PRESENT STATUS OF RESEARCH REACTOR DECOMMISSIONING PROGRAMME IN INDONESIA

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Abstract. At present Indonesia has 3 research reactors, namely the 30 MW MTR-type multipurpose reactor at Serpong Site, two TRIGA-type research reactors, the first one being 1 MW located at Bandung Site and the second one a small reactor of 100 kW at Yogyakarta Site. The TRIGA Reactor at the Bandung Site reached its first criticality at 250 kW in 1964, and then was operated at 1000 kW since 1971. In October 2000 the reactor power was successfully upgraded to 2 MW. This reactor has already been operated for 38 years. There is not yet any decision for the decommissioning of this reactor. However it will surely be an object for the near future decommissioning programme and hence anticipation for the above situation becomes necessary. The regulation on decommissioning of research reactor is already issued by the independent regulatory body (BAPETEN) according to which the decommissioning permit has to be applied by the BATAN. For Indonesia, an early decommissioning strategy for research reactor dictates a restricted re-use of the site for other nuclear installation. This is based on high land price, limited availability of radwaste repository site, and other cost analysis. Spent graphite reflector from the Bandung TRIGA reactor is recommended for a direct disposal after conditioning, without any volume reduction treatment. Development of human resources, technological capability as well as information flow from and exchange with advanced countries are important factors for the future development of research reactor decommissioning programme in Indonesia.

INTRODUCTION

At present Indonesia has 3 research reactors, namely the 30 MW MTR-type multipurpose reactor at Serpong Site, two TRIGA-type research reactors, the first one being 1 MW located at Bandung Site and the second one a small reactor of 100 kW at Yogyakarta Site (see Table 1). With respect to the future nuclear power plant construction, a comprehensive feasibility study and site investigation of the first plants had been carried out from 1991 till 1997. The Muria Peninsula in the northern coast of Central Java was investigated and found to be a suitable site for the first plants of a capacity of 7000 MWe. However, this programme was postponed to the year 2030 due to economic crisis.

The TRIGA research reactor at Bandung site was reaching its first critical core in 1964 and operated at maximum powert of 1000 kW since 1971. The reactor was upgraded into 2 MW power level successfully in October 2000. This means that the TRIGA Reactor in Bandung has been operated for 38 years and will then be an object for the decommissioning programme in the near future.

In order to anticipate the decommissioning programme for research reactor as well as other nuclear facilities, the Indonesian National Nuclear Energy Agency (BATAN) establishes a Division specially performing research and development work as well as services in the field of decontamination and decommissioning of nuclear devices and or nuclear facilities at the Radioactive Waste Management Development Center (RWMDC) at Serpong Site, 40 km southwest from Jakarta.

This paper discusses the present status of the research reactor decommissioning programme being developed in Indonesia pertaining to the present regulation, the management of radwaste generated by reactor upgrading operation, and the strategy of decommissioning.

REGULATION

The Act number 10 year 1997 on "Nuclear Energy" demands that the regulatory body for the activities on nuclear energy in Indonesia be in the authority of an independent body called BAPETEN (National Nuclear Regulatory Board) [1]. The same act further dictates that BATAN, according to the previous nuclear energy act performing as regulatory body as well as exuting body, assumes its function as an executing body only in performing research, development and application of nuclear energy. Consequently, the permit to perform decommissioning of research reactor should be applied to BAPETEN. According to the act, the owner of any nuclear installation, including research reactors should possess permits for construction, operation and decommissioning of their facilities, respectively. The responsible person for performing decommissioning of research reactor, based on this regulation is the owner of nuclear installation.

In order to obtain the above permit, the owner of the nuclear installation to be decommissioned has to apply it from BAPETEN, by attaching documents such as decommissioning planning, schedule, and safety analysis report [2,10]. The safety analysis report shall contain information such as:

- Inventory and classification of radionuclides;
- Analysis of document status;
- Decontamination and decommissioning technology to be applied;
- Radiation protection programme;
- Schedule;
- Quality assurance programme;
- Criteria for contamination limit; and
- Radioactive waste transportation.

The mechanism for applying for such permit and decommissioning procedure is presented in Figure1.

DECOMMISSIONING STRATEGY

The decommissioning process for research reactor basically has 3 phases. The first phase is mothballing which is defined as the safe store through controlling the nuclear facility. The second phase is entombment, which is defined as a restricted re-use of the site. The third phase is dismantling which is defined as removing all components followed by the restoration the site for an unrestricted re-used. Based on those 3 phases of decommissioning, there are two options for executing decommissioning programme, namely early decommissioning and delayed decommissioning [3]. Figure 2 shows the procedure for decommissioning of the research reactor according to these two options. Merits and demerits of early and delayed decommissioning are presented in Table 2 [4].

