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US/RUSSIAN AFFIRMATION PROCESS OF THE RUSSIAN FISSILE MATERIAL CONTAINER DESIGN

R. E. Glass (1), S. M. Nunley (2), G. Chalfant (3)

(1) Sandia National Laboratories*, Albuquerque, NM USA
(2) US Department of Energy, Albuquerque, NM USA
(3) SAIC, Albuquerque, NM USA

Background

The United States government agreed to provide the Russian Federation with containers to support the dismantlement of Russian nuclear weapons as part of the Nunn-Lugar Cooperative Threat Reduction program. In February 1996, the "affirmation" of the Russian Fissile Material container design was completed. The "affirmation" process allowed a joint program between the Russian and US governments to proceed without the exchange of sensitive weapons specific information.

The Russian Fissile Material container program is an integral part of the Cooperative Threat Reduction program wherein the US government provides assistance to the states of the Former Soviet Union for dismantlement of their nuclear stockpile. The Cooperative Threat Reduction program is managed by the US Defense Special Weapons Agency. Sandia National Laboratories was selected as the design agency and technical point of contact for the Russian Federation. The Department of Energy, which certifies containers for weapons shipments in the United States, provided an independent assessment of the Sandia designed container to assure that it met the requirements of the August 31, 1993 AT-400R Container Requirements [Sandia National Laboratories, 1993] document which was agreed to by representatives of the United States and Russian Federation.

The "affirmation" process was undertaken in lieu of a certification process. This process was a formal review by the US Department of Energy of Sandia's design and testing of the Russian Fissile Material container. The affirmation was intended to provide the Russian Federation with assurance that the container met the negotiated requirements including specific sections of IAEA Safety Series 6 [IAEA, 1985]. The process stopped short of a certification process that would have required weapons specific design information. It is the responsibility of the Russian Federation to use the information derived during the affirmation process, as well as internal resources, to obtain certification.

*Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

DISCLAIMER

Assuring that the production containers conform to the design as affirmed by the US Department of Energy is the sole responsibility of the Defense Special Weapons Agency. The affirmation does not address product manufacturing quality assurance.

This paper will provide a summary of: (1) the US/Russian jointly defined requirements document, (2) the resulting design, (3) the affirmation plan, (4) the affirmation document, (5) joint statement issued by the US and Russian representatives in February 1996 accepting affirmation of the design and (6) the current status of implementation.

US/Russian Requirements

The intent of the jointly defined requirements was to provide two versions of the container that met the requirements for a Type B Fissile Material container and address Russian specific requirements. The first version is to be used for transportation and short term storage and the second version is to be used for long term storage. The AT-400R Container Requirements document that was signed by both sides on August 31, 1993 accomplished that goal. The document specifies that the container is to be leak tight following both the normal and hypothetical accident conditions that are specified in the IAEA Safety Series 6 Regulations for the Safe Transport of Radioactive Material, 1985 Edition.

The container has a 50-year life under conditions specified for storage in Russia. To ensure this life, the materials of construction were specified. These materials were selected based on previous Russian and US container designs and the results of testing performed on a prototype. These materials were stainless steel for the overpack exterior and containment vessel and polyurethane foam for thermal and impact protection.

The types of closures were specified. There is a welded closure with an ability to be rewelded three times and a bolted closure. The only exception to the 50-year life is the o-ring in the bolted closure

There were additions to the normal conditions requirements. These included a lowering of the cold temperature to -50°C and a limit on water ingress of 10 g during the water spray test. The vibration environment was defined to be 5,000 km by road or 20,000 km by rail. Both road and rail responses were based on US data.

Hypothetical accident conditions were increased to include two additional tests. These were the fire propagation test "wherein a first container is exposed to an 800°C radiant environment for 30 minutes. A second package shall be placed above the first container within the plume of burning gases generated by the first container." The second test was an extreme fire environment which was defined as exposure to a radiant heat environment of 1050°C for 30 minutes.

The contents were simulated with a heated sphere and the internal fixturing was modeled using solid polypropylene. An aluminum thermal bridge was used to reject the radioactive decay heat. The temperature requirements are specified at the containment boundary. To preclude exchange of classified information, the Russian Federation is responsible for ensuring that the actual contents and internal fixturing are bounded by the simulated contents.

The Russian Federation is also responsible for ensuring that the contents remain subcritical and that external dose is not exceeded.

Design

The design of the AT-401R, which was discussed in Glass, et. al., 1995, has a welded closure, as shown in Figure 1. The AT-402R provides a bolted closure. Both of the containers use a common overpack for thermal and impact protection and a common purge and backfill port. The major components of the container are the protective overpack, an insert cover and the containment vessel.

