CONSTRUCTION OF CONTAINERS FOR TRANSPORTATION OF SOLID RADIOACTIVE WASTES

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ABSTRACT

The Russian Shipyard "Zvyozdochka" has constructed and tested 100 containers for transportation and storage of solid radioactive wastes (SRW). The cylindrical shaped, steel transport containers for low level solid radioactive wastes (PST 1A) are designed for transportation by all means. Each container can hold seven 200-liter (55-gallon) drums. These containers can be stacked in 6 layers in storage facilities. The containers meet the Russian GOST and IAEA ST-1 standards. The containers have been delivered to the Northern Fleet of the Russian Navy. Development of this container helps to create a self-sustaining waste transport and storage infrastructure in Russia featuring containerized waste in safe, secure facilities.

INTRODUCTION

The building of ships and submarines equipped with nuclear reactors, their operation, repair, decommissioning, and dismantlement have caused generation and accumulation of solid radioactive wastes (SRW). During past years the number of nuclear submarines (NS) to be dismantled in Russia had significantly increased in part due to the arms control agreements in strategic offensive weapons, between USSR and USA. At the present time in Russia there are 184 decommissioned nuclear submarines designated for dismantlement. Every year, on naval bases and sites alone, nearly six thousand tons of SRW is added. Absence of facilities for processing of SRW and disposal sites has led to the exhaustion of interim storage facilities for SRW.

BACKGROUND

In June 1999, the U.S. Government, under Arctic Military Environmental Cooperation (AMEC) Project 1.4 [1-2], announced a world-wide tender for the production of containers for low-level SRW that complies with Russian and IAEA standards [3-8]. FSUE "Zvyozdochka" and RSI "Onega" developed a joint proposal for a container for temporary storage and transportation of low-level SRW. At the same time, the construction simplicity, relatively low cost, necessary reliability and durability, possibility of transportation by all means of transport and compact disposing of primary packings (seven 55 gallon drums with SRW) were proposed.

From October 1999 RSI "Onega", which is a research-development arm of the shipyard "Zvyozdochka" began the design work. The container design was developed in accordance with

the terms of the license of Gosatomnadzor (State Nuclear Regulatory Agency) of Russia No CE-07-102-0261 dated 24.09.98. During the construction all the technical requirements were fulfilled. Design documentation provides radiation safety of the container in compliance with following Russian Federal norms and regulations:

- NRS (NRB) 99. Norms 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].
- SRRMM (SPORO)-85. Sanitary Rules for Radioactive Materials Management [7].

The design documentation was developed by the working group of RSI "Onega" leading specialists, 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 a part of the project the following design and normative documentation was developed:

- Technical project (consists of tender proposal) for tender;
- Technical order for design;
- Durability calculation;
- Biological protection calculation;
- Working drawings;
- Technical Specifications;
- Program and methodology of tests;
- Operational manual/instruction for container.

The biological protection calculation, based on the composition of the wastes and the level of their gamma radiation up to 30- mRem/h (0.3 mZv/h) at distance of 0.1 meter from the surface, yielded the optimum container wall thickness (0.006 m). Based on durability calculations the design was finalized and working drawings of all construction elements were developed. The design was labeled PST 1A. 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 are selected according to GOST 26291-84, based on the most severe conditions of use, taking in account possible extreme/emergency conditions during transport.

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

- Department of Emergency Situations of Ministry of Atomic Energy (Minatom) of Russia,
- Nuclear and Radioactive Safety State Control Department of Russian Ministry of Defence (MOD),
- Chief Medical Officer of Arkhangelsk region State Sanitary-epidemic Control Center of Russian Ministry of Public Health,
- 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 repair.

GENERAL INFORMATION ABOUT FSUE "ZVYOZDOCHKA"

The Federal State Unitary Enterprise (FSUE) "Zvyozdochka" is a specialized enterprise for shipbuilding, ship-repairing and recycling of the ships and vessels (see Fig. 1). FSUE "ME" Zvyozdochka" is an advanced, well-equipped ship repairing and shipbuilding complex with high technical and industrial potential.

