1 General

1.1.1 This Safety Guide was prepared as part of the Atomic Energy Regulatory Board's (AERB) programme for establishing Codes of Practice and Safety Guides relating to Nuclear Power Plants (NPPs). It supplements the Code of Practice on Safety in NPP Operation (AERB/SC/O). The provisional list of Safety Guides on Operation is given at the end of this publication.

1.1.2 Surveillance includes planned activities carried out periodically to verify that all items important to safety are capable of performing their functions as specified for operation of the plant within prescribed limits during normal operational states and during and following accident conditions and to detect in time any deterioration which could lead to reduced reliability ageing or any other unsafe condition.

1.1.3 The activities carried out under surveillance can be classified as :

(i) Monitoring plant parameters and system status;
(ii) Checking and calibrating instrumentation;
(iii) Testing and inspecting structures, systems & components and surveillance; and
(iv) Evaluating results and verification of corrective actions.

1.2 Objective

1.2.1 The main objectives of the Safety Guide are:

(i) To give emphasis on the need to establish a surveillance programme at the NPP with the mainaim of early detection of any deteriorating condition of items important to safety to ensure timely corrective actions;

(ii) To give guidelines on the administrative aspects of surveillance to highlight delineation of responsibilities, achieve administrative control and have effective audit, reviews and documentation; and

(iii) To recommend the surveillance methods for implementation of surveillance.

1.3 Scope

1.3.1 The Safety Guide includes requirements of and suggestions defining the basis and extent of surveillance programme.

1.3.2 Technical and administrative aspects of development of surveillance programme are also covered.

1.3.3 Though inspection and testing to meet acceptance criteria, in-service inspection and preventive maintenance are necessary complements to a surveillance programme, these are not included here since they are covered by other Safety Guides (see AERB/SG/0-2 and AERB/SG/0-7)

1.3.4 The Guide includes recommendations on the frequency and extent of surveillance and gives a typical list of parameters, structures, systems and components on which surveillance may be carried out. It also points out that for any specific NPP, reference has to be made to the respective technical specifications which contain special section on surveillance requirements mandatory to the operation of that NPP.

2. SURVEILLANCE PROGRAMME

2.1 A surveillance programme shall be established to verify that provisions for safe operation made in the design, and those that were checked during construction and commissioning, continue to exist during the life of the plant. At the same time, the programme shall verify that safety margins are adequate. This programme shall be approved by the Regulatory Body.

2.2 The surveillance programme shall:

(a) delineate in sufficient scope and depth the surveillance aims and requirements with respect to structures, systems and components important to safety;

(b) specify the frequency of surveillance and provide for the scheduling of those activities;

(c) specify the standards to be applied and provide for appropriate procedure to be used during the conduct and assessment of each surveillance activity;

(d) verify that the structure, systems and components important to safety remain within the operational limits and conditions (refer AERB/SG/O-3);

(e) specify the authority and responsibility assigned to both individuals and to on-site and off-site organisations involved in determining and carrying out surveillance activities;

(f) specify the qualifications of the personnel who perform the surveillance activities;

(g) indicate the points at which reviews are required;

(h) specify the requirements for records to be kept, their retention and retrievability; and

(i) provide cross references to other documents relevant to the surveillance programme.

2.3 The interfaces between the surveillance programme and other programmes such as the commissioning, preventive maintenance, in-service inspection, quality assurance, and plant operations programmes, shall be given due consideration.

2.4 Not all structures, systems and components require the same frequency and extent of surveillance. Quality assurance principles enable the surveillance requirements to be derived in a graded manner so that the extent of such requirement is consistent with the safety function performed by the structure, system or component. Classification of systems as indicated in the Safety Guide on Safety Functions and Component Classification (refer AERB/SG/D-1), may be utilised to decide the extent of surveillance requirement.

2.5 In developing the programme mentioned in sub-section 2.2, the following aspects should be included.

(a) requirements established during safety analysis, operational limits and conditions and other applicable requirements of the Regulatory Body;

(b) results of the commissioning programme, with particular attention to base line data, the as- built state of the plant and the acceptance criteria; and

(c) the availability and operability of items important to safety and the detection of deficiencies and incipient failures that might occur during operation or prior to returning items to service after maintenance, repair or modifications.

2.6 The surveillance programme shall be developed by the operating organisation[1] sufficiently early to permit the programme to be properly implemented as and when plant items become operational during the commissioning phase and, where appropriate, on installation. Implementation shall be scheduled so that the plant safety does not depend on untested or unmonitored structures, systems or components.

2.7 To meet the requirements of section 2.6, the following aspects shall be included:

(a) the programme and its supporting procedures to be developed, reviewed and approved sufficiently in advance for them to be available when needed;

(b) the surveillance procedures to be tested to the extent practicable during the commissioning phase;

(c) parameters to be recorded (during and after construction but prior to plant operation) as baseline data for use as reference points in monitoring. Certain bench marks and alignment references, for example, may need to be permanently marked, measured and recorded to provide as-built references for subsequent comparison; and

(d) provide design features necessary to facilitate the implementation of surveillance programme.

2.8 The surveillance programme shall be reviewed periodically at least once in 5 years or earlier as required in the light of experience technological development, design modifications or new knowledge and be updated as appropriate by the operating organisation and approved by the Regulatory Body.

---

1 where an operating organisation is not defined, these functions are the responsibility of the responsible organisation or plant management as delegated by responsible organisation.

3. SURVEILLANCE REQUIREMENTS

3.1 General

3.1.1 The surveillance programme shall cover all structures, systems and components important to safety, including the auxiliary systems essential for the performance of these items. The scope of the programme should be sufficiently broad to provide a basis for ensuring that all systems operate within acceptable operational limits and conditions (see AERB Safety Guide SG/O-3). Particular attention shall be given to:

(a) the availability of reactor shutdown systems, i.e the protection system, the safety actuation systems, and the safety system support features (see AERB Safety Guide AERB/SG/D-3);

(b) core cooling systems, in particular emergency core cooling system and residual heat removal system;

(c) the integrity of barrier between the radioactive products and the environment (e.g. fuel cladding, primary pressure boundary and containment); and

(d) the availability of other items that could adversely affect safety if they malfunctioned.

3.1.2 A typical list of parameters, structures, systems and components that may be included in the surveillance programme and the type of surveillance that may be appropriate is provided in Annexure I.

3.2 Integrity of Barriers

3.2.1 Surveillance measures necessary to verify fuel cladding integrity include, but not necessarily limited to:

(a) inspection of new fuel, core components and associated items such as flow-restricting device and locating devices in accordance with agreed schedule prior to loading into the core. This inspection as detailed in the Safety Guide AERB/SG/O-10A, may include visual, metrological and more sophisticated methods (such as helium tests and NDTs);

(b) monitoring thermal and hydraulic conditions such as flows, temperature, pressure, gross and local power to ensure adherence to operational limits and conditions both for steady state and transient state;

(c) monitoring of the reactor coolant radioactivity, chemical quality (e.g. by sample analysis) and failed fuel detection system;

(d) appropriate inspection of irradiated fuel before re- use, storage or transportation (e.g. by visual inspection or leak tests); and

(e) monitoring the radioactivity and chemistry of water or gas in the irradiated fuel storage facilities.

