**SUPPORT REQUIREMENTS FOR SAFETY MANAGEMENT**

**FOR DECOMMISSIONING OF RESEACH REACTORS**

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**Abstract**

In Egypt there are two research reactors in operation, the first research reactor (ETRR-1) went critical in 1961. The second one (ETRR-2) has commissioned in 1992. Both reactors are owned and operated by Egyptian Atomic Energy Authority (EAEA) and controlled by Egyptian Nuclear and Radiological Regulatory Authority (ENRRA). As bases for controlling the construction and operation of the reactors, there are several regulations available. Individual experts and expert organizations (TSOs) should know and take into account the relevant legislation and regulations and the regulatory requirements that are in force in the country whose regulatory body is being supported. On the basis of lessons learned from other experiences, this paper provides some insights into areas that a regulatory body needs to pay attention during decommissioning. Also, the regulatory aspects of the decommissioning process, such as the need for good interaction between the operating organization and the regulatory body and the preparation of adequate technical and regulatory rules for all decommissioning stages are discussed. This work provides the regulatory body with the necessary areas for which TSO support/ advise during different stages of decommissioning process. These supports/ advices includes legal regulatory framework for decommissioning, decommissioning strategies**,** early planning for decommissioning, changes from operation phase to decommissioning, establish regulations and guides for decommissioning, immediate post shutdown activities,shutdown and preparation for dismantlement, preparation for dismantlement and acceptable end state .

In Egypt with lacking decommissioning experience, the regulatory body must also become acquainted with the subject, develop staff knowledge and a regulatory framework. Working from the beginning in a close relationship with the operator will help in anticipating regulatory changes that, in some cases, imply additional costs. This cooperation will add mutual confidence, and will also help to develop a safety culture in the decommissioned, which, in the long term, will also reduce costs.

1. **INTRODUCTION**

The word ‘decommission is defined in Nuclear Regulatory Commission (NRC) regulations (10 CFR 20.1003) as: "to remove a facility or site safely from service and reduce residual radioactivity to a level that permits: 1) release of the property for unrestricted use and termination of the license; or, 2) release of the property under restricted conditions and the termination of the license.”The regulator plays an important role in encouraging attention to future decommissioning activities. The prime role of the regulator is to ensure safety during construction, operation and decommissioning, and when a site is made available for reuse. The regulator may, however, be faced with key challenges in ensuring compliance of that decommissioning activities are with regulations. This establishes a need to consider decommissioning strategy, proposals and cost estimates. Features that reduce or limit the risk of exposure to staff and public during decommissioning are of interest to the regulator.

Organizations with responsibilities for safety and the control of radiation risks (regulatory body) may need to obtain expert advice from organizations or individuals external to their own organization. Many regulatory bodies have generally identified a need to use, to a greater or lesser degree, sources of advice external to themselves. The Fundamental Safety Principles state that a State’s regulatory body must maintain adequate technical competence to fulfill its responsibilities [1]. Individual experts and expert organizations should know and take into account the relevant legislation and regulations and the regulatory requirements that are in force in the State whose regulatory body is being supported. The provider of external expert support does not replace the regulatory body when providing support. In instances where the provider of external expert support will need to interact with interested parties, it should be made clear that the regulatory body has approved such contact and that the regulatory body retains its responsibilities and makes the final decision [2]. Regulation of decommissioning, unlike the operational phase, is dynamic in nature and there is a need for continuous changes and adjustments to be made in the regulatory process. In addition, the hazards associated with the various decommissioning operations are usually less than those in the normal operation of the facility and do not require the same degree of regulatory rigour. The experience obtained in this area has shown the need for flexibility in the way in which the decommissioning process is regulated. A graded regulatory approach may be used to take account of the different hazards presented in decommissioning and to appropriately utilize regulatory resources.

