Application of the ALARA Principle in Dismantling and Disposal of a Research Reactor Primary Cooling System Delay Tank

A. Savidou, F. Tzika, S. Hatzidakis, I.E. Stamatelatos
Institute of Nuclear Technology Radiation Protection, NCSR Demokritos

Abstract

This work discusses the decommissioning plan of GRR-1 reactor old delay tank. The tank inner surface area presents low contamination. In this work the processes and methods that will be used to decontaminate, cut, dismantle, remove and release of the delay tank materials in a safe and organized manner in order to prevent undue radiation exposures to the facility staff, public and the environment according to the ALARA principle are discussed.

1. Introduction

The Greek Research Reactor (GRR-1) is a 5 MW open pool-type reactor, cooled and moderated with light water. The delay tank under consideration was part of the reactor's old primary cooling system (1961-1989). Its purpose was to delay the circulation of water in order to allow decay of short lived radionuclides in the coolant. The tank is located in the reactor pump room (Fig. 1). Since the pump room area is required for the installation of the replacement cooling system, it was decided to decommission of the tank. The delay tank is a cylindrical carbon steel container of 1 m radius, 8 m length, providing a main water inlet and a main water outlet at the lower part of its front and back opposite sides, respectively. It is internally subdivided in 6 sectors. The maximum thickness of steel is 10 mm. The tank inner surfaces were coated with paint and preliminary measurements indicated that are contaminated. The total volume of the tank is 25 m^3 and its estimated mass is of about 5500 kg.

In this work the processes and methods that will be used to decontaminate, cut, dismantle, remove and release of the delay tank materials in a safe and organized manner in order to prevent undue radiation exposures to the facility staff, public and the environment according to the ALARA principle are discussed.

The main tasks of this project are the following: (a) Radiological Characterization, (b) Radiation Protection Program, (c) Radiological accident analysis, (d) Project plan approval from the Safety Review Committee and the Greek Atomic Energy Authorities, (e) Training, (f) Decontamination, (g) Dismantling, (h) Waste management, (k) Final area status survey, (l) Final report preparation

World wide knowledge and experience on decommissioning of nuclear facilities and systems has been recently reviewed by IAEA in the technical report 'State of the art technology for decontamination and dismantling of nuclear facilities' [1].

2. Radiological Characterization

The radiological characterization survey of the tank consisted of direct measurements for gamma and beta radiation using portable radiation monitors, *in situ* gamma ray spectrometry using a NaI detector system, smear sample analysis for measuring transferable alpha and beta-gamma contamination, high resolution gamma ray spectrometry using a HPGe detector system and a total beta system to analyze the activity in fragments of the paint coating.