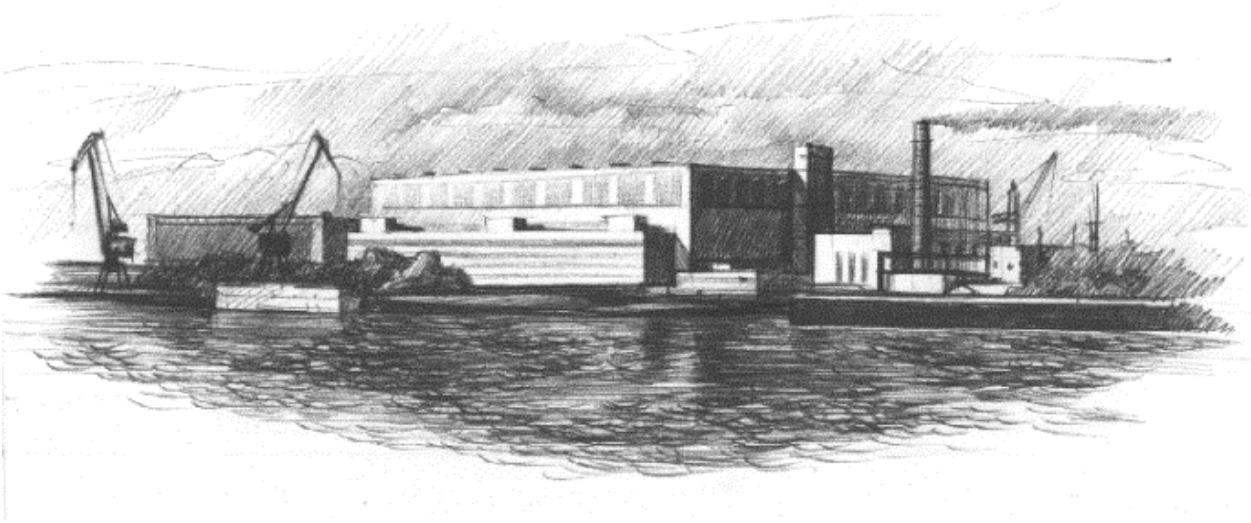

Fig. 1 The view of the "Zvyozdochka" Shipyard

Basic types of activity of the enterprise are:

- repair, re-equipment and modernization of the ships and Navy vessels;
- repair and testing of the ship equipment and mechanisms;
- construction of civil ships (trawlers, dry-cargo ship);
- construction of large modules and Jack-Up platforms for the usage in the Arctic shelf;
- assembling, welding of metal structures under the contracts with the Russian and foreign customers;
- recycling of the ships and vessels with scrapping of constructions on Marten piece;
- developing of design and technological documentation for production and types of jobs concerning the basic activity;
- designing and fabricating of the equipment and handling devices RW storage.
- unloading of spent nuclear fuel from the ships designated for utilization
- collecting, temporary 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 complex of shops: steel structure fabrication shop, piping prefabrication shop, electroplating shop, machinery shop, propellers producing shop, shops for repair of the ship 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 years", authorized by the decision of Russian Federation Government of October 23, 1995. The state customer of this program is 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's order #518 of May 28, 1998. The state customer-coordinator of these works is the Ministry of Atomic Energy of the Russian Federation (Minatom). Specialists from "Zvyozdochka" Shipyard are permanent representatives on Interdepartmental Coordination Councils on the questions of handling radioactive wastes and recycling of nuclear submarines. They also participate in the work of Board of the Ministry of Atomic Energy of the Russian Federation.

The enterprise has long-term experience with the Russian regulating bodies (Gosatomnadzor, Minatom, Gosstandart, etc.) and has a State license from Gosatomnadzor on designing and manufacturing of equipment for storage of radioactive wastes.

Steel structure fabrication shop is one of the basic shops of the enterprise, which consists of (Fig. 2):

- assembling and welding bays;
- bays of special processing of plates.

The bays of special processing of plates have the following equipment:

- shot blasting and priming line;
- gas-cutting machines "Crystal";
- gas-cutting semi-automatic machine;
- hydraulic presses.