3.2.2 Surveillance measures necessary to verify the integrity of the primary reactor coolant pressure boundary include, but are not necessarily limited to:

(a) leak-rate measurements, for example on make-up or leakage collection, vapour recovery or stack loss monitoring, tritium concentration level in certain areas;

(b) inspection and pressure tests on the primary pressure boundary (see Safety Guide on In-service Inspection for Nuclear Power Plants, AERB/SG/O-2, for further details);

(c) recording of system transients and comparing them with assumptions made in the safety report, where appropriate;

(d) testing the operability and tightness of closure devices that are part of the boundaries;

(e) monitoring leak-detection systems (process and area radiation instruments, temperature detectors, acoustic detection system, etc.);

(f) monitoring to assure that nil-ductility transition temperature considerations are satisfied; and

(g) monitoring the physical, chemical and the radio- chemical quality of the primary and secondary reactor coolants as per technical specification for operation.

3.2.3 Surveillance measures necessary to verify containment integrity include, are not necessarily limited to:

(a) leak-rate tests performed on the containment;

(b) tests of penetration seals (embedded parts, cable penetrations, etc.) and closure devices such as air locks and isolation dampers that are part of the boundaries, to demonstrate their leak-tightness and, where appropriate, their operability;

(c) structural integrity inspections;

(d) monitoring conditions within the containment such as temperatures, pressures and atmospheric composition; and

(e) efficacy of vapour suppression system.

3.2.4 The surveillance programme shall include tightness checks, leak test of systems and components designed to contain radioactive materials such as efficiency test on absolute filters, or continuous testing as appropriate such as by on-line monitoring.

3.3 Safety Systems

3.3.1 Shutdown System

The surveillance shall cover shutdown systems and components provided to shutdown the reactor and to keep it under guaranteed shutdown, to ensure that design limits are not exceeded either under anticipated operational occurrences or during initial operation of systems required to mitigate the consequences of accident conditions. The latter includes:

(a) protection of primary systems against unacceptable pressure surges (safety and instrumented relief valve)

(b) actuation of safety system as intended.

Surveillance shall demonstrate the availability of the protection system, including all redundant parts, verify the set points at which actuations occur, and the acceptability of all response times and the shutdown margin.

3.3.2 Emergency Core Cooling System and Residual Heat Removal System

All structures, systems and components with functions that mitigate the consequences of accident conditions shall be subjected to periodic surveillance to demonstrate their availability to the fullest extent practicable and to detect any degradation of their performance. These functions include, but not necessarily limited to: emergency core cooling and residual heat removal to the ultimate heat sink.

3.3.3 Containment System

(a) containment isolation;

(b) containment cool down and pressure limitation/vapour suppression system;

(c) control of radioactive effluent discharges resulting from accident conditions; and

(d) control of combustible gases within the containment, where applicable.

3.3.4 Safety System Support Features

The availability of safety system support features shall be verified according to the importance of the system they serve.

Functions associated with structures, systems and components important to safety that shall be considered to include, but not necessarily limited to, the supply of:

(a) emergency power;

(b) cooling water;

(c) process and instrumentation air;

(d) cooling and lubrication; and

(e) easy accessibility to equipment and control stations.

3.4 Other Items

Other items that shall be subjected to surveillance are those items that, should they fail, are likely to give rise to, or contribute to, abnormal or accident conditions. These include:

(a) systems relied on for shutting down and cooling the reactor under normal plant conditions, including control systems such as those provided to control reactivity, feed water supply, reactor pressure and temperature;

(b) instrumentation and equipment and associated instrument for both operational states and accident conditions;

(c) control room habitability and access;

(d) high energy piping and associate piping restraints;

(e) structural supports (e.g. stack stay wires, pipe supports;

(f) fire prevention, detection and fighting systems including mobile pump sub-system;

(g) emergency facilities and equipment including unrestricted access thereof;

(h) protection against internal and external events;

(i) communication systems;

(j) irradiated fuel storage facilities including cleanup systems;

(k) fuel handling equipment and facilities;

(i) radioactive waste treatment and storage facilities;

(m) plant security;

(n) turbine and generator speed control and their protection systems, where appropriate;

(o) RB ventilation equipment for normal and accident conditions; and

(p) condition monitoring of all important rotating equipment.

4.0 SURVEILLANCE FREQUENCY

4.1 Determination of Surveillance Frequency

4.1.1 Surveillance frequency for an item shall be based on its importance to safety; the more severe the consequences of malfunction or failure to function, the greater is the need to prevent them. Other things being equal, the need to detect incipient failures in time thus to reduce the probability of malfunction or failure to function increases with increase in magnitude of consequences.

4.1.2 Surveillance frequency should have the following objectives:

(a) plant parameters and operability of items continue to remain in accordance with operational limits and conditions;

(b) functional performance of the items;

(c) detect incipient failures, as feasible;

(d) minimise a defect developing between two successive surveillance actions to such an extent as to lead to accident conditions; and

(e) meet the requirements of AERB and other applicable industrial codes and standards.

4.1.3 Surveillance frequency should be determined from the following:

(a) consequences of malfunction or failure to function;

(b) the mean time between failure (MTBF) derived by using such information as manufacturer's recommendation, results of type tests, endurance tests and cycle tests;

(c) expected mechanisms of failure, age of the item, components used and service conditions, and results of reliability analysis;

(d) experience gained in the plant and elsewhere;

(e) constraints such as radiation exposure to operating personnel, inaccessibility and inoperability of the item during test; and

(f) trend monitoring.

4.1.4 As appropriate, the following may be considered in the optimisation of surveillance frequency:

(a) the extent of redundancy with respect to minimum operability requirements;

(b) operational constraints to exercise surveillance such as perturbations during steady operation (e.g. control rod exercising at power in BWRs) and the need to avoid unwarranted scrams, and stress cycles of critical components such as primary system pressure boundary components and fuel clad;

(c) scheduling surveillance considerations with other activities such as optimised shutdown planning including utilisation of unplanned outages;

(d) consequences of excessive testing such as rapid ageing resulting in lower reliability; and

(e) extent of automation of surveillance.

4.1.5 Limitations in using calculated reliability data for determining surveillance frequency arise from the following:

(a) statistically meaningful data is rarely available except for fault events with high frequency. Most items for which such information is required, have low frequency for fault events. This problem is particularly true for state-of-the-art items in high obsolescence technologies;

(b) industrial experience has shown that while endurance, cycle and type testing are essential, they can rarely provide conclusive reliability figures for plant conditions;

(c) establishment of complete and correct event tree and fault trees to identify common cause failures is an unduly difficult task influenced by the schematic design of applicable safety system support features (such as a fuse or isolating valve being common); and

(d) in many cases, direct usage of published data on failure rates is inappropriate as priorities, both in design and determination of test frequency, would depend on whether defect is the result of a gradual growth of identifiable flaw or takes place suddenly.

It is therefore necessary that the operating organisation determine the frequency of surveillance based on its best estimates and revise them with experience and should be compatible with the results of the safety analyses.

4.1.6 Where frequency is determined on limited experience on reliability of system, initially adopted surveillance frequency shall be based on conservative assumptions.

