



# STANDARDS FOR MODIFICATION OF RESEARCH REACTORS



Atomic Energy Licensing Board  
Ministry of Science, Technology & Innovation  
Batu 24, Jalan Dengkil, 43800 Dengkil  
Selangor Darul Ehsan

Tel: 03-8922 5888  
Fax: 03-8922 3685  
Laman Web: <http://www.aelb.gov.my>

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## INTRODUCTION

### OBJECTIVE

- 1.1 The objective of this standard is to establish requirements and provide practical guidance on the safety related aspects of the modification of research reactors such that these projects can be implemented without undue risks to personnel, the public, the environment or the reactor.

### SCOPE

- 1.2 The requirements and recommendations established by this document apply to modifications of research reactors. It covers all safety, security and safeguard aspects of a research reactor modification, such as modification project categorization, design, installation and commissioning, as well as regulatory requirements on review and assessment and approval of modification projects.
- 1.3 The modification shall not subject to safeguard requirement, unless it dealing with nuclear material, such as movement, handling and storing.

### INTERPRETATION

- 1.4 For the purposes of this Guideline, unless the context requires otherwise:

“Items important to safety” means item that is at of a safety group and/or whose malfunction or failure could lead to radiation exposure of the site personnel, or members of the public.

Items important to safety include:

- Structure, systems, and components (SSCs) whose malfunction or failure could lead to undue radiation exposure to site personnel or members of the public;
- SSCs that prevent anticipated operational occurrences from leading to accident conditions;
- Those features that are provided to mitigate the consequences of malfunction or failure of SSCs;

“*Structure, System and Components (SSCs)*<sup>1</sup>” means a general term encompassing all of the elements (items) of a facility or activity which contribute to protection and safety, except *human factors*;

“*Modification (or reactor modification)*” means a deliberate change in or addition to the existing reactor or experimental facilities, with potential safety implications, intended for continuation of the reactor operation. It may involve safety systems or safety related items or systems, procedures, documentation or operating conditions;

“*Operating organization*” means the organization authorized by the AELB to operate a specific reactor;

“*Operating personnel*” means individual workers engaged in operation of an authorized facility;

“*Operational limits and conditions*” means a set of rules which set forth parameter limits, the functional capability and the performance levels of equipment and personnel approved by the AELB for safe operation of the research reactor facility. They include safety limits, safety system settings, limiting conditions for safe operation, surveillance requirements, and administrative requirements”;

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<sup>1</sup> “**Structures**” are passive elements: building, vessel, shielding etc. “**System**” comprise several *components*, assemble in such way as to perform a specific function. “**Component**” is a discreet element of a *system*. Example of *component* are wires, transistors, intergrated circuits, motors, relays, solenoid, pipe, fitting, pumps, tanks and valve.

“*Quality assurance*” means all planned and systematic actions necessary to provide adequate confidence that an item or service will satisfy given requirements for quality;  
and

“*Regulatory Body*” means Atomic Energy Licensing Board;

## 2. SAFETY REQUIREMENTS FOR A MODIFICATION PROJECT

### Responsibilities of the operating organization

- 2.1. The operating organization shall have the prime responsibility on the safety of research reactor through its lifetime, including, modification. The responsibility of the operating organization on the safe planning and implementation of a modification project shall not be delegated, even if execution of the related tasks is delegated to an external organization (e.g contractors). The operating organization shall ensure that any contractor that may be involved in a modification project is made aware of and complies with the safety requirements established by the AELB.
- 2.2. In relation to modification of research reactors, the operating organization shall be responsible to ensure that all the requirements established by this document are achieved, including:
- Establishment of approved procedures for controlling modification projects;
  - Ensuring that the categorization criteria established by this document are applied;
  - Performing safety analysis of a proposed modification project;
  - Ensuring that quality assurance requirements are applied during all phases of a modification project;
  - Ensuring that reactor safety documents are followed and kept up-to-date;
  - Ensuring that the requirements for review and assessment and approval are met.
- 2.3. The operating organization shall be responsible for all the management aspects of the modification project. These include establishment of the objectives and the structure of the project with definition of the responsibilities, functions, and duties of different involved persons and groups, and for allocation of adequate resources.