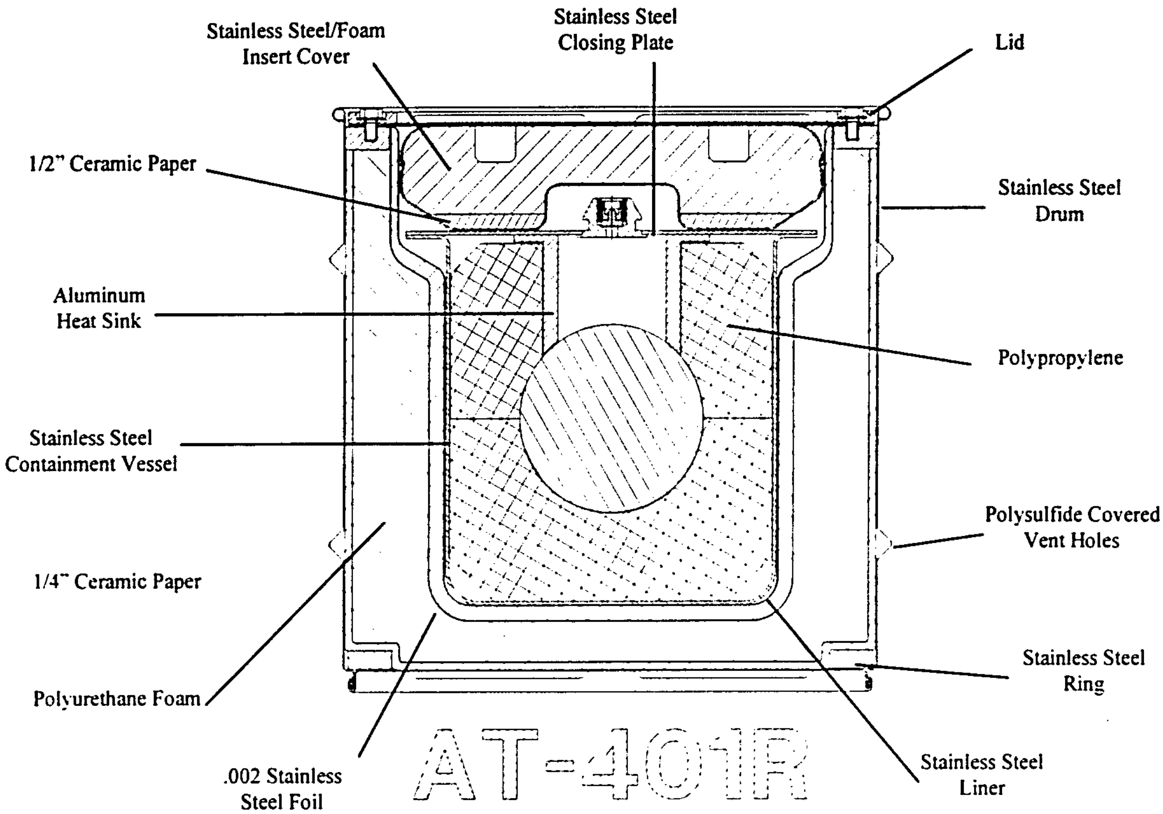

Figure 1: AT-401R Design

The overpack consists of a stainless steel drum and liner. Internal to the overpack are two layers of a ceramic paper insulation and a high density polyurethane foam. The overpack provides thermal and impact protection for the containment vessel.

The insert cover consists of a stainless steel shell with a ceramic fiber insulation and polyurethane foam. The insert cover provides access to the containment vessel and a similar level of thermal and impact protection as the overpack.

The containment vessel is a 23 mm thick stainless steel vessel. The welded vessel has a flange to which a flat plate is welded. The flange was sized to allow for four welds of the containment vessel. The bolted vessel is fabricated with a substantial flange weldment to which the lid is bolted.

All of the components internal to the containment vessel were specified for compliance testing only. It is the responsibility of the Russian Federation to ensure that the internal support structure and heat transfer mechanisms provide a comparable level for their specific contents.

The adequacy of the design was substantially demonstrated through the test program that is documented in AT-400R Affirmation Summary [Sandia National Laboratories, 1996] and is summarized in Table I. The first column designates the test unit with the notation Compliance Test Unit, CTU, followed by the type of container, 401 or 402 and then the serial number. The results of all of these tests were that the Russian specified parameters were met and all of the packages remained leak tight.

