Decontamination and Decommissioning Activities in the Nuclear Research Institute Rez

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ABSTRACT

The Nuclear Research Institute Rez plc (NRI) is a leading institution in the area of nuclear R&D in the Czech Republic. NRI operates two research nuclear reactors. LVR-15 is a light-water moderated and cooled tank nuclear reactor with forced cooling with maximum power of 10 MWth. LR-0 is a pool-type light-water zero power reactor. NRI also operates many facilities as a hot cell facility, research laboratories, technology for radioactive waste (RAW) treatment, $^{60}$Co irradiators, an electron accelerator, etc. Except of facilities which will be decommissioned in the future, there are many old obsolete facilities, which will be decommissioned soon in the frame of liquidation of old environmental liabilities. NRI has gained many experiences in the field of RAW treatment and decommissioning of nuclear facilities and ionizing radiation workplaces.

KEYWORDS: decontamination, decommissioning, dismantling, fragmentation, radioactive waste, processing, conditioning, disposal, research nuclear reactor, spent nuclear fuel, ionizing radiation source, remediation, environmental liabilities

INTRODUCTION

Decommissioning and decontamination and RAW management are some of many activities of the Nuclear Research Institute Rez plc. The Institute performs decommissioning of ionizing radiation sources workplaces and is an integral part of the system of institutional RAW management in the Czech Republic. The Institute provides the management of most institutional RAW (RAW from research, industry and medicine) produced in the Czech Republic (more than 90 %) and is also the biggest producer of institutional RAW in the Czech Republic (approx. 60 %).

CENTRE OF RADIOACTIVE WASTE MANAGEMENT

Centre of Radioactive Waste Management (further also Centre) performs decontamination and decommissioning activities as well as management of RAW. The Centre provides complex services, i.e. the taking-over of RAW, characterization, storage, processing and conditioning into a form allowing the disposal into the repository for RAW. The Centre operates the technology for RAW treatment and also provides the storage of spent fuel from the research nuclear reactor LVR-15 operated by NRI in the High level waste store. Laboratory of RAW characterization, which is an integral part of the Centre, develops new radiological waste characterization procedures. Laboratory of decontamination is also an important part of the Centre.

Storage of RAW

High level waste store (HLWS) serves for storage of RAW and spent fuel from the LVR-15 research nuclear reactor operation. The HLWS is constructed as a hall. The lower part of the hall is made of reinforced concrete monolith to the height of 5.65 m and the upper part is constructed as a prefabricated hall. Outer dimensions are 36.95 x 16.26 x 9.91m. There are 2 pools for storage of IRT-2M spent fuel, 1 box for dry storage of EK-10 spent fuel and 7 boxes for storage of RAW. The total capacity of the store is 1410 m³. The view into the store is provided in Fig. 1.
The Fragmentation and decontamination facility is designed for the safe treatment of solid RAW. RAW is separated according to its composition and contamination, then the operations of fragmentation and decontamination follow. The effort is to minimize the amount of material needed to be disposed and the production of secondary wastes needed to be treated. The goal is maximum unrestricted release of decontaminated materials. The facility consists of 4 parts:

1) Manipulation area – serves for manipulation with contaminated objects before processing.
2) Dismantling box – serves for basic characterization and dismantling.
3) Fragmentation box – serves for fragmentation of contaminated objects.
4) Decontamination box – serves for decontamination of fragmented parts.

All boxes are equipped with adjustable closing doors and removable roof. The overhead cranes and fork lift truck serve for manipulation with contaminated objects. The facility is equipped with ventilation system, the fragmentation box and the manipulation area are equipped with additional local ventilation system. The facility is equipped with the system for drainage of spent decontamination solutions.

The list of methods used for fragmentation and decontamination is provided in Table 1. The view into the facility is provided in Fig. 2. The fragmentation of solid RAW is provided in Fig. 3.