- 2.4. The operating organization shall ensure that proper safety precautions and controls are applied with regard to all persons involved in the implementation of modification, and with regard to the public and the environment. These include provision of advance information and training with regard to radiological hazards, appropriate use of radiation protection and measuring devices, and the appropriate recording and evaluation of the radiation doses incurred.
- 2.5. The operating organization shall ensure that all persons who will be involved in making the modification are suitably trained and qualified, and have experience in such work. Arrangements shall be made to ensure that the reactor manager is actively involved in the planning and implementation of modification projects. Depending on the type of a modification project, a project manager may need to be appointed. The reactor operating personnel shall be involved in different stages of a modification project and should be trained with respect to the effect of such modification on the reactor safety and operation.
- 2.6. The operating organization shall update all reactor safety documents, such as the safety analysis report, the operational limits and conditions, and the relevant operation, maintenance and emergency procedures.

### **Categorization criteria and approval routes**

- 2.7. Any proposed modification shall be categorized on the basis of its importance to safety under one of the following two categories:
- Category A: Modifications that:
    - (i) Involve changes in the approved operational limits and conditions,
    - (ii) Affect items important to safety, or
    - (iii) Entail hazards different in nature or more likely to occur than those previously considered.

- Category B: Modifications that are not categorized as Category A.

- 2.8. Modifications of Category A require review and approval from the reactor management and the licensee safety committee and shall not be implemented before approval has been obtained from the AELB.
- 2.9. Modifications of Category B require review and approval from the reactor management and the licensee's safety committee, with written notification to the AELB at least one month before the implementation of such modifications. Records of modification under this Category shall be reviewed at intervals by the AELB to ensure that there are no disagreements in the interpretation of the criteria for approval.
- 2.10 Installation of a new experiment or experimental device (or changes to an existing one) shall also be considered as a modification project. Some of these projects may be categorized under Category A (e.g. installation of in-core irradiation devices, high pressure and temperature loops, cold neutron source). This type of experiments shall be subjected to a similar treatment as modification under Category A, as specified in the document. Some others may be categorized under Category B (e.g. repetitive or similar sample irradiations, minor modification to an existing experimental device).

### **Specific safety requirements**

- 2.11. Figure 1 shows the overall process for a modification project of Category A. This process may differ according to the type of modification to be conducted. Figure 1 also indicates the interaction between the operating organization and AELB during different stages of the project implementation.
- 2.12. Modifications under Category A shall be subjected to safety analysis and Quality Assurance Program (QAP) for design, fabrication, installation, and commissioning in order to ensure that they satisfy the same requirements as the existing facilities.

