RUSSIAN CONTAINERS FOR TRANSPORTATION OF SOLID RADIOACTIVE WASTE

Vladimir G. Petrushenko, Edward P. Baal, Dmitry Yu. Tsvetkov, V.R. Korb
FSUE "Zvyozdochka", Severodvinsk, Russia 164509

Vladimir S. Nikitin, A. A. Mikheev
RSI "Onega", Severodvinsk, Russia 164509

Andrew Griffith
U.S. Department of Energy, Germantown, MD 20874, USA

Patrick Schwab and Ashot Nazarian
Science Applications International Corporation, Germantown, MD 20874, USA

ABSTRACT

The Russian Shipyard "Zvyozdochka" has designed a new container for transportation and storage of solid radioactive wastes. The PST1A-6 container is cylindrical shaped and it can hold seven standard 200-liter (55-gallon) drums. The steel wall thickness is 6 mm, which is much greater than standard U.S. containers. These containers are fully certified to the Russian GOST requirements, which are basically identical to U.S. and IAEA standards for Type A containers. They can be transported by truck, rail, barge, ship, or aircraft and they can be stacked in 6 layers in storage facilities. The first user of the PST1A-6 containers is the Northern Fleet of the Russian Navy, under a program sponsored jointly by the U.S. DoD and DOE. This paper will describe the container design and show how the first 400 containers were fabricated and certified.

INTRODUCTION

All activities associated with nuclear powered ships and submarines, including construction, operation, repair, decommissioning, and dismantlement, generate solid radioactive wastes (SRW). During recent years the number of nuclear submarines to be dismantled in Russia has significantly increased due in part to the arms control agreements in strategic offensive weapons between Russia and the United States. Every year, on naval bases and sites alone, nearly six thousand tons of SRW is added. The absence of facilities for treatment and disposal of SRW has led to the exhaustion of the interim storage facilities for SRW.

In June 1999, the U.S. Government, under the Arctic Military Environmental Cooperation (AMEC) Program [1-2], announced a world-wide tender for the production of reusable containers for transport and storage of low-level SRW that would comply with Russian and IAEA standards [3-8]. FSUE "Zvyozdochka" and RSI "Onega" jointly proposed a container design, featuring construction simplicity, relatively low cost, reliability, durability, lifting capability by crane and forklift, and transportability by truck,

rail, ship, barge and aircraft. The proposed container was cylindrical in shape and large enough to hold seven standard 200-liter (55-gallon) drums.

The proposal was accepted by the U.S. Government's contracting agent, so RSI "Onega", which is the research-and-development arm of the shipyard "Zvyozdochka," began the design work in October 1999. The design was labeled PST1A-6 (or УКТ 1А-6 in Russian). The first 100 PST1A-6 containers were officially delivered to the Northern Fleet of the Russian Navy in October 2000. The second set of 300 containers is expected to be delivered in October or November 2001.

GENERAL INFORMATION ABOUT FSUE "ZVYOZDOCHKA"

The Federal State Unitary Enterprise (FSUE) "Zvyozdochka" is a specialized enterprise for shipbuilding and ship repair, as well as for the recycling of materials from dismantled ships and vessels (see Fig. 1). FSUE "ME" Zvyozdochka" is an advanced, well-equipped complex with extensive technical and industrial capabilities.

