DEVELOPMENT OF A DUAL-PURPOSE CASK AND STORAGE PAD SYSTEM FOR MANAGEMENT OF RUSSIAN SUBMARINE SPENT NUCLEAR FUEL

Robert Dyer, U.S. Environmental Protection Agency, Washington, D.C. 20004
and
Steinar Høibråten[1], Tatiana Makarchuk[2], James Ballowe[3], and Randy Snipes[4]

ABSTRACT

The governments of Norway and the United States have been working with the Russian Federation to manage the environmental issues associated with the large quantity of Russian submarine spent nuclear fuel currently stored in Northwest Russia. With the implementation of recent international environmental security and demilitarization agreements, a relatively new program, the Arctic Military Environmental Cooperation (AMEC) between the Defense Ministries of Norway, Russia, and the United States, has been expanded. AMEC Projects 1.1 and 1.1-1 address specific environmental issues associated with the removal and storage of spent nuclear fuel from nuclear submarines being decommissioned in Northwest Russia. This spent nuclear fuel, if not properly managed, could release radioactivity to the Arctic environment.

A two-part approach to this problem is being implemented by AMEC Projects 1.1 and 1.1-1. The first part of the overall approach is the development of a spent nuclear fuel cask suitable for both transportation and interim storage (up to 50 years) of the spent nuclear fuel being removed from decommissioned Russian submarines. The second part of the overall approach is the development of suitable facilities for storing the dual-purpose casks. These projects provide a safe and environmentally sound interim solution for managing the spent nuclear fuel until final disposal is attained.
The Norwegian Defence Research Establishment for Norway, ICC Nuclide of Minatom for the Russian Federation, and the Environmental Protection Agency for the United States initiated AMEC Project 1.1, involving the 40-tonne spent nuclear fuel cask development, in February 1997. The specific objective of Project 1.1 is to design, fabricate, test, and certify a prototype cask. After certification of the prototype cask, it is planned that sufficient numbers of these casks will be fabricated to allow removal and safe management of the spent nuclear fuel.

AMEC Project 1.1-1, the storage pad development, was initiated in July 1998. The objective of this project is to design, construct, and license a facility suitable for interim storage of the casks containing the spent nuclear fuel.

Together, these two AMEC projects will provide a safe and reliable integrated solution for management of the Russian spent nuclear fuel from decommissioned submarines residing in Northwest Russia.

[1] Norwegian Defence Research Establishment, Oslo, Norway.
[2] ICC Nuclide, St. Petersburg, Russia.
[3] NAC International, Norcross, Georgia.
[4] Oak Ridge National Laboratory, Oak Ridge, Tennessee.

INTRODUCTION

Northwest Russia is the location of the greatest number of nuclear powered submarines in the world. The fuel, if not properly managed, could release significant concentrations of radioactivity to the sensitive Arctic environment and become a serious global environmental security issue. Norway, Russia, and the United States are working together to address this concern in Arctic Military Environmental Cooperation (AMEC) Projects 1.1 and 1.1-1. AMEC Projects 1.1 and 1.1-1 address specific issues facilitating the transport and storage of spent nuclear fuel from nuclear submarines being decommissioned in Northwest Russia.

Two primary issues are being addressed by these AMEC projects. The first issue involves the development of a 40-tonne spent nuclear fuel cask suitable for both transportation and interim storage (up to 50 years) of the spent nuclear fuel being removed from the submarines. The second is the development of suitable facilities for interim storage of the dual-purpose casks.

The Norwegian Defence Research Establishment for Norway, ICC Nuclide of Minatom for the Russian Federation, and the Environmental Protection Agency for the United States initiated AMEC Project 1.1, involving the cask development, in February 1997. The specific objective of Project 1.1 is to design, fabricate, test, and certify a prototype 40-tonne transport and storage cask.

AMEC Project 1.1-1, "Storage Pad Development," was initiated in July 1998. The objective of this project is to design, construct, and license a facility suitable for storing the 40-tonne casks containing spent nuclear fuel.