Table I: AT-400R Compliance Test Sequence

Test Unit	Test Sequence
CTU401-1	Free Drop Side, Free Drop CGOC, Free Drop End, Immersion
CTU401-2	Insolation
CTU401-3	Vibration
CTU401-4	Crush Side, Puncture Side, Pool Fire
CTU401-5	Crush End, Puncture End, Pool Fire
CTU401-6	Crush Side, Puncture Side, Pool Fire
CTU401-7	Crush CGOC, Puncture CGOC, Pool Fire
CTU401-8	Fire Propagation
CTU401-9	Fire Propagation
CTU401-10	Normal Thermal
CTU401-11	End Drop, End Puncture, Pool Fire
CTU401-12	Three rewelds, CGOC Crush, CGOC Puncture, Pool Fire
CTU401-13	Corrosion
CTU402-1	Water Spray, Water Spray, Stacking, Water Spray, Free Drop Side, Water Spray, Free Drop CGOC, Water Spray, Free Drop End, Water Spray, Penetration Lid, Water Spray, Penetration Closure, Water Spray, Penetration Side
CTU402-2	Insolation
CTU402-3	Fastener Life Cycle, Immersion
CTU402-4	Vibration, Crush Side, Puncture Side, Pool Fire
CTU402-5	Crush CGOC, Puncture CGOC, Pool Fire
CTU402-6	Crush End, Puncture End, Pool Fire
CTU402-7	Crush CGOC, Puncture CGOC, Pool Fire
CTU402-8	1050°C Radiant Heat
CTU402-9	High Pressure Water Spray, Normal Thermal
CTU402-10	Side Drop, Side Puncture, Pool Fire

Affirmation Plan

The U. S. Department of Energy, Nuclear Explosive Safety Division (NESD) is the certifying authority for weapons related radioactive materials transport in the United States. Due to the necessary lack of information on contents for the AT-400R, NESD was unable to provide certification for the AT-400R. NESD did agree to provide an affirmation of the AT-400R, as designed and tested, to ensure that it met the requirements given in the requirements document. The Defense Nuclear Agency was independently responsible for assuring and affirming production quality.

The affirmation team consisted of NESD staff and subject matter experts from Martin Marietta Energy Systems, Y-12 Plant at Oak Ridge. Included in the affirmation process was a review and approval of the test plan and test procedures as well as the instrumentation and data collection and retrieval. A complete data package was provided to the affirmation team prior to affirmation testing. The affirmation team reviewed the test plan and examined the test specimens to ensure that test specimens represented the proper configuration. Members of the affirmation team were present to observe all compliance testing of the AT-400R including all preparation of container test specimens. The affirmation team reviewed the test results and analyses and documented their conclusion regarding the capability of the container to meet the requirements.

The NESD notified Sandia and the Defense Nuclear Agency that any production nonconformances of critical or major components will invalidate the affirmation process.

The affirmation plan [Nunley, 1995] provided a table that listed each of the required tests (normal, hypothetical accident and Russian specific) and the test unit that would demonstrate compliance. The affirmation plan further provided detailed text of the verification process for each requirement. For example, the verification of the requirement for containment vessel sealing stated: "The affirmation will consist of a review of the test plan to ensure both welded and bolted containment vessels are appropriately tested, a review of the SNL leak test procedures, witnessing the leak tests performed and reviewing the leak test results after the container is subjected to the normal environment tests, the accident environment tests, and the Russian specific tests. Container test specimens will be modified by the addition of a penetration into the containment vessel lid to allow for containment boundary evacuation and leak testing. The modification to a structural component of the containment boundary is less than desirable; however, the required leak rate, combined with the design and materials of construction would not easily permit alternative leak test methods. The affirmation team will use ANSI N14.5 leak test criteria as no other standards have been identified..."

This document provided a road map for the affirmation process that led to the successful completion of the test program and timely agreement from all parties that the package as designed and tested at Sandia, met the requirements jointly agreed to by the Russian and US sides. The normal certification process would have taken substantially greater time and involved greater risk in the production of the containers that was ongoing during the affirmation process.

Affirmation Document

The Affirmation Document is a report that documented the review performed by subject matter experts from the US Department of Energy and Lockheed Martin Energy Systems, Y-12 Plant (Oak Ridge, Tennessee) to verify that the AT-400R, as designed and tested, met the requirements of the August 31, 1993 AT-400R Container Requirements Document.

The report was prepared following the outline of the Affirmation Plan and the August 31, 1993 AT-400R Container Requirements Document and consisted of five chapters. The last section of each chapter presented any findings to document ongoing activities and/or any potential areas of non-compliance. A summary and brief discussion of the highlights of each chapter follows.

Chapter 1 presented background information and discussed the scope of the affirmation process. The most pertinent part of the scope included a statement that the affirmation cannot be interpreted as a Type B package certification under IAEA or United States Regulations. This statement was required because the Department of Energy, Albuquerque Operations Office, is not the certifying authority for containers used for international shipment of radioactive material or United States non-weapons related containers.

