

# Guidelines for the Review of Research Reactor Safety: Revised Edition

Reference Document for IAEA Integrated  
Safety Assessment of Research Reactors  
(INSARR)

Vienna, December 2013

**Services Series 25**

GUIDELINES FOR THE REVIEW OF  
RESEARCH REACTOR SAFETY:  
REVISED EDITION

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# GUIDELINES FOR THE REVIEW OF RESEARCH REACTOR SAFETY: REVISED EDITION

REFERENCE DOCUMENT FOR IAEA INTEGRATED SAFETY  
ASSESSMENT OF RESEARCH REACTORS (INSARR)

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## **FOREWORD**

The Integrated Safety Assessment of Research Reactors (INSARR) is an IAEA safety review service available to Member States with the objective of supporting them in ensuring and enhancing the safety of their research reactors. This service consists of performing a comprehensive peer review and an assessment of the safety of the respective research reactor. The reviews are based on IAEA safety standards and on the provisions of the Code of Conduct on the Safety of Research Reactors.

The INSARR can benefit both the operating organizations and the regulatory bodies of the requesting Member States, and can include new research reactors under design or operating research reactors, including those which are under a Project and Supply Agreement with the IAEA.

The first IAEA safety evaluation of a research reactor operated by a Member State was completed in October 1959 and involved the Swiss 20 MW DIORIT research reactor. Since then, and in accordance with its programme on research reactor safety, the IAEA has conducted safety review missions in its Member States to enhance the safety of their research reactor facilities through the application of the Code of Conduct on the Safety of Research Reactors and the relevant IAEA safety standards. About 320 missions in 51 Member States were undertaken between 1972 and 2012.

The INSARR missions and other limited scope safety review missions are conducted following the guidelines presented in this publication, which is a revision of Guidelines for the Review of Research Reactor Safety (IAEA Services Series No. 1), published in December 1997. This publication details those IAEA safety standards and guidance publications relevant to the safety of research reactors that have been revised or published since 1997.

The purpose of this publication is to give guidance on the preparation, implementation, reporting and follow-up of safety review missions. It is also intended to be of assistance to operators and regulators in conducting safety assessments of research reactors, helping them to address individual safety issues such as the ageing of, or major modifications to, research reactors, and other types of safety review, such as internal reviews and audits by the reactor management, peer reviews and regulatory inspections. This publication supersedes the 1997 version of the guidelines for the review of research reactor safety.

The IAEA officers responsible for this publication were A.M. Shokr and H. Abou Yehia of the Division of Nuclear Installation Safety.

#### EDITORIAL NOTE

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## 1. INTRODUCTION

### 1.1. GENERAL BACKGROUND

The IAEA performed its first research reactor evaluation on DIORIT (Switzerland) in October 1959 [1]. Six more evaluations were performed between 1960 and 1971. In 1972, the IAEA began to regularly review the safety of research reactors by means of safety review missions according to the IAEA Statute at that time [2]. The IAEA generally conducted these safety review missions upon request by Member States operating research reactors. Additionally, the IAEA could propose safety review missions to facilities subject to a Project and Supply Agreement. According to the IAEA Statute for missions to Member States with Project and Supply Agreements there is a requirement for the project to comply with relevant IAEA Safety Standards.

From 1972 to about 1976, safety reviews to research reactors under Project and Supply Agreements were referred to as “safety inspections.” During this period of time safety reviewers considered themselves IAEA safety inspectors and their main interest was to examine the legal framework and organization of the radiation protection programme and to examine the legal and operational radiological practices. Nuclear safety aspects such as safety analysis and operational procedures were gradually introduced into the scope of missions. From 1976 until 1987, the missions were not considered safety inspections but were referred to as “safety advisory missions” in various IAEA official documents. Mission objectives were mainly related to operational safety aspects and the scope included mainly nuclear safety related areas such as the safety analysis report, operational limits and conditions, operating and maintenance procedures, reactor modifications and regulatory supervision. The reviews were conducted following a questionnaire based on the IAEA safety standards series at that time.

In 1987 the IAEA announced the creation of a formal approach to providing a safety review service<sup>1</sup>. This approach was named Programme for Integrated Safety Assessment of Research Reactors (INSARR). INSARR reviews are conducted at the request of the government of the host country.

Since 1988, the objectives and scope of the safety reviews, formalized by the INSARR designation, have been expanded to cover design, commissioning and siting and also to include emphasis on the exchange of information between reviewers and the host organizations. The missions are conducted following defined procedures discussed in Section 2. The format of the reports also became standardized, being changed only for differences in mission objectives and scope.

In 1997 the review procedures used for INSARR missions were formalized and documented in [3], the preceding version of this publication. As the IAEA continued to issue safety standards within its safety series, establishing a consistent and comprehensive set of safety requirements and safety guides for research reactors, enhancements to the formal INSARR

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<sup>1</sup> In 1982, the IAEA had initiated a similar programme to the INSARR, but to enhance the operational safety of nuclear power plants. This was the IAEA Operational Safety Review Team (OSART) mission programme.

review procedure were made from about the mid-2000's and were reflected in the format and content of the INSARR reports. Enhancements were mainly in regard to mission preparation, conduct and follow-up. The extant review procedure is presented in this publication. The IAEA research reactor safety standards collectively form the basis upon which INSARR missions are performed, and the key areas upon which the review guidelines are based are noted in Section 3.

Since 2000, a three stage approach was applied for the INSARR, which comprises the following steps:

- A pre-INSARR mission to present the INSARR methodology, to discuss and define with the host organization the topics to be reviewed and the material to be sent to the IAEA before the main mission, and to obtain preliminary information about the facility;
- The main INSARR mission to conduct the review and provide a report on the findings;
- A follow-up INSARR mission to determine the status of actions taken by the host organization in response to the main mission findings, to clarify any misunderstandings in response to mission findings and to obtain feedback on the effectiveness of the INSARR.

The prime objective of INSARR missions has been to conduct a comprehensive safety review of research reactor facilities and to verify compliance with the IAEA's Safety Standards. However, an important benefit from INSARR missions has also been the mutual transfer of knowledge and experience between mission experts and host organization personnel. Certain missions have identified areas where the host organization had developed a particularly good approach to certain safety topics, to the extent that the IAEA review team recognized these as good practices and have recommended them for application at other facilities. Missions are not intended to be regulatory inspections, but are based on a peer review approach.

This publication presents the current INSARR organizational process and review guidelines, updating the previous version [3] to follow the structure of NS-R-4 [4] and to take into account the provisions of the Code of Conduct on the Safety of Research Reactors [5]. The main review areas remain basically unchanged and the references are revised to include the IAEA research reactor safety standards published since 1997.

## 1.2. PURPOSE AND SCOPE

The purpose of this publication is to provide guidance on the preparation, implementation, reporting and follow-up of safety reviews of research reactors. The guidance on the preparation of the review is intended for both the host organization and the review team. The guidance on the conduct of the mission is mainly directed to the review team. The guidance in this report is to be used for safety reviews of research reactors conducted by the IAEA. The guidelines could also be used for periodic safety reviews conducted by the operating organization of the reactor facility or by the regulatory body.

The present publication is applicable to the following types of safety reviews:

- (a) INSARR and other safety review missions requested by a host organization of a Member State (government, regulatory body or operating organization);
- (b) INSARR and other safety review missions to research reactors under a Project and Supply Agreement with the IAEA;

- (c) Peer reviews by operators in neighbouring states or by other research reactor operators, or by other parts of the operating organization;
- (d) Self-review/audits by the research reactor management;
- (e) Self-assessment by the host organization.

The guidelines could also be applied to other types of safety reviews, such as:

- Initial safety assessments of a research reactor project at the design or site evaluation stages;
- Reassessments of a research reactor project in order to monitor adherence to good safety practices;
- Long term safety reviews when ageing of the research reactor facility may be of concern;
- Regulatory inspections and audits.

In accordance with the IAEA publications on the safety of research reactors, [4-10], [13] and [17], the review guidelines in this publication are applicable to most types of research reactors. In the case of homogeneous reactors and sub-critical assemblies, their use may need to be adapted as appropriate for the given facility. For some specific aspects of research reactors with power above several tens of megawatts or non water cooled research reactors, some topics may require additional review than that suggested in this publication. In particular, this publication does not cover the review of fast neutron research reactors or prototype power reactors. In such cases the OSART review guidelines [6] could be of assistance.

Research reactors are used for a wide variety of purposes and applications such as research, training, radioisotope production, neutron beam physics, neutron radiography and materials testing. These purposes and applications call for many different design features, power levels and operational regimes. A graded approach for safety reviews is thus applicable. Guidance on application of the graded approach to the safety requirements for research reactors is presented in [7].

### 1.3. STRUCTURE

The present publication consists of three sections and two Appendices. Section 2 presents guidance on the preparation, conduct and follow-up for an INSARR. Section 3 presents detailed guidelines on all review areas that may be covered in a comprehensive safety review. The guidance is provided in a structured way so that those developing a plan and programme for a specific review can cover selected areas to the depth that is required by the scope and objectives of the review. Appendix I provides the format of the main INSARR mission report, which can also be used for other safety review mission reports, and guidance on the information that the report should include for each review area. Appendix II is a checklist for conducting a facility walk-down.

## **2. PREPARATION, CONDUCT, REPORTING AND FOLLOW UP OF AN INSARR**

### **2.1. PREPARATION OF AN INSARR**

#### **2.1.1. General**

Any research reactor safety review, whatever the defined scope and resources are, must be adequately prepared. The success of a specific assessment and the efficiency with which personnel, time and financial resources are used depend on the attention which has been given to the preparation. Section 2 discusses full-scope INSARR missions. These missions represent the most comprehensive type of research reactor safety reviews/assessments performed. Other types of safety review missions include fact-finding missions, Technical Cooperation (TC) expert missions, and safety advisory/expert missions. These latter mission types utilize the elements of the INSARR procedures, except that they are generally more focused in scope and do not consist of the three-stage INSARR programme discussed below. Nevertheless, the INSARR methodology is generally applicable and should be used as a reference for these other types of safety related missions. The format of the mission reports is similar to that of the INSARR but is usually adjusted as required by the scope and objectives of the missions.

A proposal for an INSARR may be initiated by the regulatory body or by the operating organization (one Member State regulatory body has a licensing requirement for an IAEA INSARR, to be performed about every 5 years). For research reactors under a Project and Supply Agreement, the IAEA may propose an INSARR mission to provide advice and assistance on applying the IAEA Safety Standards. The review team leader will be an IAEA staff member with broad experience in all aspects of research reactor facilities and has participated in other safety reviews. The preparation of the review is organized by the review team leader, with active participation of the counterpart organization.

Before embarking on the review, funding arrangements should have been discussed and agreed upon between the requesting Member State and the IAEA. The funding arrangements can vary from the IAEA funding the host organization for most of the review, to the Member State providing the entire funding. In the latter case this should not affect the independence of the review. For some INSARR reviews, financial obligations may be shared by the IAEA (bearing travel expenses and daily allowances for the review team members). The Member State counterpart will normally be asked to provide local transportation for the review team members and in some cases may contribute towards local accommodation costs.

Since 2000, as noted in 1.1, the INSARR programme has comprised three stages:

- (i) Pre-INSARR mission;
- (ii) INSARR main mission;
- (iii) Follow-up mission.

### **2.2. PRE-INSARR MISSION**

The implementation of an INSARR mission to review the safety of a particular research reactor starts with a pre-INSARR mission. This mission is typically of a two to three days duration and conducted by one or two IAEA staff members. During the pre-INSARR mission

all the details of the main mission are decided upon to ensure that the mission is carried out effectively, and to meet a common understanding on the conduct of the INSARR mission.

The IAEA team members discuss the main features of the INSARR, the facility's preparation for the review, including in particular the availability of the necessary documentation and the review methods to be used. The pre-INSARR should also include a brief walk-down of the facility with the IAEA review team members.

During the pre-INSARR mission the followings items should be agreed upon between the IAEA review team members and the counterparts:

- (a) Definition of objectives, scope (main review areas; see Section 3), strategy, review methods and schedule;
- (b) Type, format and contents of the advanced information package;
- (c) Selection of the size and membership of the review team;
- (d) Logistical matters.

Subsequent to the pre-INSARR mission, but before the main mission, the review team leader and the counterpart will coordinate to prepare the:

- (e) Finalization of the selection of review team members;
- (f) Advance information/documentation package for the mission review team members, including the counterpart contact(s) for the review areas;
- (g) Agenda and work plan;
- (h) Finalization of logistical matters;
- (i) Briefing of the review team.

Further information on each of the above items (a) to (i) are presented below.

### **2.2.1. Definition of objectives, scope, strategy and review methods**

The objectives of an INSARR mission may be related to aspects of the design, site selection and evaluation, commissioning, operation, decommissioning or refurbishment of a research reactor. For any review the objectives must be clearly defined and agreed to by all parties concerned. In some cases the Member State counterpart may set the general scope as well as the detailed mission objectives. Alternatively a Member State may request the IAEA for an INSARR mission with a general objective, in relation to one or more of the aspects mentioned above, but request that the detailed review areas be developed by the review team leader, in agreement with the Member State counterpart. There is a wide variety of review objectives that may be chosen, but the overall objective of any review should be to enhance the safety of the research reactor under review. The guidance provided in this publication has been developed to achieve this objective. An INSARR mission itself is basically a peer review process and is not a regulatory inspection or audit. The review is based on the IAEA safety standards, and takes into account international good practice.

To ensure that the objectives of a specific mission will be met, the precise scope of the review areas should also be established. The mission scope defines the level of detail to which the objectives will be pursued. It is worthwhile to note that the scope of a specific mission will be limited by the available time, personnel and financial resources.

Various strategies should be considered to establish the most efficient and effective way of achieving the agreed objectives. In some cases, for example, where a comprehensive review of the safety of a facility is required, a multidisciplinary review team examining the facility intensely over a relatively short period may be most efficient. If the aim of the mission is to focus on a chosen topic (e.g. an upgrade project for a primary coolant system) advice and direct interaction on a one-to-one basis over a prolonged period involving more than one mission may be appropriate.

The review methods should be agreed upon. Usually this will involve a facility walk-down to cover all aspects of the mission scope, assessment of relevant documentation and discussions with facility staff. The review team should be able to observe or make their own radiation and contamination checks, with their own instrumentation, if the review team requests this. Special types of inspections (e.g., inspection of a reactor vessel wall thickness or detailed corrosion inspection of equipment) or testing of equipment performance that may require special instrumentation or preparation would be pre-defined in the mission scope.

### **2.2.2. Counterpart contact(s) for the review areas**

The host organization should provide to the review team leader a list of personnel who will act as technical counterparts during the mission. Normally there will be one main counterpart who will coordinate contacts with other counterparts, depending upon the mission scope.

