

PROGRESS ON COOPERATIVE US AND RUSSIAN PROGRAMS TO IMPROVE ENVIRONMENTAL AND PHYSICAL SECURITY OF SNF IN NW RUSSIA

R. S. Dyer, U.S. Environmental Protection Agency, Washington D.C., United States
R.L. Snipes, Oak Ridge National Laboratory, Oak Ridge, Tennessee, United States
Eleonora Barnes, U.S. Environmental Protection Agency, Washington D.C., United States
V. Kovalenko, RF Ministry of Atomic Energy, Moscow, Russia
V. Godunov, RF ICC Nuclide, St. Petersburg, Russia

ABSTRACT

Northwest Russia contains large quantities of spent nuclear fuel, solid radioactive waste, and liquid radioactive waste that potentially threaten the fragile environment of the surrounding Arctic region. The United States is currently providing assistance to the Russian Federation (RF) in managing some aspects of these issues. Some current projects include the development of prototype transport and storage containers, container storage facilities, and modernization of a LRW treatment facility. Additional projects are being initiated to improve the efficiencies of fuel loading, increase the fuel capacities of the containers, and assist in the management of other radioactive components from nuclear submarines. Considering the recent terrorist attacks there has been increased interest in the physical protection of all SNF whether in Russia or any other country.

INTRODUCTION

Northwest Russia is the location of approximately 20 percent of the world's nuclear power and marine propulsion reactors. Since the late 1950s, Northwest Russia has been the home for an increasing number of nuclear submarines, icebreakers, and other nuclear powered vessels. This geographic region has more marine nuclear propulsion reactors than any other place in the world. As a result, there is a vast quantity of spent nuclear fuel (SNF), solid radioactive waste (SRW), and liquid radioactive waste (LRW) in Northwest Russia. If these are not properly managed, they could release significant concentrations of radioactivity to the sensitive Arctic environment and could become a serious global environmental security issue.

Large quantities of SNF from Russian decommissioned nuclear submarines and civilian icebreaker fleet are currently in storage in Northwest Russia. The fuel is currently stored either onboard submarines or in floating storage vessels. Existing Russian transport infrastructure and reprocessing facilities cannot meet the requirements for moving and reprocessing currently stored fuel and the fuel from submarines awaiting decommissioning. Some of the fuel is damaged, stored in an unstable condition, or of a type that cannot currently be reprocessed. Also, some of the existing storage facilities being used in Northwest Russia are unsafe both from a health and safety aspect, as well as an environmental perspective. The removal, handling, interim storage, and shipment of the fuel pose technical and ecological challenges. The management of other radioactive components, such as the LRW and the submarine reactor compartment sections, from the decommissioned submarines also present technical and ecological challenges.

The U.S. Environmental Protection Agency (EPA), with support from the Department of Defense, the Department of State, and the Department of Energy's (DOE) Oak Ridge National Laboratory, is working closely with the Ministry of Atomic Energy (Minatom) of the Russian Federation (RF) on two multilateral cooperative projects which provide assistance to the RF in the management of some of their military and civilian SNF. These two projects involve the development of prototype containers and container storage facilities to meet RF military and civilian requirements. Specifically, these projects involve the development of prototype dual-purpose, metal-concrete containers for the transport and storage of RF SNF and the development of suitable storage facilities for the containers. These are the first dual-purpose containers developed for use in Russia. The projects also address the limitations of the existing infrastructure at the various military and civilian facilities. These projects are designed to provide a safe and environmentally sound interim solution for managing the SNF until permanent storage is attained.

The United States and Norway have also been working with the Russian Federation in the LRW processing area. The countries have just completed the redesigning and modernization of a LRW treatment facility at the RTP Atomflot Facility in Murmansk, Russia.

Additional projects are being considered to improve the efficiencies of fuel loading, increase the fuel capacities of the containers, and assist in the management of other radioactive components of the decommissioned submarines. Evaluating and demonstrating options for providing interim storage for the reactor compartments of the decommissioned submarines is an example.

