DEVELOPMENT OF FLOTATION SYSTEMS FOR RUSSIAN NAVAL VESSELS

S. I. Barmin and V. B. Kalashnikov, GUP "Severny Reid," Russia
R. S. Dyer and E. Barnes, U.S. Environmental Protection Agency, Washington, D.C.
R. L. Snipes, Oak Ridge National Laboratory, Oak Ridge, TN

ABSTRACT

More than 150 Russian Naval nuclear submarines of the "November," "Echo," "Alpha," "Delta," "Yankee," "Charlie," "Oscar," "Hotel," "Victor," and "Typhoon" classes have been removed from active fighting status. Nuclear submarines built in the 1950s and 1960s are being removed from active service due to their age, while later class nuclear submarines are being removed from active duty as a result of the international treaties on a reduction of armaments. These submarines are currently in storage at various Russian Naval bases. The majority of these submarines contain two nuclear reactors for supplying power. These nuclear submarines, including their reactor compartments, are in storage awaiting decommissioning and proper disposal. It could be some time before the large financial and material resources required to salvage or properly dispose of this large number of submarines and components are available. Therefore, appropriate actions should be taken to ensure that the submarines, or critical components of them, remain afloat for the period necessary to ensure proper disposal.

An Experimental Transportable Polystyrene Plant (ETPP) used for production and insertion of polystyrene has been developed and successfully applied to a limited number of intact submarines to ensure their ability to remain afloat. This system could also be applied to sections of decommissioned submarines, such as reactor compartments, currently floating in unstable conditions in bays in Northwest Russia.

INTRODUCTION

The "Alpha" class of Russian Navy nuclear submarines was the first to be decommissioned in 1974. Russian nuclear submarines that were removed from service before 1988 because of reactor emergencies were sunk in the Kara Sea. The current process used by the Russian Navy for decommissioning and salvaging nuclear submarines is to separate the submarine structure into 3 major sections—the center reactor section and the two remaining end sections. The center reactor section consists of a 3-block unit—the reactor compartment and the 2 adjacent compartments. As a result of Russia's nuclear submarine decommissioning activities more than 30 submarine reactor sections are currently stored at Russian Naval bases and industrial areas in Northwest Russia. The Russian Federation has not yet developed their plan or technology to support the long-term storage or disposal of these reactor compartments. Until the final plans are developed these 3-block reactor sections will be stored afloat.

Typically, the submarine 3-block reactor sections are hermetically sealed by welding the ends shut to keep them afloat while awaiting final disposition. Over time these sealed reactor sections could become unpressurized due to corrosion and the 3-block reactor sections could sink causing radiological contamination of adjacent territory. This is unacceptable from an ecology standpoint.

Additional action is required to ensure that these sections maintain their buoyancy to prevent them from sinking in the areas where they are currently moored. The SUE "Severny Reid" has designed and offered the Russian Navy a system that will provide additional assurances that intact decommissioned submarines or its components (e.g., the 3-block compartment reactor sections), will remain a float. The facility, shown in Figure 1, was developed and produced under the design documentation MGNPEP "Ecopol" at (TS)KB MT "Rubin." The facility contains an ETPP used for the production and delivery of polystyrene. The system has been successfully demonstrated by placing the hydropolystyrene mixture (a mixture of polystyrene and seawater) into the unpressurized ballast tanks of several intact nuclear submarines. This concept could also be applied to submarine sections, such as the reactor section, or ships that have been removed from active service.

Fig. 1. The ETPP injecting polystyrene into decommissioned submarines.

RANGE OF APPLICATION ETPP

The ETPP can provide the following solutions:

- Provides assurances that contaminated nuclear submarine reactor sections remain afloat during movement and long-term storage.
- Provides guaranteed buoyancy for durable storage of nuclear submarines and ships removed from active service of the Russian Navy that are being stored at their bases for an indefinite time period.
- Provides guaranteed buoyancy for conveyance of decommissioned nuclear submarines and ships to the appropriate industrial plants for their salvaging.
- The technology could possibly be modified to lift specific sunken objects.