### **2.2.3. Selection of the size and membership of the review team**

Proposals for the selection of the number of main INSARR mission review team members are made during the pre-INSARR mission. The size of the review team will also depend on the type of the facility (power, design and operational complexity, unique or standard reactor type) and on the experience of the reviewers and on the mission scope. Typically the review team consists of a team leader who is an IAEA staff member, a deputy team leader who could also be an IAEA staff member and 3 to 7 external experts. An administrative assistant from the IAEA may also be a member, depending upon the scope and needs of the mission. Proposals/suggestions for the individual review team members may also be discussed at this time. The review team leader, in consultation with the Member State counterpart, determines the composition and size of the review team. The prime requirements of members of the review team are:

- (a) Independence;
- (b) Expertise and experience in the topics to be reviewed;
- (c) Familiarity with the standards, guides and other IAEA publications that form the basis of the review;
- (d) Familiarity with the type of facility to be reviewed;
- (e) Language capability.

The selection process should pay special attention to avoid any potential conflict with the Member States' interests by the nationality of the experts as well as potential commercial conflicts from staff of a competitive facility, or private company. Observers may be invited with the mutual agreement of both parties.

The review team members should be recruited taking into account their experience with similar facilities and with the topics that they will examine. Therefore, the assignment of specific tasks within the review team should be made in accordance with the special

competencies of the individual members. The ability of the review team members to prepare their contributions to the final mission report should also be taken into account.

Other factors that may have to be taken into account in choosing the review team members will depend upon the type of review, the scope and its objectives. If an INSARR mission is to undertake a comprehensive safety evaluation of a particular facility, consideration must be given to ensure that the review team provides a balanced international view of best practices. If the main aim of the review is to enhance safety awareness and influence attitudes within the host organization, greater consideration has to be given to the ability of review team members to communicate effectively with a wide range of individuals within the host organization. The confidence of the host organization in the abilities, expertise and views of the members of the review team will determine, to a large extent, the effectiveness of implementing changes necessary to enhance safety. Other considerations include the ability of review team members to support each other, such that a synergistic approach to the review is developed. As review team members will learn from the experience obtained during a safety review, new review teams should include at least one member who has participated in a previous mission.

#### **2.2.4. Logistical matters**

The host organization for the INSARR mission is required to confirm the date and duration of the mission and is usually required to provide office facilities and other administrative resources as required (e.g., accommodation, transportation, office room(s) and office facilities, communication requirements and secretarial assistance). These requirements need to be decided and agreed upon, so that they are in place when the mission review team arrives to undertake the assessment.

Depending upon the duration and complexity of the mission, a secretary/administrator may accompany the review team to facilitate preparation of reports, letters, and other documents. The organization hosting the INSARR mission will also have to make resources available to handle document translation and interpretation, if required, and also to resolve difficulties that may arise during the mission. The involvement of media is not normally part of the mission and review team members should not be involved with any public statements regarding the mission. Following the mission there may be a press release issued, upon agreement with the Member State counterpart and the IAEA Division of Public Information. The Member State may also issue its own press release following the mission.

#### **2.2.5. Finalization of review team members**

The final selection and confirmation of review team membership is made by the review team leader, in consultation with the Member State counterpart. The main mission will usually be three to nine months after the pre-INSARR mission, so final selection is made during this period, prior to the main INSARR mission. Prospective review team members should be consulted by the review team leader before they are formally proposed to the Member State counterpart. Though the counterpart organization should not have any overriding influence on the choice of the review team members, there may, nevertheless, be circumstances where its viewpoint has to be given serious consideration, for example, when competing commercial interests are involved. Review team members with the nationality of the counterpart Member State are excluded.



### **2.2.6. Advance information and documentation package for the mission review team members**

The advance information and documentation package (in English) required for the main mission implementation is usually prepared by the host organization and sent, preferably in electronic format, to the review team leader. Its content should be based on the objectives and scope of the mission.

The information and documentation package should provide as much advance information as possible for the mission review team to facilitate adequate technical preparation for the mission review team members. The review team leader then co-ordinates the distribution of the advance information package prior to the main mission to the review team members. The review team leader may also send out the agenda and work plan, at the same time, to the review team members if these are finalized. Since the team's preliminary review of the documentation provided can influence the working plan for the review, the information and documentation package should be obtained and distributed if possible about a month before the main mission to permit timely finalization of the agenda and working plan.

Regardless of the mission specific objectives, the advance information package from the host organization should normally comprise, as a minimum:

- General description of the main technical, nuclear, thermal-hydraulic and operational characteristics of the reactor;
- Relevant safety analysis sections of the Safety Analysis Report (SAR);
- Facility organizational chart, including functional responsibilities;
- Mission-specific documentation.

During the main mission the advance information and documentation package may be supplemented with self-assessment results and other detailed information. Maintenance, test and operational records, operational procedures, operational flow sheets, drawings of buildings, systems and equipment, and electrical and instrumentation schematics would be typical of this type of detailed information.

### **2.2.7. Agenda and work plan**

The agenda and work plan should develop the tasks required and the allocation of tasks to individual review team members. The agenda and work plan should identify all tasks which are to be performed before, during and after the main mission. Each task should be described in a manner such that each review team member who is assigned various tasks will have a clear understanding of the specific objectives.

The review team leader develops an initial plan and then members of review team, as well as the host organization, should be consulted and involved in helping the review team leader finalize the agenda and work plan. Proper planning should ensure that all tasks will be executed according to procedures and a schedule which will allow sufficient time for contingencies as a result of examination of particular topics, discussions with counterparts, review team meetings, preparation of the exit meeting report and an exit meeting. The review team leader has the overall responsibility for fulfilling the objectives of the review and ensuring that the agenda and work plan are followed.

Regardless of the mission specific objectives, the agenda provided by the review team leader should normally comprise, as a minimum:

- Mission objectives, scope and expected output;
- Work plan for the mission;
- Timing of the assessment activities, including hold points, together with any interdependence;
- References to relevant IAEA standards, guides, and other documents, that will form the basis of the review;
- Relevant information from previous missions, to be used as a reference.

The final agenda and work plan is sent by the review team leader to the host organization for approval, in advance of the main mission, such that the counterpart can commit to make the necessary staff and documentation and other logistical needs available at the appropriate time. The review team leader then ensures that the review team members are provided with the final agenda and work plan, prior to the main mission.

#### **2.2.8. Finalization of logistical matters**

Just prior to the main mission the logistical matters, particularly for accommodation and provision of local transport for the team, will be confirmed by the review team leader with the host organization.

#### **2.2.9. Briefing of the review team**

The review team leader is responsible for ensuring that the review team is adequately prepared. The scope of the preparation will depend on the type of mission and the previous experience of review team members. In all cases, communications via e-mail in the weeks prior to the main mission should ensure that all members of the review team (including any clerical support staff) are fully aware of the objectives and the scope of the mission and of the specific roles and responsibilities of each review team member. Any residual financial and other administrative arrangements and procedures should also be finalized with review team members.

Prior to the main mission, the review team members should have a clear understanding of the mission outputs and their format. There are three general outputs of the main mission:

- Oral feedback provided by review team members via discussions with the counterparts throughout the mission;
- An executive summary report, presented at the exit meeting, providing immediate advice to the counterpart organization, summarizing the main conclusions and recommendations of the review;
- A final mission report (the main output) providing recommendations, suggestions and good practices for the host organization.

The review team leader is responsible for ensuring that review team members are informed of any changes to the final arrangements before they embark on travel.

## 2.3. CONDUCT OF THE MAIN INSARR MISSION

### 2.3.1. General

The main INSARR mission is conducted typically three to nine months after the pre-INSARR mission. The time gap between the missions however may depend upon the proposed scope of the review and activities in the facility. The duration of the main INSARR mission is typically one to two weeks, depending on the scope of the mission. The review team leader will have prepared the agenda and work plan, detailing the proposed work schedule, prior to the mission and forwarded this to the review team members and the host organization.

Before starting the INSARR mission, the review team members normally arrive at the facility site at least one day before, and receive a short briefing held by the review team leader. From the preliminary review of the advance information documentation package, the review team members will have some knowledge of the facility and the mission scope. Depending upon the extent and quality of the mission-specific documentation provided by the counterpart and the review preparation time, the review team will also have some specific information on the condition of the facility.

Activities of the mission start with an entry meeting. The entry meeting will allow the introduction of review team members, observers (if any) and counterparts and a review of the agenda details. The INSARR review team acquires the mission information by review of documentation, interviews with facility staff, facility walk-down and direct observation of activities and status of systems and equipment. Throughout the mission, detailed discussions with the counterparts of the host organization are carried out to ensure an understanding of identified issues in order to formulate recommendations for improvement.

The INSARR review team should meet each morning and evening to discuss the daily activities and to develop a consensus on emerging issues. The discussions of the review team help to ensure that all its members are well informed of the progress of the review and benefit from the observations of other experts. These meetings are also an opportunity for the review team leader to reinforce the review methodology. Those issues for which the review team has reached consensus are presented to the counterpart, preferably at the next morning meeting giving the facility representatives an opportunity to express their views regarding the issues.

As the assessment proceeds, each review team member drafts a summary on their review area and findings, which could be presented in the form of an issue page (see Appendix I) for inclusion in the mission report and for possible inclusion in the executive summary report at the exit meeting. At the end of the assessment phase a period of time is reserved for completing and presenting the executive summary report at the exit meeting and for rechecking any open topics, and for starting the preparation of the draft mission report. Final preparation and editing of the main report is made by the review team leader (with the assistance of the review team members) after the mission.

### 2.3.2. INSARR activities

The following activities are performed during the main INSARR mission:

- (a) Briefing of review team;
- (b) Entry meeting with counterpart and facility staff;

- (c) Examination and assessment of safety and technical documentation;
- (d) Facility walk-down;
- (e) Observation of operation activities;
- (f) Technical discussions with facility staff;
- (g) Exit meeting with the management of the host organization and the involved counterparts.

Information on these activities is provided below.

(a) Briefing of review team

As soon as possible upon arrival at the accommodation, the review team will be briefed by the review team leader. This briefing will reiterate the information forwarded after the pre-INSARR mission, with any recent updates and is mainly devoted to a detailed discussion of the programme, as documented in the agenda for the mission.

(b) Entry meeting with counterpart and the facility technical staff

Prior to starting the review, the counterpart, facility staff and others who may be involved in the review team's activities, must be adequately briefed. This briefing, which is normally the responsibility of the review team leader, should be in the form of an entry meeting and should address the following administrative items:

- (i) Introduction of the review team members to the counterpart;
- (ii) The needs of the review team, especially for technical documentation and staff communications;
- (iii) The method of communicating and reporting the results of the review;
- (iv) Discussion of the draft agenda.

At the entry meeting the draft agenda containing the detailed work schedule will be discussed and finalized. If the preparation process has been timely and no unforeseen circumstances have occurred at the facility there would be few changes expected to the agenda. Minor changes during the week may be expected; these are incorporated into the final agenda, which is documented in the main mission report. The agenda and detailed work schedule should be agreed upon during the entry meeting between the review team, counterpart and facility staff. The agenda should include the following items:

- Presentation by the counterpart on the general status of the facility, including planned activities and incidents;
- Daily meetings of the review team to discuss general progress, preliminary recommendations and suggestions and to revise the work schedule, if this becomes necessary;
- Special meetings to brief counterpart authorities on the (preliminary) review conclusions and recommendations;
- A final exit meeting where the review team presents to the management of the host organization and the involved counterparts a summary of the main conclusions and recommendations that are expected to be in the final report.

(c) Examination and assessment of safety and technical documentation

The examination and assessment of safety and operational documentation relevant to the objectives and scope of the mission is essential to the effectiveness of the safety review. Some review and assessment of the relevant documentation by the review team members should have preceded the main mission. This first review is usually limited to verifying or highlighting specific review items. However, in some missions further documentation is often made available during the entry meeting or shortly after. Therefore, further review time during the main mission may be necessary to examine relevant information that was not previously provided. The review team leader should have reviewed the IAEA historical mission files to check on the implementation status of previous mission recommendations and suggestions.

(d) Facility walk-down

Direct observation of the reactor facilities via a walk-down to observe reactor structures, systems and components (SSCs) is an important aspect of the review process. Observation of the reactor facilities is intended to allow the review team to obtain a general appreciation of the reactor conditions and the visual status of safety related SSCs, as well as on the general adherence to good housekeeping practices and industrial health and safety practices. Being part of the observations of the general condition of the SSCs, the walk-down should extend to support facilities and structures outside the reactor building such as emergency power supplies (usually diesels), back up cooling water supplies, and security access control features (which might influence emergency response capabilities). The walk-down outside the reactor building is also an opportunity to observe the potential for, and protection provided against, external hazards such as forest or bush fires, flooding, external traffic accidents, and large scale storage of hazardous materials.

Appendix II provides a checklist for a facility walk-down. The list is not intended to be used as a strict audit process, but rather as a guide to assist the reviewer during a walk-down.

(e) Observation of operational activities

Direct observation of operational and handling activities such as reactor startup, shutdown system operation, fuel handling, and tests such as responses of the reactor and equipment to anticipated operational occurrences such as simulated loss of power events may be included in the review work plan.

The observation of operational activities may include checking the use of procedures and instructions, quality control practices, and operator responses. A better understanding of the operation and procedures will then be obtained by observing direct interactions of the operating staff with equipment. The time dedicated to observations of operational activities is usually limited to one working day or less. Observing activities may help the reviewer to obtain an understanding of the staff's level of training, experience with the reactor systems and knowledge of the reactor procedures.

(f) Technical discussions with facility technical staff

Discussions with the management, operating staff and other reactor support staff provide important inputs for the safety review. The discussions should be used to:

- (1) Obtain additional information not covered by the available documentation;
- (2) Obtain answers to questions and clarify issues that may have arisen from the documentation review, observations of operational activities and the facility walk-down;
- (3) Identify needs for operating staff training.

Discussions with the facility staff are to be used to exchange information between reviewers and counterparts. In order to promote a frank and open attitude to the discussions, they should be conducted in a cooperative manner and not have the character of an interrogation.

## 2.4. REPORTING THE SAFETY REVIEW FINDINGS

The findings of the review team must be communicated to those who have responsibilities for and influence on the safety of the facility. The extent and type of the final report will depend upon the scope of the review and its objectives. However, all types of missions are expected to encompass the elements discussed below.

### 2.4.1. Technical notes

While conducting the safety review, team members should write down notes on the main safety issues found during the day. These notes form the basis for discussions during the daily meetings of the review team members, and they should be the basis for preparation of the mission report, which should contain details on the facts, recommendations, suggestions and good practices observed by the review team members (see Appendix I). The mission report should contain sufficient information, with references, to enable individuals who were not involved in the safety review to understand the issues covered during the mission.