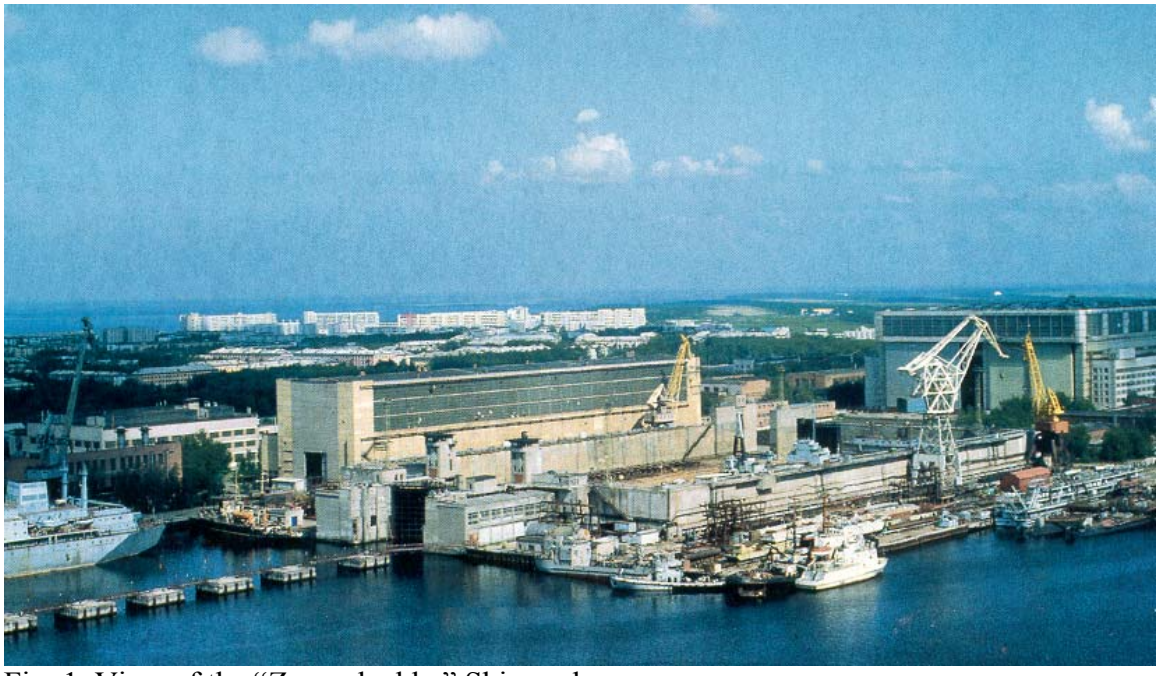

Fig. 1. View of the "Zvyozdochka" Shipyard

Basic types of activity of the enterprise are:

- repair, re-equipment and modernization of ships and vessels of the Russian Navy;
- repair and testing of ship equipment and mechanisms;
- construction of civil ships (trawlers, dry-cargo ships);
- construction of large modules and Jack-Up platforms for use in the Arctic shelf;
- assembly and welding of metal structures under contracts with Russian and foreign customers;
- recycle of materials from dismantled ships and vessels;

- design and fabrication of the equipment and handling devices SRW storage;
- unloading of spent nuclear fuel from ships; and
- collection, storage and treatment of liquid radioactive wastes (LRW) and SRW.

The enterprise has engineering devices that provide descent, lifting and skidding of the ships and vessels on/from building berths and an extensive complex of workshops, including the steel structure fabrication shop, the piping prefabrication shop, the electroplating shop, the machine shop, the propeller production shop, shops for repair of shipboard equipment and mechanisms, and the paint shop. The Shipyard has facilities for dismantling nuclear submarines, facilities for storage, transportation, and treatment of LRW and SRW. It also has shore facilities for unloading, transportation, and temporary storage of spent nuclear fuel.

The enterprise participates in implementation of the Russian Federal program "Handling of Radioactive Wastes and Spent Nuclear Materials, their Recycling and Disposal for 1995-2005", authorized by the decision of Russian Federation Government of 23 October 1995. The state customer of this program is the Ministry of Atomic Energy of the Russian Federation (Minatom).

The enterprise is one of the main contractors for recycling and scrapping of nuclear submarines, which are carried out in accordance with the Russian Federation Government Order № 518 of 28 May 1998. The state customer-coordinator of this Order is Minatom. Specialists from "Zvyozdochka" Shipyard are permanent representatives on Interdepartmental Coordination Councils on the questions of handling radioactive wastes and recycling of nuclear submarines.

The enterprise has many years of experience with the Russian regulatory agencies (Gosatomnadzor, Minatom, Gosstandart, etc.) and has a State license from Gosatomnadzor for designing and manufacturing SRW storage equipment.

DESCRIPTION OF THE PST1A-6 CONTAINER

General Requirements

The PST1A-6 container is shown in Figure 2. The container is stronger and more durable than most U.S. low-level waste containers. The vertical wall thickness is 6 mm; the top and bottom components are 8 mm thick. The special paint and gaskets can withstand extreme temperatures from -60^{o}C up to $+70^{o}$C. The container can also retain its radioactive contents under an extreme air pressure variation, in which the ambient air pressure goes down to 25 kPa (3.6 psi).

Fig. 2. PST1A-6 Container with Seven Standard 200-liter Drums

The container complies with requirements of IAEA and Russian Federation regulations [3,8]:

- IAEA Type A transportation packaging as described in "Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised in 2000), IAEA Safety Standards Series № TS-R-1 (ST-1, Revised)"; and
- Russian Type A transportation packaging as described in GOST 16327-88 "Transportation packaging for radioactive materials: General specifications."