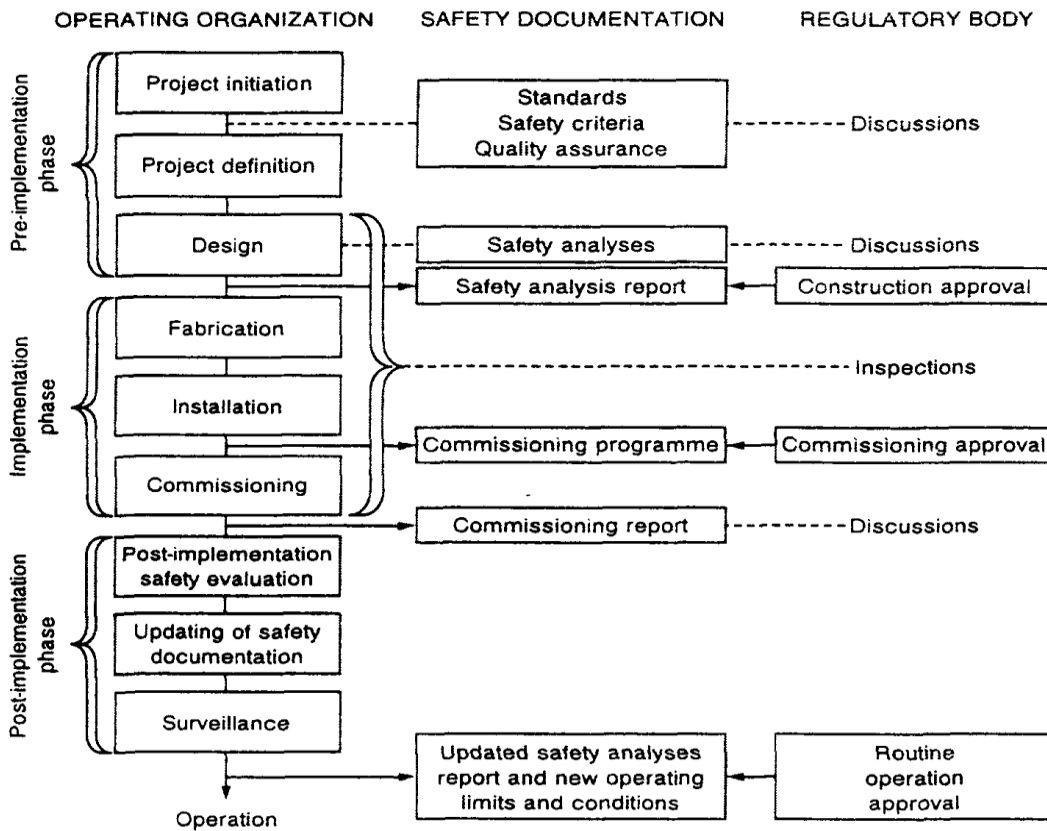


Figure 1: Flow chart indicating interaction between the operating organization and AELB for the approval process of Category A modification projects

- 2.13. General and specific requirements for design of a category A modification project are provided in Appendix 1. Guidelines and further discussions on the various activities that will have to be considered during the different stages of a typical Category A modification project are provided in Annex 1.
- 2.14. Some modification projects may involve dismantling of existing irradiated (and/or contaminated) components. No project can be approved before establishing how the irradiated (and/or contaminated) components will be dismantled, handled, safely stored and disposed. Appendix 2 provides the requirements for dismantling, handling, storing

and eventual disposal of irradiated components in connection with a modification project. Radiologically contaminated components shall be handled according to the radiation protection and radioactive waste management program, as specified in the safety analysis report.

### **3. REGULATORY REVIEW AND APPROVAL**

- 3.1. Reference is made to Figure 1, which indicates the necessary interaction between the operating organization and the AELB during the planning and implementation of Category A modification projects. The operating organization shall inform the AELB on any proposed modification at an early state of the process (at the project definition stage).
- 3.2. The approval process of a modification project shall be performed at different appropriate stages as indicated in Figure 1. The approval of routine operation of a modification project will be based on the results of its commissioning stage. In addition to the approval of routine operation, some modification projects may also require construction and commissioning approval (see Figure 1). These projects require hold points during their implementation for regulatory review, assessment and for the approval process. In these cases, the hold points shall be determined by the AELB and discussed with the operating organization during the pre-implementation phase. Some other projects may only require revision of the safety analysis, for example, proposed change to a safety system setting, which normally does not require fabrication, installation or commissioning stages.
- 3.3. Schedule indicating the time-scale for submitting safety documents for regulatory review and assessment shall be determined by the operating organization on a case by case basis and has to be agreed upon by the AELB during the pre-implementation phase of a modification project.
- 3.4. For obtaining a construction approval, the operating organization shall submit to the AELB information which demonstrates that the design of the modification will result in a safe facility and that construction will achieve the design intents. Application for construction approval shall be supported by a revised safety analysis report (or safety analysis report for modification) which includes the following information related to the modification project:

- a) A description of the purpose of modification;
  - b) A justification for the necessity of the modification;
  - c) A description of the structure of the organization set up for the project and the responsibility and duties of the involved groups and personnel;
  - d) The requirement and criteria for design;
  - e) A list of new or modified safety devices connected to the reactor;
  - f) Revised safety analysis that considers each credible failure mode of the modified SSCs as a postulated initiating event for a new event scenario;
  - g) Revised operational limits and conditions based on the results of the safety analysis;
  - h) Revised radiation protection program which take into consideration the modified SSCs and the relevant activities of the modification project, including its normal operation;
  - i) A description of the need for the disposal of radioactive waste generated in connection with the modification project;
  - j) A description of the manufacturing and installation processes involved;
  - k) A description of the commissioning process;
  - l) A description of the training program designed to enable the reactor operating personnel to cope with unusual operation during the implementation of the project;
  - m) The preparation of all documentation, including any new or temporary emergency procedures and the associated staff training program;
  - n) Quality Assurance Program that covers different stages of the modification project;
  - o) A list of the relevant documentation that needs to be updated;
  - p) A special surveillance program if this is necessary for design verification;
  - q) Schedules for implementation phases of the modification.
- 3.5. For obtaining a commissioning approval, the operating organization shall submit to the AELB information which demonstrates that the modified SSCs were installed according to the design intents and the commissioning programme is designed to check and verify the safety of the modified reactor. Application for commissioning approval shall be supported by a revised safety analysis report for modification that includes all the