Table 1. List of methods used for fragmentation and decontamination

<table>
<thead>
<tr>
<th>Fragmentation</th>
<th>Decontamination</th>
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<tbody>
<tr>
<td>Power hydraulic shears (stationery or portable)</td>
<td>Vacuuming (vacuum cleaner with HEPA filter)</td>
</tr>
<tr>
<td>Mechanical saw (stationery)</td>
<td>High-pressure water jet</td>
</tr>
<tr>
<td>Abrasive cutting wheel (stationery or portable)</td>
<td>Chemical decontamination</td>
</tr>
<tr>
<td>Oxy acetylene cutting (portable)</td>
<td>Foam decontamination</td>
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<tr>
<td>Plasma arc cutting (portable)</td>
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</table>
Another equipment for processing and conditioning

The evaporation unit is used for processing of aqueous liquid RAW. The decontamination factor is about $10^3$ and the condensate can be discharged into the environment after measurements. The concentrate is cemented into 200 l drums by means of a batch-type cementation unit. The treatment of pressable solid RAW consists of in-drum, low pressure compaction (into 100 l drums) and embedding of the 100 l drum within a 200 l drum with concrete.
Laboratory of RAW characterization

The Laboratory performs RAW characterization before processing and after conditioning. The Laboratory is equipped with all necessary instruments for RAW characterization, e.g. surface contamination and dose rate measurement instruments, gamma spectrometers. The Laboratory is also equipped with the gamma scanner (Fig. 4) which is used for non-destructive characterization of the radiological composition of 200 l drums with the conditioned RAW. The radiography instrument is under development within the frame of the IAEA technical cooperation program.

![Gamma scanner](image)

Laboratory of decontamination

Another part of research activities (Laboratory of decontamination) is focused on the research of contamination processes and the development of decontamination methods, for the needs of Centre as well as that of another institutions. The Laboratory also performs assessments of the easy of contamination and decontamination of materials for customers from the Czech industry.

REMEDIATION OF OLD ENVIRONMENTAL LIABILITIES

After more than 45 years of service, some of the technological equipment used for research purposes in the nuclear field shall be decommissioned. The goal is to remedy environmental liabilities and eliminate the possible negative impact on the environment. Based on this postulate, optimal remedial actions have been selected and recommended for the environmental remediation.

The characterization of environmental liabilities has been already carried out. The work was carried out to obtain information on the NRI site, degree and extent of environmental pollution and potentially endangered target groups. The first stage was the collection of information. The following stages include the identification and characterization of potential sources of risk, potentially exposed receptors and exposure pathways, potential chemical compounds, radionuclides and media of concern. Then the relation between the exposition and the risk was estimated. Information on natural conditions at the site was obtained through hydrogeological studies of the pollution and information on sources of ionizing radiation and radioactive contamination using dosimetric measurement and radiochemical analyses. Based on the summarization and assessment of the obtained results, priorities of remediation were defined and a technical conception of remedial actions and the estimation of expenses were determined. Then the remediation project has been prepared.

Decay tanks

The project of the facility has been prepared in 1958 and the building has been in use since 1961. Building 211/5 was designed for storage and decay of concentrated RAW containing only short-lived radionuclides, but also RAW containing...
long-lived radionuclides have been deposited. Receiving of RAW has been cancelled in 1990. Building 211/5 contains two cylindrical tanks with a length of 9.5 m and a diameter of 3 m, each with a capacity of 63 m$^3$. The tanks are past the design life (the design life is 25 years). The decay tanks are made from structural steel jacketed by stainless steel inside the vessel. The tanks are equipped with two openings, which served for waste receipt. The tanks are placed into two separate concrete bunkers with 1 m thick walls located partially below ground. Above the bunkers, there are located a masonry building with a slippage for RAW, ventilation equipment and equipment for taking of water samples from tanks. Tank A contains only a small amount of liquid low-level waste (LLW). Tank B contains 2.5 m$^3$ of solid high-level waste (HLW) (tins containing irradiated samples residues of irradiated measuring probes from the reactor vessels, tins containing fission material) and also 8 m$^3$ of liquid (see also Fig. 5). The main identified radioisotopes are $^{60}$Co, $^{137}$Cs. However, there is anecdotal evidence that the amount up to 2 g of $^{239}$Pu may also have been deposited in the tank at some time. The maximum dose rate in a distance of 10 cm above the pile of solid RAW is approx. 2 Gy/h. The leakage and spillage from the storage tanks and direct irradiation from in-situ material were identified as the main risks to the environment and/or to employees.

