Radiation Control Experience during JPDR Decommissioning

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ABSTRACT

The JPDR decommissioning program was begun in 1986, by the end of March 1991 most of activated and contaminated equipments were removed. The cumulative collective dose equivalent since initiation of the program is about 0.28 man-Sv. Dose distribution of workers engaged in dismantling of the reactor internals and the RPV showed hybrid log-normal distribution. Radioactive aerosol generation with mechanical cutting tools was higher than that with thermal cutting tools.

INTRODUCTION

Japan Power Demonstration Reactor (JPDR) is a BWR-type experimental power plant (12.5MWe) that begun to generate electricity for the first time in Japan in 1963. The plant was shut down permanently in 1976. The JPDR decommissioning program was begun in 1986. By the end of March 1991, reactor internals and a reactor pressure vessel(RPV) were dismantled using an underwater plasma arc cutting system and an underwater arc saw cutting system, respectively, in order to reduce exposure to workers and aerosol generation. This report describes radiation control experience during the decommissioning.

EXTERNAL EXPOSURE CONTROL

During the dismantling work, dose reduction measures for workers were taken, such as remote dismantling techniques, installation of shield. The cumulative collective dose equivalent since initiation of the JPDR decommissioning program is about 0.28 man-Sv. The collective dose equivalent for the removal of the reactor internals and the RPV was 0.073 man-Sv and 0.11 man-Sv, respectively. Figure 1 shows management data of JPDR decommissioning. Most of the exposure resulted from the removal of dross in fuel pool produced by underwater plasma arc cutting and the installation of a water tank which allowed the RPV to be submerged in water when it was cut.

Dose distribution models of workers are important in evaluation of collective dose in the planing stage. The distributions of cumulative dose of workers who engaged in the dismantling of the reactor internals and the RPV showed hybrid log-normal distribution[1]. Figure 2 shows hybrid log-normal plots

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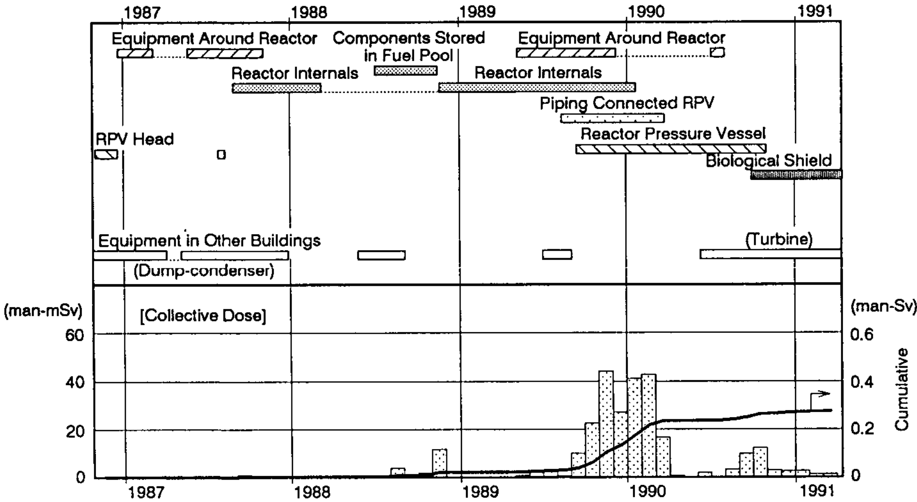

Figure 1 Management data of the JPDR decommissioning

of cumulative doses of the two groups. These dismantling work continued more than one fiscal year during which individual dose was restricted below the dose limit. The scattering of cumulative dose of the several workers who received the highest dose in FY 1989 decreased compared with that of total period of dismantling. This implied the effort of dose reduction and leveling off the dose of the workers to prevent the dose of small part of the worker becoming much higher compared with others.