### 2.4.2. Exit meeting

Before the review team leaves the reactor facility, an exit meeting is always conducted during which the review team leader orally conveys the main recommendations and areas of good practice to representatives of the operating organization and possibly to the regulatory body. The attendees at the exit meeting are determined by the counterpart organization. As a minimum, those with significant executive responsibilities for safety should attend, including the reactor manager.

A review team meeting is arranged for the preparation of the exit meeting, during which the results of the review team member's individual assessments are discussed and consolidated.

An executive summary report is provided to the operating organization during the exit meeting. The executive summary may be signed by the review team members. The executive summary should be considered as a preliminary compilation of the main conclusions and recommendations, and good practices that the review team has identified. Suggestions are not normally included.

The exit meeting should be conducted in a free and open manner, without indicating censure for significant events which may have been discussed, or for very negative findings.

During the exit meeting, commitment and follow-up actions necessary to enhance safety may be discussed but it is up to the host organization to decide on its response to the formal mission report, when it is issued. There may be a number of minor technical items that still remain to be clarified by facility staff. Items such as these are normally expected to be communicated to the review team leader as soon as possible after the mission, for inclusion in the final mission report.

### **2.4.3. Mission report**

Following the mission, the executive summary report is developed into a final mission report, in order to provide a permanent record of the review. The final INSARR mission report is normally prepared under the responsibility of the review team leader, who will co-ordinate the production of the report with the review team members. The counterpart is provided with a draft copy during final review to check that technical information related to the facility is correct and to provide counterpart views on the findings for the individual issues in case these were not completed during the mission discussions.

The format of the main INSARR mission report is provided in Appendix I. Section 1 of the report provides background information on the facility and the INSARR mission. Section 2 describes the method of conducting the review, the review criteria and the results of the facility walk-down. Section 3 discusses the conclusions and main recommendations of the mission and should show to what extent the objectives of the mission were achieved and, as such, provide a starting point for plans for future reviews. A general statement regarding the overall safety of the facility could also be presented. Appendix 1 of the report contains issue pages covering the issues in each of the review areas in the scope of the mission. The issue pages include observations, bases and references, possible safety consequences, counterpart views and measures on the findings, recommendations, suggestions and good practices. The final report also contains annexes that include the mission agenda and a list of the persons met during the mission.

Recommendations, suggestions and good practices are defined as follows:

### **Recommendations**

Recommendations are review team advice for improving safety based on IAEA Safety Standards and recognized good practices. The recommendations focus on WHAT is recommended to be done. The ‘Suggestions’ section described below may mention approaches on HOW to implement the recommendations. The recommendations are designated with the letter “R” in the mission report.

### **Suggestions**

Suggestions are review team proposals in conjunction with a recommendation, or they may stand on their own. They may indirectly contribute to improvements in safety, but they are primarily intended to enhance performance. The suggestions are designated with the letter “S” in the mission report.

## **Good Practices**

Good practices are outstanding and proven performance, programmes, activities or uses of equipment that contribute directly or indirectly to operational safety and sustained good performance. A good practice is markedly superior to that observed elsewhere, not just the fulfilment of current requirements or expectations. It should be superior enough and have broad application to be brought to the attention of other research reactor operators and be worthy of their consideration in the general drive for excellence. The good practices are designated with the letters “GP” in the mission report.

The INSARR mission report is submitted by the IAEA through the official channels to the Member State concerned. The report will be designated as a restricted distribution IAEA document, not to be released to the public. However, the facility may wish to use the document in an unrestricted manner. Some INSARR mission reports have been posted by the counterpart organization on the web, allowing public access. The facility may, in certain cases, also request the IAEA to change the restricted designation, after the restricted version has been issued.

## **2.5. FOLLOW-UP INSARR MISSION**

### **2.5.1. General**

The Follow-up INSARR mission is typically conducted one to two years after the main mission, depending on the number of recommendations and the urgency of their implementation. The duration of the follow-up mission is usually three to five days, depending on the scope of the mission. The follow-up mission should include at least one of the external experts and one of the IAEA staff who participated in the main INSARR mission. The responsibility for responding to the formal recommendations and suggestions of the review team rests with the Member State. The purpose of the follow-up mission is to determine the status of implementation of all recommendations and suggestions that resulted from the main INSARR mission and to assess whether adequate actions have been taken by the facility to address the identified weak points and enhance the safety of the facility.

The follow-up mission should be organized following the same procedures as for the main review, but the scope of the mission should be limited to examination of the areas where weak points were identified.

### **2.5.2. Host organization responsibility**

The host organization has the primary responsibility for considering and implementing the recommendations of the mission. In many circumstances, a formal response to the recommendations and suggestions from the main mission review report is prepared.

When the list of recommendations is relatively small, the operating organization should keep an updated list of actions to facilitate follow-up. If the recommendation list is extensive, then a more detailed action plan should be developed to facilitate follow-up. Reports stating the progress status of the implementation of recommendations should be prepared for the IAEA, prior to the follow-up mission.



### **2.5.3. Review team responsibility**

The review team is responsible for determining the status of implementation of the recommendations and suggestions from the main INSARR mission. The review team should examine only the areas related to the recommendations and suggestions and make an independent assessment of the status of the actions taken to implement them. The review team has no formal responsibility to ensure that the recommendations and suggestions are implemented because implementation is the responsibility of the Member State.

The review team leader should also take the responsibility of ensuring that non-restricted information, such as good practices and generic feedback from the review mission, is disseminated to other Member States with similar facilities, where such information may lead to an enhancement of safety.

### **3. REVIEW AREAS AND GUIDELINES**

#### **3.1. REVIEW AREAS**

This chapter provides a comprehensive list of review areas and associated detailed guidelines for an INSARR safety review. Not all these topics will be covered in the typical INSARR mission. The coverage will depend on the scope and objectives of the review, as determined by the counterpart in conjunction with the IAEA review team leader.

The comprehensive list of review topics, from which any individual INSARR scope can be formulated, is based upon the safety requirements presented in [4] and also upon the guidance on safety analysis and preparation of the safety analysis report [8]. The Code of Conduct on the Safety of Research Reactors, which contains provisions on best practices to achieve a high level of safety, is an important basis for the definition of review areas.

The IAEA safety standards relevant to research reactors collectively form the basis and the reference for the review areas of INSARR missions. Other IAEA publications, such as the safety reports, provide detailed guidance and examples useful for the review.

The review areas which are covered by a full INSARR mission include the following:

- (a) Design;
- (b) Safety analysis;
- (c) Safety Analysis Report;
- (d) Construction;
- (e) Commissioning;
- (f) Siting and protection against external events;
- (g) Operational limits and conditions;
- (h) Safety culture;
- (i) Regulatory supervision;
- (j) Safety committees;
- (k) Operating organization and reactor management;
- (l) Training and qualifications;
- (m) Conduct of operations;
- (n) Maintenance and periodic testing;
- (o) Modifications;
- (p) Utilization and experiments;
- (q) Management System;
- (r) Radiation protection;
- (s) Radioactive waste management;
- (t) Emergency planning;
- (u) Decommissioning.

The review of the facility physical protection aspects is covered by a separate and specific IAEA review service. However, the compatibility between safety and security provisions could be covered during the INSARR missions. The safety culture may also be dealt with in depth by a separate IAEA review service.

The individual guidelines for a review area should be selected to meet the objectives and scope of the mission for the area. To facilitate this purpose, the individual guidelines have

been grouped into a rather large number of individual areas so that they can be used in a modular manner to meet the needs of a specific safety review. Guidance on performing these activities also varies to cover different levels of depth. General guidance is normally presented at the beginning of each section and is followed by specific guidelines addressing particular issues related to a given area. The general guidance can be applied to reviews having as a main purpose the evaluation of the overall safety of the facility while specific guidelines involve greater depth of evaluation and supplement the general guidance.

Review team members should cover their assigned individual areas to the extent necessary to be able to make well informed judgments. It is not the intention that all the matters included in the guidelines for a given topic have to be addressed during a safety review. It is the responsibility of the reviewer to make an appropriate selection of subjects for questioning in accordance with the objectives, scope and duration of the review. This selection should be appropriate to identify weaknesses and strong points, to draw conclusions, to make recommendations on facility safety, and to fully address such issues in the mission report. The following sections present the guidelines for each of the above mentioned review areas.

## **3.2. DESIGN**

### **3.2.1. Objective**

The objective is to provide a basis for evaluation of the safety aspects of the design of research reactors. The reviewer should verify that the general principles and requirements established in [4] have been taken into account.

### **3.2.2. Guidelines**

- (1) Examine the overall design safety objective of the facility to verify the following:
  - (a) Radiation doses to individuals are in conformance with the principle of optimization of protection;
  - (b) Radiation doses to individuals do not exceed the limits prescribed by national authorities;
  - (c) Collective radiation dose commitment to individuals on and off the site is in conformance with the principle of optimization of protection;
  - (d) Environmental impact is minimal and within the limits prescribed by national authorities;
  - (e) Generated radioactive waste, including radioactive effluents, are in conformance with the principle of optimization of protection.
- (2) Verify that the reactor design is based on defense-in-depth concepts wherein multiple levels of protection are provided for ensuring that:
  - (a) All reasonably practical design provisions have been taken to prevent accidents;
  - (b) All reasonably practical design provisions have been taken to mitigate the consequences of accidents to individuals on and off site and to the environment.
- (3) Identify a variety of operational states and verify that the reactor is designed to operate safely within a predefined range of parameters for those states.

- (4) Verify that the response of the reactor and associated systems to a variety of events will allow safe operation or power reduction without the need to activate safety systems.
- (5) Verify that multiple means for ensuring each of the following basic safety functions are provided:
  - (a) The capability to shut the reactor down and maintain it in a safe shutdown condition for all operational states and accident conditions;
  - (b) Adequate core heat removal for normal and accident conditions;
  - (c) Confinement or containment of radioactive materials to prevent or minimize their release to the environment.
- (6) Determine that conservative design margins were adopted for all operating parameters.
- (7) Verify that equipment and procedures are in place to:
  - (a) Prohibit deviations from normal operation;
  - (b) Prevent anticipated operational occurrences that could lead to accident conditions;
  - (c) Control and mitigate accidents.
- (8) Ensure that on-site and, where appropriate, off-site emergency plans aimed at mitigating the effects of the release of radioactive effluents to the environment are in place.
- (9) Identify those safety-related systems that do not, but could utilize:
  - (a) Redundancy to improve reliability and to meet the single failure criterion;
  - (b) Diversity to enhance reliability and reduce the potential for common cause failures;
  - (c) Independence (or separation) to enhance reliability and minimize common cause failures;
  - (d) Testability to permit inspection, servicing, and tests at prescribed intervals over the lifetime of the facility.
- (10) Verify that no single failure of a component can result in loss of capability of a system to perform its safety function.
- (11) Verify that the reactor protection system is capable of automatically initiating required protective action for the full range of postulated initiating events to safely terminate the events.
- (12) Examine the design of the buildings and structures to verify that they are designed:
  - (a) For all operational states;
  - (b) In a manner to keep radiation levels and releases on and off the site during all operational states within prescribed limits;
  - (c) For a degree of leak tightness consistent with reactor safety analysis;
  - (d) With ventilation and air flow rates consistent with reactor safety analysis.

- (13) Examine the design of the reactor core to verify that:
- (a) Individual fuel elements are consistent with neutronic, thermal-hydraulic, mechanical, material, chemical, and irradiation constraints of the core as a whole;
  - (b) Fuel damage is kept within acceptable limits during accident conditions;
  - (c) Maximum permissible design limits specified for all operational states are not exceeded;
  - (d) The reactor can be shut down and held subcritical for all operational states and accidents.
- (14) Examine the design of the reactivity control system to verify that:
- (a) Sufficient negative reactivity is provided to make the reactor subcritical, and to maintain it subcritical in all operational states, taking into account the core condition with the highest positive reactivity contribution;
  - (b) Maximum positive reactivity addition rate is limited to values justified in the reactor safety analysis.
- (15) Examine the thermal-hydraulic design to verify that:
- (a) Reactor fuel parameters are maintained below specified safety limits during all operational states;
  - (b) Safety margins, including margins for error and engineered tolerances for the safety limits, are consistent with the reactor safety analysis.
- (16) Examine the design of the reactor coolant system to verify that:
- (a) Adequate, reliable, long term core cooling is provided for all operational states;
  - (b) Provisions for testing, surveillance, and inspection are provided;
  - (c) A reliable system is available for shutdown cooling, where required;
  - (d) In reactor coolant systems with penetrations at or below core level, redundant, testable features have been considered to prevent core uncovering;
  - (e) Where primary coolant drainage and subsequent core uncovering could occur, suitable arrangements such as syphon breaks are provided.
- (17) Examine the reactor shutdown system design to verify that:
- (a) At least one, fast acting, automatic shutdown system is incorporated;
  - (b) Sufficient shutdown reactivity is provided to safely shut down the reactor and maintain it subcritical under all operational states and accident conditions;
  - (c) The speed of action and shutdown margin provided are consistent with the reactor safety analysis assumptions;
  - (d) A single failure will not prevent the system from completing its safety function.
- (18) Examine the design of the reactor protection system to verify that:
- (a) It is automatic and independent of other systems;
  - (b) Automatic protective actions cannot be prevented or impaired by manual actions;
  - (c) Redundancy and diversity are utilized to the extent that each postulated initiating event can be detected and protective action initiated in at least two different ways;

- (d) Fail-safe action is provided for ensuring safe condition for the reactor in the event of a protection system failure;
  - (e) All components can be functionally tested;
  - (f) Once initiated, protective actions go to completion;
  - (g) Protection system settings are established with an adequate margin between the initiation point and a safety limit to permit the protective action to correct the situation;
  - (h) Protective interlocks and trips cannot be overridden;
  - (i) Manual reactor trip initiation is provided.
- (19) Examine the design of the emergency core cooling system to verify that:
- (a) The capability exists to maintain core temperatures within written limits specified in the reactor safety analysis during all shutdown conditions;
  - (b) Significant fuel failure is prevented for the range of loss of coolant accidents specified in the reactor safety analysis;
  - (c) A single failure in the system will not prevent the system from fulfilling its intended function;
  - (d) Provisions for testing, surveillance, and inspection are provided.
- (20) Examine the design of the confinement or containment to verify that:
- (a) It is capable of withstanding loading from accident events including those arising from all postulated internal and external events;
  - (b) Proper margins are provided for the highest calculated pressure and temperature loads expected during design basis accident conditions;
  - (c) Suitable means are provided to control the release of radioactive materials during design basis accident conditions;
  - (d) The degree of leak tightness is commensurate with the requirements of the reactor safety analysis;
  - (e) Provisions are made for initial and periodic leak tests, routine testing, and ventilation filter replacement.
- (21) Examine the design of the instrumentation and control to verify that:
- (a) The arrangement of instrumentation and displays utilizes ergonomic principles and provides optimal conditions for assimilation of information;
  - (b) Sufficient instrumentation is provided to monitor reactor systems and reactor core parameters during all operating, shutdown, refueling, and maintenance conditions, and for recording all safety-related variables;
  - (c) Adequate instrumentation is provided to monitor emergency conditions;
  - (d) Sufficient indicating and recording instrumentation is provided to monitor important reactor parameters following anticipated operational occurrences and accident conditions;
  - (e) Provision is made for startup neutron source indication;
  - (f) Audible and visual alarms are installed to provide indication of unacceptable deviations in operating parameters and to indicate when trip points are reached;
  - (g) Provisions for periodic testing, inspection, and maintenance are in place.