ARCTIC MILITARY ENVIRONMENTAL COOPERATION

The Arctic Military Environmental Cooperation (AMEC) Program, between the Defense Ministries of Norway, Russia, and the United States, was initiated in 1996 as an international environmental security and demilitarization agreement. In Bergen, Norway on September 26, 1996, the Norwegian Minister of Defence, the Russian Federation Minister of Defence, and the U.S. Secretary of Defense launched this cooperative effort. The Ministers signed a historic Declaration calling for contacts and cooperation among the parties to jointly address critical environmental concerns in the Arctic. The AMEC Program was established to create a forum for increased dialogue and development of additional joint activities addressing Arctic environmental issues among the United States, Russian, and Norwegian military and environmental officials. The AMEC Program is led by top environmental officials from the Norwegian Ministry of Defence (MOD), Russian MOD, and the U.S. Department of Defense (DoD).

The AMEC Program activities are primarily focused on "off the shelf" technology demonstrations. The five active project areas that deal with radioactive waste technologies are

- development of a prototype dual-purpose cask for transport and interim storage of SNF from decommissioned submarines and a storage facility for the casks;
- development of mobile technology for treatment of liquid radioactive waste at remote sites associated with nuclear submarine decommissioning;
- implementation of technologies for solid radioactive waste volume reduction;

- development of technologies for enhancement of solid radioactive waste storage facilities; and.
- radiation safety training, monitoring techniques and equipment focused on nuclear submarine dismantlement.

AMEC Projects 1.1 and 1.1-1 address specific environmental issues associated with the removal, transportation, and storage of SNF from nuclear submarines being decommissioned in Northwest Russia. AMEC Project 1.1 involves the development of a 40-tonne SNF cask suitable for both transportation and interim storage (up to 50 years) of the SNF being removed from the submarines. The specific objective of the project is to design, fabricate, test, and certify a prototype 40-tonne transport and storage cask for use in the RF. The Norwegian Defence Research Establishment for Norway, ICC "Nuclide" for the Russian Federation, and the Environmental Protection Agency for the United States initiated AMEC Project 1.1 in February 1997. AMEC Project 1.1-1 involves the development of suitable facilities for interim storage of the dual-purpose casks. The objective of this project is to design, construct, and license a facility suitable for storing 19, 40-tonne casks containing SNF. The storage pad project was initiated in July 1998.

AMEC Project 1.1 Objectives and Participants

As previously stated, the primary objectives of AMEC Project 1.1 are to design, fabricate, test, and certify a dual-purpose transport/storage cask for handling of SNF from decommissioned Russian Navy submarines.

Primary Project 1.1 Participants include:

Norway -Norwegian Defence Research Establishment (FFI), and the Institute for Energy Technology (IFE).

Russia – Russian Ministry of Defence (MOD), Interbranch Coordination Scientific Technical Centre of Nuclide Production (ICC "Nuclide"), Special Mechanical Engineering Design Office (KBSM), Izhora Works, The All Russian Design and Research Institute of Complex Power Technology (VNIPIET), The All Russian Scientific Research Institute of Experimental Physics (VNIIEF), MOD Institute #26, Ministry of Atomic Energy (Minatom), MOD- and Civilian-Gostatomnadzor (GAN), Ministry of Health, and the Ministry of Transportation.

United States – U.S. Environmental Protection Agency/Office of International Activities, Oak Ridge National Laboratory, and NAC International.

AMEC Cask General Description

The AMEC cask is a metal-concrete cask designed to contain 7 canisters each holding up to 7 SNF assemblies, for a total of up to 49 fuel assemblies. It is approximately 4.5-m high and 1.6-m in diameter. It has been designated as the TUK-MBK-VMF or TUK-108/1 by Russian authorities. When the AMEC cask is fully loaded with fuel, it will weigh approximately 40 metric tonnes. The empty cask (without the basket, fuel canisters, and spent fuel) will weigh approximately 35 metric tonnes. A schematic of the AMEC cask is shown in Fig. 1.

