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RADIOACTIVE WASTE MANAGEMENT AFTER NPP ACCIDENT: POST-CHERNOBYL EXPERIENCE

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Abstract

As a result of the Chernobyl NPP accident a very large amount of so-called «Chernobyl waste» were generated in the territory of Belarus, which was contaminated much more than all other countries. These wastes relate mainly to two following categories: low-level waste (LLW) and new one - «Conventionally Radioactive Waste» (CRW). Neither regulations nor technology and equipment were sufficiently developed for such an amount and kind of waste before the accident. It required proper decisions in respect of regulations, treatment, transportation, disposal of waste, etc.

1. INTRODUCTION

Decontamination and remediation activities in the territories contaminated after Chernobyl accident resulted in the large volumes of radioactive materials and of other materials which have activity levels less than LLW, but nevertheless can impact public health and the environment (Table 1). This type of waste has been included in regulations as so called " Conventionally Radioactive Waste" (CRW) requiring control and special management. In some documents it is referred to as "Decontamination Waste" or "Chernobyl Waste". There is also the analogue in the Ukraine and the United Kingdom called "Very Low Level Waste". Nearly all of the ash from contaminated biomass-fired facilities is classified as CRW and the lowest range of LLW, i.e. from 1 kBq/kg to 100 kBq/kg.

TABLE 1. WASTE ARISING AS A RESULT CHERNOBYL ACCIDENT

Radioactive waste	Specific activity (kBq/kg)	Annual amount (t/year)
Ash from domestic stoves and municipal heating systems	5 - 400	18,300
Sludge of run-off and sewerage	0.1 - 15	50,000
Decontaminating solutions	< 30 kBg/l	40
Wood waste	0.4 - 60	1,500,000
Solid waste after demolishing of the buildings and construction in Chernobyl areas	< 0.9	380,000
Solid loose waste (soil)	0.1 - 10	1,000

The difficulties in management of these wastes are influenced by:

- very large amounts of radioactive wastes;
- some wastes are difficult to segregate;
- lack of suitable radioactive waste storage facilities;
- variation specific activity of the wastes, which ranges mainly from 0.4 to 400 kBq/kg.

2. REGULATIONS

The basic regulations that existed in the field of waste management in the former USSR did not consider wastes generated as the result of remediation nor decontamination activities in areas polluted by radioactive deposits after a large scale nuclear accident. Also they did not cover all aspects of waste management, including waste characterization, methods of treatment and conditioning, quality requirements for final immobilized waste form, conditions of transportation, storage and disposal performance.

In addition to basic regulations these ad hoc documents were adopted which provide the main background for waste management concept:

- Generic Control Levels of Intervention, (1993);
- Position on Decontamination and Waste Management for the Waste Generated as a Result of Actions to Mitigate the Chernobyl Accident Consequences, (1993);
- Regulation on Waste Management after Decontamination and Handling of Materials Contaminated with Radionuclides, (1993);
- Ad Hoc Rules of Waste Transportation and Disposal Sites Operation, (1994);
- Ad Hoc Regulations on Demolition of Contaminated Buildings and Waste Disposal in the Abandoned Zone, (1992);
- Regulations on Control of the Decontamination Waste Disposal Sites and Safety Assurance of Their Operation, (1993), etc.

3. TREATMENT

The main problem of the treatment of the "Chernobyl waste" is in the form of a volume reduction, which is achieved by evaporation of liquid waste and compation of solid ones.
Volume reductions of around 5 times are normal for solid waste supercompactors, but it is necessary to break large sheets of asbestos and similar materials into small fragments for optimum compaction. Engineered barriers should be used and personal protective clothing worn in order to protect workers and prevent the spread of asbestos fibres into the environment.

Incineration of combustible wastes has been practised as a volume reduction technique for many years, typically reductions of around 100 times are achieved. Woody wastes are suitable for this process and possibly small quantities of other combustible wastes such as wallpaper and polymer coatings could be included with wood. The disadvantage is that sorting of combustibles from non-combustibles may be required and that off-gas treatment is necessary. The ash from incinerators should be automatically removed and incorporated into concrete if it is LLW.

The immobilization technology of using thermoplastic encapsulation was developed at Brookhaven National Laboratory (BNL) in the United States to treat radioactive hearth ash generated from burning contaminated wood. Both the BNL and the Institute of Power

Engineering Problems (IPEP) collaborated to complete bench- and pilot-scale treatability studies.