- (22) Examine the design of the electrical power supply system to verify that:
- (a) It conforms to the requirements of the reactor safety analysis;
  - (b) An emergency electrical power supply is provided when required for systems that are essential to safe shutdown and cooling of the reactor;
  - (c) The maximum period for interruption of all electrical power specified in the reactor safety analysis is met;
  - (d) Provisions for periodic, functional testing of the emergency electrical power supply are in place when that system is required.
- (23) Examine the design of the facility auxiliary and support systems to verify that:
- (a) The systems act to prevent the uncontrolled release of radioactive materials;
  - (b) The systems act to prevent the malfunction of items important to safety;
  - (c) Fuel handling and storage assure sub-criticality, adequate cooling, minimum corrosion, adequate containment, adequate radiation shielding, and adequate ventilation;
  - (d) Adequate ventilation, filtration, and radiological monitoring, particularly in areas that could experience airborne radioactivity, are provided;
  - (e) Provisions are made to prevent fires and explosions, and to mitigate their consequences;
  - (f) Adequate communications and alarm systems are provided to ensure reactor safety and the safety of experimental facilities.
- (24) Examine the design of experimental devices to verify that:
- (a) In all operational states, the devices do not pose an unacceptable hazard to the reactor, other experiments, on-site personnel, or to the public and the environment;
  - (b) Neither operation nor failure results in an unacceptable reactivity insertion in the reactor;
  - (c) Monitoring, limits, and environmental conditions as appropriate are provided for experiments and experimental facilities.
- (25) Examine the design of the radioactive waste systems to verify that:
- (a) Releases of radioactive material are controlled, minimized, monitored, and maintained within limits set by the national authority;
  - (b) Techniques such as shielding and decay are utilized to reduce doses to personnel and releases to the environment;
  - (c) Adequate on-site storage and recovery facilities are provided;
  - (d) Adequate means are provided to control, sample, and monitor airborne and liquid effluent discharges to the environment.
- (26) Based on consistent overall radiation protection concepts, the design of the radiation protection systems should be examined to verify that:
- (a) Shielding, ventilation, filtration and decay systems are in place;
  - (b) Adequate radiation area and airborne radioactivity monitoring systems are in place to monitor operational states and accident conditions;
  - (c) Structural materials have been chosen to minimize doses to personnel and damage to equipment during operation, inspection, maintenance, and repair of the reactor;

- (d) The effects of radionuclides such as nitrogen-16, tritium, and argon-41 produced by neutron activation in reactor process systems have been given due consideration in providing radiation protection;
- (e) Access control is provided for areas that could have radiation levels in excess of those in normal operating areas.

### 3.3. SAFETY ANALYSIS

#### 3.3.1. Objective

To provide a basis for evaluating the safety analysis in accordance with [8]<sup>2</sup>, for ensuring that the safety of the reactor has been analyzed and evaluated to demonstrate that it is adequate. Detailed guidance on safety analysis is presented in [9].

#### 3.3.2. Guidelines

- (1) Determine whether the safety analysis provides:
  - (a) Analyses of the response of the reactor to a range of postulated initiating events that could lead either to anticipated operational occurrences or to accident conditions;
  - (b) Consideration of experimental devices with respect to both their own safety aspects and their effect on the reactor.
- (2) Verify that the safety analysis has been used as a basis for:
  - a) Establishment of the operational limits and conditions of the reactor;
  - b) Development of operating procedures;
  - c) Periodic testing and inspection programmes;
  - d) Record keeping;
  - e) Maintenance schedules;
  - f) Modification proposals;
  - g) Emergency planning.
- (3) Verify that the postulated initiating events and the envelop design basis accident for the reactor have been properly identified.
- (4) Verify that the results of the safety analysis are reflected in the safety analysis report.
- (5) Determine that, as a minimum, the set of postulated initiating events for the safety analysis includes:
  - (a) Loss of electrical power,
  - (b) Insertion of excess reactivity;
  - (c) Loss of flow;
  - (d) Loss of coolant;
  - (e) Erroneous handling or failure of equipment or components;
  - (f) Special internal events such as fires, explosions and flooding;

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<sup>2</sup> The mentioned safety guide was developed taking into consideration the General Safety Requirements Part 4 "Safety Assessment for Facilities and Activities"



- (g) External events such as earthquakes, weather emergencies, floods, fires and aircraft crashes;
  - (h) Human error.
- (6) Verify that the set of postulated initiating events covers all credible accidents that influence the safety of the reactor.
  - (7) Verify that each postulated initiating event and its consequences have been analyzed and presented in a manner that:
    - (a) Categorizes accidents by type with limiting cases identified;
    - (b) Indicates the course of events and likely consequences for the limiting cases;
    - (c) Demonstrates that the risk and the safety margin associated with operation of the reactor are acceptable.
  - (8) Determine for each postulated initiating event that the following information has been considered in the evaluation:
    - (a) Input parameters, initial conditions, boundary conditions, assumptions, models and codes used and their validation;
    - (b) Sequence of events and performance of reactor systems;
    - (c) Sensitivity to single failure modes and common cause failures;
    - (d) Sensitivity to human factors;
    - (e) Potential for fission product releases and radiation exposures;
    - (f) The extent to which the safety systems and any non-failed process systems are required to function under accident conditions.
  - (9) Determine that design limits for all relevant parameters have been specified for each operational state of the reactor and for accident conditions.

### 3.4. SAFETY ANALYSIS REPORT

#### 3.4.1. Objective

To provide a basis for determining the adequacy of the safety analysis report to meet its purpose. General requirements are provided in [4] and detailed guidance on the SAR content is presented in [8]. The review team should assess the consistency of the methods used in the safety analysis report with the methods and practices described in [8].

#### 3.4.2. Guidelines

- (1) Determine whether the safety analysis report provides:
  - (a) A basis for operational limits and conditions;
  - (b) Guidance for preparing operating procedures and emergency plans;
  - (c) Sufficient information to allow the regulatory body to make an independent assessment of the safety of the reactor as a basis for licensing and approval of reactor operation;
  - (d) A basis for facility understanding by operators and experimenters.

- (2) Determine whether the safety analysis report gives:
  - (a) A detailed description of the reactor site;
  - (b) Safety principles and general design criteria to protect the reactor, operating personnel, the public, and the environment;
  - (c) Analysis of the potential risks to the reactor, provisions to mitigate them, and the impact of any reactor incident;
  - (d) Analysis of accident scenarios and incorporated safety features to avoid them or mitigate their consequences.
- (3) Determine whether a new safety analysis report or amendments to the existing one was required and completed for the following situations:
  - (a) New construction;
  - (b) Relicensing;
  - (c) Refurbishment;
  - (d) Significant modifications;
  - (e) Power level increase;
  - (f) Core fuel conversion;
  - (g) Changes in operational limits and conditions;
  - (h) Equipment upgrade, replacement or repair;
  - (i) Changes in site characteristics;
  - (j) Experiments with significant relevance to reactor safety;
  - (k) The advent of modern safety standards, new regulatory requirements, or international codes of practice.
- (4) Ensure that the safety analysis report presents:
  - (a) A general description of the facility including, as appropriate, a historical review of upgrades and modifications, comparison with similar facilities, safety features, the experimental programme, management organization, and facility drawings;
  - (b) Safety principles and general design criteria including, as appropriate, overall safety objectives, safety principles important to design, design criteria applied to safety related systems, classification of structures, components, and systems, external events, codes and standards, design methods; qualification of structures, components and equipment; and design for internal fire protection;
  - (c) Site characteristics including, as appropriate, a general site description, natural external events, geology, seismology, meteorology, hydrology, oceanography, nearby industrial, transportation, and military facilities, population distribution, natural environment, land, and water usage, baseline radiological levels, atmospheric dispersion of radioactive materials, dispersion of radioactive materials through surface and ground waters, and mitigation measures required for postulated accidents;
  - (d) Building and structures including, as appropriate, reactor building design features, drawings, tests, and inspections, and auxiliary structure descriptions that are important to safety;
  - (e) Reactor information including, as appropriate, a summary description of the reactor, fuel element design, fuel properties, and lifetime operating characteristics, reactivity control system; core nuclear design, thermal hydraulic design, and materials utilized in the core structure, fuel and absorbers;

- (f) Reactor coolant systems and connected systems including, as appropriate, a summary description supported by drawings and elevation diagrams of the primary coolant system, the secondary coolant system, the moderator system, emergency core cooling, decay heat removal, the primary purification system, and the primary make-up system;
- (g) Engineered safety features including, as appropriate, types, locations, and brief descriptions of the engineered safety features with information in such areas as reliability, redundancy, diversity, and the ability of materials to withstand accident conditions;
- (h) Instrumentation and control including, as appropriate, the power regulating system, the reactor protection system, alarm systems, interlocks, other instrumentation systems required for safety, and the control room layout and ergonomic assessment;
- (i) Electric power including, as appropriate, normal AC power supply, uninterruptable DC/AC power supply as appropriate, cables and routing;
- (j) Auxiliary systems including, as appropriate, fuel storage and handling, water systems, process auxiliaries such as compressed air, sample handling, air conditioning, heating, cooling, ventilation, and fire protection;
- (k) Reactor utilization including, as appropriate, experimental facilities, irradiation facilities, design safety principles, safety analyses, method of review and approval for new experimental devices, and materials forbidden in experiments;
- (l) Operational radiological safety including, as appropriate, radiation protection policy of the organization; overall radiation protection programme, quantitative account of sources of radiation at the facility, facility design for radiological safety, handling and movement of radioactive materials, dose assessment for normal operation, procedures and training, equipment and instrumentation, environmental monitoring, access control and zoning, shielding, ventilation for radiological control, area and effluent radiation monitoring, solid, liquid and gaseous waste, and anticipated direct radiation exposures within the facility;
- (m) Conduct of operations including, as appropriate, organizational structure, staff selection, training and qualification, review and audit functions, operating procedures, maintenance, testing, and inspection programmes, records and reports, and fire protection procedures;
- (n) Environmental assessment to the extent required by the national regulatory body and that may include analysis of gaseous and aqueous release for all operational states and accident conditions, effects of radionuclide uptake in plant and animal life, ultimate heat sink effects, transport and disposal of spent fuel and radioactive waste, and both the positive and negative socioeconomic impacts of the facility on the neighboring population;
- (o) Commissioning programme including, as appropriate, summary, details of the commissioning organization, management system, stages for commissioning, and operational limits and conditions, equipment installation and test procedures, test schedules, and sequence of commissioning systems and equipment, and summary of commissioning results;
- (p) Operational limits and conditions as determined in the safety analysis including:
  - (i) safety limits on important process variables which, if exceeded, could result in undue exposure to personnel or release of undue amounts of radioactivity to the environment;
  - (ii) safety system settings for those variables and parameters that if not controlled could result in safety limits being exceeded;

- (iii) establishment of limiting conditions for safe operation to provide acceptable margins between normal operating values and safety system settings;
  - (iv) surveillance requirements that prescribe the frequency and scope of tests to demonstrate that performance levels are being met;
  - (v) organizational structure and responsibility, staffing requirements, review and audit of facility operations, required procedures, operational event review requirements, and reports and record requirements;
- (q) A management system including, as appropriate, provision for control of all activities associated with the facility such as design, procurement, construction, manufacturing and operation, services and procedures to which quality assurance applies, quality assurance implementation, including review and audit, means to demonstrate compliance with acceptance criteria, regulatory requirements, design bases, codes and standards, validation and verification of control measures, test programmes, resolution techniques for non-conformance events and evaluation of their effects on safety;
  - (r) Decommissioning, including, as appropriate, feasibility of decommissioning without undue risk to personnel, the public and the environment, evidence that considerations for decommissioning have been included in the design, construction and operational lifetime of the reactor;
  - (s) Emergency planning and preparedness for radiological accidents including, as appropriate, approval by the appropriate authorities, agreement with relevant public authorities and regulatory bodies for provision of assistance and emergency support, development of credible accident scenarios with emergency actions for each, availability of resources and communications to manage each accident scenario, provision for drills and tests at prescribed time intervals, and provision for review and updating of the emergency plan.

### 3.5. CONSTRUCTION

#### 3.5.1. Objective

The objective is to provide a basis for evaluating the construction of the reactor and associated requirements [4] and their adequacy. The review team should determine whether the as-built facility meets the design intention regarding major safety systems such as: means of confinement or containment, protection system, electrical supply, radiation monitoring and fire protection systems.

#### 3.5.2. Guidelines

- (1) Verify that buildings, structures, and systems construction:
  - (a) Meets the design assumptions of the reactor safety analysis;
  - (b) Conforms to construction and installation drawings and design specifications including materials of construction;
  - (c) Meets construction relevant codes and standards of local, national, and international organizations;
  - (d) Has been reviewed and approved by the appropriate regulatory body.

- (2) Determine whether buildings and structures:
  - (a) Form the required barrier against uncontrolled release of radioactivity to the environment;
  - (b) Act as barriers to keep radiation levels and radioactive releases on and off the site in conformance with the principle of optimization of protection and within prescribed limits during all operational states;
  - (c) Provide protection against external events to enclosed safety systems;
  - (d) Provide a degree of leak tightness and ventilation air flow consistent with the reactor safety analysis;
  - (e) Permit testing of penetrations, doors, and airlocks.
- (3) Determine whether ventilation systems:
  - (a) Control and minimize release of airborne radioactive effluents to the environment;
  - (b) Protect operating staff members and experimenters from undue radiation exposure;
  - (c) If required, maintain sufficient differential pressure among the different parts of the confinement or containment system and between the inside of the confinement or containment and the outside atmosphere;
  - (d) Provide an appropriate ambient environment for personnel and for items important to safety;
  - (e) Provide for inspection, testing and replacement of air filters and traps.
- (4) Determine whether electrical power supplies provide enough power of suitable quality to systems and equipment in order to ensure their capability to perform their safety functions when required.
- (5) Verify that radiation monitoring systems provide measurements and warnings that are adequate to minimize radiation exposure to operating personnel and experimenters.
- (6) Verify that fire protection systems are adequate to ensure that the adverse effects of fire or explosion do not prevent items important to safety from performing their safety functions when required.