There are several criteria for selection of the decommissioning options. These criteria are different from one country to the other. They are, namely [5,11]:

1. Availability of repository for radwaste disposal
2. Re-use of reactor site for other purposes
3. Escalation of disposal cost
4. Technological capability for decommissioning
5. Financial capability
6. Social support

A preliminary study for the development of decommissioning strategy for Bandung TRIGA Mark II Reactor based on the above criteria has been conducted. The study was done by referring to the international experiences as well as domestic data calculated based on weighting and scoring method [12]. The study concludes that for Indonesia an early decommissioning is recommended. This option is more favourable by taking into account the fact that in the near future the radioactive waste repository will be available, the reuse of the reactor site for other nuclear installation is possible, and the land price is high. It is more advantageous, therefore, to adopt an early decommissioning, than re-use the site for other nuclear installation. Some cost calculations based on the Indonesian findings show that an early decommissioning is more attractive and cheaper than any delayed decommissioning [5]. Decommissioning strategies in several Asian countries as well as Indonesia's concept are presented on Table 3.

FACILITIES FOR SUPPORTING REACTOR DECOMMISSIONING

In order to support the implementaton of the early decommissioning strategy discussed above, RWMDC has been developing methods and equipment for decontamination, dismantling and decommissioning management. At RWMDC there are several devices for radioactive waste management as well as for decontamination of nuclear devices namely sand blasting, chemical treatment, ultrasonic, evaporator, incinerator, interim storage for low and intermediate wastes, and shallow land radwaste repository for the near future.

Sand Blasting

In order to avoid crude or corrosion product, fat or oil, carbon, phosphate or for marking purpose and surface finishing, RWMDC has installed one unit of wet sand blasting system of Vaqua-D type. This apparatus is used both for research and development purposes and process optimisation for decontamination. Serial tests have been done in order to optimise process parameters such as abrassive concentration, distance and angel spot, type and size of sand, etc.

Chemical Treatment

The chemical method is effective for decontamination of medium and big devices. Usually chemical substances used as decontaminant in this methods are acid, oxidator, reductor, dispersant, etc. RWMDC has installed one unit of immersion tank with 200 x 60 x 110 cm size, enough for 1000 litres of water. For accelerating the decontamination process an immersion tank is connected with pipe from boiler and circulation pump under feed flow of 750 l/h. Serial tests have been carried out in order to optimise the process parameters such as homogenisation, temperature, steam pressure, type and concentration of decontaminant, etc.

Ultrasonic

The ultrasonic method which applies bubble phenomena for accelerating the decontamination process is adopted in RWMDC. The Crest Ultrasonic Cleaner IM-3310 type has been installed. This method is effective for the decontamination of small size objects. Ultrasonic unit contains 2 generators, 2 transducers, each of 40 kHz, and one immersion tank of 51 x 46 x 50 cm. Chemical substances used in this method are EDTA, HNO_3 or detergent.

Hot Cell

For dismantling or decontamination of devices or apparatus with high exposure dose one uses the hot cell with manipulators.

Evaporator

For volume reduction of liquid waste as well as liquid secondary waste from decontamination process, RWMDC operates one unit of evaporator for a maximum concentration of 0.02 Ci/m^3 with operating capacity of 0.75 m^3/h. The unit is designed to reduce waste volume to a maximum ratio of 50:1, depending on the initial salinity.

Incinerator

In order to burn solid and combustible radioactive waste, RWMDC has installed one unit of incinerator with a capacity of 20 kg/h and also 2 cementation units for conditioning ash and solid wastes. The activity limit for this unit is 10^{-4} Ci/m^3 for alpha emitters and 10^{-2} Ci/m^3 for beta-gamma emitters.

Radwaste Repository

RWMDC in near future has been planning for operating a shallow land disposal site for low and intermediate radioactive wastes generated from the present nuclear programme. The potential site is located near south Jakarta, at a distance of 30 km from the Serpong site. The the site is approximately located 90 m above the mean sea level. At a distance of 200 m to the south-south east (SSE) from the repository there is a small river (river Cisalak) and 800 m to the south-south west (SSW) there is river Cisadane. The repository is a concrete vault type with 11 x 11 x 2,5 m size. The vault was designed for containing 300 waste concrete shells, each of 950 litre volume or 1425 drums each of 200 litre size. The total activity of each shell is estimated to be 6 Ci, hence the total vault activity equals to 1800 Ci [13].

