RADIOACTIVE WASTE DISPOSAL IN THE RUSSIAN FEDERATION

Nikolai Laverov, Vice-President, Russian Academy of Sciences
Yuriy Shiyan, Russian Academy of Sciences
Paul Childress, Consultant, Lynchburg, VA USA

ABSTRACT

There are currently few licensed repositories for disposal of radioactive waste within the Russian Federation. This impasse has evolved due to extreme concerns by local and state governments about the safety of such facilities and the lack of coordinated action by the many ministries and agencies that each have some responsibility for the design, siting, licensing and operation of these facilities. The lack of adequate Federal budget and leadership for disposal facilities have led to multiple de facto storage areas at the many waste-generator sites. Thus, the different Russian ministries and agencies must be coordinated to achieve a functioning repository and the proper social and budgetary needs that must be satisfied to accomplish this goal. The Russian Academy of Sciences' involvement in expediting the repository includes site characterization, performance assessment, and nuclear safety.

INTRODUCTION

Even before the dissolution of the Soviet Union, the sheer mass of radioactive waste being generated in that country was demanding development of new long-range management and disposal solutions. The Russian Federation, also referred to as Russia, is heir to most of the liabilities arising from the nuclear activities of the Soviet Union, with the waste issue being one of the most important. No waste management strategy is complete without being able to demonstrate safe disposal of all waste streams/forms, but this requirement is particularly difficult in Russia due to a number of reasons. This paper presents past and current statuses, and then addresses the desired path forward for nuclear waste disposal strategies in the Russian Federation.

BACKGROUND

The Russian Federation stretches across eleven time zones and is by far the largest country in the world. As is the case with most countries that have vast spaces, including the United States, initial waste management strategies tend to be one of dumping the effluent into a convenient location and hoping for the best. Such strategies initially included dumping liquid waste into adjacent rivers (Ob, Yenisey) or seas (Barents, Kara, Okhotsk and Japanese) and either land burial or sea disposal of solid wastes [1]. Eventually, safer methods were developed with the help of scientists from institutes of the Russian Academy of Sciences and agencies/institutes of what is now the Ministry of Atomic Energy (Minatom).

Figure 1 shows most of the locations of nuclear waste generators in Russia. As shown in Figure 1 and in the listing of generators/sources below, the nuclear waste issue cannot be isolated in any one area of Russia; it is truly a national issue. The generators can be broadly categorized as follows:

- Power – 26 reactors at ten sites, including the dual-purpose reactors at Tomsk and Krasnoyarsk.
- Military - Four main areas, two for servicing the Northern Fleet at Murmansk and Severodvinsk and two for servicing the Pacific Fleet at Vladivostok and Petropavlovsk; an estimated total of 339 naval reactors in operation [2].
- Research – Dozens of small research reactors all over Russia.
- Production – Primarily large complexes for fuel or weapon material (Mayak at Chelyabinsk, Siberian Chemical Combine at Tomsk, Mining & Chemical Combine at Krasnoyarsk, Electrosol Fuel Production Facility near Moscow.
- Medicine – Isotope producers and nuclear medicine users and researchers all over Russia.
- Industrial – Producers and users of X-ray machinery and other nuclear industrial tools (oil well logging, etc.