### 3.6. COMMISSIONING

#### 3.6.1. Objective

To provide a basis for evaluation of the commissioning programme and procedures for research reactors [10], and to ensure the requirements established in [4] are met. The review team should determine the adequacy of the organization for commissioning, scheduled tests and related procedures. If the commissioning stage has already been completed, the review team should review the accuracy of the results as compared to the design specifications.

#### 3.6.2. Guidelines

- (1) Verify that an adequate commissioning programme has been prepared for the purpose of demonstrating that all design objectives have been achieved, and that the programme has been reviewed and approved by the safety committee and the regulatory body.

- (2) Verify that the necessary features, e.g., special neutron detectors and counting equipment, have been incorporated into the design of the reactor and related facilities to facilitate the reactor commissioning process.
- (3) Verify that experimental devices have been given adequate consideration in the commissioning programme, and that new experimental devices are subject to appropriate additional commissioning procedures.
- (4) Determine whether development of the commissioning programme has been a co-operative effort involving the operating organization, designers, manufacturers, and constructors.
- (5) Verify the adequacy of the organization that has been set up for the commissioning regarding the various groups involved, their staffing, responsibilities and training.
- (6) Verify the adequacy of the Quality Assurance (QA) programme for commissioning regarding its provisions associated with the management, performance and evaluation of commissioning activities.
- (7) Examine the commissioning stages and verify the adequacy of the tests and prerequisites included in each of the stages.
- (8) Verify that appropriate procedures have been prepared for each of the tests envisaged in the commissioning programme and that these procedures have been prepared and reviewed in accordance with the QA programme for commissioning.
- (9) Verify that the commissioning programme includes adequate provisions for dealing with verifications, reviews, audits, deviations and keeping of records and updating of the safety analysis report.
- (10) Review the commissioning programme and determine its adequacy with respect to the following objectives:
  - (a) Determination by measurement under realistic conditions of all safety relevant reactor characteristics;
  - (b) Verification, on the basis of measured data, of the relevant safety requirements;
  - (c) Provision of additional information and data from commissioning for completing safety documentation, technical documentation, and operating procedures;
  - (d) Provision of familiarization and training opportunities for operating and maintenance personnel.
- (11) Verify that commissioning tests are arranged in functional groups and in a logical sequence that includes:
  - (a) Pre-operational tests;
  - (b) Initial criticality;
  - (c) Low power tests;
  - (d) Power tests.

- (12) Verify that the procedures covering commissioning tests include:
- (a) Purpose of the test and results expected;
  - (b) Safety provisions required to be in force for the test;
  - (c) Test instructions;
  - (d) Provisions for data collection, data analysis, evaluation of the results, identification of deficiencies, and corrective actions.
- (13) Verify the accuracy of the results from the commissioning tests and the involvement of the operating personnel in the performance of the tests.
- (14) Ensure that all commissioning test results, whether produced by the operating organization or by suppliers, are available to the operating organization and are maintained for the lifetime of the facility.
- (15) Ensure that, for the as-built reactor, the analysis of postulated accidents and the capability of the safety systems to limit the consequences of such postulated accidents are fully documented before loading fuel.
- (16) Verify that all facility components and systems have been constructed in accordance with their design intent and that they meet the safety criteria.
- (17) Verify that a comprehensive commissioning report has been prepared that presents and assesses the results of commissioning, in particular, the action taken for unsatisfactory test results, if any.
- (18) Verify that the results of commissioning have been incorporated into the safety analysis report and that the approved operational limits and conditions include the commissioning results.

### 3.7. SITING AND PROTECTION FROM EXTERNAL EVENTS

#### 3.7.1. Objective

To provide a basis for evaluating the safety aspects of the reactor siting and design as established in [4], [11-16].

The review team intent should be to verify that, the site chosen in the case of a new research reactor together with the design of the facility takes into account the principle of optimization of protection in regard to potential public doses from normal operation and from accidents. With an existing facility, the review team should examine documentation and records, and visit the site to establish that changes in the characteristics of the site, such as surrounding population and other external changes or the facility, such as an increase in power level, do not significantly affect the safety of the site. If the review team is examining the design, the design basis parameters for external hazards and protection of safety related structures and components from these should be included in the review.

### 3.7.2. Guidelines

- (1) Discuss the siting and protection of the facility from external events with experienced members of the operating organization, and examine relevant documentation such as the safety analysis report and siting justification to assess the degree to which:
  - (a) The site is commensurate with the potential hazard from the facility;
  - (b) The site chosen ensures that the number of people likely to be affected by accidental releases from the facility is minimized, taking due account of other aspects of the population distribution such as the nature and distribution of the population around the site (the site chosen for a facility with a significant off-site hazard potential should avoid proximity to institutions with relatively large numbers of immobile people, such as hospitals or old people's homes, and with large concentrations of the population in the prevailing wind direction);
  - (c) Controls exist and have been applied to ensure that changes in the characteristics of the site have not adversely affected the safety of the facility by increasing the probability of an accident occurring or either increasing the consequences of an accident. In cases where such changes in the site characteristics have occurred, the reviewer should assess the extent to which these have been off-set by additional engineered and/or administrative protection and mitigation features.
- (2) When reviewing the siting of the facility in greater detail, the reviewer should examine the safety analysis report, emergency plan, siting justification documentation, and periodic reviews of this documentation, and discuss site issues with relevant personnel, to establish that:
  - (a) The emergency plan is compatible with the safety analysis for the facility and the characteristics of the site are taken into account;
  - (b) Potential changes in the site characteristics are considered during periodic reviews of the facility and the safety analysis report such as:
    - (i) Population in the vicinity of the reactor;
    - (ii) Potentially hazardous plant or activities in the vicinity of the site which could have an impact on the safety of the facility under review;
    - (iii) Meteorological conditions (the predicted conditions may be different from those taken into account);
    - (iv) The routes, types and frequency of aircrafts, and other types of transport such as trains, trucks, and ships carrying potentially hazardous materials;
    - (v) New buildings that could affect the dispersion of radioactive releases from the site or which may affect the civil engineering aspects of the site in a way that may, during their construction or afterwards, create a hazard to the site;
    - (vi) Aquifers, ground water, and surface water courses;
    - (vii) Aspects of the topography and road structure of the area around the site which could affect the movement of people in an emergency. This will establish the changes in the potential impact of the facility to the population and environment and the design basis for external events (natural and man-induced) affecting the facility.
  - (c) A programme of review of the site characteristics is in place to monitor any change and to verify the original design assumptions and data base.



### 3.8. OPERATIONAL LIMITS AND CONDITIONS

#### 3.8.1. Objective

To provide a basis for evaluating the adequacy of the research reactor operational limits and conditions (OLCs) [4] and [17].

#### 3.8.2. Guidelines

- (1) Determine that a detailed set of operational limits and conditions has been developed for the reactor which may either be a part of the safety analysis or be incorporated into a separate document, which contains:
  - (a) Safety limits on important process variables which, if exceeded, could result in undue exposure to personnel or release of undue amounts of radioactivity to the environment;
  - (b) Safety system settings for those variables and parameters that if not controlled could result in safety limits being exceeded;
  - (c) Limiting conditions for safe operation to provide acceptable margins between normal operating values and safety system settings. This includes equipment requirements (both characteristics and number of such equipment in operational conditions) to ensure safe operation;
  - (d) Surveillance requirements that prescribe the frequency and scope of tests of safety systems to ensure compliance with approved operational limits and conditions;
  - (e) Administrative requirements such as:
    - (i) Organizational structure and responsibilities;
    - (ii) Staffing requirements;
    - (iii) Facility review and audit requirements;
    - (iv) Procedure requirements to ensure limits are not exceeded;
    - (v) Operational event review requirements;
    - (vi) Reports and records requirements.
- (2) Verify that the operational limits and conditions are derived from the reactor safety analysis and constitute a comprehensive envelope for the safe operation to protect the staff, the public, and the environment.
- (3) Verify that the applicable operational limits and conditions have been reviewed and approved by the regulatory body.
- (4) Verify that the approved operational limits and conditions are presented by clear statements of their objectives, applicability, specification and justification.
- (5) Verify that the operating organization reviews regularly the approved operational limits and conditions in order to make revisions arising out of operational experience.
- (6) Verify that the operational limits and conditions include requirements for provisions to be taken if a safety limit, safety system setting or limiting condition for safe operation is not satisfied.

- (7) Determine if a safety limit, safety system setting or a limiting condition for safe operation have been violated during the reactor operation and which actions were taken in the case of violation.
- (8) Determine the controls established by the operating organization to ensure compliance with the approved operational limits and conditions and to facilitate the verification that the operation is conducted in compliance with them.

### 3.9. SAFETY CULTURE

#### 3.9.1. Objective

The basis for evaluating safety culture within the organization is considered as part of safety verification. The review should establish the extent to which an adequate set of safety culture attributes, and attitudes in individuals and organizations exist, as described in [18] and [19], which ensures that safety issues, as an overriding priority, receive the attention that their significance warrants.

#### 3.9.2. Guidelines

- (1) Examine the organizational structure and the organization policy to determine whether:
  - (a) Clear and comprehensive safety policy statements are provided by the organization and made available to all staff which make its responsibilities and attitudes to safety well known and understood;
  - (b) Adequate management structures are available to provide clear accountability for safety with clearly delegated functions and responsibilities;
  - (c) Adequate and appropriate resources are devoted to safety;
  - (d) An appropriate degree of self-regulation exists with organizational arrangements for peer reviews and audits;
  - (e) There is evidence of corporate commitment to the safety policies and the development of safety awareness of individuals.
- (2) Examine the management arrangements for the control of the activities important to safety and their application to identify:
  - (a) That a clear definition of individual responsibilities and lines of authority exists;
  - (b) Whether matters related to safety are controlled by well documented management procedures and arrangements, and the degree to which these are followed, reviewed, and reinforced;
  - (c) The extent to which managers ensure that their staffs are fully competent for their duties;
  - (d) The degree to which management institutes a programme of maintenance practices by audit, review, and comparison.
- (3) By discussion with management and individuals and by observing areas such as operational practices and housekeeping, determine whether:
  - (a) The system of rewards and sanctions, management attitudes and communication with individuals develops good attitudes and motivation among staff members;

- (b) Individuals are encouraged to have a questioning attitude towards matters affecting safety, to have a rigorous and prudent approach to their tasks, and are not afraid to communicate their concerns on safety matters and suggestions for improvement with line managers and others.
- (4) Determine whether a corporate level safety policy exists by answering the following questions:
  - (a) Has a safety policy statement been issued? Is it clear? Does the policy express the overriding demand for nuclear safety?
  - (b) Is the safety policy brought to staff attention from time to time?
  - (c) Are managers and workers familiar with the safety policy and can staff cite examples that illustrate its meaning?
- (5) Examine safety practices at the corporate level by posing the following questions:
  - (a) Does the corporate board have expertise in safety?
  - (b) Do formal meetings at this level include agenda items on safety?
  - (c) Do operating staff attend formal meetings to discuss the safety performance of the facility?
  - (d) Is there an active nuclear safety review committee which reports its findings at corporate level?
  - (e) Is there a senior member of the board with safety as a prime responsibility? How is he supported and assisted in his duties? What is his standing compared with that of the heads of other functions?
  - (f) Are the resource requirements for the safety function reviewed periodically at corporate level, and which results have been achieved?
- (6) Safety responsibility should be questioned as follows:
  - (a) Has the assignment of safety responsibilities been clearly stated and documented?
  - (b) Has the responsibility of the reactor manager been clearly stated and accepted?
  - (c) Are the documents that identify safety responsibilities kept up to date and reviewed periodically, and with what result?
- (7) Examine training programme with the following questions:
  - (a) Does all training and retraining important to safety culminate in formal assessment and approval for duties? What is the success/failure record? What is the proportion of operating staff time devoted to training and how does this compare with the practices of other research reactors for a similar size and type of facility?
  - (b) Which resources are allocated to training? How does this compare with the allocations in similar facilities?
  - (c) Is the quality of training programme assessed at corporate and reactor management levels?
  - (d) Is there a periodic review of the applicability, correctness and results of training courses? Does this review take into account operating experience feedback?
  - (e) How frequently are production requirements permitted to interfere with scheduled training?

- (f) Do staff members understand the significance of the operational limits of the facility in their areas of responsibility?
  - (g) Are the staff educated in the safety consequences of the malfunction of facility items?
  - (h) Are the staff trained in the special importance of operating procedures? Are they regularly reminded? Are they trained in the safety basis of the procedures?
  - (i) Can training staff cite examples of operating errors that have resulted in modifications to a training programme?
  - (j) For maintenance personnel, do training sessions make use of mock-ups before a complex maintenance activity is performed?
  - (k) Do training programmes address safety culture?
- (8) Examine the selection of managers by providing answers to the following:
- (a) Do the staff recognize that attitude toward safety is important in the selection and promotion of managers? How is this recognition fostered?
  - (b) Do annual performance appraisals include a specific section on attitude towards safety?
  - (c) Can causes be identified in which safety attitude was a significant factor in approving or rejecting a promotion to management level?

### 3.10. REGULATORY SUPERVISION

#### 3.10.1. Objective

To provide the basis for evaluating the regulatory activities, the reviewer should determine that the reactor is subjected to independent assessment and inspection and that the facility operates in compliance with license requirements. In particular, the review team should verify that the facility is regulated by an appropriate regulatory or institutional body and that an adequate legal framework exists [4]. The requirements that apply to the regulatory supervision of nuclear facilities in general are established in [20] and guidance on how to meet these requirements is provided in [21], [22] and [23]. The Agency Integrated Regulatory Review Service (IRRS) is also available to provide peer review advice to regulatory bodies.

