Safety Assessment of the Solid/Liquid Waste Managements System in Cernavoda NPP Unit 2

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European Union (EU) required that the Safety Level of Cernavoda unit 2 to be comparable to those of the other European Nuclear Power Plants (NPPs). One of the technical items subject to these requirements is a safety review for the waste management systems. In this paper the safety review for the liquid and the solid waste handling systems of CANDU plants are performed by reviewing the design documents and operation experiences of Cernavoda units 1 and 2 and Wolsong units 1,2,3,4.

1. Liquid waste system

The most severe accident case for the liquid waste management system can be assumed when the effluent from the waste tanks is released directly to the condenser cooling water discharge duct without a decontamination process. The relevant failure modes can occur under a combination of the following failures.

a) Failure of a sampling of the liquid contents in a tank

b) Failure of a liquid effluent monitoring through the dispersal flow pass.

c) Failure of a sampling of the condenser cooling water from the condenser cooling water (CCW) duct.

For the liquid waste management system without a failure, the dilution process may be used to reduce the concentration of the contaminants in the tanks. Furthermore, active liquids containing more than 2.1×10^{-3} μCi/mL of a total β and γ activity will normally be processed by a combination of a filtration and an ion exchange. For the liquid waste management system without a decontamination process, it is considered unlikely that any of the active liquids will have high concentrations of radioactive materials. Normally, the activity of the liquid effluents is from 1×10^{-7} μCi/mL to 1×10^{-6} μCi/mL from the operation experience of the Wolsong nuclear power plants (NPPs). Liquid effluents containing more than 1×10^{-5} μCi/mL are not expected during the overhaul period. These quantities of the activity of the liquid waste are lower than 1.08×10^{-3} μCi/mL, the effluent concentration limit (ECL) for the Wolsong NPPs. Table 1 shows the amount of the liquid waste from CANDU6 during the past years, from which the activity concentration also can be shown to be lower than 1×10^{-5} μCi/mL.

Table 1. Release of radioactive materials from CANDU6 (TBq/y)

Source	Point Lepreau	Gentilly-2	Wolsong unit1	Embalse	CANDU6 Average	*Cernavoda unit 1
Tritium	254	160	79.1	238	183	58.3
Total Beta-Gamma	1.26E-2	9.03E-3	4.68E-4	2.95E-3	6.27E-3	-

* Data from FSAR of Cernavoda unit 1 is the annual average from 1997 to 2003.
** Data for the other plants are from the FSAR of Wolsong unit2,3,4 (average from 1988 to 1994)

Therefore, the failure of the liquid waste management system would not result in an annual radiation dose to the public in excess of the dose limit (1 mSv/yr) of ICRP 60, as shown in Table 2 which shows the estimated public dose from CANDU6.

Table 2. Estimated public dose from CANDU6 (μSv/y)

Source	Point Lepreau	Gentilly-2	Wolsong unit1	Embalse	Cernavoda unit 1
Tritium	0.027	1.6	2.2	19.2	-
Total Beta-Gamma	0.558	0.0034	0.24	23.8	-
Total	0.59	1.6	2.4	43.0	1.04

2. Solid waste system

A separate solid waste management system is provided for each CANDU NPP unit. This system includes the facilities to handle the following types of solid radioactive wastes: spent resins, spent filter cartridges, low activity solid wastes, organic fluids, oil and chemicals, etc. The spent resin handling system is the most critical solid waste handling system because of its high activity level. Besides, replacement of spent filter cartridges is processed during an overhaul period, and the spent filter cartridges are moved to and stored in the on-site solid waste storage facility.

The most severe accident case for the spent resin transfer system can be assumed when the spent resin of one transfer procedure is released directly to the floor of the service building during the spent resin transfer process. The relevant failure mode can occur under a combination of the following failures.

a) Failure of a transfer line of the spent resin transfer system

b) Fail to control the valve (7914-V10)to the spent resin storage vaults.

The activity of the heat transport and the spent fuel bay systems resins is due to almost entirely cesium-134 and cesium-137. The activity of the moderator resins, however, is due to mainly cobalt-60, chromium-51 and carbon-14, which are low energy beta emitters. The calculated amount of radioactive cesium could be shielded in the contamination control zones of the service building, and the low energy beta could be shielded by the 60cm-thick concrete outer walls of the service building.

Usually the amount of solid wastes produced in a nuclear power plant is inversely proportional to the radioactivity release to the environment. Because Korean NPP's try to reduce a radioactive release to as low as possible, far below the regulations, the amount of solid wastes becomes about the maximum. Compared to other Pressurized Light Water Reactor (PWR) plants operated in Korea, the CANDU 6 reactors in Wolsong produced the least amount of solid radioactive waste as well as the lowest total activity. Table 3 shows the volume of spent resins produced in Cernavoda unit 1 for several years, which are less than those of Wolsong units 1/2/3/4.

The amount and activity level of the solid wastes produced in a CANDU 6 NPP are less than those of a PWR NPP.. The solid wastes of the Cernavoda unit 2 shall not be released to the environment in the event of the solid waste management system failure.

Table 3. Volume of the Spent Resin Produced in Cernavoda unit 1 (Unit in m^3)

System	1996	1997	1998	1999	2000	2001	2002	Total
Heat Transport	0.000	2.080	0.000	2.120	2.160	2.160	2.000	10.520
Moderator	3.000	2.800	1.200	1.400	1.800	2.000	1.200	13.400
Spent Fuel Bay	0.000	2.260	2.260	0.000	2.260	0.000	2.250	9.040
Shield Cooling	0.000	0.200	0.200	0.000	0.200	0.200	0.000	0.800
D_2O Cleanup	1.200	2.330	1.800	1.800	1.400	0.600	0.600	9.730
Liquid Zone Control	0.000	0.400	0.200	0.200	0.200	0.400	0.000	1.400
Liquid Radwaste	0.025	-	-	0.040	-	-	-	0.065
FM Auxiliary	0.000	0.000	0.200	0.200	0.400	0.000	0.600	1.400
Total	4.225	10.070	5.860	5.760	8.420	5.360	6.660	46.355

References

1. Cahill, J. et al. "Radioactive Liquid Waste Management System," 86-79210-DR-001, Atomic Energy of Canada Ltd., 1993.
2. Cernavoda unit 2 FSAR, Chapter 11. Radioactive Waste Management
3. FSAR of Wolsong 2/3/4, Chapter 11. Radioactive Waste Management, KEPCO.