**NATIONAL TSO**

In October 2011, the Egyptian Nuclear and Radiological Regulatory Authority (ENRRA) were established as an independent regulatory body (with the entire NCNSRC staff members). The research staff members of ENRRA with the acquired experience since 1984 have undertaken R& D work in the field of radiological and nuclear safety and have taken the role of an internal TSO. Also, the regulatory function was undertaken through committees which are mainly composed of the research personnel. In 27 Nov. 2017 law 7/ 2010 has been revised in order to further separate the former NCNSRC to rejoin the EAEA as a partly scientific research center with no regulatory function named: Nuclear& Radiological Safety Research Center NRSRC. It is one of EAEA centers, established by law no 211 for the year of 2017 and found on July 1st 2021as a scientific research center with a future vision to serve as TSO with response to the RB and other relevant governmental organizations in Egypt and neighboring countries.

**2. LEGAL REGULATORY FRAMEWORK FOR DECOMMISSIONING**

States are required to establish a legal framework to regulate nuclear facilities and to establish a regulatory body [2]. The fundamental safety objective of protecting people has to be achieved without unduly limiting the operations of facilities or the conduct of activities that give rise to radiation risks. The number and types of facilities to be decommissioned present in the country, together with the types of decommissioning activities planned for the future, will influence the content of the legislation, as well as the extent of the regulatory infrastructure that is needed to ensure safety. States are also required to develop national policies and implementation strategies for safety and radioactive waste management including decommissioning. The legal framework will ensure that a regulatory body is established, that is given the necessary authority and is effectively independent from organizations in charge of the utilization and promotion of radiation technologies. The legal framework will also have to ensure that the adequate supporting infrastructure and appropriate supporting facilities and services such as training, personal dosimetry, environmental monitoring, calibration services and radioactive waste management are available. It will have to be ensured that sufficient human resources are available in the State to support the programme and that the necessary research and development work is being carried out.

**3. KINDS OF ORGANIZATIONS MAY NEED SERVICES FROM TSOs**

TSOs can provide the breadth and depth of services from technically competent experts needed to support many organizations, for example:

* Operating organizations
* Research organizations
* Reactor vendors
* Mining organizations
* Fuel fabrication
* Spent fuel treatment organizations
* Regulatory bodies
* Governments

**3. AREAS FOR TSO EXPERT SUPPORT [3]**

The areas for which TSO expert support may be necessary include the following:

* Research activities;
* Licensing, review and assessment (relating to the management system,engineering analysis, safety analysis or independent verification);
* Development of policy;
* Development of regulations and implementation of regulatory functions(e.g. inspections, enforcement, development of regulatory guidance);
* Advanced technical analysis and computer simulations and modelling;
* Technical evaluations of tenders and technical specifications;
* Emergency response support and guidance;
* Assessment and evaluation of different professional views, and ensuringtransparency in addressing these views;
* Testing, measurement, inspection and analysis services;
* Development of regulatory infrastructures;
* Technical support for meeting the obligations of international conventions;
* Legal or financial advice;
* Communications support;
* Staff training;
* Project management and administrative support.

**3.1. SPECIFIC AREA FOR TSO EXPERT SUPPORT [4]**

## **3.1.1 REGULATORY GUIDANCE**

Regulatory guides are normally issued by the regulatory body to recommend detailed operational and technical guidelines in order to ensure that legislative and regulatory requirements are satisfied. They are meant to explain to a licensee what the regulatory body considers to be good practice but may not necessarily represent obligations. Regulatory guides are subject to revision and amendment with changes in use of radioactive materials, technical developments, in national policy and changes in international and/or national radiation protection standards. The level of detail in regulatory guides may vary from one State to another one and is being influenced by several factors such as the number and extent of facilities and activities subject to the legislation. In some States, guidance is given on a case by case basis, but such a system is best applicable when only one or two similar facilities are subject to control.

**3.1.2. REGULATORY FRAMEWORK**

The decommissioning of a nuclear facility generally proceeds through the stages below. In some cases the work proceeds uninterrupted to the final end state, while in other cases there may be long periods of relative inactivity between stages. For instance, many nuclear power plants are located on multi-unit sites, and the other units continue to operate. In such cases the decommissioning activities may be limited to the first phase and portions of the second phase, where after the facility may rest in a safe storage state until all of the units are shut down and ready for full site decommissioning. The pace of activities may be dictated by the availability of funds or other strategic interests of the operator [6].