#### 3.10.2. Guidelines

- (1) By examining documentation and discussing with the staff of the regulatory body and the operating organization, the reviewer should identify whether:
  - (a) A regulatory body, or an equivalent institutional body, exists to regulate reactor safety related activities;
  - (b) The regulatory body is effectively independent of the operating organization or, at least, in the case of a country with a relatively small nuclear programme, is independent of the management of the reactor facility;
  - (c) The regulatory body is responsible for governmental surveillance and control with regard to nuclear safety in all activities of nuclear research reactors;
  - (d) The relationship between the operating organization and the regulatory body is based on mutual understanding, respect and confidence;
  - (e) A licensing process has been established;
  - (f) The regulatory staff are adequately qualified and knowledgeable and have sufficient resources to fulfill their responsibilities;

- (g) Despite the responsibilities of the regulatory body for surveillance and control with regard to all problems relevant to nuclear safety in the siting, design, construction, commissioning, operation and decommissioning of research reactors, the operating organization management accepts that the responsibility for safety of the facility, and for demonstrating an adequate level of safety remains with them, not with the regulatory body.
- (2) For a more in depth review, the reviewer should examine:
    - (a) The institutional bases for the regulatory body (e.g. laws, regulations);
    - (b) The lines of communication between the operating organization, the regulatory body, and the government;
    - (c) The licensing process, as an ongoing activity;
    - (d) The qualifications of the regulatory body staff and the availability of outside consultants where and when necessary;
    - (e) The provision of sufficient resources, commensurate with the size of the nuclear programme.
  - (3) The reviewer should examine the details of the licensing programme to ensure that the regulatory body:
    - (a) Has established or adopted safety policies, principles, associated criteria, regulations and guidance upon which the regulatory activities are based;
    - (b) Has provided the operating organization with information on its regulatory approach, organization, procedures and decisions;
    - (c) Has free unimpeded access to all relevant documentation including safety analysis report, management arrangements, facility operating records, quality assurance records, and safety committee minutes and documents.
  - (4) The reviewer should also examine the following:
    - (a) The existence of a safety analysis report to facilitate the safety assessment of the reactor facility;
    - (b) The existence of independent means of review and approval within the operating organization that can provide judgment on the adequacy of the safety of the facility and may endorse proposals for action by the reactor manager;
    - (c) Safety related documentation submitted to the regulatory body by the operating organization;
    - (d) The programme of review and assessment as applied to the various stages of the licensing process;
    - (e) The adequacy of licensing review with regard to the reactor design, construction and operation;
    - (f) That only suitably qualified and experienced persons hold posts that can affect safety;
    - (g) That regulatory inspections are carried out to ensure conformance with the operational limits and conditions and applicable regulations, codes and standards;
    - (h) Information concerning safety related incidents including its treatment;
    - (i) Planned modifications which may have a significant effect on safety;
    - (j) Experiments which may have a major effect on safety and are beyond the scope of the existing limits and conditions and the safety analysis report;

- (k) Enforcement of regulations, including conditions attached to the license and any necessary corrective actions.

### 3.11. SAFETY COMMITTEE

#### 3.11.1. Objective

One proven and recommended mean to ensure adequate safety is the establishment of an appropriate safety committee or advisory group to provide independent advice on safety matters to the management of the operating organization. The objective of the following guidelines is to determine whether an appropriate safety committee exists and meets regularly to supervise the safe operation of the reactor [4].

#### 3.11.2. Guidelines

- (1) By examining documentation and discussing with the staff of the operating organization, the reviewer should identify whether:
  - (a) A safety committee or an equivalent advisory group exists to review safety aspects of the operation of the research reactor and its associated facilities;
  - (b) The committee includes members who are independent of the operating organization;
  - (c) The safety committee is composed of members who are adequately qualified to perform their task (various members may be experts in special fields but the committee as a whole provides advice covering sufficient safety areas);
  - (d) The committee advises on all aspects affecting the safety of the facility during design, construction, commissioning, operation, and decommissioning;
  - (e) Terms of reference for the safety committee have been agreed on by the committee and the operating organization and approved by the regulatory body;
  - (f) The advice of the committee is transparent to management of the facility and the regulatory body.
- (2) For a more in depth review, the reviewer should examine:
  - (a) The records of the meetings of the safety committee and of the operating organization to examine how complete these records are, what matters are discussed, whether all points of view are recorded, the frequency of the meetings, to what extent the advice of the committee is followed, and what follow-up action is instigated;
  - (b) The terms of reference for the safety committee to check whether it is required to consider and provide advice on:
    - (i) Safety policy matters;
    - (ii) Management arrangements devised to ensure safety and any proposed changes to these arrangements;
    - (iii) Safety aspects of facility design, construction, commissioning, operation, maintenance, testing, experiments, utilization, modification, and decommissioning;
  - (c) The qualifications and experience of members of the committee;
  - (d) The procedure for the operating organization to reject the advice of the committee;
  - (e) The way in which urgent safety proposals are handled;
  - (f) Reporting of incidents and faults affecting safety to the safety committee.

- (3) The reviewer should also examine the records to verify that the committee has considered or reviewed management arrangements related to:
- (a) Appointment of persons to posts which can have an impact on safety;
  - (b) The working of the safety committee;
  - (c) Control of construction and installation of a new reactor facility;
  - (d) Control of modifications to the design of a reactor facility under construction;
  - (e) Commissioning and decommissioning;
  - (f) Control of modifications to an existing reactor facility;
  - (g) Control of experiments and research proposals that may affect the safety of the facility;
  - (h) Examination, inspection, maintenance, and testing of items which affect safety;
  - (i) Control of fissile material and radioactive material;
  - (j) Record keeping of matters important to safety;
  - (k) Training of persons who have an impact on safety;
  - (l) Emergencies;
  - (m) Preparation, approval, updating, and review of safety documentation;
  - (n) Peer review of the safety of the facility;
  - (o) Quality assurance aspects of items and systems important to safety;
  - (p) Radiation protection;
  - (q) Operational limits and conditions;
  - (r) Operating instructions;
  - (s) Control and discharge of radioactive waste;
  - (t) Adequacy of resources (personnel, funds) to ensure safe operation.

### 3.12. OPERATING ORGANIZATION AND REACTOR MANAGEMENT

#### 3.12.1. Objective

To provide a basis for evaluating the adequacy of the operating organization and reactor management. The review team should examine that the following is established and being implemented according to the requirements presented in [4]:

- Structure and responsibilities of the operating organization;
- Operating personnel;
- Radiation Protection personnel;
- Additional support personnel.

#### 3.12.2. Guidelines

- (1) The reviewer should examine the organizational chart, management section of the safety analysis report, quality assurance programme, policy documents, and job descriptions for safety related posts, and discuss with relevant personnel to ensure that:
- (a) A clearly defined operational structure is available to and understood by relevant personnel;
  - (b) Functions and responsibilities are clearly defined and understood by relevant personnel;
  - (c) The operating organization has overall responsibility for safety;
  - (d) The reactor manager has the responsibility for the safe operation of the reactor and this has been clearly defined in a written delegation of responsibility by the operating organization to the reactor manager;

- (e) The reactor manager has the necessary authority to fulfill the responsibilities of the post;
  - (f) Other members of the operating organization of prime importance to safety, such as senior health physicist and reactor physicist have necessary authority and resources to fulfill their duties.
- (2) In undertaking a deeper review of the organization, the reviewer should examine the structure and responsibilities of all the support functions as well as those directly involved in the operation of the reactor. This will include maintenance, training, chemical analysis, quality assurance, radiation protection, engineering support, and peer review groups.
  - (3) The degree of independence of the health physics function and quality assurance functions from reactor management should be reviewed.
  - (4) The reviewer should verify that all the posts that can affect safety have been identified and appropriate written description of responsibility and associated authority provided to the individuals holding the posts.
  - (5) Interviews should be conducted with a selection of the staff including the reactor manager and at least one operator to assess the degree to which the responsibilities of their posts are defined and understood and that they are suitably qualified and experienced for their positions. Their interviews should also assess that the operating staff has adequate standards of and a proper attitude toward safety.

### 3.13. TRAINING AND QUALIFICATIONS

#### 3.13.1. Objective

To provide a basis for evaluating training programmes and personnel qualification at research reactors [4]. The review team should verify that programmes for personnel training and retraining are in place and are consistent with the guidelines described in [24].

#### 3.13.2. Guidelines

- (1) Examine the facility training and qualification programme to determine whether it contains:
  - (a) Facility training organization and administration;
  - (b) Requirements for initial operator training and certification;
  - (c) Requirements for requalification training.
- (2) Determine whether the organization and administration of the training and qualification programme includes:
  - (a) The structure of the training organization;
  - (b) Requirements for qualifications of instructors;
  - (c) Provision of resources for training support;
  - (d) A description of training materials and the content of those materials;
  - (e) Procedures for selection of personnel.



- (3) Determine whether initial operator training and certification includes:
  - (a) An organized curriculum with written and practical examinations;
  - (b) Specific and adequate instruction in reactor theory, radiation protection, operational limits and conditions, facility systems, and operating procedures for operational states and accident conditions;
  - (c) Written examinations and practical checkouts;
  - (d) Certifications for all phases of qualification with minimum levels for satisfactory completion;
  - (e) Maintenance of training records for at least three years following termination of employment.
- (4) Determine whether operator requalification training:
  - (a) Is conducted on a regular basis such as a one or two-year cycle;
  - (b) Has an organized curriculum with written and practical examinations;
  - (c) Provides certification for completion of requalification with minimum levels for satisfactory completion;
  - (d) Provides for maintenance of requalification records for at least three years following termination of employment.
- (5) Determine whether training is provided in areas not specifically required for operator certification such as calibration and maintenance, life saving techniques and firefighting.

### 3.14. CONDUCT OF OPERATIONS

#### 3.14.1. Objective

To provide a basis for evaluation of research reactor conduct of operations. The review team should verify that operations are carried out in accordance with written procedures, that housekeeping is acceptable and that records and reports are well maintained [4], [17], [25] and [26].

#### 3.14.2. Guidelines

- (1) Verify that adequate written operating procedures are available to operators in the reactor control room and effectively used.
- (2) Determine whether personnel involved with operation and use of the reactor are adequately trained in the procedures and their use.
- (3) Verify that core management and fuel handling are carried out in accordance with the requirements of nuclear and radiation safety.
- (4) Verify that up-to-date information concerning the design, construction, commissioning, and operation of the reactor facility including site and environmental data, design specifications, details of material and equipment, as-built drawings, operating and maintenance manuals, and quality assurance documents are available and retrievable.

- (5) Ensure that written operating procedures include adequate, technically accurate, and complete written instructions for the following activities:
- (a) Startup, operation, and shutdown of the reactor and, where appropriate, operation of experimental devices;
  - (b) Loading, unloading, and movement within the reactor of fuel elements and assemblies, reflector assemblies, experimental devices, and other core components;
  - (c) Routine maintenance of major components or systems that could affect reactor safety;
  - (d) Surveillance required by the operational limits and conditions including periodic inspections and tests of SSCs that are essential for the safe operation of the reactor;
  - (e) Implementation of a radiation protection and control programme consistent with applicable regulations;
  - (f) Authorization of operation and maintenance and conduct of irradiations and experiments that could affect reactor safety or insert reactivity in the core;
  - (g) Operator response to anticipated operational occurrences and, to the extent feasible, accident conditions;
  - (h) Emergency actions;
  - (i) Handling of radioactive waste and monitoring and control of radioactive releases;
  - (j) Surveillance, as required, of the reactor and its auxiliary systems during reactor shutdown periods.
- (6) Determine that operating procedures are periodically reviewed and updated.
- (7) Verify that changes to operating procedures are made in accordance with predetermined internal procedures and that changes are made known to operating personnel.
- (8) Verify that procedures for operation and use of the reactor are consistent with operating limits and conditions.
- (9) For activities related to operations, tests, maintenance, or experiments not covered by existing procedures, determine whether appropriate procedures were prepared, reviewed, and approved prior to the start of the activities, and whether training of relevant staff was conducted.
- (10) Verify that adequate facilities are provided for handling, storage, and disposal of spent fuel.
- (11) Verify that new fuel is handled and stored in a manner that will prevent criticality and that will minimize the possibility of theft.
- (12) Verify that a validated calculation basis exists for the loading of fuel, reflectors, safety activation devices, and experimental devices in the core and that all core configurations are in accordance with design intent and assumptions specified in the operational limits and conditions.
- (13) Check that packaging and transportation of fresh and irradiated fuel elements have been carried out in accordance with national and international regulations, and as appropriate in accordance with IAEA regulations for the safe transport of radioactive material [27].

- (14) Determine whether the following records and reports related to the operation of the reactor are available and retrievable either as self-standing documents or as parts of procedures:
- (a) Routine operating data including logbooks, reading sheets, checklists, and automatically recorded data;
  - (b) Core management, fuel behavior, and fuel handling activities;
  - (c) Performance evaluation of safety systems;
  - (d) Current operational status and components out of service;
  - (e) Written instructions for temporary procedures or procedures that vary from existing, approved procedures;
  - (f) Maintenance, periodic testing, and inspection;
  - (g) Safety categorization of experiments and modifications;
  - (h) Location and transfer of radioactive sources and fissile materials;
  - (i) Staff qualification and training;
  - (j) In-service failures, safety related occurrences, and incidents;
  - (k) Radiation exposure and medical records;
  - (l) Radioactive waste storage and shipment;
  - (m) Radioactive effluent releases;
  - (n) Environmental monitoring results;
  - (o) Quality assurance audits and reviews;
  - (p) Relevant commissioning records including startup test reports;
  - (q) Records relevant to decommissioning;
  - (r) Communications with regulatory bodies.
- (15) Verify that entries in logbooks, checklists, and other operating records are timely, complete, adequately reflect facility activities and status, and are signed and dated.
- (16) Ensure that adequate storage of records and reports is provided.
- (17) Verify that only the most current version of each document is used by operating personnel.
- (18) Check that adequate retention periods for records are specified.
- (19) Verify that for facility and equipment operations:
- (a) Lines of supervision are clearly defined;
  - (b) Shift turnovers are formal and complete;
  - (c) Responsibilities and authority are clearly defined by position descriptions and procedures.
- (20) Verify that the following elements are taken into account or fulfilled during the facility and equipment operations:
- (a) Compliance with established operational limits and conditions;
  - (b) Correctness of and adherence to alarm set points;
  - (c) Operator vigilance and supervision;
  - (d) Programme to track and repair out-of-service equipment;
  - (e) Changes in documentation of system and component status;

- (f) Off-normal conditions are apparent to operators;
- (g) Lighting is adequate;
- (h) Instrumentation is unobstructed, clearly readable, and understandable to operators;
- (i) Defective and out-of service instrumentation is clearly apparent to operators;
- (j) Communications equipment is properly operating;
- (k) Radiation survey instruments are available at appropriate locations and in proper working order;
- (l) Housekeeping and cleanliness are satisfactory.

(21) Determine that equipment is operating properly and that:

- (a) There is protection from adverse environmental conditions;
- (b) Instruments are calibrated;
- (c) Drive belts show no excess wear;
- (d) Fasteners and supports are properly installed;
- (e) Insulation is installed where appropriate.

### 3.15. MAINTENANCE AND PERIODIC TESTING

#### 3.15.1. Objective

To provide a basis for evaluating the preparation and implementation of inspection, periodic testing and maintenance programmes [4], [28] and [29].

The review team should verify that such programmes exist and ensure that the above activities satisfy the requirements. The reviewer should also conduct a facility walk-down and observe, if possible, some of these activities to assess the quality and performance aspects.