4.1.7 To minimise adverse effect on reliability of Items due to thermal, mechanical or other cycles caused by excessive testing, testing of items provided for a safety function may be suspended with prior approval of AERB as applicable when not required. In such cases, appropriate testing to confirm operability requirements according to operational limits and conditions, shall be conducted before any changes in operational state are made.

4.1.8 An important source of common cause failure is the use of a defective test signal or calibration reference unit. Another could be the common human element. Detailed procedures particularly those relating to normalisation (return to service) after surveillance activities should take account of such common cause failure sources.

4.2 Extent of Surveillance

4.2.1 The extent of testing shall be adequate to meetthe following:

(a) detect incipient failures and the need to modify maintenance frequency, to detect corrosion attack;

(b) meet requirements stated in operational limits and conditions and other applicable codes and standards;

(c) manufacturer's recommendations, results of type tests, endurance tests, etc.;

(d) experience in plant or elsewhere on the nature and extent of failures;

(e) adverse effect on reliability of systems and components due to service conditions encountered during test (an example is the code considerations on selection of hydrostatic test pressure for a pressure vessel due to material ageing, embrittlement because of irradiation, corrosion etc.); and

(f) operation of redundant components by putting them to operation in rotation.

4.2.2 The extent of surveillance shall be reviewed periodically. Two aspects that require special consideration are design changes, information on failure modes of similar systems and components, and aspects to be considered in the implementation of corrective action after failure such as control of radiological environment in the plant, radiation dose commitment to personnel and duration of unplanned nonavailability of the item.

4.3 Periodic Re-evaluation of Surveillance Frequency and Extent

Periodic re-evaluation of the established frequency and extent of surveillance shall be undertaken to establish their effectiveness in maintaining the system or component in an operational state. Procedures shall be established for ensuring that such re-evaluation is carried out and any necessary changes approved by the appropriate authorities. For this purpose, the following should be considered:

(a) performance of the system or component, particularly its failure rate;

(b) corrective action required after failure;

(c) performance of similar systems and components in similar plants and environments;

(d) design changes associated with the system or component; and

(e) information of failure modes causing abnormal occurrences or accidents.

5. IMPLEMENTATION OF THE SURVEILLANCE PROGRAMME

5.1 General

5.1.1 The surveillance programme shall be implemented to ensure that all portions of the structures, systems, and components important to safety are included.

5.1.2 The method of surveillance shall provide, where practicable, for verification of the operability status of all the components from the input sensor to the actuated equipment, including the automatic and manual portions. Where this is not practicable, overlapping surveillance methods (online and offline) shall be used. The methods shall be such that failures in each redundant portion or component of a system can be detected.

5.1.3 Where alternative controls are provided for a system or component, all such controls shall be included in the programme.

5.1.4 Surveillance shall be carried out under conditions such that the results can be compared with those obtained from previous surveillance activities including base-line data.

5.2 Surveillance Methods

5.2.1 Monitoring

5.2.1.1 Monitoring gives an immediate indication of plant status to operating personnel. The parameters significant for plant safety including status of systems that are not normally in operation, but which may be required to operate during any off-normal conditions, shall be monitored.

5.2.1.2 Monitoring is normally done by the operating personnel either from the main control room or during periodic tours of the plant. This takes the form of noting the parameter values shown by instruments, data loggers or computer printouts, and by observation of plant conditions.

5.2.1.3 Monitoring may also involve sampling. Such sampling may be on-line or manual and may be for chemical analysis, radiochemical analysis, material analysis,or isotopic purity analysis. Since the techniques involved in such sampling and analyses are specialized, these activities are generally conducted by specially trained personnel.

5.2.1.4 Monitoring of instrument channels that give readings should be done by one or more of the following:

(a) comparing readings on channels that monitor the same variable with allowance for any differences in the process variable between sensor locations;

(b) comparing readings between channels that monitor the same variable and bear a known relationship to one another; and

(c) comparing readings between channels that monitor different variables and bear a known relationship to one another.

5.2.2 Functional Tests

5.2.2.1 A functional test shall ensure that the tested system or to the extent practicable, structures, systems and components should be tested under conditions in which they are expected to operate to fulfil their intended functions. A functional test of equipment shall consist, as appropriate, of one or more of the following:

(a) manual start of equipment. Test duration shall be sufficient to achieve stable operating conditions. Where starting a specified component is not practical, operation of the starting device in 'test' position may be acceptable if the component is subsequently tested at the first opportunity provided by the plant operations;

(b) manually controlled electric operation of valves, with timing of the stroke, if appropriate. In cases where full stroking of the valve is not permissible because of operating conditions, a partial stroke test or a valve control system test may be acceptable, but full stroke testing should be done routinely during plant shutdown;

(c) injection of a test signal of appropriate magnitude to give a suitable actuation of the output or a read-out, as required;

(d) initiation of the actuating device and observation of the resultant operation;

(e) testing automatically calculated set points to verify responses to each variable entering in the computation;

(f) checking the manual initiation of safety functions;

(g) testing of the status and operability of interlocks, bypasses, bypass and test indications, and bypass and test annunciation circuits; and

(h) monitoring of the appropriate parameters during the test.

5.2.3 Calibration and Response-time Verification Tests

5.2.3.1 A calibration verification test is intended to check whether a known input to the instrument or channel gives the required output (analogue, digital or bistable). In analogue channels, linearity and hysteresis may also be checked.

5.2.3.2 Response-time testing shall be required on safety systems or sub-systems to verify that the response times are within specified limits.

5.2.3.3 The response time test shall include as much of each safety system, from sensor input to actuated equipment, as is practicable in a single test. Where the entire system from sensor to actuated equipment cannot be tested as a whole, verification of system response time shall be accomplished by measuring the response times of discrete portions of the system and showing that the resultant of all response times is within limits of the overall system requirements.

5.2.3.4 Calibration and response times shall be verified by tests that do not require removal of detectors from their installed location unless such tests are incapable of detecting whether response time changes are beyond acceptable limits. In such cases, sensors shall be removed for a special bench test if practicable, if not , the manufacturer's test results may be used, provided that:

(a) satisfactory assurance is obtained that aging does not degrade performance beyond acceptable limits;

(b) the manufacturer's test results are not invalidated by system design in which the sensor is installed; and

(c) the test results have been documented and tests performed in accordance with quality assurance requirements of the operating organisations's quality assurance programme.

5.2.4 Inspections

Inspections other than those conducted as a normal exercise of monitoring are necessary complements to a surveillance programme. However, such inspections are not addressed in this guide but discussed in the Safety Guides on In-Service Inspection for NPPs (AERB/SG/O-2) and in the Maintenance of NPPs, (AERB/SG/O-7).

5.3 Surveillance after Maintenance, Repair or Modification

5.3.1 Before any system or component is returned to service after maintenance or repair, surveillance shall be performed to ensure that the objective of maintenance or repair actions has been achieved, that the limits and conditions for normal operation associated with that system or component are satisfied, and that the plant can be operated safely. This shall include the surveillance of connected systems and other systems in the work area that may have been disturbed by the repair or maintenance action and normalisation of configuration changes.