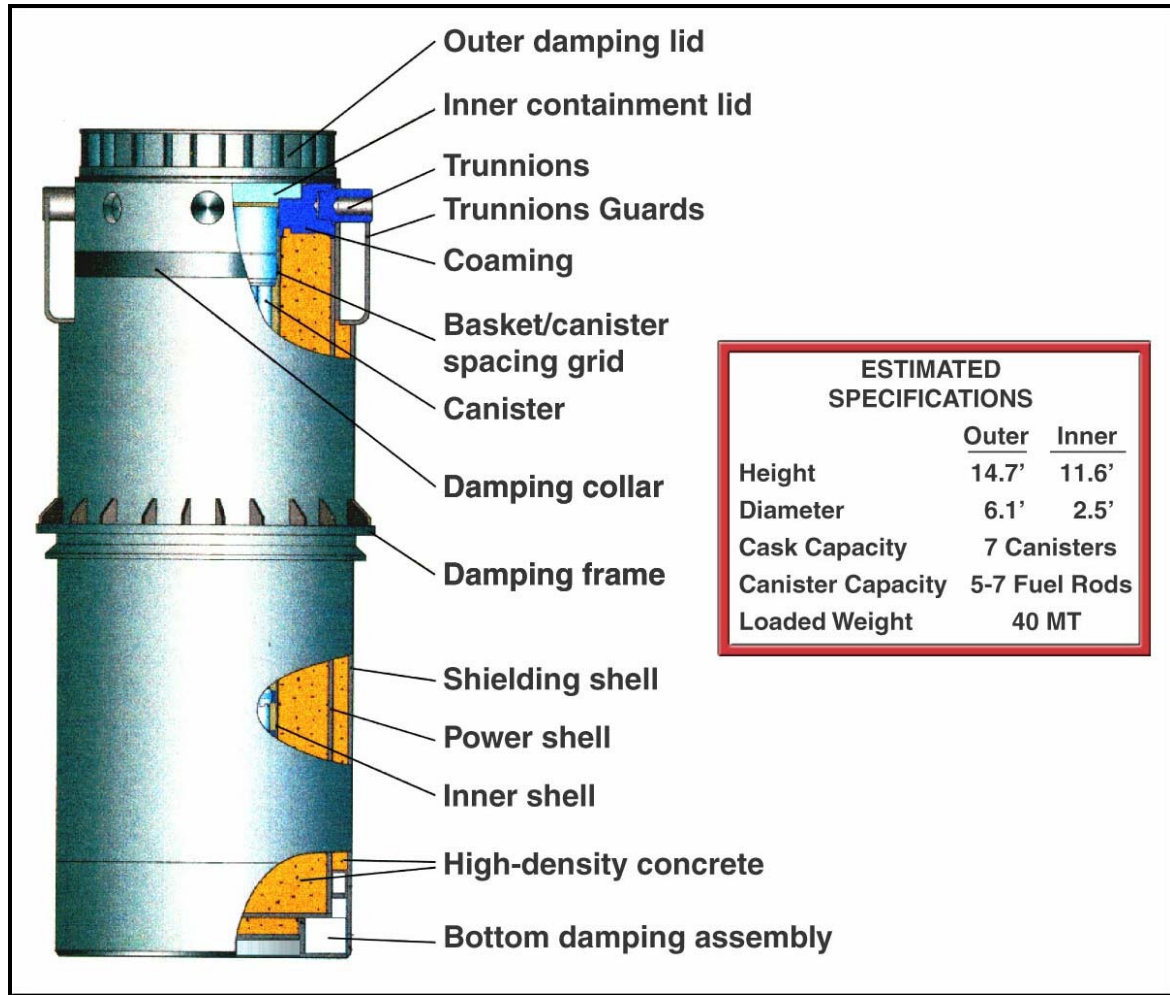


Fig. 1. Schematic of the AMEC 40-tonne prototype cask.

The AMEC cask is comprised of three concentric metal shells attached to a common forging (coaming) at the upper end and metal bottom pieces for each of the shells. Heavy-duty, high-density concrete is poured between the metal shells to form two separate concentric concrete shells. The inner concrete shell is significantly thicker than the outer concrete shell and serves as the primary structural and shielding element for the cask. The outer concrete shell provides additional strength and shielding but also serves as a sacrificial shell which functions as an “impact limiter” in case of an accident.