![Fig. 5 RAW stored in the decay tank B](image)

The procedure of remediation will be as follows:
1. Construction of an one-purpose facility above the storage tanks serving for accommodation of technology for removal of RAW and its treatment. It will be equipped with hot cells and manipulators.
2. Removal of RAW from tanks and its direct conditioning in the one-purpose facility, demolition of one-purpose facility.
3. Removal of a bunker concrete roof, decontamination and fragmentation of the tanks and the equipment.
4. Decontamination and demolition of building parts, final restoration of the site.

**Liquid RAW storage tanks (Building 211/3)**

Three steel tanks of the same construction as the decay tanks described above are located in concrete bunkers with 1 m thick walls. Only one tank is in use. It receives liquid RAW from the LVR-15 research reactor. The tanks are older than the design life. One tank is too corroded to be used. The integrity of the tanks and surrounding bunkers is doubtful. All three tanks are understood to be contaminated with $^{137}$Cs, $^{60}$Co and $^{90}$Sr. The leakage or spillage from tanks were identified as the main environmental risk. After a removal of a bunker concrete roof, the tanks and the equipment will be decontaminated and fragmented.

**Old RAW treatment technology (Building 241)**

The old RAW technology comprises the evaporation unit and an auxiliary equipment. The technology was in operation since 1962 to 1992 and consists of a vertical tube evaporator with a natural circulation with a capacity of 4 m$^3$ liquid LLW per hour and other technology (moisture separators, heat exchangers, piping, storage tanks, mix-bed filters).
corresponds approximately to 40 metric tons of steel. The technology is contaminated mainly with $^{137}\text{Cs}$, $^{60}\text{Co}$ and $^{90}\text{Sr}$. After the preliminary in-situ decontamination, the technology will be dismantled and RAW treated.

**Contaminated equipment (Building 250)**

Building 250 “Radiochemistry” houses radiochemical laboratories, hot and semi-hot cell complexes and an auxiliary equipment. Two laboratories called “Alpha halls” contain eight sets of wall boxes (so called “Alpha boxes”) and a number of glove boxes. All the boxes should be decommissioned. The boxes were used for manipulations with alpha radionuclides and present a significant alpha contamination. The box walls consist of plexiglass with a thickness of 10 mm. The total volume of boxes is approx. 80 m$^3$. The possibility of contamination with alpha radionuclides was identified as the main risk to employees. After the preliminary in-situ decontamination, the technology will be dismantled and treated as RAW.

**Special Sewage System**

The system consists of a double walled stainless steel pipe network situated in a steel channel. The system with a total length of 410 m is placed underground into a concrete corridor. The system is used for transportation of liquid RAW from various facilities (research reactors, radiochemical laboratories) to a RAW treatment facility. The system is contaminated mainly with $^{137}\text{Cs}$, $^{60}\text{Co}$ and $^{90}\text{Sr}$. Leakage of wastewater from piping was identified as the main risk to the environment. After the preliminary in-situ decontamination of the pipes, the soil above the concrete corridor will be removed and the corridor will be opened. After the characterization, the pipes will be dismantled and treated as RAW.

**RAW stored in the reloading site (Building 211/6) and in the Red Rock surface repository**

Building 211/6 was initially constructed as a temporary reloading site to handle conditioned RAW but consequently was used also for storage of various RAW before processing and dry storage of spent research reactor fuel. At present only solid LLW (mainly an old technological equipment) is stored there. RAW is stored in 8 concrete boxes each with dimensions of $5.5 \times 8 \times 4$ m ($1400$ m$^3$ total capacity). The bases of the boxes are 4 m below ground level and drain to four closed sumps. The building has a steel roof. The total volume of stored RAW is approximately 600 m$^3$. A complete inventory is available but this gives only a very general description of the waste contained in the boxes. The content of one storage box is illustrated in the Fig. 6. The waste is contaminated mainly with $^{137}\text{Cs}$, $^{60}\text{Co}$ and $^{90}\text{Sr}$. Leakage of liquid waste in boxes, wash-off of contamination from RAW by rainwater and direct irradiation from in-situ material were identified as the main risks to the environment and/or to employees.