5.3.2 Before any system or component is returned to service after a modification, the system or component shall be subjected to test similar to those used in the commissioning phase, as described in the Safety Guide on Commissioning Procedures for NPPs (AERB/SG/O-4), to substantiate that the design intent of modification has been complied with. The surveillance programme shall be re-evaluated and revised if necessary. When carrying out modifications on a multi-channel system, it is preferable to complete the work on one channel to allow a reasonable surveillance period to ensure that the modifications are adequate and reliable before similar modifications are carried out on other channels. This practice will help avoid potential common-mode failures and possibly unnecessary plant trips.

5.3.3 After making any modification of the reactor core in a manner that may alter the core physics parameters, a testing programme shall be conducted to verify the acceptability of the modified configuration. This testing programme should be similar in content to the initial criticality, low-power physics and power tests described in the Safety Guide on Commissioning Procedures for NPPs (AERB/SG/O-4). However, the scope of the tests may be abbreviated to confirm that values of only those parameters that may have been altered.

5.4 Test Equipment

5.4.1 General

All test equipment, whether called for in the design or otherwise required for the surveillance programme, shall be available, operable and calibrated to acceptable standards. In so far as feasible, test equipment should be permanently installed.

5.4.2 Control and Calibration

A programme shall be established and maintained for calibration and control of test equipment and reference standards used in surveillance. It shall provide for prompt detection of inaccuracies, and for timely and effective corrective action. This programme shall include the following general requirements:

(a) **equipment identification:** Test equipment and equipment used as calibration reference standards shall be identified to enable their calibration status to be verified;

(b) **use of equipment:** Before test equipment is used in a surveillance test, its calibration status and operability shall be verified;

(c) **calibration procedures:** Detailed procedures shall be provided for calibration of test equipment, the accuracy of calibration shall be commensurate with functional requirements and, where appropriate, reference standards used;

(d) **calibration records:** Records to demonstrate that established schedules and procedures for calibrating test equipment and reference standards have been followed shall be maintained for each piece of equipment. These records shall provide a calibration history, showing calibration intervals, date of last calibration and the next calibration due, conformance or non-conformance to required tolerances before and after adjustments, and any limitations on use. It is often desirable to affix a sticker directly to the test equipment, giving the dates of previous calibration and the next one due.

5.4.3 Out of Calibration Test Equipment

When test equipment is found to be out of calibration, the validity of tests done since the last calibration shall be evaluated. For the purpose, it is recommended that a history of usage for each piece of test equipment be maintained. Test equipment found to be out of calibration shall be identified by a tag or other suitable means.

6. ADMINISTRATIVE ASPECTS

6.1 Responsibilities

6.1.1 The ultimate responsibility for preparing and executing an adequate surveillance programme rests with the operating organization. Plant management shall be responsible for adhering to the operational limits and conditions (see safety guide on operational limits and conditions for nuclear power plants, AERB/SG/O-3) and therefore to the surveillance requirements contained therein.

6.1.2 With respect to the surveillance programme, the operating organization shall assign the authority and responsibilities both within its own organisational structure and to other organisations, and shall specify lines of communication. It shall ensure the timely conduct of surveillance, documentation and reporting, and the evaluation of results.

6.1.3 Independent verification that the surveillance programme is implemented in accordance with quality assurance requirements may be carried out by persons from operating organisation. It shall be conducted by individuals not directly involved in the surveillance activities. In addition, independent verification should also be done periodically by an agency authorised by AERB.

6.1.4 The operating organisation shall review the design to ensure that necessary provisions have been made to permit adequate surveillance of items important to safety. It shall also keep records of data collected and approved during commissioning as base-line data and as acceptance criteria for results of operational surveillance. The operating organisation shall also ensure that surveillance procedures have been validated to the extent practicable during this period.

6.1.5 The operating organisation shall be responsible for ensuring that the personnel carrying out the surveillance programme are properly trained and qualified for the specific area for which they are responsible. For this purpose, a training programme should be established to provide on-the-job training, in particular, arrangements should be made for these personnel to participate, to the extent practicable, in the development and conduct of commissioning test programmes and the evaluation of results. This programme should incorporate applicable operating experience, and provide for personnel to participate in manufacturers' schools, refresher training and other training programmes as considered necessary.

6.1.6 Surveillance programme shall be prepared, reviewed, approved and implemented in accordance with quality assurance requirements. Detailed guidance on these requirements is available in the AERB safety code on QA and relevant safety guide on QA (AERB/SC/QA and AERB/SG/QA-5).

6.1.7 The operating organisation shall submit surveillance report and information required by the regulatory body.

6.2 Surveillance Procedures

6.2.1 Procedures shall conform to the general provisions of Section 2 of the Safety Guide on Quality Assurance during Commissioning and Operation of Nuclear Power Plants, (AERB Safety Guide No. AERB/SG/QA-5), dealing with procedure contents, review and approval, temporary procedures and procedure adherence.

6.2.2 Procedures shall be so written to ensure unambiguous interpretation and that compliance is feasible. Where possible, relevant parameters shall be specified so that they are meaningful and directly available to personnel conducting the surveillance.

6.2.3 Procedures shall require that instrumentation and alarms associated with the system under test or calibration be checked.

6.2.4 Procedures shall clearly state the operating conditions required during the performance of surveillance activities. These conditions shall be such that surveillance does not result in the violation of operational limits and conditions.

6.2.5 Since certain activities may require that systems or components important to safety be removed out of service, it is essential that the procedures include both prerequisites for removal and specific directions for complete and proper return of these systems and components to service in stipulated time in order to ensure that the limits and conditions for normal operation are not violated.

6.2.6 Procedures for monitoring plant parameters or system status may require use of checklists, completion of prepared tables, or plotting of graphs.

6.2.7 Procedures shall clearly specify acceptance criteria and the measuresto be taken if these acceptance criteria cannot be met (see 6.1.4 and 6.5.4).

6.3 Scheduling of Surveillance

6.3.1 In scheduling surveillance, the following shall be considered:

(a) avoidance of undue interference with normal operation, in particular, during expected transients or at a power level where control of the plant is difficult;

(b) completion of a test or calibration during a single shift as far as feasible, or adoption of measures to ensure continuity such as overlapping of crew members, special briefings, and the use of a log book or checklist;

(c) reduction of the risk of common-cause failure due to personnel error. It is desirable that testing or calibration is done by different individuals and at different times;

(d) availability of qualified personnel to perform specific surveillance tasks and to initiate and carry out corrective action, should an abnormal result be observed;

(e) the possibility of carrying out several tests or calibrations simultaneously, so long as risks to the plant or interference between tests can be avoided;

(f) provision for sufficient flexibility to accommodate specific generation demands that may occur during certain periods;

(g) minimisation of plant transients. It is desirable to take advantage of planned or unplanned shut- downs, start-ups, or partial load conditions to undertake those tests that require these conditions or that may result in load reductions or plant trips; and

(h) minimisation of personnel radiation exposure; in particular, when surveillance requires entry into high-radiation zones during power operations.

6.3.2 Control room personnel shall be provided with the relevant list of tests to be performed, particularly those referred to in sub-section 6.3.1(g); they shall be aware of their implementation requirements and shall monitor any effect on the plant.