Main Technical Characteristics/Parameters of the PST1A-6 Container

Type of waste: low-level SRW.
Temperature of exploitation: from + 70^{o}C down to - 60^{o}C.
Service period: not less than 10 years.
External and internal diameters: 2.000 m and 1.860 m.
External and internal heights: 1.274 m and 0.950 m.
Wall thickness: 6 mm.
Construction material: Russian steel type 10XSND.
Shape: cylindrical.
Internal volume: 2.58 m^3.
Mass of the empty container: 990 kg.
Maximum payload mass for storage only: 5300 kg.

Maximum payload mass for transport: 2300 kg.
Ratio between the shortest distance from the center of gravity projection onto supporting horizontal surface to any lateral side flip-over edge and the center of gravity height over supportive horizontal surface is not less than 1.25.
The paint is resistant to decontamination solutions.
The paint will not crack, chip or peel at temperatures from -60^{o}C to $+70^{o}$C.
Removable lid is sealed with a gasket made of a special rubber (IRP3012) that remains flexible at temperatures as low as -60^{o}C.
The lid is bolted to the container body with 16 bolts.
The container will retain its contents if the ambient pressure is reduced down to 25 kPa, or if the internal pressure increases up to 100 kPa.
The lid has two D25 pipe fittings for the purpose of leak testing the container.
The sidewall of the container is equipped with a protected (sealed) box for the documents that must accompany the container.
The container can be lifted by crane or forklift.
The lid of the container has four eyes for lifting it by crane.

Documentation

The following documents are available with the containers:

- exploitation instructions (users' manual);
- technical specifications;
- Certificate of Compliance to IAEA standards for Type A packaging;
- Certificate of compliance to GOST standards; and
- program of tests, including the test results.

Exploitation Rules

The container is reusable. Before each loading it is necessary to check visually the condition of the rubber gasket and to grease it. If the gasket is broken or deformed, it must be replaced. Even if the gasket is not broken or deformed after 10 loading and unloading operations, it must be replaced anyway. Furthermore, after 10 loading and unloading operations, it is necessary to examine the container, including a leakage test. Radiating safety during loading and unloading operations, storage, and transportation of loaded containers is the user's responsibility and all users must satisfy the federal standards and regulations [4-8].

Radiation Safety Requirements and Composition of the SRW

Experience has shown that basic low-level SRW generated in the Russian Navy's Northern Fleet are typically the following wastes:

- rags, working clothes, canvas, boards, paper etc.;
- plastic, rubber, hoses, scraps of cable, insulation wastes; and
- scrap structural metal, pipes, pipe fittings, small-sized equipment etc.

In accordance with the Russian standard [7] solid wastes are subdivided into 3 groups:
Group 1: SRW with gamma-radiation level up to 30 mrem/hour (0.3 mSv/hour) at a distance of 10 cm from the surface;
Group 2: SRW with gamma -radiation level from 30 mrem/hour (0.3 mSv/hour) up to 1000 mrem/hour (10 mSv/hour) at a distance of 10 cm from the surface; and
Group 3: SRW with gamma -radiation level more than 1000 mrem/hour (10 mSv/hour) at a distance of 10 cm from the surface.
Low-level SRW corresponds to the Group 1 according to the Russian standard [7]. The gamma activity of SRW of the Russian Navy's Northern Fleet is caused primarily by two radionuclides: Cs-137 (70 %) and Co-60 (30 %).

Transport Categories

The transportation of SRW as radioactive material in the Russian Federation is regulated by PBTRV-73 standard [6]. This standard establishes transport categories of radiating packages as shown in Table 1. According to the PBTRV-73 standard, containers in the first three transport categories can be transported by all common types of transport, including aircraft. In accordance with this standard, SRW packed in the PST1A-6 container shall be treated as radiating packages not higher than the third transport category and can be transported by truck, rail, ship, barge, or aircraft. Thus, the PST1A-6 container meets the same basic requirements as similar U.S. containers: less than 200 mrem/hour at the surface of the container and 10 mrem/hour at the distance of 1 m.