THE NEED FOR ACTION IN NORTHWEST RUSSIA

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 on the earth. As a result, there is a vast quantity of spent nuclear fuel in Northwest Russia.

Improper management increases the risk for and the potential environmental impact of this spent nuclear fuel. Spent nuclear fuel, and other waste, from an estimated 380 submarine reactors are reportedly being stored in Northwest Russia. Eighteen reactor cores are currently being stored on floating storage ships or barges. Other nuclear reactor fuel is being stored in-place, on-board decommissioned submarines. In addition, some spent nuclear fuel is being stored in containers not designed for long-term fuel storage.

There is a high potential for negative environmental impact caused by inadequate management of this spent nuclear fuel. Potential environmental impacts to the region includes: (1) the contamination of local and regional ground water, (2) the contamination of vegetation and wildlife throughout the entire region, and (3) ultimately contamination of the food chain for both animals and man.

The militaries of Norway, Russia, and the United States are committed to protecting the environment, particularly a fragile ecosystem like the Arctic. The populations that border this region need an environmentally sound Arctic to ensure their health and, in some cases, their economic livelihood.

AMEC was formed to deal with these issues in a cooperative and constructive manner. Several AMEC projects were created to help ensure that the militaries of the Kingdom of Norway, the Russian Federation, and the United States do their part to help assess, preserve, and restore the Arctic environment.

ARCTIC MILITARY ENVIRONMENTAL COOPERATION

On September 26, 1996, in Bergen, Norway, Jorgen Kosmo, Norwegian Minister of Defence; Igor Rodionov, Russian Federation Minister of Defense; and William J. Perry, U.S. Secretary of Defense launched a cooperative effort called the AMEC forum. The Ministers signed a historic Declaration calling for contacts and cooperation among the parties to jointly address critical environmental concerns in the Arctic.

AMEC is a forum for dialogue and joint activities among United States, Russian, and Norwegian military and environmental officials. This forum addresses Arctic environmental issues that are related to each participant's militaries' unique capabilities and activities.

AMEC is led by top environmental officials from the U.S. Department of Defense (DoD), Norwegian Ministry of Defense (MOD), and Russian MOD who are designated as the AMEC Principals. For the U.S. DoD, Ms. Sherri Goodman, Deputy Under Secretary of Defense for Environmental Security provides policy oversight. She has designated Rear Admiral Andrew Granuzzo, Director, Environmental Protection, Safety and Occupational Health Division, Chief of Naval Operations as the U.S. Principal. For the Russian MOD, General – Colonel Sergei Grigorov, Director of Ecological Security is the Russian Principal. For the Norwegian MOD - Mr. Svein Styrvold, Deputy Director General, Department of Defence Resources is the Norwegian Principal.

Seven projects have been approved by the AMEC Principals. They are primarily focused on "off the shelf" technology demonstrations. The five projects that deal with radioactive waste technologies are:

1. Development of: (1) a prototype dual-purpose cask for transport and interim storage of spent nuclear fuel from decommissioned submarines and (2) a storage pad for the casks.
2. Development of mobile technology for treatment of liquid radioactive waste at remote sites associated with nuclear submarine decommissioning.
3. Implementation of technologies for solid radioactive waste volume reduction.
4. Development of technologies for enhancement of solid radioactive waste storage facilities.
5. Radiation safety training, monitoring techniques and equipment focused on nuclear submarine dismantlement.

Two additional AMEC projects that deal with non-radioactive waste problems are:

1. Demonstration of technologies for clean-up of hazardous waste on military bases in the Arctic (this project involves only Norway and Russia).
2. Demonstration of "Clean Ship" technologies for the collection and processing of ship-generated waste.

SUMMARY OF AMEC PROJECT 1.1

AMEC Project 1.1 Objectives

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 spent nuclear fuel from decommissioned Russian Navy submarines.