![Fig. 6 RAW stored in Reloading site (Building 211/6)](image_url)

Storage operations at the “Red Rock” site started in 1988. Solid LLW is stored in ISO shipping containers. The stored waste includes RAW arising from reconstruction of the LVR-15 research reactor (primary circuit, ventilation system,
etc.). A redundant equipment (heat exchangers, tanks, filters) is also stored at this site. The total storage area is 300 m². The total amount of RAW is approx. 90 metric tons. The waste is contaminated mainly with ¹³⁷Cs, ⁶⁰Co and ⁹⁰Sr. Rain wash-off from contaminated equipment to soil and groundwater and irradiation from in-situ material were identified as the main risks to the environment and/or to employees.

The RAW from both storage sites will be transported to the Fragmentation and decontamination facility and then sorted, processed and conditioned. Some part of RAW will be after decontamination released into the environment.

**RAW from archive program and experimental irradiated channels**

RAW from archive program has been accumulated over a period of 15 years. These are irradiated surveillance specimens and experimental samples of steel for reactor pressure vessels. The specimens are transported and stored in closed metal vessels with a diameter of 130 mm and a height of 170 mm. In a distance of 0.5 m the surface dose rate does not exceed 0.2 Gy/h. The total number of vessels with the specimens is in order of hundreds. The specimens are stored in hot cells in the Building 250 and in the High level waste store (HLWS). The experimental irradiated channels made from aluminium and stainless steel were used in the LVR-15 research reactor. The total volume is 2 m³. The maximum dose rate in a distance of 1 m is 100 mGy/h. Direct irradiation from in-situ material was identified as the main risk to employees. RAW from the archive program will be sorted according to the activity and then put into the special shielding unit and send for disposal into the final repository or storage to the HLWS facility. A part of the RAW has already been processed and conditioned and sent for disposal. A main part of experimental irradiated channels was liquidated in 1996, there remains a small part which will be liquidated as soon as possible. The channels are fragmented under water and then put into the shielded containers and transported for disposal or for further storage in the HLWS.

**DECOMMISSIONING AND DECONTAMINATION ACTIVITIES**

**Reconstruction of VVR-S research reactor**

The reconstruction of the VVR-S research reactor (now LVR-15 research reactor) connected with the replacement of the reactor vessel carried out in 1988 was the greatest activity. Also the primary circuit, ventilation system and reactor control system were replaced. The aluminium reactor vessel was then disposed into interim storage and in the future will be fragmented and disposed into a final repository. The reactor reconstruction also resulted in generating various RAW, such as irradiation channels, ventilation system, equipment built in hot cells, reactor cooling circuit tubes, filters. This waste was put into the interim store and is assumed to be treated in the Fragmentation and decontamination facility with emphasis on efficient decontamination and unrestricted release as non-radioactive waste.

**Decommissioning of ionizing radiation sources workplaces**

In 2000, a laboratory (not operated by NRI) for renovation and maintenance of dials with phosphorescent paints spiked with ²²⁶Ra was decommissioned. As these types of measuring devices were banned from further use it was decided to close the laboratory in the year 2000 after some 40 years of operation. The laboratory was decontamination for further unconditional use, all RAW were processed and conditioned and a part of RAW was after decontamination released into the environment.

Last year NRI also won a contract for decommissioning of a workplace for the production of so called radium needles having served for radiotherapy in the past. The glove boxes having served for Ra-needles production should contain 1 – 2 g of ²²⁶Ra. The decommissioning will be completed at the end of 2003. The view on the glove boxes is provided in Fig. 7.
CONCLUSION

NRI has gained many experiences in the field of RAW management and decommissioning of nuclear facilities and ionizing radiation workplaces. The character of the environmental liabilities is very specific and requires special remediation procedures. The experience gained during the remediation process will be used for future activities connected mainly with the decommissioning not only facilities operated by NRI Rez (research reactors, radiochemical laboratories, hot cell complexes, etc.), but also facilities operated by other companies (workplaces with ionizing radiation sources, nuclear facilities, nuclear power plants).