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PRINCIPAL PROVISIONS OF THE DECOMMISSIONING CONCEPT FOR THE WWR-M RESEARCH REACTOR

The decommissioning Concept for WWR-M research reactor is developed to meet the requirements of the current Ukrainian legislation. The main goal of the Concept is to provide a strategic stage of the work planning, including all the required justifications with a sufficient level of detail. It will allow during the next planning stage to develop the decommissioning project and other documents required to obtain the decommissioning license. The Concept is the institutional and technical document, which defines and substantiates the basic administrative, organizational, and technical measures for the preparation and implementation of the reactor decommissioning. It also describes the main activities and works, defines the procedure, conditions for their implementation and provision, and planned deadlines.

Keywords: research reactor, decommissioning, dismantling, radioactive waste.

1. Introduction

The decommissioning of a research reactor, like that of any nuclear facility, is an integral and inevitable stage of the cycle. The essence of decommissioning is the consistent implementation of a set of administrative and technical measures aimed at the cessation of all activities related to the functional purpose of the reactor, and its transformation into an environmentally safe state that does not require control by the regulatory authorities. For any reason that leads to the reactor final shutdown, it is a mandatory stage of the life cycle and requires careful planning of both the decommissioning process as a whole and its individual components using a large amount of design documentation. According to international experience, decommissioning requires significant intellectual efforts and material costs, balanced planning, a special legal framework, careful organization, coordination and control of works, creation of the special infrastructure, implementation of innovative engineering solutions, and highly qualified personnel [1 - 3].

According to the current Ukrainian legislation, the operator at different stages of the life cycle of nuclear installation must be prepared for future decommissioning. At the end of 2020, a new normative document [4] came into force, according to which the Institute for Nuclear Research is obliged to develop the Decommissioning Concept for the WWR-M research reactor and submit it for approval.

The developed Concept meets the requirements of the normative document [4] and is based on the requirements of the current Ukrainian legislation and international standards for the safe use of nuclear energy. It meets the current scientific and technical level. It focuses on the needs of society in the future. The Concept was developed taking into account the recommendations of the IAEA [5 - 7] and the experience of countries implementing the decommissioning projects for the research reactors [8 - 13]. The Concept is aimed to plan and perform the decommissioning works on the WWR-M research reactor and spent nuclear fuel (SNF) storage, both located on the site of the Institute for Nuclear Research, as defined by the current operational license. The Concept corresponds to the ongoing decommissioning planning according to the IAEA classification [14]. The Concept defines and substantiates the basic technical and organizational measures for the preparation and implementation of the reactor decommissioning, the sequence of works and activities, and required conditions for their implemententtation and provision.

2. Selected decommissioning strategy

Decommissioning is the final stage of the reactor's life cycle and is to be performed by the termination or diversification of the buildings and structures, while removing the radioactive substances, and returning the site for unconditional use. At the same time, the safety and protection of personnel and the environment from the radiological and man-induced impact must be ensured undoubtedly. Decommissioning is a complex process that includes decontamination, dismantling of equipment, demolishing of structures, and radioactive waste management.

The Concept envisages a strategy of immediate dismantling based on the plans for further use of the reactor site [15, 16]. It is envisaged to use the reactor building with the "hot-cells" as a separate laboratory for the research and use of radiation technologies. It might be done after the transfer of the main reactor building, the part of the existing operational infrastructure, and auxiliary buildings to this laboratory. Results of the radiological survey [17] will be taken into account in the development of the technical design for the laboratory while determining the reactor equipment, systems, and premises that could and should be used for the needs of this laboratory, as well as which systems need upgrading/replacement and refurbishment. Needed modification of those premises must be scheduled during the dismantling works in accordance with the future functional purpose of such premises.