#### 3.15.2. Guidelines

- (1) Determine that an overall programme for maintenance, periodic testing and inspections of systems and equipment exists with the following components:
  - (a) Systems and equipment covered;
  - (b) Mode of maintenance and inspection;
  - (c) Frequency;
  - (d) Responsible person by name or title;
  - (e) Authorization mechanism;
  - (f) Procedures for testing and resumption of normal operation.
- (2) Determine that maintenance, periodic testing and inspection activities are conducted to ensure:
  - (a) Compliance with operational limits and conditions;
  - (b) Adequacy of the safety status of the reactor.

- (3) Verify that maintenance work on installed equipment, removal of equipment from operation for maintenance purposes, and reinstallation of equipment after maintenance is:
  - (a) The overall responsibility of the reactor manager;
  - (b) Conducted with due regard to maintaining the level of safety of the reactor as specified in the operational limits and conditions.
- (4) Verify that there are written procedures for maintenance, periodic testing and inspection of reactor equipment, in particular all items important to safety, and that the procedures are based on the reactor safety analysis and manufacturers' recommendations.
- (5) Ensure that:
  - (a) A clearly defined structure for authorization of performance of all maintenance and periodic testing exists;
  - (b) Removal, replacement, repair, and service of items important to safety are performed only by specifically authorized personnel;
  - (c) A system of work permits is used including appropriate check-off procedures, before and after the conduct of work in accordance with a quality assurance programme;
  - (d) The results of maintenance and periodic testing are assessed by properly qualified personnel in order to verify compliance with operational limits and conditions.
- (6) Determine that the frequency of maintenance and periodic testing of individual SSCs ensures adequate reliability, taking into account:
  - (a) Their relative importance to safety;
  - (b) The likelihood of their failure to function as intended;
  - (c) Requirements established in the reactor safety analysis and any subsequent revisions.
- (7) Determine that measuring and test equipment is:
  - (a) Calibrated against national or international standards at recommended intervals;
  - (b) Subject to controlled use;
  - (c) Tagged and removed from service when out of tolerance.
- (8) Determine that a means of immediate rectification exists when calibrations, checks and inspections reveal a non-conformance with safety system settings or limiting conditions for safe operation of the reactor.
- (9) Verify that resumption of normal operation is permitted only by the person responsible for the coordination of maintenance work.
- (10) Ensure that records of maintenance and periodic testing conform to the requirements of the quality assurance programme. In particular, verify that they:
  - (a) Are technically accurate, adequate, and complete;
  - (b) Are current, dated, periodically reviewed, signed, and available to operating staff.

- (11) Determine that procedures exist for all maintenance, periodic testing and inspection activities required by the operational limits and conditions and that they:
  - (a) Are technically accurate, adequate, and complete;
  - (b) Are current, dated, periodically reviewed, signed, and available to operating staff;
  - (c) Provide for corrective action following an out-of-specification calibration;
  - (d) Set up criteria for a successful calibration.
- (12) Determine that a master maintenance schedule exists for maintenance, periodic testing activities and inspection, and that there are means for ensuring their completion, record retention, and compliance with the frequency requirements.
- (13) Verify that all maintenance, periodic testing and inspection activities are performed with proper safety equipment and radiological protection, with procedures available and in use, and are properly documented.
- (14) Determine that a routine preventive maintenance programme exists and that it includes an appropriate lubrication programme, rotation in operation of redundant equipment, verification of spare equipment operation, drive belt replacement, painting, filter replacement, and draining of systems subject to freezing.
- (15) Determine that the preventive maintenance programme in place pays special attention to systems, equipment, and components to ensure that ageing effects do not cause failure.

### 3.16. MODIFICATIONS

#### 3.16.1. Objective

To provide a basis for evaluating research reactor modifications. The review team should verify that modifications are assessed to determine their safety impact and taken into account in the safety documents of the facility [4] and [30].

#### 3.16.2. Guidelines

- (1) Verify that there is a procedure for classifying modifications into those that have safety significance and those that do not.
- (2) Verify that modifications with safety significance are subjected, according to the procedures, and have been subjected, as appropriate, to safety analyses, design, construction, and commissioning procedures equivalent to the original design, with particular attention being given to site environment changes such as population movement and general site usage.
- (3) Verify that the following types of modifications having safety significance are submitted for review and approval by the regulatory body:
  - (a) Changes in approved safety limits;
  - (b) Changes in approved limiting conditions for safe operation;
  - (c) Those that could have a significant impact on safety;

- (d) Those that create new safety hazards or hazards not previously addressed in the reactor safety analysis;
  - (e) Those that reduce an existing margin of safety.
- (4) Determine that all reactor and facility modifications have been subjected to an internal review by the facility operations staff and by the safety committee in accordance with the requirements of the procedures.
  - (5) Determine that a procedure for controlling modifications exists, that it has been implemented, and that, as appropriate, it includes:
    - (a) A description of the proposed modification;
    - (b) Justification for the modification such as ageing, backfitting, and upgrading;
    - (c) Internal organization, arrangements associated with the modification and specific responsibilities;
    - (d) Design requirements and criteria;
    - (e) A safety assessment that supports the modification;
    - (f) Specifications of the manufacturing processes;
    - (g) Installation procedures;
    - (h) Commissioning process;
    - (i) Testing and inspection of the completed modification;
    - (j) Review of operational and emergency procedures;
    - (k) Documentation updating;
    - (l) Special requirements for training and operator certification;
    - (m) Quality assurance requirements.
  - (6) Verify that modifications have to be and have been optimized with respect to reducing the radiation exposure of personnel.
  - (7) Verify that clear delineation of responsibilities for design, installation, commissioning, and acceptance of modifications has been established and observed.
  - (8) Determine, for each facility or system, that due consideration is (and has been) given to the following items in assessing and implementing the modification:
    - (a) Core reactivity effects;
    - (b) Radiation protection including shielding, waste, the potential for increased personnel exposures, and the potential for uncontrolled release to the environment;
    - (c) Safety devices including interactions with the reactor protection system and any deleterious effects;
    - (d) Heat generation;
    - (e) Cooling;
    - (f) Internal pressure and potential for explosion;
    - (g) Flux perturbations;
    - (h) Protection against external hazards.

### 3.17. UTILIZATION AND EXPERIMENTS

#### 3.17.1. Objective

To provide a basis for evaluation of research reactor utilization and experiments [4] and [30]. The reviewer should verify that procedures for experiments exist and are used. In the case of experiments with significant impacts on safety, it should be verified that they have followed a formal licensing process including commissioning.

#### 3.17.2. Guidelines

- (1) Verify that each new experiment is reviewed through an established internal procedure for its safety significance.
- (2) Verify that each experiment judged to be of safety significance was submitted to an internal safety committee for review and to the regulatory body, if appropriate.
- (3) Verify that modifications to experimental devices are subjected to the same procedures used for the original device.
- (4) Verify that a safety analysis has been prepared for every new reactor experiment which may significantly affect reactor safety.
- (5) Verify that all experimental devices loaded into or directly connected to the reactor are designed to the same standards as the reactor itself and are fully compatible in terms of material used, structural integrity, and radiological safety.
- (6) Verify that experimental devices and equipment are designed:
  - (a) So that in all operational states, they will not cause unacceptable operational and radiological consequences to the reactor, other experiments, site personnel, the public and the environment;
  - (b) So that neither operation nor failure results in an unacceptable reactivity change to the reactor;
  - (c) With appropriate monitoring of experimental parameters in the reactor control room;
  - (d) With appropriate operational limits and conditions;
  - (e) To preserve the confinement or containment and shielding of the reactor when they penetrate reactor boundaries;
  - (f) With protection systems that protect both the device and the reactor from any hazard arising from the experimental device.
- (7) Verify that procedures are in place to ensure that when the reactor itself is utilized to produce experimental results, all aspects of the design assumptions as reflected in operational limits and conditions are met.
- (8) Verify that the use and handling of experimental devices is controlled by written procedures that state the responsibilities for those involved with experiments.



- (9) Determine that a procedure for reviewing proposed experiments and reactor utilization exists and that it includes:
  - (a) The means of integrating the experimental device with the reactor system;
  - (b) The selection and justification of the criteria employed in the design of the experimental device with consideration given to specific items such as reactivity effects, temperature, pressure build-up, heat generation, and explosive materials;
  - (c) A safety assessment of the device itself and of its effects on the reactor and personnel;
  - (d) Requirements for the preparation and validation of special operating and maintenance documentation;
  - (e) Requirements for any special personnel training in operating procedures, radiological rules and instructions associated with performance and handling of the experiment, and emergency arrangements;
  - (f) Commissioning and functional testing requirements;
  - (g) Decommissioning considerations and procedures;
  - (h) Procedures to ensure adequate communication and intervention between operators and experimentalists;
  - (i) Disposal of radioactive waste generated by the experimental programme;
  - (j) Application of QA programme.
- (10) Review the overall utilization and experiment programme to verify that:
  - (a) Operating personnel are responsible for co-ordination and safety of all reactor experiments;
  - (b) Operating personnel have available all information necessary for safe operation of experiments;
  - (c) Close cooperation exists between operating personnel and experimenters;
  - (d) Procedures are established in advance for modifications of experiments;
  - (e) The reactor manager or a designated member of the operating personnel has the authority to direct any operation of experimental equipment;
  - (f) Approved methods and procedures are used for handling experiments;
  - (g) Compliance with operational limits and conditions on experiments, including radioisotopes, is observed;
  - (h) Appropriate encapsulation and radiation protection controls are observed.

### 3.18. MANAGEMENT SYSTEM

#### 3.18.1. Objective

The objective of the following guidelines is to provide the basis for evaluating the verification of safety in accordance with the management system and procedures at research reactors. The review team should verify that the responsibilities of the operating organization are defined and implemented [4], [19] and [31].

#### 3.18.2. Guidelines

- (1) Review the documentation of the facility and interview the staff of the operating organization to verify the following:
  - (a) A management system is established and effectively implemented;

- (b) The management system has been considered by the safety committee and, where required, by the regulatory body;
  - (c) There is evidence that audits and reviews are conducted to verify the application of quality assurance to items affecting safety;
  - (d) An individual has been identified who is responsible for the implementation of the programme.
- (2) A more in-depth review of the management system aspects should:
- (a) Examine in detail the management system to assess whether it is in accordance with the references noted above;
  - (b) Compare the management system with the Safety Analysis Report to check that items important to safety, as identified by the safety analysis, are adequately covered by quality assurance requirements;
  - (c) Examine the records of the facility to check on the frequency, depth, and quality of management system audits and reviews;
  - (d) Discuss with a variety of individuals from the operating organization the degree to which management system concepts are understood and followed by those with an influence on safety;
  - (e) Discuss the management system and its application with the persons responsible for it to assess their understanding of responsibilities and whether they have access to senior management in the organization independent of the reactor management;
  - (f) Ensure that the management system covers all aspects of safety including reactor operation, experiments and emergency arrangements;
  - (g) Ensure that violations, deficiencies, and non-conformities necessitating corrective actions are properly identified, recorded, and rectified, including those of the management system itself;
  - (h) Ensure that adequate management system records are kept and archived.
- (3) Verify that activities related to the following topics are subjected to particular controls established in written procedures:
- (a) Reactivity and criticality management including core configuration changes, manipulation of equipment or material in the vicinity of the reactor core, fuel storage, etc.;
  - (b) Core thermal safety including changes in the core loading and geometry;
  - (c) Safety of experimental devices including their design, construction, installation, commissioning, operation and decommissioning;
  - (d) Reactor modifications including their assessment, implementation and resuming reactor operation;
  - (e) Component and material manipulations including fuel and objects which may have any interference (mechanical, thermal, electrical or nuclear) with the reactor;
  - (f) Human surveillance as applied to experimenters, visitors and trainees;
  - (g) Maintenance, periodic testing and inspections including authorization, performance and verification of tests, repairs and changes;
  - (h) Commissioning testing and evaluation of results;
  - (i) Preparation of safety related document such as operating procedures and keeping of records.

### 3.19. RADIATION PROTECTION

#### 3.19.1. Objective

To provide a basis for evaluating the radiation protection programme, procedures and practices. The review team should verify that a radiation protection programme is established and implemented according to [4], [32] and [33]

#### 3.19.2. Guidelines

- (1) By examining the radiation protection programme, determine whether the operating organization:
  - (a) Has established a clear policy on radiation safety;
  - (b) Demonstrates support for radiation safety;
  - (c) Has provided adequate resources to the radiation protection organization.
- (2) Verify that a radiation protection programme has been established consistent with regulatory requirement and that it provides:
  - (a) Control of radiation doses to individuals present on the site including exposure limits and actions required if limits are exceeded;
  - (b) Control of the amounts of radioactive substances released to the environment from operation of the reactor including release limits and actions required if limits are exceeded;
  - (c) Reference levels for radiation dose rates that take into account the particular characteristics of the reactor and experimental facilities;
  - (d) Monitoring and records of internal and external personnel radiation exposures including lifetime doses and action reference levels;
  - (e) Reports to the regulatory body.
- (3) Determine that the radiation protection programme is provided by means, in addition to procedures and administrative requirements, to enable its implementation, and includes:
  - (a) Sufficient and appropriate instrumentation and equipment for personnel monitoring and protection;
  - (b) Workplace radiological monitoring and surveys (external radiation level and contamination monitoring);
  - (c) Environmental radiological surveillance;
  - (d) Decontamination of personnel, equipment, and structures;
  - (e) Compliance with applicable regulations for disposal of radioactive materials;
  - (f) Compliance with applicable regulations for shipment of radioactive materials;
  - (g) Maintenance of records and reporting of activity releases including dose estimates up to the site boundary;
  - (h) Record keeping of inventories of radiation sources;
  - (i) Adequate training in radiation protection practices;
  - (j) Periodic reviews, audits, and updates to ensure its objectives are being satisfied;
  - (k) Facilities, equipment, and instrumentation for contamination monitoring and for decontamination of personnel and equipment;
  - (l) Worker responsibility for radiation protection and safe work practices;

- (m) Review by the health physics staff, the operations staff, and new employees of lessons learned from past occurrences;
  - (n) Calibration of survey and monitoring equipment on a regular basis;
  - (o) Review and analysis of the hazards associated with experimental programmes and individual experiments;
  - (p) Clear, well written procedures for radiation protection evolutions with a mechanism for review, approval, and feedback.
- (4) Evaluate whether co-operation exists between the radiation protection staff and the operating personnel in preparing operating and maintenance procedures and in providing direct assistance when radiation hazards are anticipated.
- (5) Verify that the operating organization has adequate and qualified health physicists and health physics support personnel with:
- (a) Clearly defined authority and functional responsibilities;
  - (b) Reporting lines independent of reactor management;
  - (c) A co-operative working relationship with reactor management;
  - (d) Access to levels of management that have authority to establish and enforce operational procedures.
- (6) Verify that for all operational states and accident conditions adequate provisions has been made for:
- (a) Radiation shielding, ventilation, filtration and decay systems;
  - (b) Area radiation and airborne radioactivity monitoring instrumentation.
- (7) Determine that:
- (a) The radiological zoning is adequately defined and implemented in the different locations in the facility;
  - (b) Access control is provided to areas that could have radiation levels in excess of those in normal operating areas;
  - (c) Reactor operation and facility modifications are planned, reviewed, supervised, and implemented from the perspective of avoiding unnecessary exposure to radiation and keeping unavoidable exposure in conformance with the principle of optimization of protection.