6.4 Administrative Control of Tests and Calibrations

6.4.1 For purposes of administrative control, the following shall be established:

(a) clear division of responsibility betweenthepersons conducting tests or calibrations and the person responsible for the operational control of the plant (e.g. shift supervisor);

(b) a test permit to be issued by plant operating personnel to the person responsible for the test in accordance with plant procedures. This permit shall clearly delineate the boundaries of the system being tested and specify all safety requirements;

(c) a written procedure for the test or calibration to be carried out;

(d) adequate communication between the test personnel and the operator in the control room; and

(e) a system for cancelling test permits to ensure that the system is returned to operation in a correct condition after testing.

6.4.2 During a test, the operator in the control room shall be kept informed of the status of the safety systems. Where the design has not provided for an indication in the control room of the status of the items important to safety, an appropriate procedure using tagging or other devices shall be adopted in the system poised condition,

6.4.3 When redundant systems are provided in a safety system, then only one sub-system should be taken up for repair, calibration or testing. Only after it is demonstrated to be in service, the work be taken up in other sub- systems and one at a time. During such period of repair, testing or calibration of this sub-system, the sub- system concerned shall be kept in safe configuration to meet the required design intent during accident conditions.

6.5 Evaluation of Surveillance Results and Corrective Actions

6.5.1 As surveillance results are obtained, they shall be compared with the acceptance criteria by the person conducting the surveillance. Should the results fall outside of tolerances, corrective action shall be initiated. In any event, where deviations from acceptance criteria occur that may prevent adherence to limits and conditions for normal operation, the person responsible for the operational control of the plant (e.g. shift supervisor) shall be informed.

6.5.2 Once a specific surveillance activity has been completed, the results shall be reviewed by a competent person other than the one who performed the surveillance. This review shall establish whether or not the surveillance has been properly completed and ensure that all results satisfy the approved acceptance criteria.

6.5.3 Surveillance results shall be examined, where appropriate, for trends that may indicate equipment deterioration. This can be done by reference to previously obtained data.

6.5.4 Surveillance programme should include appropriate steps to be taken for postulated deviations from the acceptance criteria, based, in the first instance, on design information and design analysis.

As a general rule, the actions to be taken when a deviation is detected shall include, as appropriate:

(a) actions by plant operating personnel, if so required, to compensate for the deviation and to maintain operation within limits and conditions for normal operation. On multi-channel systems, this may involve placing the failed component or channel in a fail safe state until repairs and testing are completed;

(b) notification to the appropriate level of authority in the operating organisation;

(c) remedial maintenance (see Safety Guide on Maintenance of Nuclear Power Plants, AERB/SG/O-7), to be carried out by plant personnel with collaboration of specialists if necessary;

(d) assessment of safety implication of the deviation with respect to future operation, remedial maintenance and surveillance programme;

(e) consultation, if necessary, with design personnel and specialists;

(f) assessment of the implications of deviations with respect to design of the system or component, computer modelling of the system, operator training, plant procedures, emergency measures, and regulatory requirements; and

(g) modifications to appropriate documents, plans, drawings, etc.

6.5.5 When the remedial maintenance or modification required as a consequence of a deviation has been completed, surveillance of the repaired, replaced or modified system or component shall be conducted before its return to service, as described in section 5.3 of this guide.

6.6 Audits, Reviews and Documentation

6.6.1 In accordance with quality assurance requirements, the surveillance programme, including its procedures, schedules, surveillance frequency, results and reports, shall be periodically audited and reviewed to ensure that the objectives of the programme indicated in 1.2.1. are met.

6.6.2 All results of surveillance activities shall be documented and recorded. Arrangements shall be made for documentation to be issued and maintained in accordance with quality assurance requirements. The following is a list of typical documents related to surveillance activities:

(a) logs and log books giving read-outs of safety system parameters;

(b) recorder charts and computer printouts;

(c) reports of tests, calibration and inspections; evaluation of results and corrective actions;

(d) surveillance procedures;

(e) records of completed surveillance;

(f) reports of relevant reviews and audits; and

(g) checklists for system and component status.

6.6.3 These documents should be used as a basis for reviews carried out to:

(a) demonstrate compliance with operational limits and conditions;

(b) detect trends indicating system or component deterioration.

6.6.4 Recommendations and guidance on audits, reviews and documentation are to be found in the Code of Practice on Quality Assurance for Safety in Nuclear Power Plants, AERB/SC/QA, and the associated Safety Guides.

ANNEXURE-I

EXAMPLES OF PARAMETERS, SYSTEMS, STRUCTURES AND COMPONENTS OF DIFFERENT TYPES OF REACTOR PLANTS REQUIRING SURVEILLANCE

This annexure provides a typical list of parameters, structures, systems and components that may be included in a surveillance programme.

It is emphasised that this is not part of the Safety Guide, but is attached to provide information helpful to the user in understanding the practical application of principles recommended in the Guide.

It is to be noted that although this annexure is generally applicable to PHWR and BWR type of reactors, variations may exist due to particular designs and to requirements of various national practices.

For an understanding of the headings of the columns in Tables I and II, reference should be made to section 5.2.

The tables include a column indicating where inspection is normally performed on certain structures and components as part of surveillance. Even though this Guide does not address in- service inspection or inspections following maintenance (see section 5.2.5) some in-service inspections have been included in the 'inspection' column as these considered helpful to the user.

ANNEXURE-I (Cont'd)

TABLE-I : PRESSURISED HEAVY WATER REACTOR PLANTS

Sl. No.	Item	Monitoring	Instrument Check	Functional Test	Calibration
1	2	3	4	5	6
1.	**PROTECTION SYSTEM**				
1.1	**Trip Parameters**				
1.1.1	Neutronic Parameters				
	. High neutron power	+	+	+	+
	. High log rate	+	+	+	+
	. High count rate trip (when start-up counters are used)	+	+	+	+
1.1.2	Process Parameters				
	. High Pump room pressure	+	+	+	+
	. High PHT pressure	+	+	+	+
	. Low PHT pressure	+	+	+	+
	. PHT flow very low	+	+	+	+
	. High boiler differential temperature	+	+	+	+
	. Low/V.low boiler level	+	+	+	+
	. Moderator level high/low	+	+	+	+
	. Deaerator level low	+	+	+	+
	. Secondary shutdown system banks unavailable	+	+	+	+
	(a) poison tank level	+	+	+	+
	(b) gas tank level	+	+	+	+
	. Adjuster rod				
	. Adjuster rod coolant flow low	+	+	+	+
	. PHT storage tank level	+	+	+	+
1.1.3	Discrete Parameters				
	. Primary shut-off rod leaving top limit switch without trip signal	-	-	+	-
	. No primary circulating pump running	-	-	+	-
	. Actual demand power high	-	-	+	-
	. Manual trip	-	-	+	-
	. Seismic acceleration trip	-	-	+	-