The initial state of the reactor site before the start of decommissioning is defined by the fact that the reactor is finally shut down after the normal operation, and both spent and fresh nuclear fuel are removed outside the site. Moreover: 1) all necessary decommissioning documentation is already developed and approved; 2) the contract awarded to a subcontractor on the removal of the decommissioning radioactive waste, including the waste acceptance criteria and the cost considerations; 3) the necessary equipment is purchased, established and tested; 4) systems and elements important to safety are commissioned; 5) required changes are made to the staff schedule; necessary reorganization has been arranged; there is sufficient amount of qualified personnel; all necessary training is performed; management system is established.

The end-state of the reactor site after the completion of decommissioning works is characterized by: 1) all buildings, systems, and elements, for those further use is not expected, is demolished and dismantled; 2) decommissioning radioactive waste is transferred for the recycling and disposal; 3) non-radioactive waste is removed from the site; 4) the reactor site is released from the regulatory controls following the lift of the restrictions for unlimited site use. Later it follows the transfer of the main reactor building, part of the existing infrastructure, and auxiliary buildings to the laboratory for research and use of radiation technologies.

According to the selected strategy, the following goals of the reactor decommissioning are defined:

risk minimization during the execution of decommissioning work; risk management foresees the elimination of pollutants or their displacement to the disposal facility, if necessary;

reduction to a minimum of the generated radioactive waste; this goal is achieved by means of decontamination of contaminated material, resulting in reuse or disposed as a waste of the lower category;

minimization of the decommissioning expenditures.

Taking into account the features of the WWR-M reactor, the main objectives solved by the Concept are the following:

perfect and timely planning of all types of activities;

use of the novel management methods for all kinds of decommissioning activities;

application of the nowadays technologies and technical tools;

definition of the safety requirements and work efficiency;

ensuring the compliance with the safety norms, rules, and standards, protection of personnel, population, and environment at all decommissioning stages;

permanent use of a system for the collection of information, processing, and storage, which may have a significant impact on the process;

ensuring a consistent decrease of the impact on the personnel, public, and environment by the implementing work in separate phases;

minimization of waste generation, recycling, and final disposal;

consistent release of the reactor site from ionizing radiation sources, currently under control, down to the exempt levels;

provision of the social protection to the reactor personnel;

public relations on the decommissioning challenges aiming the safety justification confirmation for the planned and executed activities.

The ideology of execution for decommissioning works implies the following principles:

execution of works by a limited amount of personnel, the number of working personnel will not exceed 40 - 45 people;

individual dose limited 10 mSv/year for the work execution, as determined by the established norms;

pollution of environmental objects adjacent to the Institute for nuclear research site and urban areas must be even less than the norms established for the public in the case of emergency situations;

generated radioactive waste should be characterized by a specific activity, placed into relevant transport packages at the place of the work execution, and transferred for long-term storage or disposal.

It is necessary to consider that the reactor site is located nearby the city residential area and the intensive transport routes, which imposes even more increased requirements for the organization and execution of the decommissioning works with the provision of radiation and environmental safety for the population [18].

3. Sequence of decommissioning work execution

3.1. General requirements for the planning and work performance

Decommissioning represents a set of measures after the removal of nuclear fuel and the final shutdown of a nuclear installation. It makes impossible further use for the purposes it was constructed and ensures the safety of personnel, the public, and the environment. The main measures that consist of the decommissioning project are the following: planning, ensuring of transition from the reactor shutdown to the decommissioning, decontamination and dismantling, radioactive waste management, and remediation of the reactor site [19 - 21]. All auxiliary measures such as project management, maintenance, supervision, physical protection, etc., also must be included in the inventory of decommissioning activities.

All decommissioning works are composed of different but typical types of technological activities. Practical implementation, evidently, requires a special scientific and engineering development and safety justification, environmental eligibility, practical implementation of the specific approaches, and basic technology based on the radiation safety principles. Specific features for dismantling works are determined by the following factors: the high-level radiation fields inside the premises as a result of contamination of systems and equipment by radionuclides; the need to perform dismantling works within a limited space of premises occupied with a variety of contaminated equipment; the need for dismantling and fragmentation in place of the large-scale systems and equipment before removing and transportation. Three basic principles are applied: 1) dismantling performed on room-by-room, but not on systems and components; dismantling performed in each room, independently of the systems; 2) dismantling starting from the less contaminated equipment to the more contaminated one; 3) minimizing the secondary radioactive waste (solid, liquid and aerosol).