The cask is sealed at its upper end by two separate metal lids. The inner lid serves as both a shielding and first containment barrier for the contents. The outer lid serves as the second containment barrier and provides structural protection for the inner lid. The outer lid also serves as an “impact limiter” or “damping device” during an accident. The bottom portion of the cask and the outer lid of the cask both incorporate metal-rib damping devices as an integral part of their construction. Previous generations of metal-concrete casks have utilized removable damping devices bolted onto the cask. However, the AMEC cask incorporates the damping

devices into the actual construction of the cask bottom, outer lid, and cask body. Therefore, the cask requires no additional bolt-on damping devices.

The cask design has been reviewed by U.S. and Russian teams to identify alternative schemes for providing the appropriate physical protection of the SNF being stored or transported in the cask.

AMEC Cask Design Requirements

The AMEC cask is designed to be handled and transported by the existing infrastructure used by the Russian Navy for the existing Russian all-metal TK-18 transport casks. The TK-18 casks were designed only for transportation of SNF. The TUK-108/1 AMEC casks will complement the existing, aging TK-18 casks. The AMEC 40-tonne cask is designed for at least a 50-year life and meets all applicable Russian and International Atomic Energy Agency (IAEA) standards for storage and transport of SNF. The AMEC cask has been certified/licensed by the appropriate Russian authorities to allow it to be used for both transport and storage of RF military SNF.

The AMEC prototype cask must meet or exceed all design and licensing requirements for fabrication and operation of the cask. The cask must also demonstrate, either through analytical calculations or testing, the ability to survive, intact and without breach of containment, the normal and hypothetical accident conditions specified in Russian regulations and IAEA Standard ST-1. These hypothetical accident conditions include

- 9-meter drop onto a flat unyielding surface;
- 1-meter drop onto a rigid upright 15-cm diameter, 20-cm high metal pin;
- complete entrainment within an 800°C fire for 30 minutes; and
- submersion under water at a depth of 15 m for a period of eight hours.

Additional tasks, such as cask dewatering and fuel drying systems, are being considered to further improve the cask performance.

Current AMEC 1.1 Project Status

The design and fabrication of the AMEC prototype cask was completed in September 1999. Design verification testing was successfully completed in August 1999. Successful 9-m and 1-m drop tests, as defined by IAEA guidelines, were also conducted on a half-scale model of the prototype cask in August 1999. Cold-testing of the full-scale prototype cask at the RTP Atomflot site in Murmansk, the Mayak processing facility in Chelyabinsk, and a naval shipyard in Severodvinsk was completed in June 2000. These tests demonstrated that the full-scale AMEC cask effectively interfaces with existing fuel and cask handling equipment at the sites and can be safely and effectively loaded, unloaded, and transported with fuel. One of the first serially produced casks of the TUK-108/1 design was loaded with “real” fuel to test the shielding provided by the cask. All design parameters were successfully met.

The AMEC cask design has been certified by the Russian Federation Ministry of Defence, Minatom, Ministry of Health, and other appropriate Russian authorities. Russian serial production of the TUK-108/1 cask began in 2000. The Russian Federation has stated that as

many as 300-400 of the AMEC casks may be required to safely transport and store all of the SNF from decommissioned nuclear submarines and other applications in Russia. Russian authorities report that 48 TUK-108/1 casks have been produced to support the SNF transport and storage requirements of the RF ongoing nuclear submarine decommissioning program. The U.S. has recently entered into a contract with the Sevmash Production Association located in Severodvinsk, Russia to produce an initial 25 of these TUK-108/1 casks for application in bilateral Russian programs supported by the U.S. Cooperative Threat Reduction Program.



Fig. 2. AMEC TUK-108 prototype cask without lids and one fuel canister installed.

