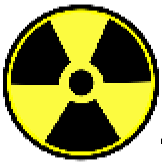
Portál pre odborné publikovanie ISSN 1338-0087

The Management of Radioactive and Non-radioactive Waste in the Nuclear Installation Decommissioning Process

Zachar Matej · Elektrotechnika, Prírodné vedy

25.12.2009



The paper presents a basic characterization of nuclear installation decommissioning in term of radioactive materials management. Large amount of solid materials created by implementation of various decommissioning activities have to be managed considering their physical, chemical, toxic and especially radiological characteristics. Finally materials could be unconditionally or conditionally released to the environment or disposed in near surface or deep geological repositories. Optimization of material flow could bring significant savings of money, disposal capacities or raw material resources.

1. Materials and waste produced in nuclear installation decommissioning

Decommissioning of nuclear installation (NI) is a complex process characterized by large diversity of involved activities, demanding various technological equipment and technological procedures, a large amount of finance and usually long duration. The final aim of decommissioning process is to release the site of former nuclear installation from radiation control and then achieve an unrestricted use of the former NI area.

One of the characteristic feature of decommissioning process is production of large amount of radioactive materials (waste) that are created during realization of decommissioning activities like decontamination, dismantling, demolition, waste management activities or radiation monitoring. Characteristics (category, amount, radioactivity) of arising waste are mainly influenced by:

- technological and radiological inventory of NI in the end of operation period that is dependent on type of reactor, construction materials and characteristics of operation period (duration of operation, number and seriousness of accidents),
- decommissioning strategy – immediate or deferred dismantling,
- accessibility and serviceability of decontamination and dismantling technologies and technologies for treatment and conditioning of radioactive waste (RAW),

- accessibility and capacity of storage rooms and disposal facilities for different categories of RAW,
- limits and condition for releasing of materials, discharging of gaseous and liquid effluents to the environment (ENV) set up by the authorities.

The main sources of primary radioactive waste from decommissioning are:

- activated construction materials of reactor and reactor systems (steel) that contains more than 90% of total activity of materials arising from decommissioning process (except of spent fuel),
- activated building structures near reactor e.g. biological shielding or reactor shaft concrete (including steel reinforcement),
- contaminated construction materials of primary circuit and auxiliary systems components (mainly steel of non-ferrous metals).

Except of mentioned primary RAW, secondary RAW also arising during decommissioning process:

- liquid RAW from chemical or electro-chemical decontamination (decontamination dilutions, electrolytes, decontaminations foams or gels)
- abrasives from mechanical decontamination of building structures,
- air conditioning filters that captured an activity of generated aerosols,
- ion exchangers using for activity reduction of liquid RAW,
- waste from treatment and conditioning of RAW (metal melting sludge, ash, laundry solutions, evaporation concentrates etc.),
- contaminated tools and equipment using for dismantling,
- waters from sanitary locks.

In specific cases (type of reactor, operational accidents) special forms and types of RAW have to be managed in decommissioning process:

- activated or contaminated graphite is typical for older type of reactors where graphite is used as a moderator (RBMK, MAGNOX) or biological shielding (A1),
- radioactive toxic and hazardous materials e.g. sodium, lead, cadmium, asbestos,
- contaminated soils, concrete (internal structures) or sediments.

Except of RAW also large amount of non-radioactive waste is produces during dismantling of technological equipment (steel, non-ferrous metals, plastic, insulations etc.) or demolition of building structures (reinforced concrete, concrete, masonry, steel constructions, prefabricates etc.). These materials are considered and managed as a standard industrial waste.

2. Radioactive materials management arising from nuclear installation decommissioning

Radioactive materials management covered several phases involved various technological operations (Figure 1). The final goal of the material management is to transform the materials arising from decommissioning process to the form that assigned that an influence on the environment will be within the limits after their releasing outside nuclear installation site.

Pretreatment of radioactive materials is used to make the next material management steps easier and more effective by reducing the risks arising from physical, chemical and radiological parameters of materials. The main activities of the pretreatment are as follows:

- collection, segregation, sorting and characterization of materials,
- basic chemical modification (reduction of chemical toxicity),
- decontamination of solid RAW (chemical, electrochemical, melting) is usually used to reach clearance (release) levels of the material or to re-categorize the RAW,
- size reduction,
- packaging of RAW for transport to a treatment facility or to a storage area.