Fig. 2 Steel structure fabrication shop

Following works are carried out in the bay of special processing:

- sandblasting (plate with the thickness up to 0.90 m; LxB=12mx2.4m; profile up to No. 14, L=6m);
- straightening of a steel plate (B=3m, L=12m, t=0.20m) on the rollers;
- straightening and bending of a plate (up to T-joints #20);
- bending of a plate (thickness up to 0.20 m) on a plate bending machine;
- bending and edging on the press (B=2.5m, L=5m, t=0.20 m);
- cutting of a steel plate on guillotines;
- punching from plates (hydraulic press with force up to 630 tonne, dimensions of a table are 2.1m x 1.8m);
- heating of details and annealing of welded seams of units of overall dimensions up to 1.4mx2.0mx1.0m;
- various kinds of thermal cutting and electric welding, namely:
    1) acetylene-oxygen cutting of steel and special alloys;
    2) manual and machine plasma cutting of non-ferrous metals and alloys;
    3) manual gas-flux cutting of non-ferrous metals and their alloys;
    4) semi-automatic welding in CO_2 atmosphere;
    5) manual welding of special alloys and stainless steel in argon atmosphere.

Assembly and welding bays are equipped with:

- assembly-welding stands for assembling and welding metal constructions with application of automatic and semi-automatic welding under flux and in shielded gas atmosphere.
- automatic and semi-automatic welding machines.

Technology of big sections and big units assembly of vessel hulls and different constructions was adopted.

THE PROCESS OF FABRICATION OF PST 1A CONTAINERS

FSUE "Zvyozdochka" executes the whole scope of work, including designing, fabricating, testing, certifying containers in accordance with the requirements IAEA and the Russian Federation [3-8]. Total amount of enterprise works includes the following services:

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

Prior the beginning of fabrication, the technical services of "Zvyozdochka" study in detail the design documentation, issue the working technologies for each type of production, in which the necessary equipment, outfitting, tools are specified. Before start the work all steel rolling passes a

sandblasting line for the removing of rolling scale and priming of surfaces. The process of containers fabricating includes a number of operations, which are carried out on the equipment and with application of technological equipment, which are in disposition of shops of FSUE "Zvyozdochka". Following the technology of manufacturing hull structures of vessels and modules, accepted at the enterprise, the whole process of manufacturing of containers in the following technological procedure:

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. At the same time with the manufacturing of details in the stet shop of hull manufacturing the fittings (bolts, nuts, pins and such) are processed according to the drawings in the machinery and forge shops, which then are passed to the assembly.

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 carbonic gas atmosphere with the use of standard equipment. In order to exclude operations on marking-out the edge of rigidity 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

The machining of flanges of cylindrical containers and covers and the drilling of holes is carried out in the propeller shop. Flanges and covers of cylindrical containers are pierced on a surface in order to provide the most dense mutual attachment on lathes model 1525,1540. The ring groove for the sealing gasket is processed also on lathes, during the same installation with the flange of the hull. The apertures on flanges for the installation of fixture are drilled without preliminary marking-out according to the appropriate conductor in both shops on radial drilling machine tools such as 2A-53.

Priming and painting

The priming and painting is carried out in the paint shop according to the technology of 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 BVR 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.

Tightness check

The tests are carried out in the mounting workshop. The pipelines for tests are brought to the pipe fittings in the container covers. The control of internal pressure is carried out according to the pressure fall on a test manometer, endurance under the pressure is 30 minutes.

Industrial safety

As container production does not contain technological operations new to the enterprise, the questions of ensuring industrial safety have been addressed in accordance with accepted regulations.

Environmental control

During the technological operations of manufacture of containers no emissions exceeding the norm confirmed by shop permits, both on quantitative and qualitative parameters.

Quality control

"Zvyozdochka's" long-term functioning quality control system provides reliability and quality of production. This quality is confirmed by long-term practice of production delivery to the representatives of military acceptance of Russian Federation Ministry of Defense, successful presentation of civil production to English Lloid and also to Norwegian DNV. Russian Federation State Standard (Gosstandart) carries out checking of measure devices and techniques of their performance in order to provide quality of production.

TECHNICAL REQUIREMENTS FOR THE PST 1A CONTAINERS

General requirements

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

- IAEA: type A package according to the document IAEA " Regulations for the Safe Transport of Radioactive Materials. Edition 1996. Safety Standards Series ST-1";
- Type A transportation packaging according to GOST 16327-88 "Transportation packaging for radioactive materials. General specifications."

Main characteristics/parameters of the PST 1A container

Type of the wase: low-level SRW.
Temperature of exploitation + 70^{o}C-40^{o}C.
Service period - not less than 10 years.
External and internal diameters – 2.000 and 1.860 m.
Wall thickens- 0.006 m
Shape - cylindrical.
Internal volume – 2.58 m3.