It is reasonable to distribute all systems and equipment of the reactor into three groups, namely: 1) systems and equipment that will be fully dismantled during decommissioning; 2) systems and equipment that will be used during decommissioning; 3) systems that remain in operation (for the needs of the laboratory in the future). The first group includes the reactor vessel with the core; primary and secondary cooling circuits with the water purification system of the primary circuit; the control rod system; emergency cooling system and backup water supply; radiation protection system (concrete shielding); interim storage of the SNF BV-1; experimental devices. The second and third groups include power supply system; special ventilation and air filtration system; special sewage; fire-fighting system; physical protection system; heat supply system; the load-lifting devices and hoisting mechanisms; complex of heavy “hot-cells”.

Equipment dismantling includes the following main types of work:

dismantling of equipment (fully, as a single piece, disassembling on separate elements, fragmentation, etc.);

transportation of disassembled equipment, its elements, and fragments in the containers or without them between the areas inside the reactor building;

segmentation (size reduction) of equipment, its elements or fragments to smaller fragments, whose dimensions are determined by the technical characteristics of the technological equipment of subsequent operations.

The set of dismantling works is divided into two parts: the preparation for dismantling and actually dismantling itself, which includes the removal of material.

Preparation for dismantling includes:

survey of structures and constructions which are subject to dismantling;

study and coordination of working conditions;

technological performance project;

arrangement of the temporary shielding to prevent dust, garbage, and pollution;

preparation of access paths;

delivery and installation of equipment, the preparation of equipment setup for the temporary support of structures during dismantling.

Dismantling includes:

separation of parts;

removal of the separated parts, survey, sorting, and stacking;

demolishing of concrete structures;

separation of materials suitable for re-use;

shipment and transportation of materials from disassembling places to their further use.

The choice of dismantling technologies is based on the principle of maximal use of the mechanical (cold) methods for fragmentation that provide a minimal emission of radioactive aerosols into the atmosphere of technological premises and the environment during the dismantling work [19]. The main criteria for the optimal choice of technologies and instrumental tools for the practical implementation are the implementation of two mandatory conditions: 1) compliance with all radiation safety norms and labor protection; 2) technical, technological, and economic implementation of all important procedures and technologies within the reasonable terms.

All dismantling works will be conducted in a sequence that does not lead to an impact increase of any negative factors. The main attention at the dismantling works will be drawn to a) durability and stability of the structures remaining after the dismantling of the supporting and adjacent elements; b) prevention of falling for structures after removal of their supports (bolts or welding). There will also be effectively monitored charges/releases into the environment and the impact of dismantling operations on the interconnected systems and constructions and other work.

The dismantling works will be performed with increased safety requirements: using overalls, special footwear, and other means of individual protection, including respiratory protection if necessary. The dismantling works will be performed, as a rule, continuously, by the schedule, which provides the most efficient use of resources.

3.2. Activity for the preparation of decommissioning during the reactor operation

Still, during the reactor operation, there will be performed the set of works directed toward the preparation of decommissioning. The following measures are permanently under development:

classification, accounting, and forecast of the radwaste volumes, which will be generated during the reactor operation and decommissioning;

collection, processing, and storage of information related to the buildings, constructions, and the reactor systems and elements, which will be required for the reactor decommissioning;

works aimed at the preparation and removal of the SNF;

collecting the material and technical resources for the decommissioning;

development of the decommissioning documentation;

application and approval of the decommissioning license;

public relations on the decommissioning problems.

3.3. Termination of the reactor operation

3.3.1. Termination of operation before the spent fuel removal

The termination of operation (TO) is the stage preceding the decommissioning, namely, the final stage of reactor operation, which will be performed after the decision-making process about the reactor final shutdown. The basic goal of activity at this stage is the conversion of the reactor into the state when the SNF is absent on the rector site, i.e., SNF was removed from the reactor core and cooling pond for safe long-term storage [21].