AMEC Project 1.1 Participants

The primary entities participating in this technical project are as follows:

Primary Norwegian Participants

Participant	Role in the Project
Norwegian Defence Research	Norwegian AMEC 1.1 Project Officer and Technical Oversight
OEDC Halden Reactor Project	Technical Expert – Radiation Safety

Primary Russian Participants

Participant	Role in the Project
Russian Ministry of Defence – MOD	RF AMEC 1.1 Project Officer and the Ultimate Cask User
ICC Nuclide – Interbranch Coordination Scientific-Technical Centre of Nuclide Production	Project Manager for the Russian Federation
KBSM – Special Mechanical Engineering Design Office	Designer of the AMEC Cask – The TUK-108
IZHORA Works	Fabricator of the AMEC Cask
VNIPIET – All Russian Planning and Design, Research, and Technological Association	Nuclear Design and Safety Analyses and Nuclear Power Technology
VNIIEF – The All Russian Scientific Research Institute of Experimental Physics	Nuclear Design and Safety Analyses
MOD Institute #26	Concrete Design
MINATOM – Ministry of Atomic Energy	Certifying Agent of the AMEC Cask for the Russian MOD
MOD- and Civilian-Gostatomnadzor (GAN)	Military and Civilian Certifying Agents of the AMEC Cask

Primary United States Participants

Participant	Role in the Project
EPA – U.S. Environmental Protection Agency, Office of International Activities	U.S. AMEC 1.1 Project Officer/Project Management
ORNL – Oak Ridge National Laboratory	Integrating Project Manager/Lead Technical Expert
NAC International	Technical Experts in Cask Design, Fabrication, Testing and Certification

AMEC Cask General Description

The AMEC cask is a metal-concrete cask designed to contain up to 49 spent fuel rods from decommissioned Russian submarines. It is approximately 4.5 meters high and 1.6 meters in

diameter. It has been designated as the TUK-MBK-VMF or TUK-108 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.

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 elements for the cask. The outer concrete shell provides additional strength and shielding but also serves as a sacrificial shell during accident scenarios.

The cask is sealed at its upper end by two separate metal lids. The inner lid serves as the containment barrier for the contents while the outer lid serves as structural protection for the inner lid and as an "impact limiter" or "damping device" during accident scenarios.

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 and outer lid and therefore needs no additional bolt-on damping devices.

A simplified schematic of the final AMEC cask is shown in Figure 1.

AMEC Cask Requirements

The AMEC cask is designed to be handled and transported by the existing infrastructure used by the Russian Navy for the all-metal TK-18 transport casks. The TK-18 casks were only designed for transportation of spent nuclear fuel. The TUK-108 AMEC casks will complement the existing TK-18 casks. The AMEC 40-tonne cask is designed for at least a 50-year life.

The AMEC cask is designed to meet all applicable Russian and International Atomic Energy Agency (IAEA) standards for storage and transport of spent nuclear fuel.

The AMEC cask will be certified/licensed by the appropriate Russian authorities to allow it to be used for transport and storage.

The AMEC prototype cask must be proven to meet or exceed all design and licensing requirements for fabrication and operation of the cask. It must also demonstrate, either through testing or analytically, 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 metal pin 20-cm high;
- complete entrainment within a 800^{o}C fire for 30 minutes; and
- submersion under water at a depth of 15m for a period of 8 hours.

