Radioactive Waste Storage Technologies in the Arctic for the Russian Navy

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ABSTRACT

The inventories of nuclear materials in northwest Russia represent a serious environmental risk. The national policies of the U.S., Norway, and Russia have converged to address this risk through the Arctic Military Environmental Cooperation (AMEC) initiative. This paper discusses joint activities on solid radioactive waste (SRW) storage technologies in the Arctic for the Russian Navy. These are Western as well as Russian developments and will facilitate meeting Russia's needs for storing solid radioactive waste from decommissioned nuclear submarines. All work is directed at applications at Andreeva Bay or other SRW management sites in northwest Russia. Andreeva Bay is the Navy site with the largest inventory of SRW, and the Russian Navy has recently completed construction of an SRW storage facility at this site. The technologies which have been selected so far are 1) a coating for concrete and metal, 2) containers for waste storage and transportation, and 3) various materials used in handling and storage. The demonstration phase is under way and will last one year. The coating has been applied and tests of its performance are in progress. In addition to field tests in the Russian Arctic, thermal cycling tests have been performed in a laboratory to determine the aging parameters of the coating. Radioactive waste containers have been delivered from the U.S., and a Russian container design is in progress. The ultimate goal of AMEC Project 1.4 is to develop Russian self-sustainable capabilities for application in the extreme climate of the Arctic. These technologies will help shift the Russian Navy practices of bulk, open-air storage to an approach that includes containerized waste placed in a modern storage facility. The ongoing trilateral cooperation of this project is critical to achieving the policy goal of safe, secure storage for radioactive waste in northwest Russia.

INTRODUCTION

The radiological and environmental challenges in the Russian Northwest depend in many ways on the reduction of wastes from decommissioned nuclear submarines at Northern Fleet facilities of the Russian Navy(1-6). Arctic Military Environmental Cooperation (AMEC) is a cooperative effort between the U.S., Norway, and Russia to address some of the issues of nuclear waste management(1). The actual work of AMEC is divided into projects. The mission of AMEC Project 1.4, which was approved on December 19, 1996 by the AMEC Principals, is to improve Russian Navy capabilities in solid radioactive waste storage and thus minimize the spread of radiological contamination. The ultimate goal for this project is developing a self-sustaining radioactive waste storage capability, which will permit the Russian Navy to store its solid radioactive waste safely and securely without participation from the U.S. or Norway.

In addition to the submarines being dismantled under the START I Treaty, the Russian Navy is also dismantling other nuclear-powered submarines as they reach the end of their design lives or as the Navy decides they are no longer necessary. As of June 1996, some 80 nuclear submarines had been removed from service in the Russian Northern Fleet(1), but about 50 were still awaiting defueling (2) which is the first non-arms-related step in the dismantling process. Adding to the complexity of this decommissioning program is that a proportion of this backlog of non-defueled vessels has been stored afloat for 5-10 years or more after being taken out of service. If the START II Treaty enters into force, the Russian Navy will dismantle even more nuclear-powered submarines.

The Ministry of Atomic Energy (Minatom) is responsible for spent fuel and radioactive waste management in Russia. Historically, when the Russian Navy generated spent fuel and radioactive waste, Minatom or its predecessor ministries would take these materials from the Navy for safe, secure management. The relationship between the Russian Navy and Minatom (or its predecessor ministries) functioned fairly well until the Soviet Union dissolved in the early 1990s. This created a financial crisis in the new Russian Federation, which caused Minatom to gradually slow its receipts of spent fuel and radioactive waste to a trickle. Thus, for most of the 1990s, the Russian Navy has been struggling with vastly increased spent fuel and waste generation rates and vastly decreased spent fuel and waste management support services from Minatom. The result has been a rapid accumulation of radioactive materials on Russian naval bases.