Table I. Russian Transport Categories for SRW

Transport category	Any point of the external surface, mrem/hour	At a distance of 1m from the package, mrem/hour
1	0.5	Not detectable
2	50.0	1
3	200.0	10
4	1000.0	50

Drum Lifters

In order to place drums into the PST1A-6 container or remove drums from the container, a lifting tool in necessary. FSUE "Zvyozdochka" designed and built a simple drum lifter that is lightweight and can be operated remotely. The device fits standard 200-liter (55-gallon) drums and it is adjustable because these drums have slight variations in their diameters. The lifting capacity is 550 kg.

TESTING AND CERTIFICATION

FSUE "Zvyozdochka" performs an air leakage test and a lifting test on each container. In accordance with IAEA and GOST 16327-88 requirements, the testing program contains the list of tests below. FSUE "Zvyozdochka" has all the necessary equipment for conducting these tests.

Water Spray Test

Water is sprayed on the container, imitating exposure to rain at the rate of approximately 5 cm per hour for at least one hour. Equipment includes tray, sprayer, and water supply system.

Stacking Test

The container is placed under a load equal to the weight of five fully loaded containers for 24 hours without leaking. Equipment includes a base-plate with a smooth and horizontal surface; a plate of carbon steel at least 8 mm thick, and with horizontal dimensions at least as large as those of the surface of the container being tested; a load of 31.5 tonnes; and a suitable capacity crane.

Drop Test

Two containers were selected at random from the production run and loaded with the transport payload, 2300 kg. They were then dropped from a height of 1.2 m on any edge or corner, and checked for leaks. The necessary equipment includes a target, crane, and a device for remote release. The target is a carbon steel plate at least 12 mm thick, with the area of the impact surface being at least twice the area of base surface of the container. The entire area of the steel plate is on top of and firmly attached to a concrete slab that weighs at least ten times as much as the container.

Puncture Test

Carbon steel rod with diameter of 32 mm with a hemispherical end with radius of 16 mm and weight of 6 kg is dropped vertically from the height of 1 m on the container mounted on a plate. The container wall was not punctured. Equipment includes the carbon steel rod and a positioning and dropping device.

Leakage (Air Tightness) Test

The container is pressurized with air up to a pressure of 100 kPa and checked for leaks. The required equipment includes a standard air pressure regulator on a line from the factory's compressed air supply system, manometers, and pipe fittings.

Certificates of Compliance

For the first batch of 100 containers, the manufacturer obtained two certificates. One certificate is Certificate of Compliance # ROSS RU C302.A90087 from Gosstandard, which is the primary Russian agency for regulating all kinds of products. This certificate confirms that the PST1A-6 container meets the requirements of GOST 16327-88 and of the approved technical specifications YaNMI.305179.012TU. The manufacturer also obtained Confirmation #2054 from the Ministry of Atomic Energy (Minatom), which states that the PST1A-6 container meets all the requirements of Type A containers.

While manufacturing the second batch of 300 containers, the manufacturer obtained Certificate-Permit #RU/2082/A-96, issued by Minatom and concurred with by the Directorate for State Oversight of Nuclear and Radiation Safety of the Ministry of Defence. This new certificate confirms that the container design complies with all the requirements for Type A containers. It covers all 400 of the PST1A-6 containers and any future production of the same design, so Zvyodochka can now manufacture more containers without the expense of applying for new certificates. On basis of this certificate, we can affirm that we have produced the first steel containers fully certified for transportation of low-level SRW in Russia.

THE PRODUCTION OF PST1A-6 CONTAINERS

FSUE "Zvyozdochka" executes every step of production in accordance with the requirements of the Russian Federation [3-8]. The complete container production process includes the following distinct activities:

- design management and quality control;
- development of design documentation for the container;
- fabrication of containers;
- certification of containers;
- testing of containers; and
- shipment of containers to the customer.

The container design was developed in accordance with the terms of the license of Gosatomnadzor (State Nuclear Regulatory Agency) of Russia № CE-07-102-0261 dated 24 September 1998. During construction all the technical requirements were fulfilled. Design documentation provides radiation safety of the container in compliance with following Russian Federal standards and regulations:

- NRS (NRB) 99, Standards of Radiation Safety [4];
- GSR (OSP) 72/87, General Sanitary Rules for the work with radioactive materials and other sources of ionizing radiation [5];
- SRTRM (PBTRV)-73, Safety Rules for Transportation of Radioactive Materials [6]; and
- SRRMM (SPORO)-85, Sanitary Rules for Radioactive Materials Management [7].