**3.1.3. DECOMMISSIONING STRATEGIES**

The following steps for establishing a strategy for decommissioning are common to all strategies:

* Identification of responsible person;
* Communicating with the regulatory authorities;
* Establishing timing and schedules;
* Collection of available radiological data on the facilities.
* Identifying the alternatives for the dismantling;
* Identifying the alternatives for waste management;
* Establishing the staffing and financial resources necessary;
* Collating the records and archives.

**IMMEDIATE POST SHUTDOWN ACTIVITIES:**

* placing the facility in a safe and secure condition;
* removal of fuel and other materials to a safe interim storage location;
* preparation of new procedures for shutdown activities, such as new radiation protection procedures;
* measurement and documentation of the radioactive inventory and its distribution.

**PREPARATION OF DISMANTLEMENT:**

* environmental impact assessment;
* new contractual arrangements with specialized contractors;
* clearly distinguishing systems and components that may be de-powered from those that are needed for ongoing functions, such as spent fuel cooling;
* removal of hazardous materials such as asbestos;
* decontamination of systems.

**DISMANTLEMENT:**

* dismantlement of systems, structures, components and buildings;
* shipping materials to a waste disposal site or a waste storage facility.

**SITE REMEDIATION:**

•removal of all residual radioactivity above acceptable levels for the chosen end state;

•final site survey.

**WORKING WITH THE REGULATOR**

The regulatory body is effective when it:

* Ensures that an acceptable level of safety is being maintained by the regulated operating organizations.
* Takes appropriate actions to prevent degradation of safety and to promote safety improvements.
* Performs its regulatory functions in a timely and cost-effective manner as well as in a way that ensures the confidence of the operating organizations, the general public, and the government.

**CHANGES FROM OPERATION PHASE TO DECOMMISSIONING**

Experience has shown that decommissioning is not simply an extension of operations, like a new operating mode. While the early stages after shutdown may resemble the activities during a normal outage, the operator will soon begin taking actions that will render the facility permanently inoperable. It is important that the management and staff of the facility understand the fundamental nature of the changes taking place during this phase. Actions will be taken that are effectively irreversible, and the operator’s staff must cope with the emotional effects that come with the realization that the facility will never operate again. New organizational and human factors issues are presented, such as the need to maintain key staff personnel and staff expertise and the need to maintain a safety focus during these changing times [3].

The need for having decommissioning plans prepared during operation is especially important in cases where a facility is unexpectedly shut down before the end of its useful life, perhaps because of economic reasons or political decisions or even an abnormal event that has resulted in serious plant damage. Having plans in place could avoid a long (and costly) hiatus while senior management decides what to do next. The plans will give the staff a new work focus that will help them overcome any emotional effects associated with the early cessation of operation of the facility. This will be true even if the plans have to be modified due to the circumstances of the shutdown.

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**SHUTDOWN AND PREPARATION FOR DISMANTLEMENT**

Final shutdown of a nuclear facility will normally be followed by a formal notification to the regulatory body and a public announcement of the shutdown. The operator may have authority under the previous operating license to remove fuel, removable core components and other radioactive materials to a safe interim storage location, such as a spent fuel pool. Before substantive decommissioning activities can begin the operator will need regulatory approval, and the operator must confirm that the broad strategic plans are still valid and that adequate financial resources are available for the immediate work ahead. The regulator will also want some reassurances regarding the operator’s plans for dealing with the organizational and human factors issues [4].