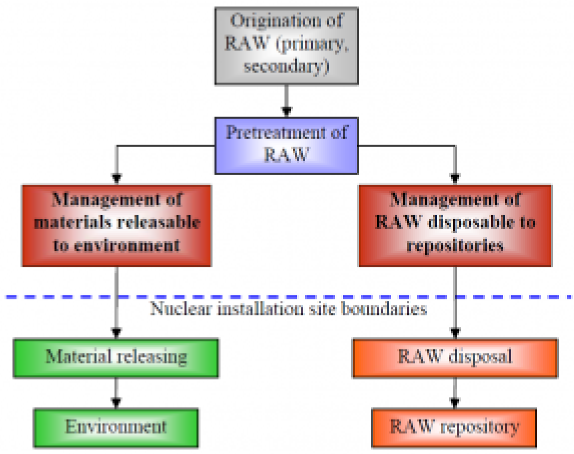


Figure 1. Basic structural scheme for material management

After pretreatment it should be considered two main streams of material flow (Figure 1.) that are described in the next chapters.

<u>2.1 Management of materials releasable to the environment</u>

Large amount of materials from decommissioning inside controlled area have such low activity of radionuclides, that allows them to be released to the environment (Figure 2.):

- just after dismantling or decontamination within pretreatment period,
- applying of nuclides radioactive decay („time decontamination"), release after storage period.

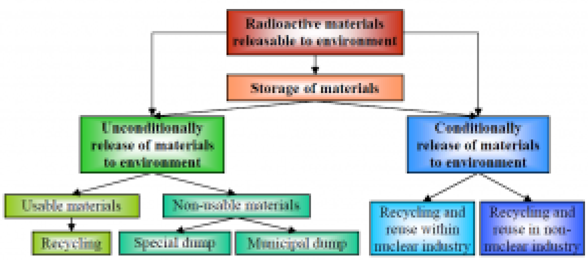


Figure 2. Releasing of material to the environment

On the basis of requirements to the following application of released materials it should be considered (Figure 2):

1 Unconditionally release of materials to the environment

Activity of unconditionally released materials is lower than a limit activity (mass and surface) for unrestricted release set up by the authorities. Release levels are usually derived from the value of maximum annual allowed individual dose for the member of critical group of persons (10 μ Sv.year^{-1}) and from the total collective dose of population (1 manSv.year $^{-1}$) caused by released material . Unconditionally released materials should be used in all areas of industry without any restriction. They could be divided into:

- usable materials from nuclear installation are after recycling used in any industrial area,
- non-usable materials are waste materials for which no practical or economical reasons for further use existed, they are disposed on municipal or special (toxic) waste repositories.

2 Conditionally release of materials to the environment

Materials with activity that exceed the limits for unconditionally release, could be released to the environment conditionally. For conditional releasing following principles should be met:

- materials are contaminated mainly with short lived radionuclides,
- long term occurrence of materials at one place is expected,
- materials are used in conformity with beforehand developed scenario,
- doses limits for public are not allowed to exceed.

On the basis of further use of conditionally released materials, it should be considered:

- Use within nuclear industry do not involved a release from radiation control, recycling (melting) is realized in nuclear locality. Then these materials should be use for fabrication of RAW packages or construction of RAW treatment equipment (high-pressure compaction).
- Use in non-nuclear industry expected a release from NI area and then usage of material under special defined conditions (rails construction, armouring in concrete).

2.2 Management of RAW determined to be disposed in RAW repositories

Materials that could not be released into the environment due to their level of activity are considered as a radioactive waste that has to be safely isolated from the environment within the repository barriers. RAW management included following steps (Figure 3.):

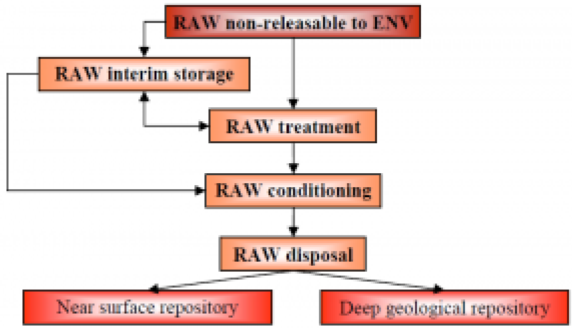


Figure 3. Management of RAW non-releasable to environment

RAW interim storage

Interim storage is understood as an emplacement of RAW to the objects allowed the control of them and protection of the ENV with the intention of RAW retrieval. Interim storage should be included into process of RAW management for the following reasons:

- RAW re-categorization by applying „time decontamination" principle, it means that less difficult technologies for treatment, conditioning and disposal can be used,
- non-accessibility of needed treatment or conditioning technologies for RAW, missing disposal facilities,
- absence of legislative regulations for RAW management, lack of financial resources.