x– naval sites, o – power reactors, + -other major sites

Fig. 1. Major nuclear waste storage sites in the Russian federation

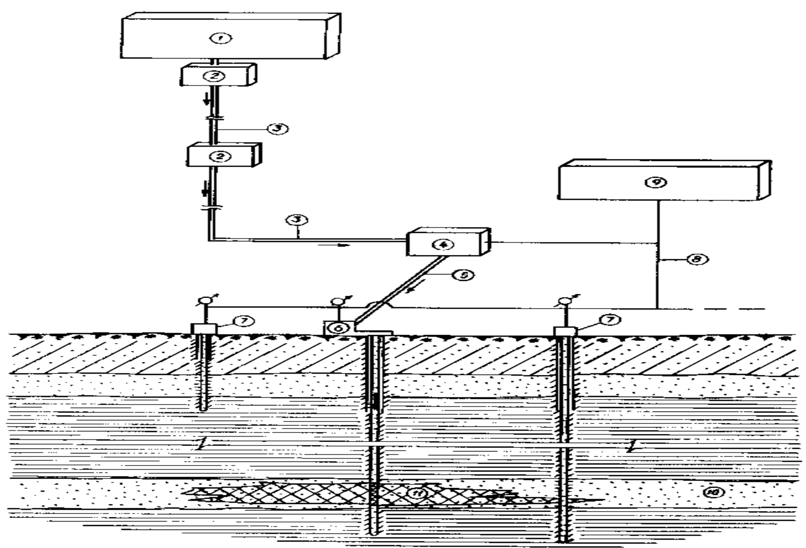
Russia has many laws governing nuclear waste and has developed its own classification system. Solid low-level waste (LLW) is defined as having activity under 10^{-2} curies per cubic meter (Ci/m^3). Liquid LLW is defined as having activity under 10^{-5} Ci per liter (L). Solid intermediate level waste (ILW) has activity from 10^{-2} to 10^3 Ci/m^3 (10^{-5} Ci/L to 1 Ci/L for liquid waste) and the activity of high-level waste (HLW) is over 10^3 Ci/m^3 (1 Ci/L for liquid waste) [1]. The total volume of nuclear waste currently stored at different locations in Russia has been estimated at over 5×10^8 m^3, not including spent fuel [3].

PAST AND CURRENT WASTE MANAGEMENT STRATEGIES

Early practices of disposal in rivers and lakes were soon found to be unsafe and were followed by extensive research into geological and deep-sea disposal. The prevention of migration of nuclides into the biosphere at levels that are toxic to humans has long been recognized as the standard of care for nuclear waste. The Soviet government in 1958 directed research into geological disposal and established guidelines to protect the environment. The approach to storage and disposal of nuclear waste was broken down into two groups – one for waste with long-lived nuclides and one for short-lived nuclides [1]. This approach allowed concentration on waste that would remain at toxic levels for an extended time.

Since the sixties, Soviet and Russian scientists have performed an enormous amount of research on ground water migration, geologic barriers, and nuclide movement in a variety of climates and terrains. Although the central Asian desert is now part of Kazakhstan, much work was performed on arid environments similar to that at Yucca Mountain. The Russian focus was on a closed fuel cycle, with reprocessing of the fuel to recover the potential energy. It led to a disposal facility for treated waste, much of it liquid, rather than for intact waste.

Initial efforts focused on volume reduction, inerting or treating the waste for direct disposal, and vitrification of the waste for packaged disposal. One approach used was the extraction of long-lived nuclides (uranium, plutonium, and transuranics) from liquid radioactive waste, leaving a prevalence of nuclides with relatively short half-lives. This slurry was treated for any specific chemical anomalies and then injected into deep geologic wells at a depth and density/volume that varied with the site and geologic medium. Some sites, such as Mayak, were not judged suitable for this disposal method. Figure 2 shows a schematic of a typical injection disposal system [1].



1 - TREATMENT PLANT, 2 - TRANSFER PUMPING STATION, 3 - LOW-PRESSURE PIPELINES, 4 - HOLDING TANK BUILDING AND INJECTION PUMPING STATION, 5 - HIGH–PRESSURE PIPELINE, 6 - INJECTION WELL, 7 - OBSERVATION MONITORING WELL, 8 - COLLECTION OF MONITORING DATA, 9 - ADMINISTRATIVE AND ENGINEERING BUILDING, 10 - RESERVOIR FORMATION, 11 - WASTES IN RESERVOIR.

Fig. 2. Schematic Deep Injection Disposal Site for Radioactive Wastes

Disposal of solid LLW in the Soviet era consisted of governmental shallow burial facilities, each operating under the name RADON. Liquid LLW was usually processed through a resin/zeolite system for purification, with the residue being solidified and buried at the local RADON facility.

Current practice in Russia focuses on storage due to the absence of disposal options. However, there are only five licensed disposal sites in Russia. They are:

- Dimitrovgrad (deep injection of liquid waste).
- Tomsk (deep injection of liquid waste).
- Krasnoyarsk (deep injection of liquid waste).
- Mayak (burial of solid or solidified waste).
- RADON/Moscow (burial of solid or solidified waste).