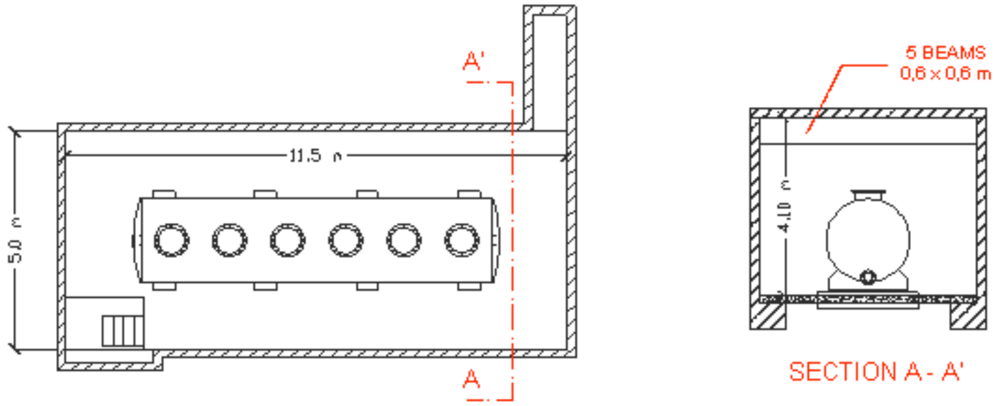

Fig. 1 GRR-1 pump room and tank

The findings of the survey showed that contamination is present at the tank internal surfaces. The contamination is mainly due to the isotopes ^{137}Cs, ^{60}Co, ^{108m}Ag and ^{152}Eu. Although the surface specific activity for the sum of these isotopes was found to be below the surface specific clearance level for metal scrap recycling, it is above the surface specific clearance level for direct reuse [2]. Moreover, the total beta surface specific activity is one order of magnitude above the contamination free level of 0.4 Bq/cm^2 provided in the national regulation [3]. The maximum (inlet of the tank) surface specific activity per radionuclide on fragments of paint as compared to surface specific clearance for direct reuse, are shown in Table 1. The estimated activity over the total inner surface of the tank is 4.1 MBq. (A= 90 m^2) assuming a uniform distribution of activity. Results of low level alpha spectrometry on smear samples, performed at GAEC Environmental Monitoring Laboratory, showed that the Uranium isotopes contamination is practically negligible (~10^{-4} Bq/cm^2).

Table 1 Maximum measured surface specific activity on fragments of paint and total surface activity compared to surface specific clearance levels.

Nuclide	Half Life (y)	Measured surface specific activity (Bq/cm^2)	Total surface activity (kBq)	Surface specific clearance levels (Bq/cm^2)
^{137}Cs	30.17	1.3	1170	10^{+}
^{60}Co	5.27	1.0	900	1^{+}
^{152}Eu	13.33	0.6	540	1^{+}
^{108m}Ag	418	0.15	135	1^{+}
Total β	-	4.6	4140	0.4^{*}
Total α	-	10^{-4} (smr)	10^{-1} (smr)	0.04^{*}

$^{+}$) Clearance level for direct reuse [2]

*) Contamination free level ref. [3]

3. Radiation Protection Programme

Enhancements and revision to GRR-1 radiation protection program [4] were required to support tank decommissioning activities [5]. Process or other engineering controls will be the preferred methods for maintaining exposures to radiation and radioactive materials ALARA. These would include: (a) control of access, (b) reduce exposure times, (c) increase distance between the individual and the source, (d) use of specialized Personnel Protective Equipment (PPE) and respiratory protection equipment, (e) containment/ confinement structures (radioactive material isolation), (f) controlled ventilation (airborne radioactive material reduction), (g) shielding. The effectiveness of controls to minimize or eliminate the exposure will be assessed by area radiation monitoring. Area monitoring includes direct dose rate measurements, surface contamination measurements (fixed and removable) and airborne radioactivity measurements. Personnel monitoring devices (TLD and electronic devices) will assess occupational radiation exposure from external sources. Occupational exposure from radioactive materials internal to an individual will be determined through monitoring of the quantities of radionuclides in the air collected through air samples or a combination of air monitoring and bioassay. The collective radiation dose to complete the task of decommissioning of the tank was estimated to be 230 μSv. The work crew size involved in the project is estimated to be of 15 persons. So the average estimated dose per person is 15.3 μSv. Since large variation in individual doses is expected this average dose estimate could be tripled and therefore, the higher dose to an individual is assumed to be 45.9 μSv. The administrative effective dose limit of occupational exposure at GRR-1 facility is 6 mSv/y.

4. Radiological Accident Analysis

Potential radiological accidents during decommissioning of the old delay tank were evaluated, by examining the inventory of radioactive material, reviewing planed activities, and considering combinations of these elements that could lead to a release of radioactive material. The radiological accident considered to present the highest potential consequences was that of a fire during decommissioning activities.

During a fire in radioactive waste the exposure would be limited to those individuals who provide initial fire suppression activities, those individuals who evacuated the facility and those individuals who are required to reenter to the reactor building in order to extinguish the fire. Assuming that at the start of the fire there were 5 people involved in decommissioning activities, who after an initial attempt to extinguish the fire (for 10 min) evacuated the area. Two workers reentered the area to extinguish the fire and during this activity they were exposed for 50 min. The collective dose to the personnel will be 12 μSv. This dose is very low in comparison to the administrative effective dose limit of 6 mSv. Moreover, fire fighting personnel responding to a fire potentially involving radioactive materials utilize self contained breathing apparatus, with a minimum protection factor of 100, which would ensure that any internal exposure would be even smaller.

Assessment of committed effective dose to individual members of the public at a distance of 500 m from the release point was made according to procedures for assessment during a radiological emergency [6]. Calculations were made under the assumption that the total activity contained in the tank is involved in the fire. The committed effective dose to an individual due to atmospheric dispersion was estimated to be 10^{-4} μSv, which is lower than the effective dose constrain of 10 μSv for the general public [3] by five orders of magnitude.