information indicated above, as amended, and a commissioning programme for modification.

- 3.6. For obtaining the approval for routine operation of a modified reactor, the operating organization shall submit to the AELB all the information indicated above, as amended, as well as the commissioning results including an assessment that the design intents of the modification project have been achieved.

#### **4. SECURITY AND SAFEGUARDS REQUIREMENTS**

- 4.1 The operating organization shall provide the information on security and safeguards to AELB prior to the commencement of modification activities, regardless of whether these activities involve nuclear material.
- 4.2 The operating organization dealing with nuclear material and single use technology is subject to the safeguards agreement and any protocols agreed and shall submit to the AELB the information and data necessary for compliance with the undertakings by Malaysia arising from such instruments.
- 4.3 The operating organization conducting activities or practices utilizing nuclear material or radioactive material is primarily responsible for ensuring the security and physical protection of such materials pursuant to applicable regulation and license conditions.
- 4.4 The design of the proposed modification shall be adequate to protect the installation from the malicious act in order to eliminate the danger to life, property and the environment;
- 4.5 All measures shall be take prior to any particular modification to ensure the security and protection of the nuclear installation to prevent lost, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving radioactive material and nuclear material or their associated facilities.
- 4.6 Procedures for the implementation and fulfillment of Safeguards requirements for any modification involving nuclear materials shall be in place prior to project implementation.

## **SPECIFIC REQUIREMENTS**

### **Security**

- 4.7 The proposed security measures during the entire period of the modification to prevent or mitigate the effects of accidental releases of radioactive material to the environment, the health and safety of persons shall be submitted to AELB prior to implementation of modification project.
- 4.8 Periodic security review shall confirm the modification activity will not tolerate the security of the nuclear installation.
- 4.9 The operating organization involve in modification shall establish requirements for the physical protection of nuclear material and radioactive materials, including:
- (a) a categorization of material based on an assessment of damage that could result from theft or diversion of a certain type and quantity of material from authorized uses or sabotage of a facility utilizing that material;
  - (b) a system of inspection and monitoring to verify compliance with applicable physical protection requirements;
  - (c) protection measures necessary for different categories of material; and
  - (d) protection measures necessary or associated installation.

### **Safeguards**

- 4.10 The operating organization involve in modification shall establish requirements for the accounting of nuclear material including a system of accounting for and control of nuclear material (SSAC).

4.11 The operating organization shall also establish record for radioactive material inventory.

4.12 The operating organization shall provide upon request to the AELB:

- (a) safeguards information;
- (b) physical access;
- (c) facilitating the performance of inspectors in their tasks; and
- (d) rendering services requested by inspectors.

4.13 The SSAC shall ensure the effective conducts of safeguards in Malaysia by establishing and implementing:

- a) A system for the measurement of nuclear material;
- b) A system for the evaluation of measurement accuracy;
- c) Procedures for reviewing measurement differences;
- d) Procedures for carrying out physical inventories;
- e) A system for evaluation of unmeasured inventories;
- f) A system of records and reports for tracking nuclear material inventory and flows;
- g) Procedures for ensuring that accounting procedures and arrangements are being operated correctly; and
- h) Procedure for reporting to the IAEA.

## GENERAL AND SPECIFIC SAFETY REQUIREMENTS FOR DESIGN

### GENERAL SAFETY REQUIREMENTS FOR DESIGN

- A.1.1 A Category A modification project shall be justified in that:
- (a) it can fulfill a necessary task;
  - (b) it can be installed and operated without compromising the safety of the reactor;
  - (c) during operational states the radiation exposure of the site personnel and members of the public remains within the dose limits, and, moreover, as low as reasonable achievable (ALARA);
  - (d) any equipment can be stored or disposed of safely after decommissioning; and
  - (e) the amount of produced radioactive waste is limited.
- A.1.2 In addition to the normal operations, such as startup, other situations should be considered for their effects on the modifications; including unscheduled shutdown followed by immediate startup, maintenance, extended shutdown, fuel changes, core configuration changes and failure of electric power and other utilities. The effects of all states of a modification project on the reactor shall be considered.