Activities at this stage are to be performed under the operation license, but the implementation requires a separate permit. SNF is subject to removal outside the reactor after aging (the aging period is subject to clarification, but not less than 180 days). Operations for retrieval, storage, and reloading of spent fuel are the same as during the reactor operation and are performed in accordance with the current operational license. The technology of SNF reloading from the core to the storage pond has been developed for many years. After the selection of a place for permanent storage or processing of spent fuel and shipment conditions, transportation routes will be defined.

3.3.2. Termination of operation after the spent fuel removal

After the removal of SNF, the operational license will be canceled and cannot be renewed. The following decommissioning works will be performed in accordance with the decommissioning license, which does not foresee the SNF management. Thus, the following works and measures are foreseen during this stage:

TO-1: final shutdown of systems, which cannot be used;

TO-2: retrieval (drainage) of the working media from the technological schemes and equipment;

TO-3: discharge of the potentially hazardous substances, which are not required for future use;

TO-4: decontamination of the reactor systems and premises;

TO-5: retrieval and transfer to the conditioning of radwaste, which was accumulated during the reactor operation or generated at the termination of operation stage;

TO-6: execution of the radiological survey (complex engineering and radiation inspection) with the goal of data collection related to the engineering and radiation conditions; this information will be used during the development of the decommissioning documentation as well as at the planning and execution of decommissioning works;

TO-7: implementation of measures directed at the life support and maintenance of the systems, which will be in operation at the next decommissioning stages;

TO-8: the gathering of the material and technical resources for the final closure and dismantling stages;

TO-9: staff training for the decommissioning works;

TO-10: development of the decommissioning documentation, which is necessary for the permission to start the final closure stage;

TO-11: implementation of administrative and organizational measures corresponding to the changed status of the reactor.

TO-12: execution of other foreseen works and measures.

The final state of the reactor at the end of this stage is characterized by the fact that all spent fuel is removed from the reactor and the radioactive materials and sources of ionizing radiation are localized as follows:

within the protective barriers, which are the boundaries of reactor systems;

in the onsite storage, which is intended for temporary storage.

3.4. Final closure

The goal of the final closure (FC) stage is the reactor transformation into condition, which excludes its use as the neutron source. The reactor does not exist as the neutron source after the fuel removal from the core and the equipment of experimental channels is dismantled. Thus, the main goal of the stage will be reached.

The following measures are planned at this stage:

FC-1: creating an additional opening to the reactor hall (gate) to remove the dismantled elements;

FC-2: the dismantling of the experimental installations located at the reactor horizontal channels.

FC-3: dismantling of the external reactor systems, which don’t influence safety and are not needed at the dismantling stage;

FC-4: execution of additional radiometry and dosimetry surveys of the reactor premises; the creation of contamination maps;

FC-5: the creation of a more precise inventory of the radioactive contaminated and activated reactor systems;

FC-6: preservation and strengthening (if necessary) of the protective barriers assigned for the prevention of the contamination spread; reinforcement of shielding around the biological shield, especially near the gate valves;

FC-7: arrangement of the temporary storage places to simplify the equipment operation (use disengaged premises) – the area for the segmentation/decontamination/storage;

FC-8: retrieval, conditioning, storage, and transfer to disposal of radwaste generated at the stage of final closure;

FC-9: assembling, operation, and maintenance (with the subsequent dismantling) of the additional equipment assigned for the removal of radioactive and hazardous substances (if necessary);

FC -10: the gathering of the material and technical resources for the dismantling stage;

FC-11: development of the decommissioning documentation, which is necessary for the permission to start the dismantling stage;

FC-12: development of necessary design and technological documentation;

FC-13: implementation of administrative and organizational measures corresponding to the changed status of the reactor;

FC-14: execution of other works and measures foreseen by the implementation program for the given stage.