Sl. No.	Item	Monitoring	Instrument Check	Functional Test	Calibration
1	2	3	4	5	6
1.2	*** Setback/stepback parameters**				
1.2.1	Process Parameters				
	. ALPAS tank level very low	+	-	+	-
	. Reactor outlet temperature	+	+	+	+
	. Boiler level low	+	+	+	+
	. Channel outlet temperature high	+	+	+	+
	. Bleed condenser level high	+	+	+	+
	. Moderator temperature high	+	+	+	-
	. Active PW R/B supply header pressure very loe	+	+	+	+
	. Bleed cooler outlet temp high	+	+	+	+
1.2.2	Discrete Parameters				
	. Master key removed from door interlock system	-	-	+	-
	. Steam discharge valve not fully closed	+	-	+	-
	. Manual setback switch	-	-	+	-
	. ECCS blocked	-	-	+	-
1.3	**Primary Shutdown system**				
	. Rod drop time	-	-	+	-
	. Rod withdrawal logic	-	-	+	-
	. Position of rods	+	+	-	+
1.4	**Secondary shutdown system**				
	. Solenoid valve opening time	-	-	+	-
	. Rod bank withdrawal logic	-	-	+	-
	. Operation on failure of PSS-logic checks	-	-	+	-
	. Poison concentration				
	. Poison tank level	+	-	-	-
	. Gas tank pressure	+	+	-	+
		+	+	-	+
1.5	**Liquid Poison Injection System**				
	. Boron Concentration				
	. Poison tank level	+	-	-	-
	. Injection valves checking for operation	+	+	-	+
		-	-	+	-
	. Injection valves checking for poised state	+	-	-	-
	. Actuation after reactor trip				
	. Actuation of SS initiation	-	-	+	-
	. Isolation of moderator purification on LPIS initiation	-	-	+	-
		-	-	+	-

* on these parameters functional test may be performed whenever test facilities are available.

Sl. No.	Item	Monitoring	Instrument Check	Functional Test	Calibration
1	2	3	4	5	6
1.6	**Moderator Dumping (where applicable)**				
	. Control and dump valves	+	-	+	+
	. Moderator level/dump level	+	-	+	-
	. Logic	-	-	+	-
	. Dumping time	-	-	+	-
2.	**REACTIVITY CONTROL SYSTEM**				
	. Adjuster rod drive speeds	-	-	+	-
	. Adjuster rod interlocks	-	-	+	-
	. Adjuster rod position indication	+	+	-	+
	. Liquid poison addition in regulation mode	-	-	+	-
	. Rate of rise of moderator level (where applicable)	-	-	+	-
3.	**MODERATOR SYSTEM**				
	. Boron concentration	+	-	-	-
	. Moderator pump logic	-	-	+	-
	. Moderator cover gas safety relief valves	-	-	-	+
	. Moderator level	+	+	-	+
	. Moderator temperature	+	+	-	+
	. Moderator pressure	+	+	-	+
	. Moderator flow	+	+	-	+
	. Calandria boxingup logic	-	-	+	-
	. Chemical , radiological and isotope analysis	+	-	-	-
	. Moderator integrity	+	-	-	-
4.	**PRIMARY HEAT TRANSPORT SYSTEM**				
	. PHT system integrity	+	-	+	-
	. Safety velves/IRVs	+	-	+	+
	. Shutdown cooling pump logic	-	-	+	-
	. Failed fuel detection	+	-	+	+
	. Chemical, radiological and isotope analysis	+	-	-	-
5.	**EMERGENCY CORE COOLING SYSTEM**				
5.1	**Heavy water injection**				
	. Sensors	+	+	-	+
	. Injection logic	-	-	+	-
	. Injection velve operation	-	-	+	-
	. Relief valves	-	-	-	+
	. Calandria and fuelling machine	-	-	+	-

	vault drain valves				
	. Integrity of rupture discs and check valves	+	-	-	-
5.2	**Light Water Injection/ Recirculation**				
	. Sensors	+	+	-	+
	. Logic	-	-	+	-
	. Valve operation	-	-	+	-
	. Relief valves	-	-	-	+
	. ECCS pump operation in recirculation mode	-	-	+	-
6.	**REACTOR AUXILLARY SYSTEM**				
6.1	**End sheild cooling system**				
	. Sensors	+	+	-	+
	. Logic	-	-	+	-
	. Chemistry	+	-	-	-
6.2	**Calandria valut/Biological shield cooling system**				
	. Sensors	+	+	-	+
	. Logic	-	-	+	-
	. Chemistry	+	-	-	-
6.3	**Annulus Gas System**				
	. Sensors	+	+	-	+
	. Chemistry and moisture content	+	-	-	-
7.	**CONTAINMENT WITH ASSOCICATED SAFETY SYSTEM AND VENTILLATION**				
7.1	**Primary containment with associated safety system and ventillation**				
	. Primary containment integrity test including testing of cable and pipe penetrations and air locks.	-	-	+	-
	. Containment isolation logic tests	-	-	+	-
7.2	**Pressure suppression, post accident pressure equalization and depressurisation**				
	* V1 to V2 integrity				
	. Isolation logic	-	-	+	-
	. Integrity	+	-	+	-

	. Coolers logic	-	-	+	-
	. Suppression pool/dousing tank level	+	-	-	+
	. Suppression pool/dousing tank chemistry	+	-	-	-
	. Dousing valve operability	-	-	+	-
	. Dousing logic	-	-	+	-
7.3	**Primary Containment Controlled Discharge System**				
	. System operability	-	-	+	-
7.4	**Primary Containment Filtration and Pumpback System**				
	. System operability	-	-	+	-
7.5	**Secondary Containment**				
	. Integrated leakage rate test including vacuum development test	-	-	+	-
	. Recirculation and purge system operability.	-	-	+	-
7.6	**Ventillation System**				
	. Particulate/Iodine filter efficiency.	+	-	+	-
8.0	**SECONDARY SYSTEM (STEAM AND FEED WATER)**				
	. Emergency feed water storage level	+	-	-	-
	. ABFP and ACEP operability and their discharge valve operability	+	-	+	-
	. Steam relief valves	-	-	-	+
	. Boiler pressure control including steam discharge valves and boiler level control	+	+	+	+
	. Boiler feed water chemistry and radiochemistry	+	-	-	-
9.0	**PROCESS WATER SYSTEM**				
	. Process water standby pumps and standby line valve operability	-	-	+	-
	. Sensors	+	+	-	+
	. Relief valves	-	-	-	+
	. Back-up fire water injection to various heat exchangers	-	-	+	-
10.	**FIRE WATER SYSTEM**				
	. Relief valves	-	-	-	+

	. Pressure switches	-	-	+	+
	. Pump logics	-	-	+	-
	. Fire fighting pump operability	-	-	+	-
11.	**COMPRESSED AIR SYSTEM**				
	. Pressure decay test	-	-	+	-
	. Instrument air moisture	+	-	-	-
	. Relief valves	-	-	-	+
12.	**FUEL HANDLING**				
	. Fuelling machine	+	+	+	+
	. New fuel transfer system	+	+	+	+
	. Spent fuel transfer system	+	+	+	+
13.	**ELECTRICAL SYTEM**				
13.1	**Standby Diesel Generators**				
	. Standby diesel generators operability test	-	-	+	-
	. Diesel fuel inventory	+	-	-	-
	. Diesel fuel quality check	+	-	-	-
13.2	**Station Batteries**				
	. Condition of batteries and DC distribution	+	-	-	-
	. Load/capacity	-	-	+	-
13.3	**Switch Gear**				
	. Emergency power supply switch gear operability	-	-	+	-
13.4	**Protective Relays**				
	. Protective relays of emergency power supply	-	-	-	+
13.5	**Automatic and Emergency Transfer System**				
	. Auto transfer and emergency transfer logic	-	-	+	-
	. Automatic/emergency transfer relays	-	-	-	+
13.6	**Emergency Lights**				
	. Emergency lights checks	+	-	+	-
13.7	**Uninterruptable Power Supply (UPS)**				
	. UPS logic/performance	-	-	+	-
13.8	**Off-site power**	+	-	-	-