CHARACTERISTICS OF THE EXPERIMENTAL TRANSPORTABLE POLYSTYRENE PLANT FACILITY

The ETPP is manufactured as a modular unit. The facility consists of seven standard maritime containers of stainless steel type with special equipment installed in them. It also contains four auxiliary modules with ventilation and heating machinery, a pneumotransport system for moving the polystyrene, aggregate for creation of the hydropolystyrene mixture, and a stabilized polystyrene hydrotransport system.

THE ETPP SPECIFICATIONS

The ETTP facility requires a 380 V, 3-phase, 50 Hz power supply. Maximal amount of power consumption during polystyrene churning and pneumotransportation to stabilizing modules is 117 kW. Fresh water at the rate of 150-200 liters/hour is used for steam production. Seawater is used for forming the hydropolystyrene mixture.

The total weight of the facility does not exceed 43.5 tonnes. The maximum weight of one module does not exceed 7.5 tonnes. The total working length of the ETPP system (unrolled position) is approximately 70 m.

The system can operation up to 8 months of the year, depending on weather conditions. The system output of polystyrene per hour is 250 kg by weight and 6.5 m^3 by volume. An injection rate of 20 m^3/hr can be achieved.

Polystyrene beads (type PSV-SV or PSV-S under OST.301-05-202-92) are the raw material used for the production of the polystyrene. These beads are small-grained transparent glassy solid beads with a 0.3–4.0 mm diameter, each containing uniformly distributed micro-impurities of steam formators – isopentane $(CH^3)2CHCH^2CH^3$ (2-methylbutane). The beads also contain a residual monomer-styrene C^6H^5-$CH=CH^2$ (phenylethylene, vinylbenzene) and a fire retardant. The feedstock (polystyrene beads) foams with the introduction of steam. The polystyrene mixture is then stabilized in four module-stabilizers. The density of the polystyrene is not less than 25 kg/m^3. The polystyrene product does not corrode or dissolve when exposed to water or seawater. Therefore, providing a long-term low-density durable. After the final mixture of polystyrene is prepared it is mixed with seawater in order to transport and inject it into the designated objects.

The period required for filling the main ballast tanks of one nuclear submarine with a total bulk volume of 51 m^3 stabilized polystyrene is 3-4 weeks, using 17-25 tonnes of polystyrene beads. Of course the specific time and amount of polystyrene required is dependent on the total volume of tanks being filled. The range for transportation of the hydropolystyrene mixture is up to 100m. The current allowable depth of usage of churned polystyrene is up to 20 m, but with plant modifications the depth of usage could possibly be increased to 100-120 m.

FURTHER DEVELOPMENTS OF THE ETPP

Utilizing the results of the ETPP trial operation the SUE "Severny Reid" enterprise is currently manufacturing the next prototype transportable polystyrene facility. The modified facility will meet the following specifications.

The output of the modified system is 300 kg/hr by weight and 7.5 m^3/hr by volume. An injection rate of 20 m^3/hr can be achieved. Due to the stabilizing module number increasing from 3 to 4 the filling period of a similar ballast tank to the one mentioned previously would be reduced to approximately 3 weeks, a reduction of 25 percent. The total weight of the modified facility does not exceed 50 tonnes.

CONCLUSIONS

The technology of filling decommissioned submarines with polystyrene for insuring that the submarine hulls maintain their buoyancy has been successfully applied. In 1999, SUE "Severny Reid" successfully demonstrated the filling of its first submarine. After evaluation of the polystyrene filling the submarine was placed in storage waiting its turn for salvaging. The proven technology of using polystyrene for ensuring flotation of submarines is now being applied. In 2000, SUE "Severny Reid" executed the filling of 7 decommissioned nuclear submarines situated in the Northern fleet bases of the Russian Federation.

It has been determined that this technology could provide secure durable storage for whole nuclear submarines, submarine reactor sections, and ships that have been removed from the Russian Navy's active service.