The final state of the reactor at the end of this stage is characterized by the fact that:

radioactive substances are localized within protective barriers, as well as in storage facilities for temporary storage;

a number of the reactor systems and elements have already been dismantled, those are not planned to be used at the dismantling stage. This does not allow to use of the reactor for the purposes it was built.

3.5. Reactor dismantling

The goal of the dismantling (D) stage is the segmentation and removal of the reactor systems and components as well as the removal of the radioactive substances outside the reactor site. For this goal the following works and measures will be performed:

D-0: decontamination of the areas and equipment for the facilitation of dismantling works;

D-1: dismantling of the reactor vessel;

D-2: dismantling of the primary circuit;

D-2-1: extraction of the heat-exchangers;

D-2-2: dismantling of the pipe-lines of the primary cooling circuit;

D-2-3: dismantling of the ion-exchange and electrophoresis filters;

D-2-4: removal of the contaminated components, which could be extracted after dismantling of other components:

D-2-5: removal of the “clean” auxiliary equipment (secondary cooling circuit);

D-3: demolishing of the biological concrete shield;

D-4: dismantling of other systems and components;

D-4-1: removal of contaminations from all areas and premises;

D-4-2: the dismantling of non-contaminated structures;

D-4-3: remediation of the reactor site (if necessary);

D-4-4: demolishing of buildings where no further use is envisaged.

D-4-5: remediation of the adjacent territory (where necessary);

D-4-6: execution of other works and measures foreseen by the implementation program for this decommissioning stage;

RW-1: radwaste management for the unconditional re-use or final disposal;

FS-1: execution of the final radiation survey of the reactor building and within the sanitary protective zone;

implementation of procedures directed on the termination of the regulatory control (development of the Final Safety Analysis Report) and the decommissioning license termination.

implementation of administrative and organizational measures corresponding to the changed status of the reactor site.

The final state after completion of the dismantling stage corresponds with the state, which should be achieved after the reactor's decommissioning. This state is characterized by the release of the site from the regulatory control with the subsequent elimination of conditions for unrestricted use.

The duration of stages of termination of operation, final closure, and dismantling will be about 60 weeks, depending on the availability of sufficient resources, technologies, and gained experience in dismantling work. The time schedule is shown in Fig. 1.