The design documentation was developed by leading specialists of RSI "Onega," who are licensed in accordance with Russian Regulations RD5.AEISH.3216-98, "Studying and Testing of Norms, Rules and Instructions for Nuclear and Radioactive Safety Knowledge." As part of the project, the following design and certification documents were developed:

- Technical project (consists of tender proposal) for tender;
- Technical order for design;
- Strength calculation;
- Biological protection (radiation shielding) calculation;
- Working drawings;

- Technical Specifications;
- Program and methodology of tests; and
- Operators' manual/instructions.

The biological protection (radiation shielding) calculation, based on the composition of the wastes and the level of their gamma radiation up to 30 mRem/h (0.3 mSv/h) at distance of 0.1 meter from the surface, yielded the optimum container wall thickness (6 mm). Based on the strength calculations the design was finalized and working drawings of all construction elements were developed. The design was labeled PST1A-6 (or УКТ 1А-6 in Russian). The containers are in full compliance with requirements of GOST 16327-88. "Packing Transport Sets for Transportation of Radioactive Materials, General Technical Terms" [8]. The reliability parameters were selected according to GOST 26291-84, based on the most severe conditions of use, and taking into account possible extreme/emergency conditions during transport.

The technical specifications for the container design were coordinated and approved by:

- The Deputy Chief Commander of the Russian Navy for Shipbuilding and Weapons,
- The Department of Emergency Situations of Ministry of Atomic Energy (Minatom) of Russia,
- The Nuclear and Radioactive Safety State Control Department of Russian Ministry of Defence (MOD),
- The Chief Medical Officer of Arkhangelsk region State Sanitary-epidemic Control Center of Russian Ministry of Public Health, and
- The Chief Officer of Ecological Safety of Russian Ministry of Defence.

The User's Manual/Instruction Set for the container describes requirements for the safe use, maintenance, and disposal of the containers.

Prior to the start of actual fabrication, the technical personnel of "Zvyozdochka" study in detail the design documentation and issue work orders for each step of the fabrication. All the necessary equipment, outfitting, and tools are specified in the work orders. Before starting the steel work all steel sheet passes a sandblasting line for the removal of rolling scale and for priming of the surfaces. The process of container fabrication includes a number of operations, all of which are performed onsite using the equipment existing in the "Zvyozdochka" workshops. Subcontractors from offsite are not necessary. The fabrication process for the PST1A-6 containers is similar to the fabrication process for ship hull structures, which has been performed at the enterprise for many years. The fabrication process consists of the following technological steps:

Cutting and Bending Operations

In the workshop of hull manufacturing the laying-out and cutting of plates is carried out. Precisely shaped details are cut on guillotines and "Crystal" machines with the given form for a welded seam. In the same shop bending of components is carried out. The walls of cylindrical containers are bent on roller model XZM 12/2000. Flanges for the

cylindrical containers are assembled in the conductor to assure the correct geometrical sizes and requirements for the surface. Concurrent with the manufacture of all the small components and details in the hull manufacturing shop, all the necessary fittings (bolts, nuts, pins, etc.) are processed according to the drawings in the machinery and forge shops, and then are passed to the assembly area.

Unit Welding and Assembly

Unit welding and assembly is carried out in the hull shop on the welding stands in accordance with the accepted technology of manual and automatic arc welding in a carbon dioxide gas atmosphere with the use of standard equipment. In order to exclude operations on marking-out, the reinforcement struts are welded in the special conductor. Cleaning of welded seams is carried out with the help of pneumatic tools and abrasive disks. All joints are checked on the "art screen".

Machining

After the welding is finished, precision machining is necessary to create the flanges on the container body and on the lid. These machining operations could not be preformed in an ordinary machine shop because these operations require extra large lathes with vertical axes of rotation. The Onega Design Bureau designed the container this way because the Zvyozdochka Shipyard has several of these special lathes in their propeller fabrication shop. The flange surfaces of the container body and lid must be machined with precision to make the lid fit properly. Each container will be sealed with a rubber gasket, which requires a ring groove to be cut into the flange on the container body. The ring groove is cut into the flange immediately after the flange is finished, which allows the container body to be mounted in the special lathe only one time for both machining operations. The bolt holes are drilled through both the container body and lid flanges at the same time to ensure that the holes are lined up properly.

Tightness Check

The leak tightness tests are carried out in the mounting workshop. A compressed air pipeline for this test is connected to one of the fittings in the container lid. The internal pressure is measured on a test manometer, which is connected to the other fitting in the container lid. Every container is tested under an internal pressure of 100 kPa for 30 minutes.