### SPECIFIC SAFETY REQUIREMENTS FOR DESIGN

#### Reactivity

- A.1.3 If human error or failure of a modified system can lead to an increase in the reactivity of the reactor, the modification shall be designed so as to limit the positive reactivity effects to those which can be responded to safely by the reactor shutdown system;

## APPENDIX 1

- A.1.4 The reactivity worth of reactor modification shall be estimated in all situations (e.g. installation, removal and failure) in order to evaluate related hazards;
- A.1.5 The reactivity worth of modified systems shall be within the authorized limits and conditions.

### **Radiation Protection**

- A.1.6 The modification should not affect the overall radiation protection concept of the initial design, particularly the reduction of doses to levels that are as low as reasonably achievable (ALARA principle).
- A.1.7 Radiation protection provisions (shielding, ventilation, monitoring devices, etc.) are normally incorporated into the reactor design. If the modification would affect these provisions, then additional measures may be necessary to reduce the dose to personnel due to the implementation of this modification project.
- A.1.8 If it is found to be necessary, barriers additional to those in the original design should be provided in order to contain radioactive or any other materials that could pose a hazard if released. If failure of the modified system could lead to degradation of either the original system or the additional system of barriers to the release of radioactive materials, the effects of such accident shall be considered in the design.
- A.1.9 The potential for uncontrolled release of radioactive material shall be limited and amounts of such material released shall be minimized by measures such as the use of delay tanks, filters or recirculation. This applies to all stages of the project, including installation, normal operation, and removal, storage and shipment of modified systems.

## **APPENDIX 1**

### **Safety Devices**

A.1.10 Whenever possible, modifications shall be designed to minimize the need for active safety devices (e.g. by the use of inherent safety features, passive systems and fail-safe design).

A.1.11 If safety devices are interconnected with the reactor protection system, they shall be designed so as to maintain the quality of the reactor protection system. The possibility of deleterious interactions of the safety devices with the reactor protection system shall be assessed.

### **Cooling**

A.1.12 Special consideration shall be given to the impact of the modification on the cooling capabilities and possible deterioration of the capability of heat removal from the reactor core.

### **Pressure**

A.1.13 Precautions shall be taken against the possible effects of high pressure in the modified systems on the core itself.

### **Selection and Compatibility of materials**

A.1.14 An appropriate safety margin shall be adopted to allow for the anticipated properties of materials at the end of their useful lifetime. The design shall provide for monitoring materials whose mechanical properties may change in service owing to such factors as corrosion or radiation induced damage. Special attention should be paid to the possibility of incompatibilities between materials under the conditions of use which could lead to a failure of containment.

### **Flux Perturbations**

- A.1.15 Neutron flux perturbations shall be evaluated, especially in the vicinity of safety related devices (e.g. neutron detectors).

### **Mechanical interactions**

- A.1.16 Vibration of modified components due to water flow shall be considered. Special attention should be paid to resonance frequency vibration.

### **Protection against External Hazards**

- A.1.17 The design of modifications should include measures to mitigate the effect of earthquakes, fires, explosions, etc., as applicable.

## APPENDIX 2

### SAFETY CONSIDERATIONS IN THE HANDLING, DISMANTLING, STORING AND DISPOSAL OF IRRADIATED COMPONENTS IN CONNECTION WITH A MODIFICATION PROJECT

#### GENERAL REQUIREMENT

- A.2.1 Procedures for handling, dismantling, storing, and eventual disposal of irradiated components in connection with a modification project shall be established at an early phase of the project.
- A.2.2 A safety evaluation for all operations connected with the handling, dismantling, storage or disposal of irradiated components shall be prepared and submitted for approval.
- A.2.3 The operation tools for the handling, dismantling and safe storage or disposal of irradiated components shall be procured and tested before the operational phase of the project begins.
- A.2.4 The radioactivity and contamination levels of irradiated or contaminated components shall be evaluated in advance. This evaluation includes estimated or measured values using appropriate calibrated radiation monitors. The worst possible combination of component failures and human errors shall be assumed in the evaluation process. The radiological hazards should be assessed for all relevant conditions. The radiation protection measures (e.g. shielding, cleaning of air, decontamination procedures and use of movable installations to facilitate handling operations) shall be demonstrated to be adequate to deal with the worst possible situation.