5. Training

Decommissioning activities are much different from typical GRR-1 operations, and as such, require special training for the existing staff and the decommissioning personnel. Individuals who require access to the work areas or restricted radiation areas will receive training commensurate with the potential hazards to which they may be exposed. In particular, personnel performing special processes will be qualified according to specific codes and standards and/or in accordance with national regulations and IAEA safety guides and reports.

6. Decontamination

Since the radiological measurements showed that significant fraction of contamination was absorbed by the paint coating, it was assumed that removal of the paint coating will also result in decontamination of the tank surfaces. Preliminary, experiments performed at our laboratory showed that a NaOH solution of 0.1 M was adequate to remove paint coating from test pieces of steel alloy similar to that of the tank material under consideration. The tank will be filled up with the NaOH solution, which will be left to act at least for 24 h. A submersible water pump will be used to drain the tank. The drained solution will be monitored and disposed of in accordance with the administrative discharge limits specified by GAEC for the NCSR "Demokritos". Although a significant fraction of radioactive contamination is expected to dissolve in the base solution and be disposed of as liquid waste, another fraction may end-up as a dry residue at the bottom of the tank together with fragments of paint and other solid material. This material will be collected after draining the tank using a specialized vacuum pump and treated as solid radioactive waste. After drying, a radiological characterization will be realized in order to demonstrate the level of decontamination of the tank. This characterization will be a prerequisite in order to proceed to the dismantling procedure.

7. Dismantling and cutting techniques

The sawing technique will be used to cut the tank, due to the negligible contamination level. During dismantling, the operator will act according to a 'cut map' knowing where to cut and how to dismantle the pieces of the tank. All pieces will be numbered, radiologically characterized, segregated and a database will be realized for the needs of the consequent waste management activities

8. Radioactive Waste Management

Waste management involves disposal of liquid radioactive waste after monitoring. Radioactivity contaminated water generated during decontamination activities may be disposed of if the discharged liquid can be shown to meet the requirements for sewage disposal. The water may be released to the public sewage system provided that the allowable administrative discharge limit is satisfied. The discharges of liquid effluent will be monitored as required in order to demonstrate compliance with regulations. The solid waste will be a direct result of the decontamination and cutting of the tank material activities. Onsite radioactive waste processing will include waste minimization, segregation, characterization and packaging. Material that can be further dismantled and decontaminated will be handled onsite. Material that cannot be decontaminated will be placed in iron drum containers. Containments will be selected by considering the contamination levels and type of waste. As the drums are filled, they will be moved to the NCSR "Demokritos" interim radioactive waste storage facility.

9. Final area status survey

Final area status survey will be performed following standard written procedures and using properly calibrated instruments. Data collected for final status survey of the room will consist of scans to identify locations of residual contamination, direct measurements of gamma and beta activity and measurements of removable beta surface activity. A report describing the survey procedures and findings will be prepared.

10. Conclusions

In this work the processes and methods that will be used to decontaminate, cut, dismantle, remove and release of the delay tank materials in a safe and organized manner in order to prevent undue radiation exposures to the facility staff, public and the environment were discussed. This work is considered as a training exercise for the personnel of the Institute of Nuclear Technology & Radiation Protection in preparation for the project of decommissioning of the GRR-1 primary cooling system now planned.

Keywords: *Decommissioning, Decontamination, Dismantling, Reactor, Tank*

References

[1] IAEA, State of the art technology for decontamination and dismantling of nuclear facilities, Technical Report Series, No 395, Vienna, 1999.
[2] Radiation Protection 89, Recommended Radiological Protection Criteria for the Recycling of Metals from the Dismantling of Nuclear Installations. Luxemburg: Office for Official Publications of the European Communities, 1998.
[3] Joint Ministerial Order 1014 (FOR) 94, Official Gazette No 216/B/6-03-2001, "Radiation Protection Regulations" (in Greek).
[4] Research Reactor Radiation Protection Internal Regulations, Δ-ΙΠΤ-Α/2004/3 R-1.0, 2004 (in Greek).
[5] IAEA, Safety Standards Series, No. RS-G-1.1 Occupational Radiation Protection, Vienna, 1999.
[6] Generic procedures for assessment and response during radiological emergency, IAEA-TECDOC-1162, IAEA 2000.