Priming and Painting

The priming and painting is carried out in the paint shop according to the instructions from the paint supplier. First, the degreasing and removing of salts from the surfaces by fresh water under high pressure by installation "Sprut" is carried out. Shotblasting is carried out by the equipment of "KIESS" firm by pellet FPISP (pig-iron cracked pellets) granulation 0.8-1.0 up to smooth degree Sa 21/2. Painting is carried out by devices БВР

of "WIWA" firm on open-chamber painting device (OCPD). The control of microclimate conditions and thickness of coverings is carried out by the sets of "ELKOMETER" firm.

Industrial Safety

As container production does not involve any technological operations new to the enterprise, the questions of ensuring industrial safety have been previously addressed in accordance with existing Russian regulations.

Environmental Control

During the fabrication operations, there are no emissions exceeding the levels allowed by shop permits, either on quantitative or qualitative parameters.

Quality Control

"Zvyozdochka's" longstanding and fully functional quality control system ensures reliability and high quality production. This production quality is confirmed by a long track record of high quality production deliveries to the Russian Federation Ministry of Defence, successful presentation of civil production to English Lloid and also to Norwegian DNV. The Russian Federation State Standard (Gosstandard) also routinely checks our measurement devices and techniques of their performance in order to provide quality of production.

Delivery

Taking into consideration favorable the geographical position of FSUE "Zvyozdochka," the container transportation to the Northern Fleet can be carried out either by sea or railroad. The transportation by sea can be performed directly from Severodvinsk to the point of destination. The loading of ships or barges can be performed directly on the territory of FSUE "Zvyozdochka", which eliminates the need for any intermediate transportation. The transportation by sea depends on seasonal conditions. Navigation in the port of Severodvinsk lasts until December, i.e. until the establishment of strong steady frosts in the Severodvinsk area and on the White Sea. The transportation by train can be performed on the route from Severodvinsk to Moscow to the point of destination, or from Severodvinsk to St. Petersburg to the point of destination. The loading of standard railroad cars can be performed on the territory FSUE "Zvyozdochka," which eliminates the need for any intermediate transportation. (See Figure 3.) The transportation by train does not depend on climate conditions and can be done during any season. It is possible to place 12 containers on each railcar.

Fig. 3. The First 100 PST1A-6 Containers Before Delivery to the Russian Navy

Ideally, containers full of waste should be stored inside a building. Figure 4 presents a conceptual model for a waste storage and handling facility, with both truck and rail access. It also has a fork lift and/or bridge crane for positioning the containers inside the facility. The building itself is modular, to allow for easy expansion if more containers full of waste need to be stored. Storage facilities such as these could be built in various locations in northwest Russia.