Most of the spent nuclear fuel and radioactive waste has accumulated in northwest Russia, at the naval bases on the Kola Peninsula. The estimated quantities of radioactive materials are as follows: up to approximately 24,000 spent fuel assemblies; 7,000 cubic meters of liquid low-level waste; and approximately 8,000 cubic meters of solid low-level radioactive waste(1). Another reference gives a higher estimate for the liquid waste: 12,400 cubic meters, with 70 percent of that volume being low-level liquid radioactive waste and 30 percent being medium-level liquid radioactive waste. The average generation rate for solid radioactive waste is about 1,000 cubic meters per year. Most of this spent fuel and radioactive waste is stored at Andreeva Bay, which is on the west side of the Litsa Fjord, near the Norwegian border. In addition to the Russian Navy, these materials and their storage conditions are recognized as priorities by several other official agencies inside Russia (3).

Information on a variety of relevant technologies was collected and discussed at AMEC technical experts' meetings starting in early 1997. At these meetings, which were held in the U.S., Norway, and Russia, the parties presented specific, practical technologies for consideration and application at the Russian Navy facility at Andreeva Bay. The technologies which have been selected so far are 1) a coating for concrete and metal, 2) containers for waste storage and transportation, and 3) various materials used in handling and storage. Other technologies may also be investigated. If the three parties agree that any new technology has a high probability of providing practical benefits, then it could be included in the future.

CURRENT PROGRESS

New Russian Waste Storage Facility:

The Russian side has completed building a solid radioactive waste storage. This facility will be primarily used to store old wastes that have been in the open air for years at Andreeva Bay. The storage facility has below-grade vaults with concrete lids and a 20-tonne-bridge crane. The estimated Russian expenditure for this facility is $7.4 million, $800,000 of which has been provided since it was first proposed as an AMEC project.

Coating Technology Demonstration: The coating material selected was Polibrid 705, a thermosetting elastomeric polyurethane supplied by Promatec Technologies, Inc., Cypress, Texas. The chemical components and application equipment were shipped via air, barge, and truck to the RTP Atomflot facilities in Murmansk, Russia, arriving on May 25, 1998. The US team followed, and, during the period June-August 1998, assembled and tested the equipment, and trained the Russian technicians. The Russians then sprayed a portion of the coating material on the concrete floor (Fig. 1) of a loading bay of a radioactive waste handling building, an indoor passage in the same building, the external surfaces of a steel container, and 24 concrete and metal laboratory test coupons. The coatings on the loading bay and indoor passage floors will be exposed to the normal working environment over the next year and their condition monitored at regular intervals. The metal container will be filled with radioactive waste and left outside, exposed to Arctic weather conditions for twelve months. The laboratory samples were taken to St. Petersburg where the coating material is being subjected to a series of qualification tests. In the meantime, the spray equipment and the remainder of the coating components will be moved to Andreeva Bay, where they will be used to coat the floor of the Russian Navy's new waste storage facility.

Fig.1. Coating Application

Fig.2. Samples of the Coating

Low-Temperature Tests of Coating: A test program for the coating (Polibrid 705) based on ASTM standard test D1211 was completed in September 1998 (7,8). The test was performed at the National Institute of Standards and Technology (NIST). The objective of the test was to determine the temperature cycling effects on this coating in order to assure its long-term performance in the Arctic environment. Samples of the coating were prepared on concrete and metal substrates as well as free film by Carboline (Fig. 2), the manufacturer of the coating material. There are a number factors influencing the aging of a coating material such as heat, ultraviolet radiation, rain, temperature cycling, etc. A modified