Max. Weight of loaded container for storage - no more than 5300 kg.
Max. Weight of loaded container for transport - no more than 2300 kg.
Ratio between the shortest distance from its 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 shall be no less than 1.25.
The paint resistant to decontamination solutions.
Removable cover is to be sealed with a gasket; hull and covering connection is fit on bolts.
The container retains contents under a reduction of ambient pressure down to 25 kPa.

Tests required

The tests comply with the requirements of IAEA and GOST 16327-88 [3,8]. The program of tests includes tests demonstrating serviceability of the container at temperature –40^{o}C.

List of the documents

Before delivery of containers, the following documents are submitted:

- exploitation instructions of container;
- certificate of conformity according to IAEA norms for type A packaging
- copy of test results, including the description of test methods according to IAEA norms for type A packaging.

Certification

The certification of the container was the responsibility of Shipyard "Zvyozdochka" and is carried out by the Russian certification organization.

The description of container

The general description for the PST 1A container is given below (see also Fig. 3). Container is made of steel type 10XSND, which can be used in a temperatures interval from –40^{o}C up to + 100^{o}C. The internal and external sides of the container are painted by paint stable in an interval of temperatures from –40^{o}C up to + 70^{o}C, and resistant to decontaminating solutions. External and internal surfaces of containers con be easily decontaminated by accepted methods of liquid and film

Fig. 3 The new SRW transport and storage container by forklift, from both sides of the container.

decontamination. Maximum allowable payload for storage is 5300 kg. During transport the maximum allowable payload 2300 kg. The container is equipped with the removable top cover. One distinctive feature of the container structure is that there are no internal fixtures, which could interfere with easy loading. The sealing of a cover of the container is carried out in the following way: flange has a ring groove, and a round section gasket made of cold-resistant rubber type IRP3012, greased by oil MTE is placed in the groove. An allowable range of temperatures for use of this type of rubber is -40^{o}C up to + 70^{o}C. The cover is equipped with protection (seal) devices. The sidewall of the container is equipped with a protected (sealed) box forthe location of the accompanying documents to the container.

The container has following cargo-lifting devices:

- lifting elements for transportation
- 4 pins for lifting of the container by crane.
- the cover of the container has 4 eyes for lifting by crane.

The cover of the container has two nozzles D25 with plugs, for performing air tightness tests.
On external surface of the container the places for necessary marking are stipulated.
Service life of the container - not less than 10 years.

Parameters of the container

Dimensions – D x H, 2.000x1.274 m.
The internal dimensions – D x H, 1.860x0.950 m.
Internal volume – 2.58 m3.
Weight of the empty container - 990 kg.
Height of gravity center- HGC, 0.680 m.

Exploitation rules of container

Before each loading it is necessary to check visually the condition of the rubber gasket to grease it. In cases of breaks or deformations of a gasket it's necessary to replace it. After 10 loading and unloading operations, the gasket must be replaced. After carrying out of 10 operations on loading and unloading of the container it is necessary to carry out periodical examination the container leakage tests. The radiating safety at loading – unloading, storage and transportation of containers with loaded SRW is provided with submitting for the federal standards and regulations [4-8].

Radiation safety requirements and Composition of SRW

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

- rags, working clothes, canvas, boards, paper etc.;
- - plastic, rubber, hoses, scraps of cable, insulation wastes;
- 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) on the distance 10 cm from the surface;

Group 2- SRW with gamma -radiation level from 30 mrem/hour (0.3 mSv/hour) up to 1000 mber/hour (10 mSv/hour) on the distance 10 cm from the surface;

Group 3- SRW with gamma -radiation level more than 1000 mrem/hour (10 mSv/hour) on the distance 10 cm from the surface.

Low-level SRW corresponds to the Group 1 according to classification [7]. The gamma activity of SRW of the Russian Navy's Northern Fleet is caused by the basic contents Cs-137 (70 %) and Co-60 (30 %).