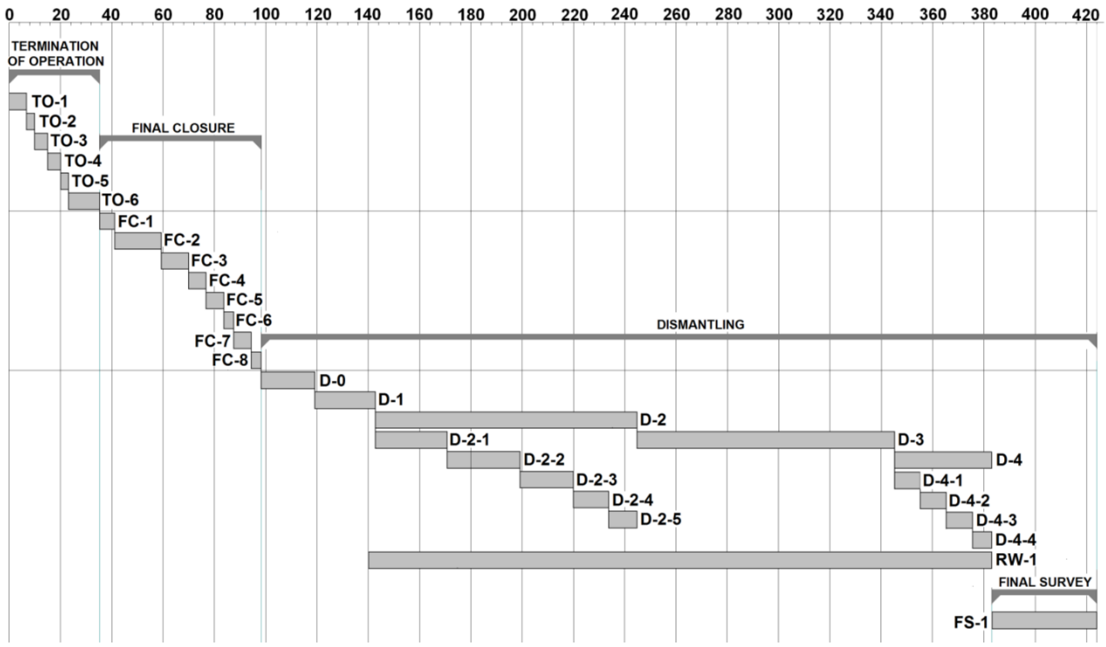

Fig. 1. The sequence of work at the decommissioning stages (time scale – working day).

4. Technical features of dismantling

The analysis of technical tasks revealed that the extraction of the reactor vessel should be considered as a key element in the sequence of dismantling works. The main difficulty in removing the reactor vessel is the radiation conditions caused by the neutron activation during the long-term reactor operation. This task requires detailed planning in order to reduce the staff exposure as low as achievable (ALARA). There are two main non-mandatory strategies for dismantling the reactor vessel: a) segmentation of the vessel; b) removal of the vessel as a whole (Fig. 2). For each of the alternatives, the following aspects were considered: the safety assessment; the technical aspects of the vessel lifting; the necessary construction modifications and demolition; the radiological consequences; the cost and time estimates. Removal of the reactor vessel as a whole was chosen as the best option [21 - 23]. The advantages are based on the following: the known technology; the existing ventilation system can be used without changes; the overhead crane in the reactor hall is in operation during the dismantling; better conditions in terms of radiation protection and safety [24, 25].

The heat exchangers can also be removed intact [26, 27]. This task can be solved by means of the technological hatch between the primary circuit pump-premise (in the basement) and the reactor hall. At first, the plates on the hatch should be removed. This will provide access to sufficient dimensions. Then the heat exchangers will be dismantled from the base support having the objective to lift them as a whole by means of the crane. If necessary, hot-cutting methods can be used for dismantling. Mechanical saws or hand tools can also be used. All openings will be sealed before removal. The last operation is the lifting of heat exchangers by the crane to the reactor hall for further transportation to the disposal site (see Fig. 2).

The use of the hydraulic hammer, such as the Brokk type, is planned for the demolition of the concrete biological shielding. It breaks the concrete with a hydraulic hammer and also is equipped with a jet that can spray the water mist over the concrete

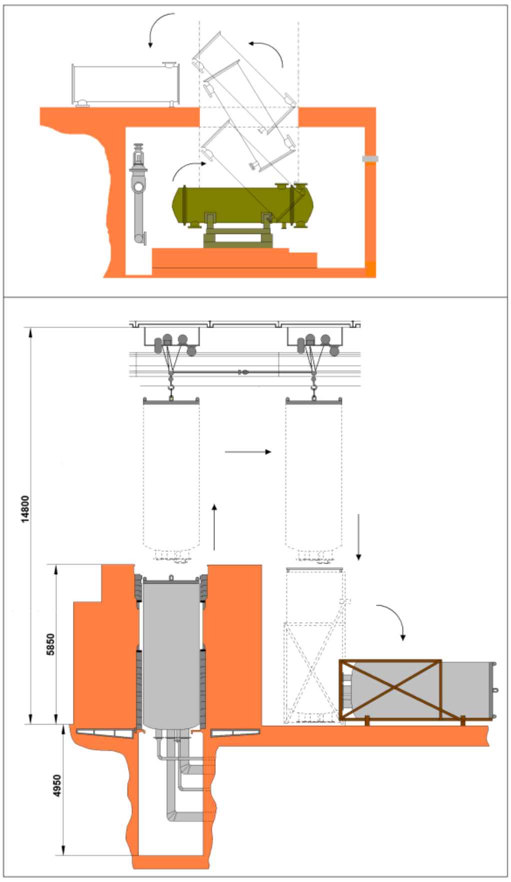

Fig.2. Removal of the heat-exchanger (*top*) and the reactor vessel (*bottom*).

dust and fix it in place, reducing air pollution. The demolition will start from the inside, so the activated material is removed first. Such a solution is acceptable for both radiological and economic aspects.