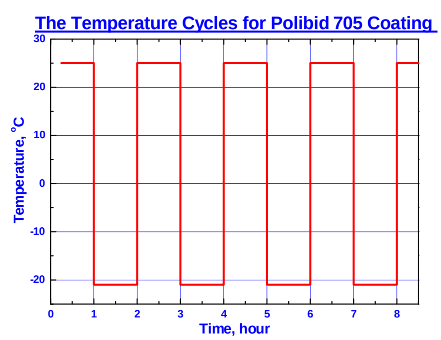

Fig.3. Temperature Cycles

technique was used for testing and evaluation of accelerated aging of a coating material due to temperature cycling. Tests in which coatings on substrates are cycled through elevated temperature, low temperature, and room temperature environments are called cold crack tests. They have been used in the coatings industry for many years as an indication of the ability of a coating to resist cracking in service and therefore are considered to be tests of coating flexibility. Results are reported as the number of cycles required to produce visible cracking in the coating. There were 200 cycles, and each cycle took over 2 hours (Fig. 3), so the actual test took about 52 days. Each of five sets was marked and checked at the end of each day by careful observation. After each milestone (50, 100, 150, and 200 cycles) the surfaces of the samples were examined under an optical microscope and images were taken for comparison. The tests showed that there were no visible changes of the surface appearance (cracks, color change, etc.) of the coating material. Our overall assessment is that the material performance in the given conditions is good and that this coating may be successfully applied in climates with frequent and sharp temperature changes, such as Northwest Russia.

<u>Solid Radioactive Waste Containers:</u>
At the Project 1.4 Technical Experts Meeting held on June 8 – 12, 1998 in Moscow, the Russian delegation stated that Russia has been doing extensive work on developing concrete containers for solid radioactive waste storage, transportation and disposal. The U.S. and Norwegian representatives agreed to support this effort and a contract has been signed. The U.S. representatives agreed to provide assistance to complete development, testing, certification, and production of 10 experimental concrete containers. The objective of this task is to provide a long-term (up to 300 years) storage and handling package.

The parties also agreed to evaluate the possibility of using containers made of metal. The U.S. representatives agreed to purchase 20 small low-level waste storage and transportation metal containers (each has an internal volume of about 2.5 cubic meters) and two large low-level waste storage and transportation containers (see Fig. 4). The two large containers meet International Systems Organization (ISO) standards and can be used as regular shipping containers. Ten of the small containers fit inside each large container for shipping purposes. The U.S. has purchased the containers from Container Products Corporation and shipped the containers to Murmansk, Russia. Both of the large containers and most of the small containers will be delivered to the Russian Navy for acceptance testing. The other small containers will be used by ICC Nuclide for certification testing. During 1999 the parties will explore the feasibility of developing a domestic production capability for such containers at Russian naval shipyards.

Fig. 4. Waste Containers

FUTURE PLANS

The various activities of AMEC Project 1.4 all fit together to develop a self-sustaining storage system, in which the Russian Navy stores its radioactive waste safely and securely without participation from U.S. or Norwegian officials. The floor of the new storage building at Andreeva Bay will be sprayed with the polyurethane coating. Additional storage building(s) could be constructed nearby in the 2002-2003 timeframe if funding is made available. The authors plan to evaluate modular construction for these additional buildings. Russian-made radiation monitoring and alarm systems could also be used in the storage building(s).

The authors also plan to provide Western personal protective equipment to protect the workers from radioactive contamination. When the waste has surface contamination, handling it may lead to contaminated dust becoming airborne. Disposable protective equipment, e.g. single-use coveralls and filter masks, is in big demand at the Russian Navy facilities. The project will therefore provide single-use disposable equipment for a limited test period as well as some multiple-use respiratory equipment in order to test the equipment's functionality relative to present equipment. A protocol defining the working conditions and procedures for application and/or decontamination will need to be developed in Russian.

The Russian design for a new radioactive waste container made of concrete will be approved and certified in 1999. Serial production could start as early as 2000, with several hundred units per year. The production rate could ramp up to over one thousand containers per year by 2002. This will allow the Russian Navy to put large volumes of radioactive waste in containers and thus minimize the spread of radiological contamination. With improved political and financial stability in Russia, the authors estimate that the objective of a self-sustaining waste storage system at Andreeva Bay can be accomplished by 2003.

CONCLUSION

The selected technologies will serve to support and enhance the Russian Navy's efforts to improve the storage of their solid radioactive waste. This shift of practice from bulk, open-air storage to an approach that includes containerized waste placed in a facility with improved containment technology will be a challenge given the current Russian economy. With the trilateral cooperation of this project, however, the waste will be stored safely and securely.

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