14.	**RADIOACTIVE EFFLUENTS**				
14.1	**Gaseous effluents**				
	. Stack gas monitors for particulate/iodine/tritium/gamma	+	+	+	+
	. Meteorogical instruments	+	+	-	-
14.2	**Liquid effluents**				
	. Gross beta, gamma and tritium activity in station discharge	+	-	-	-
	. Waste storage tank level	+	-	-	-
	. Waste storage tank water gross beta, gamma and tritium activity	+	-	-	-
	. Gross beta, gamma and tritium activity in process water	+	-	-	-
14.3	**Solid Waste**				
	. Burial facility bore holes sampling fro gross beta, gamma and tritium	+	-	-	-
14.4	**Miscellaneous**				
	. Emergency preparedness	+	-	+	-
	. Communication equipment	-	-	+	-
	. Test/calibration equipment	-	-	-	+
	. Plant security system	+	-	+	-
	. Environment radiation monitors	+	-	-	-

Notes

1. In the above tables, the frequency of surveillance checks need to be specified when + is marked. The frequency of surveillance checks will depend on the system requirement and failure rates either as observed or specified by the supplier. The frequency of testing should be so chosen as to meet the reliability target.

2. Functional test also may be performed at the time of calibration.

ANNEXURE-I (Cont'd)

TABLE-II : BOILING WATER REACTOR PLANTS

Sl. No.	Item	Monitoring	Instrument Check	Functional Test	Calibration
1	2	3	4	5	6
1.	**PROTECTION SYSTEM**				
1.1	**Trip Parameters**				
1.1.1	Neutronic Parameters				
	. Power range monitors high	+	+	+	+
	. Intermediate range monitors high	+	+	+	+
	. Source range monitors high (when these are to be used)	+	+	+	+
1.1.2	**Process Parameters**				
	. High rectorpressure	+	+	+	+
	. High drywell pressure	+	+	+	+
	. Low reactor water level	+	+	+	+
	. Core spray low water level	+	+	+	+
	. High water level in scram dump tank	+	+	+	-
	. High flow in main steam line	+	+	+	+
	. Low pressure in main steam line	+	+	+	+
	. High radiation on main steam line	+	+	+	+
	. Condenser low vacuum	+	+	+	+
		+	+	+	+
1.1.3	**Discrete Parameters**				
	. Manual scram	-	+	+	+
	. Main steam line isolation valve closure	+	+	+	+
	. Recirculation line valve closure	+	-	+	-
1.2	**Control Rods (scram function)**				
	. Insertion time for (scram function)	-	-	+	-
	. Accumulator pressure	+	-	-	-
1.3	**Liquid Poison Injection System**				
	. Pump operability	-	-	+	-
	. Boron concentration	+	-	-	-
	. Poison tank level and temperature	+	+	-	+
	. Firing circuit	+	-	-	-
	. Test squibs firing	-	-	+	-
	. System operation	-	-	+	-

2.	**CONTROL RODS (REACTIVITY CONTROL**				
	. Piosition Indication	+	-	-	-
	. Travel time	-	-	+	+
	. Freedom of movement	-	-	+	-
	. Drive coupling	-	-	+	-
	. SRM, IRM, PRM rod block logic	-	-	+	-
	. Rod worth minimiser	-	-	+	-
3.	**REACTOR PHYSICS PARAMETERS**				
	. Linear heat rate, peaking factors, minimum critical heat flux, axial and radial flux distr-ibution, shutdown margin, rea-ctivity anomalies, reactivity co-efficients.	+	-	-	-
4.	**REACTOR COOLANT SYSTEM**				
	. Recirculation system	+	-	-	-
	. System integrity	+	-	+	-
	. Safety/relief valves	-	-	-	+
	. Clean rad waste/dirty rad waste flow integrators	+	-	-	+
	. Chemistry and radiochemistry and isotopic analysis.	+	-	-	-
5.	**EMERGENCY CONDENSOR**				
	. System operability	-	-	+	-
	. Level, temperature and conden-ser vent radiation monitors	+	-	-	+
	. Chemistry	+	-	-	-
6.	**EMERGENCY CORE COOLING SYSTEM**				
	Automatic Depressurisation				
6.1	. Logic	-	-	+	-
	. Sensors	+	-	-	+
	. Operability	-	-	+	-
	Core and Containment Spray				
6.2	. Logic	-	-	+	-
	. Sensors	+	-	-	+
	. Operability	-	-	+	-

	REACTOR AUXILIARY SYSTEM				
7.					
	Control Rod Drive Hydraulic System				
7.1	. System Operability	-	-	+	-
	Reactor Building Cooling Water System				
7.2	. System operability	-	-	+	-
	. Logic	-	-	+	-
	. Sensors	+	-	-	+
	. Chemistry	+	-	-	-
	. Heat balance	+	-	-	-
	Salt Service Water System				
	. System operability	-	-	+	-
7.3	. Logic	-	-	+	-
	. Sensors	+	-	-	+
	. Heat balance	+	-	-	-
	CONTAINMENT				
8.	**Primary Containment**				
	. Containment integrity test	-	-	+	-
8.1	including testing of cable and pipe penetrations and air locks				
	. Containment isolation logic test	-	-	+	-
	. Sensors	+	+	-	-
8.2	**Pressure suppression, and depressurisation systems**				
	. System operability	-	-	+	-
	. Logic	-	-	+	-
	. Sensors	+	-	-	+
	. Suppression chemistry	+	-	-	-
8.3	**Secondary Containment**				
	. Integrity test including vacuum development test	-	-	+	-
8.4	**Containment Spray Operability**				
8.5	**Reactor Building Isolation And Emergency Clean-up System**				
	. System operability	-	-	+	-
	. Logic	-	-	+	-
	. Sensors	+	+	-	+

8.6	**Ventilation System**				
	. Particulate/Iodine filter efficiency and condition	+	-	+	-
9.	**ELECTRICAL SYSTEMS**				
9.1	**Standby Diesel Generators**				
	. Standby/diesel generators operability test	-	-	+	-
	. Diesel fuel inventory	+	-	-	-
	. Diesel fuel quality check	+	-	-	-
9.2	**Station Batteries**				
	. Condition of batteries and DC distribution	+	-	-	-
	. Load/capacity	-	-	+	-
9.3	**Switch Gear**				
	. Emergency power supply switch gear operability	-	-		
9.4	**Protective Relays**				
	. Protective relays of emergency power supply	-	-	-	+
9.5	**Automatic and Emergency Tranfer System**				
	. Auto transfer and emergency tranfer logic	-	-	+	-
	. Automatic/emergency transfer relays	-	-	-	+
9.6	**Emergency Lights**				
	. Emergency lights checks	+	-	+	-
9.7	**Uninterruptable Power Supply (UPS)**				
	. UPS logic/performance	-	-	+	-
9.8	**Off-site power**	+	-	-	-
10	**REFUELLING**				
10.1	**Refuelling Machines**				
	. Logic	-	-	+	-
	. Operability	+	-	+	-
10.2	**Reactor Cavity and Spent Fuel Storage Pool**				
	. Level and temperature	+	-	-	+
	. Water chemistry	+	-	-	-