Bench-scale treatability studies were conducted at BNL, while scale-up treatibility studies were conducted in the United States at the commertial facility of Westinghouse Environmental Systems Co. The following properties were achieved:

– loading ratio	- 75%
– compressive strength	- 300 kg/cm^2
– tensile strength	- 140 kg/cm^2, and
– leaching rate	- 10^{-7} $g/cm^{-2} \cdot day^{-1}$

4. TRANSPORTATION

The Design Department and Pilot Manufacture (DD&PM) of Sosny, Minsk, the counterpart of IPEP, has developed two types of trucks and a number of containers for transporting Chernobyl waste.

Trucks to transport very low level loose waste were designed on a basis of truck MAZ-5551 (Minsk Automobile Production Plant) and truck KrAZ-256 (Krivoj Rog Automobile Production Plant).

Containers to transport radioactive waste were designed to fit several packaging configurations. The simplest package (packaging module) is 1.48 m^3. Its dimensions are 137 cm × 121 cm × 89 cm. The biggest package with a total volume of 11.8 m^3 consists of eight modules.

Inside each module the vessel containing solid waste is placed. DD&PM designed and manufactured two types of vessel of different volume (1 m^3 and 2 m^3) for transportation of solid loose waste. A vessel consists of a stainless steel box equipped with cover and freight carrying hooks.

5. DISPOSAL

According to the "Provisional Sanitary Rules for Management of Decontamination Waste of Chernobyl Origin", this type of waste should be disposed in one of three types of repositories, each meeting different constructional requirements.

- Type 1 repository is a special engineering structure designed for radioactive waste with the specific activity in excess of 96 kBq/kg. This type of repository should be equipped with an adequate system of engineering barriers and hydrotechnical buffers to prevent release of radionuclides into the environment.
- Type 2 repository is intended for near surface disposal of the Chernobyl wastes with a specific activity from 0,96 to 96 kBq/kg. It is supposed to be equipped with simple clay and film barriers preventing migration of Cs-137 from the vaults. The repositories .of this type were constructed for Chernobyl decontamination wastes in 1986 -1988 and can be regarded as examples of such kinds of repositories
- Type 3 repositories cover all near surface disposal sites, which were set up in the abandoned territories of the Gomel region just after the Chernobyl Disaster. The "Provisional Sanitary Rules for Management of Decontamination Waste of Chernobyl Origin" defines organization of technical and radiation control in these disposal sites but does not give the requirements for their preparation and construction.

Some characteristics of Chernobyl waste disposal sites are presented in Table 2.

TABLE 2. PARAMETERS OF THE "CHERNOBYL WASTE" REPOSITORIES

Design area	11 - 19 thousand m^2
Design capacity	30 - 55 thousand m^3
Filled volume as of 01.05.96	30%
Waste layer thickness	2.4 - 3.4 m
Total activity as of 01.05.96	(3.7 - 27) 10^{10} Bq
Maximum specific activity	
^{137}Cs	(3.7-32) 10^3 Bq/kg
^{90}Sr	51 - 358 Bq/kg
$^{239,240}Pu$	0.19 - 0.78 Bq/kg

Existing regulations require the following monitoring operations for CRW repositories. During site operations the area around the repository must have access restricted to operators only. Daily radioactive monitoring at site access points is required plus monthly measurements of water levels and radioactivity in five bore holes spaced around the repository. Following closure radioactivity in these holes plus five additional ones directly over the filled repository are to be measured twice a year.

Many of the disposal sites performed after the Accident are potentially dangerous for population primarily as sources of radioactive contamination of ground and surface waters. Ravines, sand pits, foundation pits, trenches, etc., were used as "natural" locations for the sites with no due account taken regarding hydro-geological situation and landscape peculiarities.

In Belarus since 1993, radioecological monitoring of the ground water around these repositories is carried out. The system of radiation control and supervision over the processes of migration of ^{137}Cs and ^{90}Sr radionuclides away from the disposal sites has been established. The system has been installed at 11 storage sites. Each site has been fitted out with 4-5 hydrological wells, arranged below and above gradient from the storage site, allowing change of activity of radionuclides in the ground water to be recorded with sufficient reliability.

The studies carried out in spring, summer and autumn of 1993-1995 have shown that the values of ^{137}Cs and ^{90}Sr activities in water are in the range of 10-550 Bq/m^3 (Cs) and 5-150 Bq/m^3 (Sr). These values exceed significantly the values of activity of radionuclides in the ground water of the flood-lands of the Pripyat and Sozh rivers registered before the Accident. However, for all controlled repositories, the content of radionuclides in the ground water does not exceed yet the permissible limit accepted in the Republic of Belarus for drinking water (18500 Bq/m^3 and 370 Bq/m^3 for ^{137}Cs and ^{90}Sr, respectively).