### 3.20. RADIOACTIVE WASTE MANAGEMENT

#### 3.20.1. Objective

To provide a basis for evaluating the monitoring and control programme of airborne and liquid effluent, and solid wastes and their releases to the environment at research reactors, [34-36]. The reviewer should verify that provisions have been taken to ensure that effluent releases are appropriately controlled and that they are within regulatory limits. It should also ensure that solid wastes are appropriately managed, including their transport [27].

### **3.20.2. Guidelines**

- (1) Verify that effluent releases are within national limits or regulatory limits.
- (2) Review the airborne and liquid effluent release to determine whether:
  - (a) Procedures for control of effluent releases are in place and specify operations, health physics, and management responsibilities;
  - (b) Installed sampling and monitoring equipment is appropriate for the effluents being monitored;
  - (c) Environmental monitoring is adequate and appropriate;
  - (d) The radiological exposure to the general public from the release of radioactive effluents is kept in conformance with the principle of optimization of protection;
  - (e) Periodic reviews of the releases control systems (e.g., filter efficiency, sampling, monitoring equipment) are performed to ensure that they fulfill their intended purpose.
- (3) Verify that records of effluent releases and environmental monitoring are being maintained.
- (4) Review the installed effluent monitoring systems including number of instruments, type, location, interlocks, sensitivity, calibration, and maintenance. Check records of calibration and maintenance.
- (5) Review the analytical procedures used to sample and evaluate effluent releases for accuracy and adequacy.
- (6) Review the procedures for calibration of effluent monitoring instrumentation for adequacy and correctness.
- (7) Verify that ventilation is adequate in all reactor facility areas occupied by operating personnel to ensure proper personnel protection from radioactive airborne effluents.
- (8) Discuss with the personnel responsible for airborne and liquid effluent monitoring to ensure that they:
  - (a) Understand the proper use of sampling, filtering and monitoring equipment;
  - (b) Have an understanding of measurements taken by instruments for radiation counting of air samples and smear tests.
- (9) Verify that consideration was given to minimizing effluent releases in the design of experimental facilities and devices.
- (10) Verify that atmospheric dispersion data used for radioactive airborne effluent releases have not changed or been affected by new building or other construction in the near vicinity of the reactor facility.
- (11) Verify the validity of the models used to evaluate the impact of surface and ground water contamination due to releases of radioactive liquid effluents.

- (12) Determine whether adequate facilities exist commensurate with operation of the reactor and its experimental programmes for handling, segregation, treatment, conditioning, transportation, storage, and disposal of solid and liquid radioactive waste.
- (13) Determine whether consideration is given to minimizing solid or liquid radioactive waste during the design, construction and operation of experimental facilities.
- (14) Determine whether solid and liquid radioactive waste is handled and stored to maintain exposure to operating staff and health physics personnel according to the principle of optimization of protection.
- (15) Determine whether periodic reviews of sampling and monitoring systems of solid and liquid radioactive wastes are conducted to ensure that they fulfill their intended purpose.
- (16) Determine whether:
  - (a) Adequate written procedures exist for handling, segregation, treatment, conditioning, transportation, storage, and disposal of solid and liquid radioactive waste;
  - (b) Production of solid and liquid radioactive waste is reported periodically to the national regulatory body in accordance with its requirements;
  - (c) Treatment, conditioning, transportation, storage, and disposal of solid and liquid radioactive waste is being carried out in accordance with the requirements of relevant local and national authorities;
  - (d) Appropriate records are maintained of the quantities, types, and characteristics of stored solid and liquid radioactive waste and waste that is removed from the reactor site;
  - (e) Goals have been set up by the operating organization to minimize generation of solid waste.
- (17) Review the solid and liquid waste monitoring systems including number of instruments, type, location, interlocks, sensitivity, calibration, and maintenance. Check records of calibration and maintenance.
- (18) Interview the personnel responsible for solid and liquid waste monitoring to ensure that they:
  - (a) Understand the proper use of sampling and monitoring equipment;
  - (b) Have an understanding of measurements taken by instruments for radiation counting of solid waste samples.

### 3.21. EMERGENCY PLANNING

#### 3.21.1. Objective

To provide a basis for evaluating the emergency planning and the emergency preparedness [4], and [38], [39], and [40]. The review team should verify that an emergency planning programme exists and that it is implemented through written procedures.

### 3.21.2. Guidelines

- (1) Determine whether the reactor facility has an organizational framework with clearly defined individual responsibilities for emergency planning and preparedness.
- (2) Verify that a comprehensive and documented emergency plan exists that:
  - (a) Outlines all activities that may need to be implemented by the operating organization in the event of an emergency;
  - (b) Outlines for each off-site organization all activities that need to be implemented in the event of an emergency.
- (3) Verify that the emergency plan contains the following information:
  - (a) Definitions including emergency planning zone, site boundaries, and emergency classifications based on severity levels of emergencies;
  - (b) A description of the reactor including authorized power level, fuel type, and fission product inventory;
  - (c) A description of the location of the reactor facility including, as appropriate, surrounding population density, nearby industrial activity and access routes;
  - (d) Identification of the owner/operator;
  - (e) A statement of the objective of the emergency plan;
  - (f) Reactor utilization and operating mode;
  - (g) Emergency organization and responsibilities including the names and duties of those individuals authorized to act as site emergency director;
  - (h) Off-site organizations to be notified including the names of specific officials;
  - (i) Arrangements and authority to activate the emergency organization;
  - (j) Response actions for each emergency classification;
  - (k) Description of emergency facilities and equipment including locations;
  - (l) Checklist of assessment actions and recommended intervention levels;
  - (m) Conditions and indications for termination of the emergency;
  - (n) Communication arrangements to all on-site and off-site personnel and authorities.
- (4) Verify that procedures for implementing the emergency plan exist and that they:
  - (a) Provide detailed guidance for rapid and effective implementation of the provisions of the emergency plan;
  - (b) Provide on-site steps to implement protective measures related to the emergency condition, to assess the potential on-site and off-site consequences, classify the emergency, notify the appropriate local and national organizations, and to correct emergency conditions;
  - (c) Provide for activation of off-site support organizations.
- (5) Determine that adequate on-site and off-site response facilities and appropriate equipment and resources can be brought into operation without delay in the event of an emergency.
- (6) Verify that the emergency training and drills conducted are commensurate with the potential magnitude of credible reactor facility emergencies.

- (7) Verify that if necessary, provisions have been made for timely dissemination at the appropriate level of accurate, reliable, and readily understandable information to the public and to the media.
- (8) Determine whether adequate resources are available to support and implement the emergency plan.
- (9) Verify that sufficient personnel are available with appropriate training to:
  - (a) Cope with all credible emergencies;
  - (b) Protect, monitor, and decontaminate on-site personnel;
  - (c) Monitor the radiological and physical state of the facility, the site, and the environment;
  - (d) Return the reactor to a safe shutdown condition.
- (10) Verify that periodic, regular training drills including off-site organizations, as appropriate, are conducted to exercise the emergency plan and the emergency organization with records of the drills including critiques and recommendations for improvement.
- (11) Verify, for any real emergencies that have occurred, that suitable records of events including radiation levels and releases have been maintained and disseminated to operations personnel.
- (12) Verify that the emergency plan is reviewed on a regular basis.
- (13) Determine whether all credible accident scenarios have been considered in the emergency plan including:
  - (a) Severe natural phenomena (e.g. floods, earthquakes, hurricanes, tornadoes, and volcanic eruptions);
  - (b) Fires both on-site and off-site;
  - (c) Release of toxic or flammable substances on-site;
  - (d) Aircraft crash;
  - (e) Fuel meltdown due to flow blockage, loss of cooling or uncontrolled positive reactivity addition;
  - (f) Failure of a radioactive experiment;
  - (g) Civil disturbance.
- (14) Determine whether all pathways for radiation exposure and ingestion of radioactive materials have been considered in the emergency plan.
- (15) Determine whether off-site organizations are adequately trained and prepared to respond to reactor emergencies by such measures as:
  - (a) Holding periodic meetings with reactor operations staff members responsible for emergency planning;
  - (b) Maintaining awareness of modifications to the reactor facility;
  - (c) Conducting periodic reviews of the off-site aspects of the emergency plan;
  - (d) Inventorying resources and emergency equipment on a periodic basis;
  - (e) Training staff members periodically on the emergency plan;



- (f) Ensuring frequent communications with media representatives;
- (g) Conducting exercises at frequencies commensurate with the potential for off-site hazards.

### 3.22. DECOMMISSIONING

#### 3.22.1. Objective

To provide a basis for evaluating safety aspects of research reactor decommissioning [4, 41, 42].

#### 3.22.2. Guidelines

- (1) Determine whether provisions to facilitate decommissioning activities have been taken into account during the design and construction of the reactor, of the experimental devices and modifications, and whether further requirements for decommissioning, including the preparation of a detailed decommissioning plan, have been implemented by the operating organization.
- (2) Determine whether, during the operational life of the reactor, the operating organization and reactor management has:
  - (a) Maintained up-to-date reactor documentation;
  - (b) Recorded experience gained from handling contaminated and irradiated SSCs during maintenance to facilitate planning for decommissioning.
- (3) In the case that a detailed decommissioning plan has been prepared, determine whether it includes:
  - (a) A detailed set of decommissioning activities, tasks, and schedules;
  - (b) A decommissioning organization with assigned responsibilities;
  - (c) A training programme;
  - (d) Details of contractor assistance;
  - (e) Facility radiological status;
  - (f) Radiation protection;
  - (g) Radioactive waste management;
  - (h) Accident analysis;
  - (i) Final radiation survey plan;
  - (j) Cost estimate of the decommissioning method selected and funding provisions;
  - (k) Technical and environmental specifications in effect during decommissioning;
  - (l) Quality assurance provisions in place during decommissioning.
- (4) Determine whether the decommissioning plan includes an evaluation of appropriate decommission methods which might include:
  - (a) Protective storage in an intact condition after removal of all fuel assemblies and readily removable radioactive components and wastes;
  - (b) Removal of all radioactive materials and thorough decontamination of the remaining structures to permit unrestricted use.

- (5) Determine whether the decommissioning plan has been reviewed and approved by the regulatory body.
- (6) Determine whether reactor management is aware of the true technical and financial issues associated with the decommissioning process and whether the operating organization is capable to face them.



## APPENDIX I

### TYPICAL MAIN MISSION REPORT FORMAT

1. BACKGROUND
  - 1.1 History of the facility
  - 1.2 Summary descriptions of the facility and the utilization programme
  - 1.3 Summary of the Pre-INSARR mission
  - 1.4 Objectives and scope of the mission
  - 1.5 Basis for the review and documents provided by the counterpart
2. CONDUCT OF THE MISSION
  - 2.1 Method of conducting the review
  - 2.2 Review criteria
  - 2.3 Results of the facility walk-down
3. CONCLUSIONS AND MAIN RECOMENDATIONS

APPENDIX 1: ISSUE PAGES

ANNEX 1: AGENDA

ANNEX 2: LIST OF PERSONS MET DURING THE MISSION

### ISSUE PAGE FORMAT

<b>REVIEW AREA</b>
<b>ISSUE 01:</b>
<b>OBSERVATIONS:</b>
<b>BASIS AND REFERENCES:</b>
<b>POSSIBLE SAFETY CONSEQUENCES:</b>
<b>COUNTERPART'S VIEW AND MEASURES ON THE FINDINGS:</b>
<b>RECOMMENDATIONS:</b> <b>R1:</b>
<b>SUGGESTIONS:</b> <b>S1:</b>
<b>GOOD PRACTICES:</b> <b>GP1:</b>



## APPENDIX II

### CHECKLISTS FOR WALK-DOWN

#### A. HOUSEKEEPING

<b>A. HOUSEKEEPING</b>		<b>Comment</b>
A.1	Note the physical condition of the major building structures of the facility.	
A.2	Note housekeeping and cleanliness throughout the facility.	
A.3	Is portable equipment (ladders, scaffolding, heavy maintenance equipment, lifting and rigging equipment and fire protection equipment stored in designed areas when not in use?	
A.4	Are working areas tidy with equipment and materials neatly laid out?	
A.5	Are equipment and systems free of significant amounts of dust and debris?	
A.6	Are equipment identification tags labels provided for all equipment and readable and affixed in a secure and durable manner?	
A.7	Are garbage / trash containers readily available and tidy?	
A.8	Are parts and materials in inactive work areas not stored after work has been clearly completed?	
A.9	Are there any incompatible chemicals, flammable or toxic volatile materials stored in undesignated places in the facility?	
A.10	Chemical storage and bottled gas storage are correctly labelled for condition and content.	
A.11	Radioactive material storage areas are correctly identified, uncluttered and radiation fields identified	
A.12	Pools of water or oil are not evident in any areas.	
A.13	Is there a monitoring programme for housekeeping, cleanliness and a fire protection equipment checks?	
A.14	Is there evidence of routine facility walk-down by the reactor manager?	

<b>B. MAINTENANCE OF STRUCTURES, SYSTEMS AND COMPONENTS</b>		<b>Comment</b>
B.1	Managers and supervisors encourage reporting of minor deficiencies with equipment.	
B.2	Is there a formal work planning and work protection programme with suitable levels of procedures?	
B.3	Is the maintenance section appropriately sized and resourced?	
B.4	Are maintenance procedures satisfactory?	
B.5	Is there an adequate equipment maintenance, test and inspection programme and well archived historical record keeping?	
B.6	Is there an adequate spare parts system?	
B.7	Is there a satisfactory maintenance back log and tracking mechanism?	
B.8	Is there a balance between preventive maintenance and corrective maintenance?	

<b>C. INDUSTRIAL HEALTH AND SAFETY</b>		<b>Comment</b>
C.1	Protective equipment (respiratory and maintenance activities) and clothing storage area are well stocked and tidy?	
C.2	Eye wash facilities and eye protection equipment?	
C.3	Storage, use and disposal of hazardous chemicals.	
C.4	Confined space entry procedures?	
C.5	Scaffolding, hoisting and crane equipment procedures and training?	
C.6	Rotating equipment guards?	
C.7	Industrial training programme? (First aid, firefighting)	
C.8	Movable equipment and vehicle storage safety.	
C.9	Fire and smoke detectors and alarm system and personnel response, particularly in the off shifts.	
C.10	Water leakage detectors and alarm system and personnel response, particularly in the off shifts.	

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