**EARLY PLANNING FOR DECOMMISSIONING**

A significant fraction of the world’s nuclear facilities has now entered the decommissioning phase; it includes nuclear power plants, fuel cycle facilities, research reactors and other research facilities and uranium mines. It was therefore appropriate that international attention was focused. Early planning should take account of the lessons learned from decommissioning experience and cover issues such as designing for ease of decommissioning and arrangements for providing decommissioning funds. Early planning for decommissioning is endorsed by the IAEA; this planning should lead to a formal decommissioning plan that describes which activities are intended.The technical topics and responsibilities to be considered in implementing and completing a decommissioning project successfully and within budget include those listed below (some of these topics, however, may not apply to very small, simple facilities):

* Definitions of job specifications for key staff;
* The identification and appointment of the decommissioning team members;
* Assigning roles and responsibilities to all parties, including contractors;
* Setting qualifications and undertaking training;
* Routine inspections and maintenance;
* The specification of work packages (for in-house work or for outside contractors);
* Work progress and reviews;
* Data collection, records and reports;
* Licensing and regulatory aspects;
* The selection and acquisition of special equipment;
* Safety management, including radiological and non-radiological hazards;
* Emergency planning;
* Establishing the necessary and appropriate quality assurance programme;
* Project completion records and archiving.

In addition to the technical planning and management of the project there will be a need for administrative support. The administrative management should address the following:

* + The provision and approval of the project budget;
  + Equipment procurement;
  + The recording and monitoring of expenditure;
  + Cost and schedule control;
  + The placing and control of contracts (if any);
  + Personnel services;
  + Publicity and external communications, if necessary;
  + The management of a records database.

For all decommissioning work, planning is needed, resources appropriate for the project need to be allocated and there needs to be a clear allocation of responsibilities. Even the relatively simple disposal of spent sources needs to be planned, coasted and implemented in a responsible manner.

**FUNDING OF DECOMMISSIONING**

The funding of decommissioning is a key issue and for many facilities it is the main reason for lack of progress in decommissioning. Ideally, arrangements should be made for funding decommissioning before a facility becomes operational. Unfortunately, this was often not done in the past and while decommissioning funds usually exist for civil nuclear power plants, for other types of facility they do not. In view of the long-term potential hazard to the public and to the environment presented by these facilities, they should be decommissioned and, in this context, the funding issue warrants serious attention. Of course, the responsibility lies with the operators and ultimately with national governments but the international organizations should consider what help they can offer in this area. Cost estimates were often not made in the past and funds for decommissioning were therefore seldom provided. This has been of particular concern to regulators and often the public as it becomes apparent that safety could be neglected when a facility shuts down and no longer generates benefit or income and hence becomes a liability to the owner. For this reason most regulators now insist on seeing arrangements and funding for decommissioning before licences or registration documents are issued for new facilities. The cost of waste disposal and interim storage can be significant and, as mentioned above, the reduction of the quantity of radioactive waste by segregation, decontamination and size reduction can be cost effective.

**SAFETY ASPECTS**

In regard to safety it is necessary that the regulatory body takes a holistic approach that incorporates the determination of best practice, compliance with the letter of the law, while ensuring the protection of property, the worker, and the environment is accomplished. Prior to the decommissioning plan on a regular basis prior to its implementation, the decommissioning organization should be required to update the plan and to ensure that it captures all events leading to exposures of the type that have arisen during the history of operation of the facilities. Record keeping and configuration control of the organization’s management system play an important role in this regard. The safety requirements for the different decommissioning options need also to be commensurate with the associated radiation hazards. The factors that need to be considered are [6]:

* Cost–benefit and safety considerations;
* The reuse of cleared facilities;
* The opportunity costs and allocation of financial resources;
* Decisions and strategies for effective radioactive waste management;
* The scenarios and criteria associated with clearance, reuse and recycling of materials;
* The impact of deferring decommissioning;
* Use of the appropriate technology and expertise.

**MANAGEMENT OF RADIOACTIVE WASTE FROM DECOMMISSIONING**

The licensee shall manage in the frame of its radioactive waste management programme all waste streams according to the national policy and strategy on radioactive waste management, including disused sources. Much of the waste produced during decommissioning and dismantling of nuclear facilities is similar to that produced during their operational lifetime, so a major part of this new challenge is already shared with current activities. The new element, characteristic of decommissioning specifically, is the large quantity of waste containing only small concentrations of radionuclides. This requires serious attention to development and application of principles by which valuable materials may be released from regulatory control for re-use or recycling, and the need for disposal as radioactive waste minimized. The management of specific wastes containing materials such as graphite, beryllium, sodium, asbestos, etc. will also need further attention.