## APPENDIX 2

- A.2.5 A careful inventory shall be kept of material, samples, equipment and devices put into the reactor, and they shall be retrieved and accounted for at the end of their irradiation. This inventory should also include the measured or estimated radioactivity.
- A.2.6 The operation should be planned such that the personnel exposures and the amount of radioactive materials released are minimized.
- A.2.7 Measures necessary to prevent contamination of the reactor systems shall be developed and their effectiveness shall be verified.
- A.2.8 If the irradiated component can release airborne contamination, a handling process to prevent this release shall be developed (e.g. by keeping the material in leak-tight containers or by providing a system of negative pressures and filters).
- A.2.9 Decontamination procedures should be developed for all surfaces the irradiated equipment. The storage or disposal of decontaminants should be ensured

### SPECIFIC REQUIREMENTS

#### Storage

- A.2.10 If the irradiated component of the dismantled installation is to be stored on the site, the volume and the characteristics, including the measured or estimated activities of the materials to be stored, shall be evaluated and the storage available shall be shown to be suitable.

### Training

- A.2.11 All operating instructions and procedures shall be known to the reactor operating personnel. The documentation describing these procedures shall be available throughout the time of handling, dismantling, and storage of irradiated elements until final disposal.
- A.2.12 The personnel performing the handling, dismantling, and storage of irradiated components shall be given the necessary training in all aspects of these operations, including, if necessary, exercise with mock-ups, before works with irradiated components is undertaken. A method of determining the effectiveness of training should be in place.

**GUIDELINES ON VARIOUS ACTIVITIES TO BE CONSIDERED DURING DIFFERENT  
STAGES OF A TYPICAL MODIFICATION PROJECT**

**A. PRE-IMPLEMENTATION PHASE OF A MODIFICATION PROJECT**

**1. PROJECT INITIATION**

1.1 The requirement for a modification can arise from different groups of persons, such as the reactor management, the regulatory body, experimenters, equipment suppliers, etc.

1.2 It is extremely important that the general concept should be discussed by the reactor management and the AELB at an early phase of the project. It may also be appropriate to include other groups, such as the safety committee, experimenters, equipment suppliers and independent consultants.

**2. PROJECT DEFINITION**

2.1 The project definition stage involves the development of the specific objectives and the scope of the proposed modification and provides the starting point for the technical design.

2.2 Limiting conditions, safety criteria and quality requirements with regard to the implementation of the project should also be developed during this stage.

2.3 The project definition stage shall also deal with general organizational and administrative arrangements for the subsequent project steps. At this stage, the AELB should be involved in the project.

### **Safety Codes and Standards**

The applicability of existing relevant safety codes and standards should be evaluated, and in some cases development of some additional codes and standards may be required.

### **Data Collection**

The use of relevant technical data and information on material properties, process characteristics, etc., as input in the design stage is essential to the quality and safety of modification.

The existing up-to-date documentation for the facility, component or software, including all modifications, is required for establishing a pre-design database. A review of this documentation should be made. This may require physical inspection of the equipment affected by the modification, and an evaluation of the operational and maintenance history of this equipment to verify that the documentation is up to date.

The establishment of the database may also require specific measurements or tests, carried out on relevant reactor systems, in order to complete or update the information. Verification of historical data may be of importance, and the data should be carefully authenticated.

Inclusion of information on similar modification carried out elsewhere may provide an important contribution to the database.

### **Pre-design Appraisal**

The design process is usually an interactive operation. For large, complicated and/or expensive projects, several technical options should be evaluated.

This appraisal will provide the basis for a subsequent evaluation of the safety and the technical and financial feasibility of the modification and justification of the chosen option.