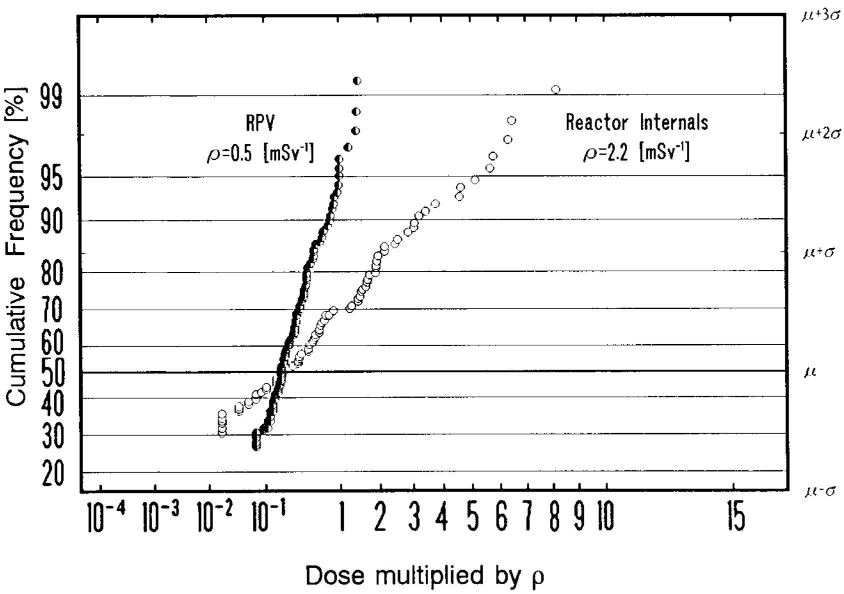

Figure 2 HLN probability plots of cumulative dose of workers engaged in removal of the reactor internals and the RPV

Various newly developed dismantling methods were adopted in the decommissioning to demonstrate their technical feasibility. In the dismantling of the forced recirculation outlet pipe connected to the RPV and penetrated biological shield, rotary disk knife cutting technique which could cut the pipe from outside of the biological shield remotely was adopted[2]. Surface concentration of radioactivity inside the pipe was 1000 Bq/cm^2 and dose rate around the RPV where the pipes were connected was a few hundred µSv/h. Table 2 shows the man-power and collective dose equivalent for the dismantling of the forced recirculation pipes with the rotary disk knife and an oxy-acetylene torch. Total man-power of the rotary disk knife cutting was 3 times higher than that of the oxy-acetylene torch and 75% of the man-power was due to installation of the cutting equipment. Collective dose equivalent in the rotary disk knife cutting was very low compared with the oxy-acetylene torch, because the workers didn't need to access the RPV to cut the pipe. 40% of collective dose equivalent of the oxy-acetylene torch was due to installation of shield around the RPV.

Table 1 Total manpower and collective dose equivalent for dismantling of forced circulation pipes

Method	Object	Man-Power (man-day)	Collective dose equivalent (man-mSv)
Rotary disk knife	outlet pipe	354	0.2
Oxy-acetylene torch	inlet & outlet pipes	110	11.5

INTERNAL EXPOSURE CONTROL

To prevent the spread of air contamination, temporary containment enclosures equipped with ventilation system were built and it was possible to reduce effectively the radioactivity concentration in air of working places. During the dismantling work, to select the most suitable measures for reduction of internal exposure, the radioactive concentration in air of working areas must be evaluated in advance. But little data is available for radioactive aerosols from dismantling work for quantitative evaluation[3,4]. Based on the measured aerosol radioactive concentration or mass concentration, normalized aerosol generation ratios, termed as immigration ratios (defined as : radioactivity in aerosols generated / radioactivity in kerf, and mass of aerosol generated / mass of kerf), were evaluated which will be used for evaluation of radioactive concentration or mass concentration in air during dismantling work.

Table 2 shows the immigration ratio for the radioactively contaminated stainless steel pipes segmentation with various

Table 2 Immigration ratios for stainless steel pipe segmentation

Cutting tool	Pipe size (inch)	Radioactivity immigration ratio (%)		Mass immigration ratio (%)	
		Range	Mean	Range	Mean
Band saw	2	5.8 - 37	13	---	< 10^{-2}
Band saw	6	10 - 58	19	---	< 10^{-2}
Reciprocating saw	12	7.0 - 24	9.9	---	< 10^{-2}
Plasma torch	12	0.23 - 0.78	0.44	0.53 - 0.82	0.66

cutting tools[5]. Because of the high radioactivity immigration ratio of the reciprocating saw, the radioactivity in aerosol generated per cut of the 12-inch pipe was about 30 times greater than that with the plasma torch. The size distribution with the plasma torch contained higher ratio of submicron aerosols than that with the reciprocating saw and showed bimodal distribution. The immigration ratios ranged from the order of 10^{-3}% to 10^{-2}% for underwater plasma arc cutting of the reactor internals and underwater arc saw cutting of the RPV.

During the reactor internals segmentation, besides the temporary containment enclosure, an air curtain was installed over the water surface of the pool to further enclose radioactive aerosols. Supply air flow rate was 40 m^3/min and exhaust air flow rate was 140 m^3/min. The ratio of the radioactive concentration of the lower side of the air stream to the upper side during the internals cutting ranged from 10 to 1000 and average ratio was 45.

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