**CLEARANCE OF MATERIALS FROM DECOMMISSIONING**

Clearance is: The release from nuclear supervision for unrestricted use (art. 37.2 Bs (3)). Note: Release from nuclear supervision does not relieve the owner of the re-leased material of the requirements based on general environmental legislation, such as requirements on the management of asbestos and chemicals, or on reuse. The vast majority of the material resulting from the decommissioning is inactive or below clearance levels and the use of clearance has the potential for saving considerable waste disposal costs. A step forward in achieving harmonization was achieved when the IAEA published its Safety Guide on clearance levels in 2004.

**DECOMMISSIONING OF SMALL FACILITIES**

Small facilities, such as research reactors and research laboratories, often present unique technical decommissioning problems. The financial and technical support available for the decommissioning of these facilities is usually limited and in countries with few or no other nuclear facilities this presents particular difficulties. This is an area in which the international organizations can be effective in providing advice and in facilitating the transfer of knowledge.

**TECHNOLOGY FOR DECOMMISSIONING**

It is evident that substantial savings of money and time can be achieved through learning from the experience of others. Various proposals were put forward on means to facilitate this transfer of knowledge between countries.

**KNOWLEDGE MANAGEMENT**

The timescales for many decommissioning projects are long and important knowledge may be lost, for example, of plant configuration and operating history, as experienced members of the workforce retire. Mechanisms for saving and managing this knowledge are required and this may be an area in which international cooperation can be effective.

**DECOMMISSIONING WORKFORCE**

It is recognized that there are often problems in retaining a knowledgeable and skilled workforce to do decommissioning work. Various ideas were put forward to help resolve this problem. They included ways of positively motivating the workforce through education and other means. One proposal was to promote the concept of professional qualifications in the decommissioning area-a Decommissioning Engineer- and to establish an internationally accepted curriculum for such a specialty.

**SOCIAL ASPECTS**

While the negative consequences cannot be fully avoided they can be reduced through the involvement of concerned parties. In many countries it is now common practice for operators of nuclear facilities, on a voluntary basis, to maintain information centers for the publican to issue regular information bulletins by way of websites, publications and other means. It is also now common for the regulatory bodies to publishdocuments describing the systems, procedures and the technical guidance theyapply to regulatory decisions. This should include information on:

* General background issues.
* Decommissioning policy and strategies.
* Waste management and material reuse considerations.
* Authorized release of sites and facilities.
* Securing long-term funding, and related responsibility.
* Framework for safety regulation of decommissioning.
* Social dimensions, including public and political relations.
* Decommissioning technologies.

**SUMMARY AND CONCLUSION**

This work has identified some of reported information and practical experience on the successful implementation of decommissioning projects. Important features and aspects that have special relevance to small facilities have been highlighted. It is concluded that careful planning and attention to detail, together with the implementation of the safety guidance given in Ref. [5], will result in the successful and safe implementation of decommissioning.

Operators and regulators will need to work cooperatively to ensure that the information is preserved and included in the design and operation of all new nuclear facilities, as well as on-going decommissioning projects. A decommissioning project requires concerted efforts to ensure safety throughout its duration and therefore, can, depending of the decommissioning strategy, to put resource constraints on a regulatory body. Some important considerations that should be taken into account are:

* Stakeholders, including governmental departments, should be involved at an early stage before the physical activities commence.
* The resources deployed by the regulator should be commensurate with the nature of the decommissioning activity to be undertaken.
* It is important to ensure that the decommissioning strategy is appropriate.
* The regulator should verify the radiation doses that are projected for the planned decommissioning activities, since predicted doses for certain activities may be on the conservative side.
* There should be a plan to segregate the radioactive waste generated during decommissioning; the absence of such a plan this could lead to the inadvertent release of contaminated material.
* The regulator must recognize the need to take account of the regulatory requirements.

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