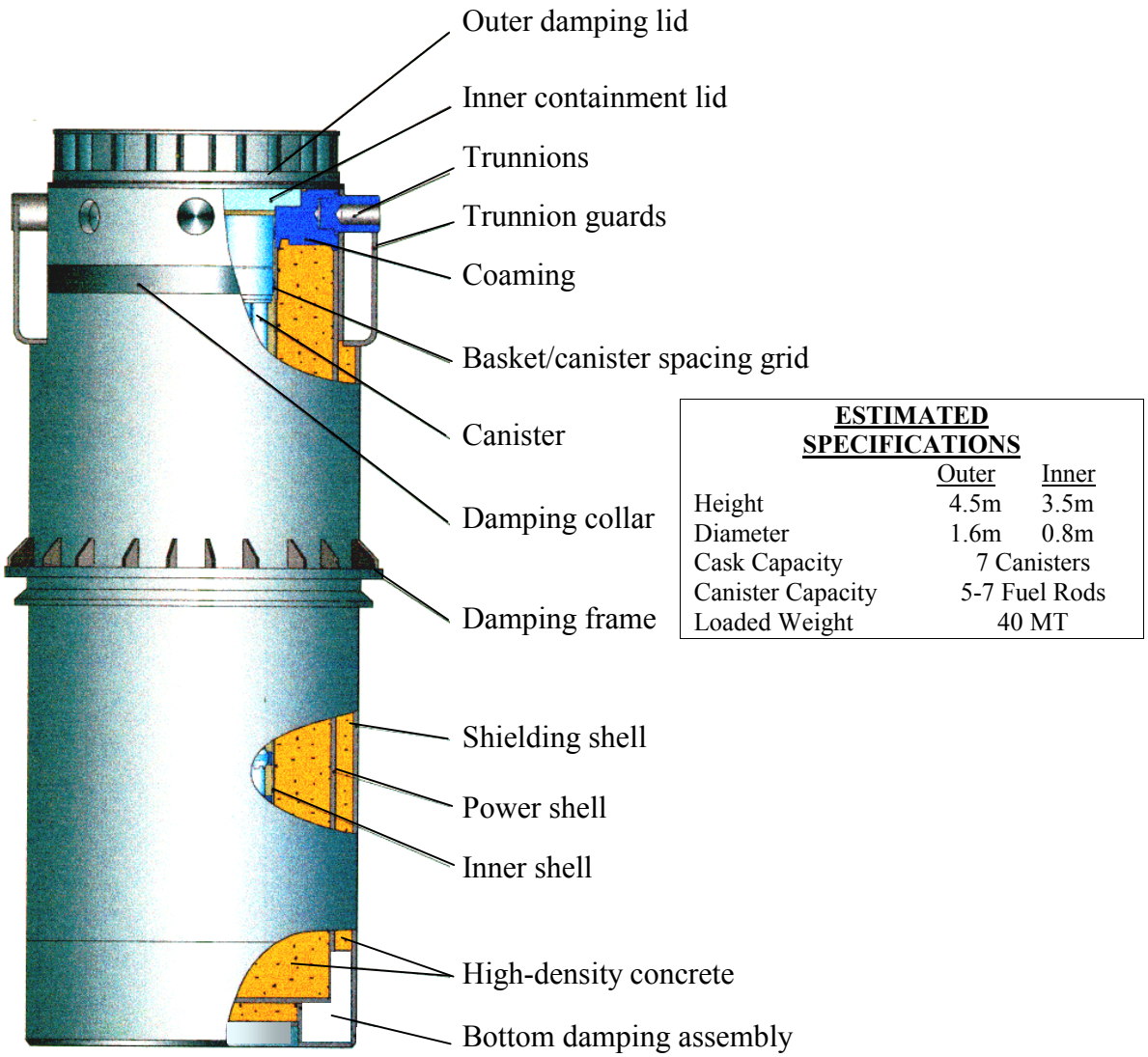

Figure 1. AMEC 40-tonne cask schematic.

Current Project Status

At this time, the design, fabrication, and design verification testing of the AMEC prototype cask have been successfully completed. The AMEC prototype cask has undergone successful in-plant testing. Successful 9- and 1-meter drop tests, as defined by IAEA guidelines, were conducted on a one-half scale model of the prototype cask. Testing has been completed at the RTP Atomflot site in Murmansk and the Mayak processing facility in Chelyabinsk demonstrating 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 with fuel and unloaded.

The AMEC cask design will be certified by the Russian Federation Ministry of Defense, Minatom, Ministry of Health, Gozatomnadzor and other appropriate Russian authorities by

mid-June. After certification, serial production of the AMEC cask is planned. The Russian Federation has stated that as many as 400-500 of the AMEC casks might be required to safely transport and store all of the spent nuclear fuel from decommissioned nuclear submarines and other applications in Russia.