The appraisal of options should cover not only the hardware for the modification (equipment, materials, etc.) but also the implementation and the operational, decommissioning and disposal aspects. These may determine the degree of interference with normal reactor operation, the required radiological safety precautions, the volume of radioactive waste, etc., and thus may affect the safety, effectiveness and costs of the project.

A technical description and a preliminary safety analysis should be provided for each option. A review scheme for comparisons between the available options and for selection of the optimum solution should be provided.

### **3. DESIGN**

3.1 During the design stage the chosen option should be developed into a fully documented and justified design of the modification.

3.2 Thus, project plans, specifications, design assessments, safety analyses, detailed drawings for manufacture and installation and all associated documentation should be produced at this stage. Commissioning, post-implementation safety evaluation and surveillance requirements should also be determined during the design stage.

3.3 A QA program should be established and implemented, covering all aspects of the design, including inspection and testing methods, installation, construction, etc.

3.4 For the design, measures should be established and documented to ensure that the applicable codes, standards and regulatory requirements are correctly incorporated into the design documents for safety related items.

3.5 Measures should also be provided for verification of the adequacy of design. This verification should be performed by individuals other than those who made the original design.

3.6 Detailed safety analyses, should be provided, to the extent necessary for the potential hazard. The analyses should determine whether the design will be safe, in particular showing:

- (a) That the new system or component complies with all relevant safety standards and that it will function safely, for all conditions of operation,
- (b) The new systems will not adversely affect the safety characteristics of other items important to safety under any conditions of operation, of the safety relevant characteristics of the reactor system,
- (c) That the modification can be carried out without significantly increasing the doses to personnel and to members of the public; this should be in accordance with the ALARA principle or with the risk of an accident, and
- (d) That the modification can be carried out without adversely affecting the safety of reactor operation, if this continues during the implementation, and that it will not introduce new hazards as a consequence of the implementation scenario and methods.

3.7 Care should be taken that up-to-date safety documents and data are used in these analyses.

The following information shall be fully documented:

- (a) That the introduction of the new system does not adversely affect the consequences, in terms of radiological or other hazards, for any conditions of reactor operation, and
- (b) That failure of the new system does not result in any new event scenario with significantly increased risks (different failure modes may have to be considered).

3.8 At the end of this analysis an updated version of the reactor safety documentation shall be produced.

3.9 The need for formal licensing or approval of modifications shall be considered at this stage.

## **B. IMPLEMENTATION PHASE OF MODIFICATION PROJECT**

This subsection covers the fabrication, installation and commissioning stages of the approved projects. Not all requirements are relevant for some projects, for example in cases where the project only involves changes to procedures.

Each stage of the project should be clearly defined and should be understood by all persons involved. In particular, the transition points between stages should be formally acknowledged.

## **4. FABRICATION**

4.1 For the fabrication stage of the project, measures should be established for:

- (a) the controlled procurement of materials,

- (b) the controlled development, revision and use of documents and drawings,
- (c) the controlled processing of materials, and
- (d) For the inspection of such activities.

4.2 New components or existing ones that have to be modified are generally fabricated or modified by suppliers in accordance with the detailed specifications (including accident criteria) that have been established during the design phase.

4.3 Before selecting a supplier, the project manager shall ensure that the supplier has gained the necessary experience for the work and is aware of all particular constraints of the projects, including QA requirements. Preliminary visits to the supplier are generally indispensable.

4.4 During fabrication, technical and quality audits shall be conducted in order to check all aspects, such as deviations from specifications, quality control and deadlines.

## 5. INSTALLATION

5.1 Measures should be established for the control of installation of equipment, and any radiation problems shall be taken into consideration.

5.2 Installation shall not commence before approval has been obtained from the AELB.

### **Management**

5.3 The management of the installation stage of the project shall cover at least the following:

- (a) Clear identification of all responsibilities, including those related to QA and radiological protection,

- (b) Frequent progress/information meetings with all (technical, operational and health physics) staff involved in or affected by the implementation,
- (c) Clear procedures with respect to the control (reporting, assessment and disposition) of deviation from approved methods and specifications or from the expected behavior,
- (d) Measurement and registration of all characteristics of the system as built; this is required for updating relevant technical documents and procedures,
- (e) Training and provision of information to internal and external staff with respect to the implementation scenario, methods, safety aspects, safe working practices, etc,
- (f) Contingencies in the project plans to accommodate unforeseen events and operational incidents which may require a revision of the working schemes.