MANAGEMENT OF RADWASTE FROM REACTOR UPGRADING

Inventory

The inventory taking of the radwastes generated from the activity of upgrading of the Bandung Research Reactor has been done. This project was performed in parallel with the reactor upgrading activity in May 1996 and in 2001 for radiation dose survey. From a series of measurements it was known that the radiation level in the core components varied from place to place. Table 4 shows the radiation level of the reactor core [6]. The number of spent fuel elements in May 1996 is 204. This fuel elements will be re-exported to the USA. Table 5 shows the radwaste inventory generated from the upgrading process, include the reflector, reactor internal components, neutron collimator, etc.

Reflector

The most important waste — based on the radiation dose level and weight — is the graphite reflector. The cylindrical reflector has outer and inner radii of 65 and 20 cm, respectively and a height of 140 cm. The graphite reflector is covered by a metal shroud of Al 6061-T651. The total weight of it is 2500 kg. Through activation analysis the main radionuclides in the graphite are found to be H^3 and C^{14}. On the other hand, the radionuclides present in the metallic shroud mainly are Co^{60} and Cs^{137}.

In the initial plan, the graphite reflector would be re-used. Therefore, after dismantling the reflector was scheduled for decontamination. A study for chemical decontamination of the reflector was accordingly conducted. In this study, NaOH, $H_2C_2O_4$ and HNO_3 at room temperature were adopted as decontaminants for cleaning the reflector [7]. The result shows that the reflector surface could be cleaned clearly. Table 6 shows the surface condition after decontamination for a few decontaminant compositions. Figure 3 and Figure 4 show the relation between the surface decontamination and the decontamination time for each decontaminant. The figures show that 2% of HNO_3 and 3% of NaOH is a good decontaminant for Al reflector shroud. Thin surface of the reflector mainly comprising 159.84 μm of scale could be removed for a 180-minute decontamination time. Generally, the surface decontamination is linearly co-related to the decontamination time.

Upon decontaminaton, however, the radiation exposure rate of the graphite reflector still remained unchanged. This problem had been predicted since there were activation products still remaining in the metal shroud as well as in the graphite reflector. Through activation, the radionuclides in the graphite were H^3 and C^{14}. On the other hand, the radionuclides in the metallic cover mainly were Co^{60} and Cs^{137}.

In the intermediate phase of upgrading process — owing to the difficulties in re-installing old reflector in the core due to haigh radiation exposure — the reflector was finally replaced with the new one. Therefore, the changed reflector was then considered as a solid radioactive waste.

In the future, it is better to dispose of the reflector directly or to condition it after cutting before disposal in the shallow land burial. Either one of these methods is recommended due to fact that the graphite weighs less than 2.5 tons (the density is 1.7 g/cm^3). This weight is far smaller by a factor of 160 than the limit for disposal of graphite in Japan. Japan decides limits for H^3 and C^{14} in the Rokasho Mura shallow land burial as follows [8].

H^3 = 3.07 x 10^{11} Bq/ton or for total in vault is 1.22 x 10^{14} Bq

C^{14} = 8.51 x 10^9 Bq/ton or for total in vault is 3.37 x 10^{12} Bq.

Based on the above limit the shallow land disposal could accept graphite of about 390 tons. The same consideration is also developed in UK and Spain [9].

Other Components

The management of reactor upgrading waste for the near future will be implemented through conditioning of the radwaste with cement matrix into a 200-litre drum with or without Pb shielding on conditioning in a 350-litre concrete shell. Based on the surface radiation level, the waste classification for conditioning could be developed. Table 7 and Table 8 show the classification of the reactor upgrading waste for conditioning. Most of the radionuclides in the reactor upgrading wastes are the activation products such as Co^{60}, Mn^{54}, Zn^{65}, Cs^{134}, Se^{75}, Sb^{124}, Mo^{99}, and Tc^{99m}.

Future Programme

Until now the Bandung reactor owner has not decided to decommission yet. However, for the next 10 to 15 years, perhaps he may decide it. In order to anticipate this situation, a preparation programme in human resources, development of technological capability as well as information flow from and exchanged with advanced countries are important factors for present stage of development in Indonesia.

CONCLUSIONS

From the above description, it can be concluded that:

1. The regulation for the decommissioning of research reactor is already issued and Indonesia has established a nuclear regulatory body from the nuclear energy implementer, from the former the decommissioning permit has to be applied.
2. Early decommissioning of a research reactor for a restricted re-use of the site for other nuclear installations is favourable for Indonesian situation.
3. Classification of reactor upgrading wastes for conditioning has been developed. A direct disposal of graphite reflector after conditioning in a shallow land disposal site is recommended.
4. A preparatory programme for the development of human resources, technological capability as well as the establishment of information inputs from and exchanges with the advanced countries in waste and decommissioning technology are important factors to develop Indonesia's capability.

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