Since the spent fuel storage tank (BV-1) is located near the reactor, its dismantling will be possible only after removing the reactor vessel. The proposed sequence of actions is the following: 1) removal of the cover metal plate; 2) cutting the connecting pipes; 3) extraction of the inner aluminum tank. The outer tank is built into the biological protection concrete, therefore, the solution is to demolish the peripheral concrete around this tank and then remove it in one piece for further segmentation.

5. Radwaste management

The decommissioning experience of the research reactors and NPP units reveals that the main source of radioactivity after the removal of spent fuel is the technological equipment and structures used for shielding purposes. This radioactivity determines the radiation situation in the reactor premises and, accordingly, the radiation dose to personnel during dismantling operations.

The activated materials, equipment, and structures include the reactor vessel and internals, graphite heat column, reinforced concrete protection, horizontal channel collimators, facings, support tools, part of pipelines, etc., i.e., mainly the components, which are located near the reactor space.

As a result of radionuclide contamination, a significant part of the premises in the reactor building, as well as many systems of process equipment becomes the sources of radiation. Therefore, it represents the origins of the radwaste to be generated during the decommissioning.

According to the information about the reactor systems intended for dismantling [16] and the proposed sequence of dismantling works, the amount of generated radioactive and non-radioactive waste was estimated. The results are presented in Table.

The estimated amount of generated radioactive and non-radioactive waste

Material	Weight of material, kg		
	Activated	Intermediate and low level	Non-radioactive
Aluminum alloy	5478	762	–
Beryllium	–	335	–
Reactor graphite	–	5940	–
Steel	243	83216	70986
Cast iron	–	–	62520
Concrete*	~42000	~84000	~700000

* It is assumed that the volume of activated concrete is about 5 % and the contaminated one is about 10 % of the total concrete volume to be removed.

The streamlines of radwaste management could be considered as a result of the specific approach to waste management according to the following main options [28]:

exemption from the regulatory control (unconditional waste disposal, reuse of materials);

authorized release into the environment (discharge, reuse of materials);

regulated disposal (for waste) or regulated transfer (for useful materials).

The management of generated radwaste foresees the following:

mandatory separation of waste by the type, the physical state, the activity, and the processing method;

maximal decrease of the initial radwaste volume during the treatment for further storage or disposal;

creation of the optimal transport and technological chain for the radwaste transportation;

strict accounting of the radwaste generation and their inventory;

ensuring the radiation and environmental safety at all stages of radwaste management;

ensuring appropriate leaching rate from waste, which meets the acceptance criteria for disposal, by creating the artificial barriers (cement matrix, primary packaging, containers, etc.) and the appropriate organization of the technological process;

personnel training by the novel radwaste management technologies.

Almost the entire complex of works on radwaste management will be performed at the stage of dismantling. The general scheme for generated radwaste management can be presented in the form of successive stages: generation, sorting, pretreatment, processing, temporary storage, transportation, and final disposal.

For the collection, sorting, processing, and temporary storage of radwaste, it is planned to use mainly the existing infrastructure for operational radwaste management. However, considering the significant volumes of radwaste and the presence of large elements, it is necessary to create the technologies for waste fragmentation (including the metal and the concrete), as well as technologies for recycling the contaminated structures (mainly metal).

Prior to the dismantling works, the priority measures will be implemented to develop the infrastructure to support the dismantling and decontamination works, as well as the safe processing and storage of radwaste.