SUMMARY OF AMEC PROJECT 1.1-1

Project Objectives

The objectives of AMEC Project 1.1-1 are to design, construct and license a transshipment/ temporary storage pad for up to 24 AMEC casks. This pad will be designed and located to maximize the use of existing Russian cask and fuel handling equipment and facilities.

Project Participants

The primary entities participating in this project are as follows.

Primary Norwegian Participants

Participant	Role in the Project
Norwegian Defence Research Establishment	Norwegian AMEC 1.1-1 Project Officer and Technical Oversight
Norwegian Defence Construction Service	Construction Experts

Primary Russian Participants

Participant	Role in the Project
Russian Ministry of Defense – MOD	RF AMEC 1.1-1 Project Officer and the Ultimate Pad User
ICC Nuclide – Interbranch Coordination Scientific-Technical Centre of Nuclide Production	Project Manager for the Russian Federation
VNIPIET – All Russian Planning and Design, Research, and Technological Association	Storage Pad Designer
RTP Atomflot/Murmansk Shipping Company	Operators of the Cask Loading and Unloading Facility in Murmansk
MOD Institute #26	Concrete Design
MOD- and Civilian-Gostatomnadzor (GAN)	Military and Civilian Certifying Agents of the AMEC Cask

Primary United States Participants

Participant	Role in the Project
EPA – U.S. Environmental Protection Agency	U.S. AMEC Project Officer and Project Management
ORNL – Oak Ridge National Laboratory	Integrating Project Manager and Lead Technical Expert
NAC International	Technical Experts in Cask Design, Fabrication, Testing, and Certification
Cold Regions Research and Engineering Laboratory/USCOE	Technical Experts in Cold Climate Construction
VPNS – Virginia Power Nuclear Services	Technical Experts in Storage Pad Construction, Operation, and Licensing for the U.S. Team

AMEC Storage Pad General Description

The AMEC transshipment/temporary storage pad preliminary design indicates the pad will be a concrete reinforced slab sized to hold up to 24 AMEC casks in a vertical position. Vertical concrete shield walls will be constructed around the outer periphery of the slab to minimize radiation dose to workers. These shield walls extend upward to about two-thirds of the cask's height. Together the concrete shield walls and the remainder of the cask enclosure will greatly facilitate the cask handling operation in inclement weather.

AMEC Transshipment Storage Pad Requirements

The AMEC transshipment storage pad must meet or exceed all Russian codes and IAEA standards and guidelines for the design, construction and licensing of a transshipment storage pad for spent nuclear fuel.

The AMEC storage pad must be designed and constructed for at least a 50-year service life.

The AMEC storage pad must be designed and constructed to withstand the extreme temperatures (-37^{o}C to $+32^{o}$C) of the arctic.

The AMEC storage pad must withstand anticipated seismic activity (6 points on the MSK/ Richter scale) in the area and remain intact and serviceable.

The AMEC pad must be located and designed to facilitate the use of existing equipment, railways and facilities.

The AMEC storage pad must be designed and constructed to facilitate loading and unloading of both TK-18 and the new TUK-108 casks between the cask fuel loading facilities (the floating service ships), the storage pad, and the rail cars.

Current Status

The "Technical Assignment" and the "Declaration of Intent" documents for the AMEC transshipment/temporary storage pad have been developed. These documents describe the basic functional and regulatory requirements for the storage pad and must be approved by the relevant Russian organizations.

The conceptual design for the AMEC storage pad is progressing and will be fully documented in the next phase of the project, the "Investment Substantiation." The full-detailed design of the AMEC storage pad will be documented in the "Technical Project" phase of the project, which is anticipated to be complete in mid-2000.

Construction of the AMEC storage pad is scheduled to begin in mid-2000 and to be completed by December 2000.