RAW treatment

RAW treatment is presented as a complex of operations and activities intended to increase safety and economy of the following phases of RAW management by:

- reduction of the RAW volume,
- removal of radionuclides from the RAW,
- changing the characteristic and composition of the waste.

The most commonly used treatment technologies are:

- evaporation, ion exchange, chemical precipitation for liquid RAW
- high-pressure compaction, incineration, melting for solid RAW

RAW conditioning

RAW conditioning is presented as a complex of operations and activities intended to make such chemical and physical form that is suitable for transport and disposal. Conditioning also includes the immobilization of the liquid RAW to a solid form. The most frequently used conditioning technologies are bituminization, cementation, vitrification etc.

RAW disposal

Disposal represents the final phase of RAW management and is defined as a placing of RAW package into the suitable disposal facility (repository) without intention of retrieval. RAW repository allowed the long time isolation of nuclides from ENV by applying multi-barriers principle:

- waste form (fixing matrix) depended on the used conditioning technology,
- waste package isolates immobilizing waste from surrounding,
- engineered barriers involved structural walls of disposal system, roof construction, backfill materials around waste package, drainage layers etc,
- natural barriers are created by host rock and surrounded geological formation.

In general, two types of repositories should be considered:

- Near surface repository (NSR) is used for short lived (half life lower than 30 years) low and intermediate level waste disposal (majority of decommissioning waste). Long lived nuclides could be disposed only within the limited concentrations. Two kinds of NSR are used for disposal of mentioned kind of RAW: surface (trench, vaults, bunkers) and subsurface (caverns, cavities, deep boreholes).
- Deep geological repository (DGR) is used for disposal of RAW that does not fulfill the limits and conditions for disposal in NSR. It means long lived intermediate and high level waste. However, currently no DGR is built up. So the RAW not disposable in NSR (e.g. activated reactor components) has to be safely stored in the special nuclear storage facilities until the DGR would be established.

3. Conclusion and future challenges

The paper analyses the material management in the process of nuclear installation decommissioning. The parameters influencing the waste production and main sources of waste are described. Individual possibilities of material release outside nuclear installation area such as unconditionally and conditionally release to the environment or disposal in radioactive waste repositories are defined in the second part of the paper.

The next work would be concentrated on developing a methodology of decommissioning material flow optimization with emphasis on radiological characteristics and material management scenarios. Detailed diagrams of material flow for basic kinds of materials (steel, non-ferrous metals, non-metal materials, concrete) arising from decommissioning would be processed. In diagrams all possible ways how to release the material from nuclear installation area would be considered. The methodology would be implemented to the existing and function calculation code OMEGA used for calculation of decommissioning parameters. Finally, the calculations would be done to check the correctness of suggested methodology.

References

1. ZACHAR, M., DANIŠKA, V., NEČAS, V. Methods of the Impact Assessment of Decommissioning of Nuclear Installation on the Environment. International Youth Conference on Energetics IYCE 2007. Budapest, Hungary, 31.5.-2.6.2007.
2. NEČAS, V. et al. Radioactive waste and nuclear installation decommissioning. Slovak University of Technology in Bratislava, Bratislava, 2007. Book for post gradual study.
3. Handling and Processing of Radioactive Waste from Nuclear Applications. Technical report series No.402. IAEA, Vienna, 2001.
4. International Basic Safety Standards for Protection Against Ionizing Radiation and for

the Safety of Radiation Sources. Safety Series No.115. IAEA, Vienna, 1996.
5. Upgrading of Near Surface Repositories for Radioactive Waste. Technical Reports Series No.433. IAEA, Vienna, 2005.

Co-author of this paper is Vladimír Nečas, Slovak University of Technology, Faculty of Electrical Engineering and Information Technology, Ilkovičova 3, 812 19 Bratislava.