Transport category

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. The first three categories of wastes can be transported by common types of transport following the PBTRV-73 standard. In accordance with this standard, SRW packed in the PST 1A container shall be treated as radiating packages not higher than the third transport category and can be transported by trucks, rail, or barge. Thus, the PST 1A 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	On the distance of 1m from the packing, mrem/hour
1	0.5	Not detectable
2	50.0	1
3	200.0	10
4	1000.0	50

MANUFACTURER AND CERTIFICATION TESTS

FSUE "Zvyozdochka" provides air leakage tests and lifting device tests of each container. In accordance with the GOST 16327-88 requirements the program contains the list of tests given below. FSUE "Zvyozdochka" has all the necessary equipment for conducting these tests.

Water spray test

Water is prayed on the container, imitating exposure to rain at the rate of approximately 5 cm per hour for not less than 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 base-plate with smooth and horizontal surface; plate of carbon steel, not less than 0.008 m thick, and with dimensions of not less than those of the surface of container being tested, load of 31.5 tonnes, suitable capacity crane.

Drop test

The container was dropped from the height of 1.2 m on any edge or corner without leaking. Equipment includes target made of carbon steel as a plate not less than 0.012 m thick with the area of the impact surface no less than two-fold area of base surface of container. Target shall be firmly placed by its entire surface on a concrete slab weighing no less than ten-fold weight of the container and firmly attached to the slab, crane, and device for remote release.

Puncture test

Carbon steel rod with diameter of 0.032 m with a hemispherical end with radius of 0.016 m and weight of 6 kg was dropped vertically from the height of 1 m on the container mounted on a plate. The container wall was not punctured. Equipment includes carbon steel rod, positioning and dropping device.

Leakage (air tightness) test

The container was pressurized with air up to a pressure of 100 kPa and checked for leaks. Structure of the stand includes tank with water, pump, manometer, and locking fittings. Equipment: a reducer from the air main of low pressure, manometers, and the locking fittings.

Certificates of Compliance

To use these containers on all the territory of Russia, the Ministry of Atomic Energy (Minatom) has awarded certificate No.2054 for of the packing set PST-1A to SUE "Onega" and has given a permit for the transportation of the container PST-1A, per YaNMI. 305179.012 TR, by all means of transport for Transport Category 3. Also, the Certificate of Compliance No. 3380219 of Russian Gosstandard, confirming that the transport container PST-1A, YaNMI.305179.012 TR complies with requirements of regulating documents GOST 16327-88 and YaNMI.305179.012 TR, has been awarded to the FSUE "Zvyozdochka". On basis of this, we can affirm that we have produced an absolutely new steel container for transportation and temporary storage of low-level SRW having no existing analogs in Russia. Recently, "Zvyozdochka" received an order for a larger batch and certification of the container's type [1]. Thereafter, it will allow us to manufacture pre-certified containers for SRW.

Set of documents provided with a container

The set of documents provided with a container are working drawings of the container; the program of tests; technical data and user's manual; certificates; and technical specifications on delivery.

Taking into consideration favorable geographical position of FSUE "Zvyozdochka" the container transportation to the Northern Fleet can be carried out either by water or railroad. The transportation by water is carried out on the route Severodvinsk – point of destination. The loading of ready production is made directly in territory of FSUE "Zvyozdochka", that excludes intermediate transportation. The transportation by water depends on seasonal conditions. The navigation in the port of Severodvinsk lasts till December, i.e. up to establishment of strong steady frosts in Severodvinsk area and nearby situated White Sea areas. The transportation by water is possible only by one shipment up to 5 thousand tonnes displacement. The transportation by train is carried out on the route of Severodvinsk – Moscow – point of destination, or St. Petersburg – point of destination.

Fig. 4 First 100 containers developed under AMEC Project1.4, and delivered to the Russian Navy

The loading of ready production railroad cars will be carried out on the territory FSUE "Zvyozdochka". The transportation by train does not depend on climate conditions and can be done during any season. The transportation of containers is carried out in railroad cars with accommodation in two levels. Taking into consideration the sizes of railroad cars (L = 12.0m; B = 2.8m; H = 2.06m) and sizes of containers: cylindrical - d = 2.000 m; H = 1.274 m in a railroad cars it is possible to place 12 containers.

CONCLUSION

Development of the PST 1A container helps to create a self-sustaining waste transport and storage infrastructure in Russia featuring containerized waste in safe, secure facilities. 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. Full-scale production of such transport containers can help to resolve the problem of SRW storage and transportation not only in Russia but also in the other countries.

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