AMEC Project 1.1-1 Project Objectives and participants

The objectives of AMEC Project 1.1-1 are to design, construct, and license a transshipment/ temporary storage pad for up to 19 AMEC casks. This pad will be designed and located to maximize the use of existing Russian cask and fuel handling equipment and facilities.

to be temporarily stored on the pad for 30-60 days, but no longer than 2 years. The storage pad is also designed to withstand the extreme temperatures (-37°C to +32°C) of the Arctic and anticipated seismic activity of 6 points on the MSK/Richter scale. The pad is located and designed to facilitate the use of existing equipment, railways, and facilities. The storage pad is designed to facilitate loading and unloading of both TK-18 and the new TUK-108/1 casks while utilizing the existing and planned cask fuel loading facilities (the floating service ships) and rail transport cars.

The storage pad design has been reviewed by U.S. and Russian teams to identify alternative schemes for providing the appropriate physical protection of the SNF being stored at the facility.

Current AMEC 1.1-1 Project Status

The RF experts have completed the project's "Technical Assignment," "Declaration of Intent," "Justification of Investments," and the design and construction documentation for the AMEC transshipment/temporary storage pad. These documents, which describe the basic functional and regulatory requirements for the storage pad, have been approved by the relevant Russian organizations. Preliminary storage pad construction activities began on site in September 2000. Figure 4 below shows the construction progress as of December 3, 2001. At that time, the storage facility concrete foundation plate and the majority of the concrete walls were complete. Today, construction of the major components, including the concrete foundation plate and walls, metal roof and cask coverings, sanitary and passage, of the transshipment/storage pad has been completed.



Fig. 4. Construction progress on the AMEC transshipment pad (December 3, 2001).

Completion of the facility radiation monitoring system, physical protection system, cold- and hot-testing, licensing, and commissioning are scheduled for July 2002. The pad should be totally operational and certified by the end of the summer 2002.

MURMANSK CASK PROJECT

The Murmansk 80-Tonne Cask Project (Murmansk Cask Project) is a multilateral project involving Finland, Norway, Russia, Sweden, the United States, the United Kingdom, the European Union, and the Nordic Environmental Finance Corporation. The project is primarily focused on the removal and interim storage of damaged and unprocessable SNF on the "LEPSE" and "LOTTA" floating storage vessels currently moored in Murmansk, Russia. This project was initiated in January 1998. The project is similar to the AMEC Project, but it has three major tasks. The first task includes the development of a dual-purpose, 80-tonne, metal-concrete container for the transport and storage of the SNF currently on the "LEPSE" and "LOTTA." The second task involves the development of a suitable interim storage facility currently planned at the RTP Atomflot Facility in Murmansk, Russia for the containers. The third task involves the upgrading and modification of the existing on-site transport and loading infrastructure to support the loading and movement of the containers.

The Technical Assignment for the cask development was completed in 2000. The Technical Assignment, Declaration of Intent, and a Comprehensive Engineering Survey have been completed for the interim storage facility. Further progress has been delayed because of the lack of agreements between the project donors and the Russian Federation concerning nuclear liability and indemnification. It is anticipated that these issues will be resolved in next few months. If so, the project could be completed in mid-2004.

CONCLUSION

Under trilateral Norwegian, United States and Russian sponsorship, a dual-purpose 40-tonne metal concrete spent nuclear fuel transport and storage cask has been designed, tested, and certified for use in the Russian Federation. The cask meets all applicable Russian Federation and international regulations for use in the Russian military program. Additional casks have been produced and are currently being used by the Russian Federation Ministry of Defence to transport and store spent nuclear fuel from their decommissioned nuclear submarines. Russian Federation officials have also discussed plans to have the 40-tonne cask certified by Russian civilian regulators in order that the cask could be used for the transport and storage of Russian civilian spent nuclear fuel. A spent nuclear fuel transshipment storage pad has been designed and is in its final construction phase. This was the first storage facility planned in Russia for dry storage of spent nuclear fuel in metal-concrete casks. This has resulted in the development of new Russian standards and regulations for integrated dry fuel storage systems. The development of this 40-tonne cask and storage facility has enabled the Russian Federation to significantly expedite its Ministry of Defence program to decommission its laid up submarines. The proper use of this cask and storage facility and appropriate accountability programs will enable the Russian Federation to safely transport, store, and account for its spent nuclear fuel.