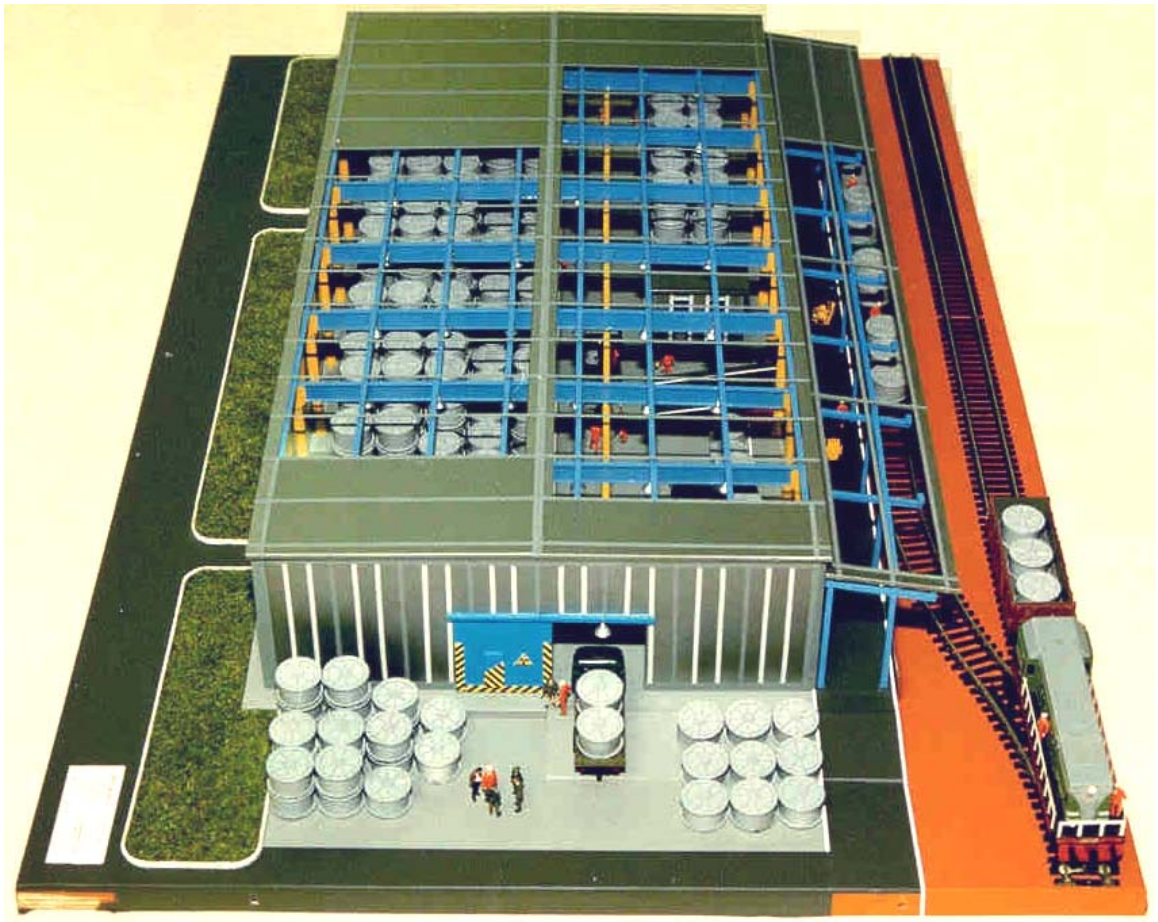

Fig. 4. Conceptual Model of a Containerized Waste Storage Facility

CONCLUSION

Development of the PST1A-6 container helps to create a self-sustaining waste management infrastructure in Russia, featuring safe and secure waste transport and storage. The container is in compliance with the requirements of Russian as well as IAEA international standards for safe transportation and storage of solid radioactive wastes. The Russian Navy has taken possession of the first 400 containers and is using them to store solid waste from dismantled Russian submarines. Some wastes are packed into drums, which are then loaded into the PST1A-6 containers, and some wastes are loaded directly into the containers. All 400 containers will be shipped from Severodvinsk to the Polyarninsky Shipyard near Murmansk in early 2002. These containers will provide safe, secure storage for roughly 1,000 cubic meters of solid waste in northwest Russia. Full-scale production of these containers could help solve the problems of SRW storage and transportation not only in Russia, but also in other countries.

REFERENCES

1. A. GRIFFITH, T. ENGOY, A. DIASHEV, P. SCHWAB, A. NAZARIAN, V. PETRUSHENKO, E. BAAL, AND V. NIKITIN, "Storage of Solid Radioactive Waste from the Northern Fleet of the Russian Navy under the AMEC Program," Report/Paper at the Symposia Waste Management 2001 Conference, Tucson, Arizona, February 25-March 1, 2001.
2. A. GRIFFITH, P. SCHWAB, A. NAZARIAN, P. KRUMRINE, AND B. SPARGO, "Stabilization and Storage of Solid Radioactive Waste from the Russian Navy's Northern Fleet under the AMEC Program", Report/Paper at the Symposia Waste Management 2000 Conference, Tucson, Arizona, February 28-March 5, 2000.
3. IAEA, "Regulations for the Safe Transport of Radioactive Material", 1996 Edition (Revised in 2000), IAEA Safety Standards Series No. TS-R-1 (ST-1, Revised), 2000.
4. Regulations of Safety Standards (NRB-99) of the Russian Federation, 1999.
5. "The Basic Sanitary Rules for the Work with Radioactive Materials", OSP-72/87 of Russian Federation, 1987.
6. "Regulations of Safe Transportation of Radioactive Materials", PBTRV–73, of Russian Federation, 1973.
7. "Sanitary Rules of the Handling with Radioactive Wastes", SanPiN 12-129-11-3938-85 (SPORO-85) of Russian Federation, 1985.
8. "Transportation packaging for radioactive materials. General specifications", GOST 16327-88, Standard of Russian Federation, 1988.