These facilities are either focused on waste generated at their site or on a local area (RADON services the Moscow area). Power plants and facilities servicing or decommissioning submarines have no disposal options.

Three facilities are currently in the process of being licensed to process liquid LLW in support of submarine decommissioning programs. They are:

- Zvezda/Bolshoi Kamen.
- Atomflot/Murmansk.
- Zvezdochka/Severodvinsk.

Note that the water discharge standard for these plants is isotopic-specific, but in general with a limit lower than 10^{-10} Ci/L. Russian disposal standards are among the most stringent in the world.

Noticeable is the absence of any facilities to support disposal of wastes arising from the power industry, medicine, industry, research or much of the military. The creation of such facilities will be costly and time-consuming, but their absence has overloaded existing storage capacity. There are plans to build storage facilities for solid waste at nuclear power stations, including regional facilities for multiple stations that would reduce construction and operation costs.

POTENTIAL PATH FORWARD

The obstacles to the creation of radioactive waste disposal facilities in the Russian Federation are significant. Organizationally, the Russian government is not suited for efficient operation. The President sets policy but depends on the ministries to execute plans. The Prime Minister's Office acts as the Chief Operating Officer and sets budgets/objectives with the other ministries. The other ministries do not consider themselves obligated to the Prime Ministry completely and each has its own set of responsibilities and authority. On the nuclear waste issues, this result in multiple layers of bureaucracy – the President has his Commission on Nuclear Waste Disposal, the Prime Minister has a Deputy Prime Minister on Science & Technology, Minatom has a Deputy Minister for Nuclear Waste, and

Gosatomnadzor (the Russian NRC), the Ministry of Ecology, the Ministry of Health, the Ministry of Emergency Preparedness are other Federal participants. Every state will also have a governor and regional officials with whom to deal. Currently all nuclear waste issues are under the responsibility of Minatom, although the requisite authority and budget are still in short supply.

Working with this network will require an extensive budget, one that Russia cannot yet afford. The real threat posed by nuclear waste must be measured against other sources of contamination – chemicals, pollutants, and other environmental hazards. As an example of competing priorities, it was estimated in 1995 that only 9% of the toxic waste being generated by the ferrous and non-ferrous industries was being recovered or safely disposed [4]. Air pollution from automobiles and fossil-fired power plants foul the air in many locations. For most Russian scientists and politicians the nuclear waste disposal issue is not a top priority and they may be right.

The fledgling market economy in Russia will not provide the capital required for development of nuclear waste facilities. The Duma will not apportion a sizeable part of the nation's budget for this effort, either. Ways that may work to provide a short-term influx of funds include the sale by Minatom of the down-blended highly-enriched uranium (HEU) from weapon dismantlement or the establishment of a waste disposal system (either for LLW or spent fuel) for small countries or countries with ill-suited geology. Either method would be significantly cash-positive and could have a portion of the profit earmarked for waste management issues.

Minatom and the Russian Government support a proposal to build a regional repository that could accept spent fuel from neighboring countries, but Article 50 of the Environmental Protection Law prohibits import of nuclear wastes into Russia. Currently spent fuel not immediately destined for reprocessing is viewed as nuclear waste by regulatory authorities. Some members of the new Duma plan to revise the Environmental Protection Law to allow the regional repository. The proposed amendment to the Environmental Protection Law has the support of Dr. Valery Danilov-Danilian, Minister of Ecology, as well as some state governors.

The good news is that there are capable resources within Minatom and the Russian Academy of Sciences that can identify, characterize and perform the required analysis to prove the acceptability of waste disposal facilities. It would benefit the worldwide nuclear industry if they were given the opportunity to succeed.

REFERENCES

1. A.I. Rybal'chenko, et al, "Deep Injection Disposal of Liquid Radioactive Waste in Russia," Izdat Press/Moscow, 1994. BMI translation 1998.
2. Bellona Report Volume 2:1996, "The Russian Northern Fleet".
3. N.P. Laverov, "Geological Aspects of the Problem of Spent Nuclear Fuel and Radioactive Waste Management," Paper presented at IAEA Workshop 1999.
4. "Nuclear Wastes in the Arctic," OTA-ENV-623, 1995.