11.	**RADIOACTIVE EFFLUENTS**				
11.1	**Gaseous effluents**				
	. Stack gas monitors for particulate/iodine/gamme	+	+	+	+
	. Meteorological instruments	+	+	-	-
11.2	**Liquid effluents**				
	. Gross beta and gamma activity in station discharge	+	-	-	-
	. Waste storage tank level	+	-	-	+
	. Waste storage tank water gross beta, gamma activity	+	-	-	-
	. Gross beta, gamma activity in process water	+	-	-	+
11.3	**Solid Waste**				
	. Burial facility bore holes sampling for gross beta and gamma	+	-	-	-
12.	**MISCELLANEOUS**				
	. Emergency preparedness	+	-	+	-
	. Communication equipment	-	-	+	-
	. Test/calibration equipment	-	-	-	+
	. Plant security system	+	-	+	-
	. Environmental radiation monitors	+	-	-	-
	. Fire protection system	+	-	+	-
	. Compressed air system	+	-	+	-

Notes

1. In the above tables, the frequency of surveillance checks need to be specified when + is marked. The frequency of surveillance checks will depend on the system requirement and failure rates Either as observed or specified by the supplied. The frequency of testing should be so chosen As to meet the reliability target.

2. Functional test also may be performed at the time of calibration.

BIBLIOGRAPHY

1. AERB Safety Code, Code of Practice on Safety in Nuclear Power Plant Operation, AERB/SC/O, 1989

2. IAEA Safety Guide, Staffing of Nuclear Power Plants and Recruitment, Training and Authorisation of Operating Personnel, 50-SG-O1, 1978

3. IAEA Safety Guide, In-Service Inspection of Nuclear Power Plants, 50-SG-O2, 1980

4. IAEA Safety Guide, Operational Limites and Conditions for Nuclear Power Plants, 50-SG-O3, 1980

5. IAEA Safety Guide, Commissioning Procedures for Nuclear Power Plants, 50-SG-O4, 1980.

6. IAEA Safety Guide, Radiation Protection During Operation of Nuclear Power Plants, 50-SG-O5, 1983

7. IAEA Safety Guide, Preparedness of Operating Organisation for Emergencies in Nuclear Power Plants, 50-SG-06, 1982

8. IAEA Safety Guide, Maintenance of Nuclear Power Plants, 50-SG-O7, 1982

9. IAEA Safety Guide, Surveillance of Items Important fo Safety in Nuclear Power Plants, 50-SG-O8, 1982

10. IAEA SAFety Guide, Management of Nuclear Power Plants for Safe Operation, 50-SG-O9, 1984

11. IAEA Safety Guide, Core Management and Fuel Handling for Nuclear Power Plants, 50-SG-O10, 1985

12. IAEA Safety Guide, Operational Management of Radioactive Effluents and Wastes Arising in Nuclear Power Plants, 50-SG-O11, 1986

13. AERB Safety Manual Governing the Authorisation Procedure for Nuclear Power Plant/ Project, No.M/NSD-3, 1989

LIST OF PARTICIPANTS

Advisory Committee on Codes, Guides and Associated Manuals for Safety in Operation of Nuclear Power Plant constituted by AERB (ACCGASO)

Dates of Meeting	:	November, 16 & 17, 1994 March 22, 1996 July 12 & 13, 1996

Members and alternates participating in the meeting:

Shri G.V. Nadkarny (Chairman)	:	Former Director E&PA, NPC
Shri V.S. Srinivasan	:	NPC
Shri T.S.V.Ramanan	:	NPC
Shri Y.K. Joshi	:	RAPS/NPC
Shri Ravindranath	:	TAPS/NPC
Shri V.V. Sanathkumar	:	MAPS/NPC
Shri R.S. Singh	:	AERB
Shri Ram Sarup	:	AERB
Shri S.T. Swamy (Co-opted)	:	AERB
Shri S.K. Warrier(Member-Secretary)	:	AERB

ADVISORY COMMITTEE ON NUCLEAR SAFETY (ACNS)

Dates of the Meeting	:	May 30, 1998. June 27,1998.

Members and alternates participating in the meeting:

Shri S.K.Mehta (Chairman)	:	Formerly DirectorReactor Group, BARC.
Shri S.M.C.Pillai	:	Nagarjuna Power Corp.
Pro. M.S.Kalra	:	IIT, Kanpur
Prof U.N.Gaitonde	:	IIT, Bombay
Shri S.K.Bhave	:	BHEL
Shri Ch.Surendar	:	NPC
Dr. U.C.Mishra	:	BARC
Shri S.K.Sharma	:	BARC
Dr. V.Venkat Raj	:	BARC
Shri V.K.Chaturvedi	:	BARC
Shri M.S.Kumra	:	BARC
Shri S.P.Singh	:	Formerly Head, NSD, AERB.
Shri G.K.De (Member- Secretary)	:	AERB
Shri G.V.Nadkarny (Invitee)	:	Formerly Director E&PA, NPC
Shri P.G.Kulkarny (Invitee)	:	BARC
Shri S.Sankar (Invitee)	:	BARC
Shri S.K.Warrier (Invitee)	:	AERB
Smt. Usha A.Menon (Permanent-Invitee)	:	AERB

PROVISIONAL LIST OF GUIDES ON OPERATION OF NUCLEAR POWER PLANTS

Safety Series Nos.	**Provisional Title**
AERB/SG/O-1	Staffing, Recruitment, Training and Authorisation of Operating Personnel of NPPs
AERB/SG/O-2	In-Service Inspection of NPPs
AERB/SG/O-3	Operational Limits and Conditions for NPPs
AERB/SG/O-4	Commissiioning Procedures for NPPs
AERB/SG/O-5	Radiation Protection during Operation of NPPs
AERB/SG/O-6	Preparedness of the Operating Organisation for Handling Emergencies at NPPs
AERB/SG/O-7	Maintenance of NPPs
AERB/SG/O-8	Surveillance of Items Important to Safety in NPPs
AERB/SG/O-9	Management of NPPs for Safe Operation
AERB/SG/O-10A	Core Management and Fuel Handling for Heavy Water Reactor Based NPPs
AERB/SG/O-10B	Core Management and Fuel Handling for Boiling Water Reactor Based NPPs
AERB/SG/O-11	Management of Radioactive Waste Arising during Operation of NPPs
AERB/SG/O-12	Renewal of Authorisation for Operation of NPPs
AERB/SG/O-13	Operational Experience Feedback

AERB SAFETY GUIDE

Published by : Publication Cell
Atomic Enregy Regulatory Board
Niyamak Bhavan, Anushaktinagar
Mumbai – 400 094.