### **Safety Aspects**

5.4 Development of the designer's safety evaluation of the installation is required and should be based on a detailed installation plan, describing activities, methods, temporary provisions, etc.

5.5 Technical or administrative measures or precautions to minimize risk during installation shall be prescribed, giving detailed procedures, and enforced.

5.6 Specific safety topics that have to be considered for the installation stage are related to:

- (a) External exposure to radiation,
- (b) Radioactive waste management, including transport, decontamination and dismantling aspects, as applicable,
- (c) Provisions required to prevent the spread of contamination and internal exposure to radiation,
- (d) Safe storage of the fuel during the modification period,

- (e) Industrial hazards, such as high voltage, vacuum, working in high places, fire, and use of chemical and of potentially dangerous tools;

5.7 Special temporary emergency procedures may have to be drafted, approved and exercised in cases where potentially hazardous situations have been identified in connection with the reactor facility conditions during installation.

### 6. COMMISSIONING

6.1 Commissioning of an approved project, which may include pre-installation tests of experimental devices and equipment, should be aimed at demonstrating the functionality and safety of the project.

6.2 Testing of experimental devices and equipment prior to installation in the reactor should be performed. Tests should be planned as part of the original design of the modification.

6.3 The safety of an implemented modification shall be verified through a commissioning program prior to and during implementation of the modification.

6.4 The adequacy of a specific commissioning program should be reviewed by the operating organization with respect to the following objectives:

- (a) Determination (by measurement under realistic conditions) of all reactor characteristics relevant to safety with respect to both the changed system and the reactor systems (in particular all items important to safety),
- (b) Verification (on the basis of measured data) of the relevant safety requirements,
- (c) Provision of additional information and data from commissioning and opportunities for familiarization and training of operating and maintenance personnel; and

(d) Adjustment of the reactor systems, affected by the modification, for optimum performance.

6.5 The completion of the modification project shall include a check to confirm that all temporary connections, procedures, arrangements, etc., which were necessary for implementation, have been removed or cancelled and that the facility has been returned to full operational status.

6.6 The basis for operational approval of the modification for routine operation shall be the successful completion of the commissioning stage, and the verification of all information and experience against the requirements of the design. A commissioning report should be produced and reviewed by the reactor management and safety committee, before submission to AELB

### **C. POST-IMPLEMENTATION PHASE OF MODIFICATION PROJECT**

#### **7. POST-IMPLEMENTATION SAFETY EVALUATION**

7.1 During the commissioning stage of the project, sufficient data should have been collected to allow verification of the safety assessment.

7.2 Some projects may, however, require a certain period of operation before sufficient information on their effects on the operation, reliability and safety of the reactor can be obtained and evaluated. In these cases, a post-implementation evaluation after a suitable trial operation period may be required. The need for such a post-implementation safety evaluation shall be identified during the design phase.

7.3 The required measurements and the evaluation methods and criteria should be specified in the project plan. Such activities can be seen as an extension of the commissioning stage before full operation.

**8. UPDATING OF SAFETY DOCUMENTATION**

8.1 The safety documentation shall be revised, to include the description of the modified reactor, taking into account the safety analysis performed, and it shall also account for results from the commissioning process. These documents are used as a basis for approval for normal operation of the changed facility. Obsolete safety documentation shall be removed from services and archived.

8.2 The safety documentation should be written and maintained according to the IAEA Safety Standards Series No NS-R-4.

**9. SPECIAL SURVEILLANCE**

9.1 The safety justification for certain modification may be dependent on technical or material characteristics that may be affected by long term reactor operation through irradiation embrittlement, corrosion or other ageing effects.

9.2 In cases where such effects cannot be predicted with sufficient accuracy from previous experience or by analysis, a safety surveillance program may be required to monitor the behaviour of the relevant characteristics.

9.3 Any special surveillance requirements determined during the design stage shall be implemented.

## REFERENCES

1. INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection. 2007 Edition.
2. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety in the Utilization and Modification of Research Reactors, Safety Series No. SS 35-G2, 1994.
3. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Research Reactors, Safety Requirements No. NS-R-4