The organization of the radwaste processing zone in the reactor hall foresees:

arrangement of temporary storage sites for the large contaminated equipment;

special facility for fragmentation with a circular cutting machine, with a self-propelled circular saw, performs cutting in the process of moving on the outer surface of objects. It is used mainly for cutting all metals (pipes of big diameter), reinforced concrete, pipes of various diameters with a wall thickness up to 1,5 cm;

arrangement of the station for the disassembly of electrical equipment, electric motors, and waste cable products;

arrangement of decontamination station;

commissioning of the radiation inspection unit for the release of materials;

arrangement of sites for the temporary storage of the clean equipment.

The disposal of decommissioning radwaste will be performed in accordance with the contract on the radwaste transfer between the Institute for Nuclear Research and the specialized enterprise (State Enterprise “UkrDO Radon”). It is the only enterprise in Ukraine that has permission for radwaste disposal. Transportation of radwaste will be performed in accordance with the license for radwaste transportation by the transport of this enterprise outside the reactor site, in correspondence with the norms and rules of radwaste safe transportation.

6. Conclusions

The Decommissioning Concept for WWR-M research reactor is a documented decision of the operator, which defines a systematized package of the basic measures for the termination of operation and decommissioning, their terms, and the main criteria for the final state of the reactor site after completion of each decommissioning stage.

The decommissioning of the reactor foresees a significant amount of work (including organizational and design) on the dismantling of equipment, systems, and metal structures.

In the process of the project documentation development, there should be resolved tasks related to the finding and selection of technological solutions for dismantling (methods, tools, and means of technological support), compliance with the safety standards (technical, fire, and radiation) and the optimization of economic indicators. In this case, decisions are to be made within the resource constraints (material, financial, human, dose, time, and others).

In particular, decommissioning (largely defined by the design features of the technological process for the equipment dismantling) features the presence of residual radioactivity (radioactive contamination and activation) on the part of the equipment, protective structures, and premises.

The following main technical measures are being implemented:

dismantling of structures, systems, and equipment (elements) of the reactor;

management of radwaste generated in the process of dismantling and their transfer to specialized radwaste management enterprises;

operation of buildings, systems, and equipment (elements) to maintain the reactor in a safe condition;

radiation surveys (including final) of the reactor components, which are not subject to dismantling, and the reactor site.

These decommissioning aspects are highlighted by the Concept in general.

The ensuring of radiation safety during dismantling is considered sufficient if the technical means and organizational measures ensure that the basic limits of radiation dose-loads to personnel and the public are not exceeded while the basic principles of radiation safety are implemented. The essence of radiation safety requirements is permanent for all stages of the reactor life cycle, including decommissioning. Namely, it means not exceeding the current limits of the main radiation doses for the personnel and public at the moment of the work execution, as well as the following standards for the emissions, discharges, and concentrations of radioactive substances into the environment. The safety assessment of the decommissioning activity was performed in order to substantiate the Decommissioning Concept. This assessment is an integral part of the Concept and is presented as an appendix to it (a separate paper on the safety assessment results is planned).

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ОСНОВНІ ПОЛОЖЕННЯ КОНЦЕПЦІЇ ЗНЯТТЯ З ЕКСПЛУАТАЦІЇ ДОСЛІДНИЦЬКОГО РЕАКТОРА ВВР-М

Концепція зняття з експлуатації дослідницького реактора ВВР-М розроблена на виконання вимог чинного законодавства України. Головна мета Концепції – забезпечити стратегічний рівень планування робіт, включаючи всі необхідні обґрунтування з достатньою мірою деталізації, що дають змогу на наступному етапі планування розробити Проект зняття з експлуатації реактора та інші документи, необхідні для отримання ліцензії. Концепція є організаційно-технічним документом, в якому визначено і обґрунтовано принципові адміністративні, організаційні і технічні заходи з підготовки і виконання зняття з експлуатації реактора, а також описано основні види діяльності та роботи, визначено порядок, умови для виконання і забезпечення їх, заплановано терміни виконання їх.

Ключові слова: дослідницький реактор, зняття з експлуатації, демонтаж, радіоактивні відходи.

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