Chapter 2 addressed the review of the container configuration. Verification of these requirements primarily consisted of a review of the engineering design drawings and a visual examination of each compliance test specimen. One important requirement was that the welded lid design (AT-401R) allow removal and rewelding of the containment vessel lid up to three times. Verification of this requirement was demonstrated by CTU401-12 which had the containment vessel lid welded, cut, and rewelded three times. Measurements were taken after each cut to ensure that the specified weld depths were obtained. This unit was subsequently used in the accident conditions testing after the fourth weld and remained leak tight after testing. It was concluded that the AT-400R design met the specified container configuration requirements.

Chapter 3 documented compliance to normal conditions of transport which included requirements contained in the IAEA Safety Series No. 6, paragraph 543 and paragraphs 621 through 624, as well as an additional water tightness requirement specified by the Russian Federation; however, since the exact contents were unknown, no assessment could be made with regard to allowable loss of contents (no greater than 10^{-6} A_2 per hour) or the external contamination limits. All compliance test specimens remained leak tight, there was no water leakage into the container after testing, and it was concluded that the requirements for normal conditions of transport were met.

Chapter 4 addressed the review of the AT-400R design for accident conditions of transport which included requirements contained in the IAEA Safety Series No. 6, paragraphs 626 through 629, as well as temperature limit goals established by the Russian Federation. The container test sequence is shown in Table I. The test orientations for each compliance test unit shown in Table I were reviewed prior to testing to ensure that the test sequence would encompass worst case conditions. It was important to conduct this review prior to testing and get agreement on the test orientations because the aggressive project schedule would not accommodate additional testing to resolve questions by the reviewers. All test specimens remained leak tight and the temperature limit goals were met thereby demonstrating that the requirements for accident conditions of transport were met.

Chapter 5 documented the verification of requirements that were designated as Russian-specific requirements. Several of these requirements were somewhat unique and they included temperature goals for normal and accident conditions of transport and, as previously discussed, exposure to extreme fire environments and fire propagation. The temperature goals for normal transport conditions were based upon an ambient temperature of 38°C with a heat source within the containment vessel and the design goal was to limit the containment vessel wall temperature to 70°C and the drum surface to 50°C. Under accident conditions, the design goal was to limit the temperature of the inner surface of the containment vessel wall to 150°C in a specified area of the containment vessel flange. It was concluded that the container design met the Russian specified requirements with the exception of the service life requirements. The service life requirements specify a 50-year life for the AT-401R (welded containment vessel lid) and a 20-year life for the AT-402R (bolted containment vessel lid); however, compliance could not be verified because activities related to material testing and analyses are ongoing. Aging analysis is periodically conducted and the results are provided to the Russian Federation.

Joint Statement

The following passages are the first three paragraphs of the Summary Statement of the Working Meeting of the U. S. and Russian Federation Specialists for the AT-400R Container Program:

"A working meeting was held between the United States of America and Russian Federation specialists from 12 through 16 February 1996 in Albuquerque, New Mexico, USA on the AT-400R container program.

As part of the implementation of the Agreement, the US side has completed the design and affirmation testing of the AT-400R container.

The design presented in the AT-400R Affirmation Summary and affirmed in the DOE AT400R Test Affirmation Report fully complies with the requirements as defined in AT-400R Container Requirements, dated August 31, 1993."

Following the agreement that the container fully complies with the requirements, the joint statement then addresses the administrative issues such as delivery of documentation and hardware and the designation of English as the official language of the documents. The document was signed on the Russian side by Gennady Kozko, representing MINATOM, Boris Barkanov, representing VNIIEF, and on the US side by Greg Chalfant, representing the Defense Nuclear Agency and Robert Alvis, representing Sandia National Laboratories.

Current Status

Since the successful affirmation of the AT-400R design and testing program in 1996, approximately 24,000 AT-400R Fissile Material Containers have been manufactured in accordance with the approved design and provided to the Russian Federation. The Russian Federation has indicated that the containers have been successfully certified for use as a Type B Fissile Material Container within Russia. An Audit and Examination conducted under the Cooperative Threat Reduction program in January 1998 verified that the containers are being used for their intended purpose of storing fissile material from dismantled nuclear weapons per the Agreement Between the Department of Defense (DOD) of the United States and the Ministry of Atomic Energy (MINATOM) of the Russian Federation Concerning the Safe and Secure Transportation and Storage of Fissile Material Through Provision of Fissile Material Containers, dated 17 June 1992 as extended May 1996.

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Agreement Between the Department of Defense (DOD) of the United States and the Ministry of Atomic Energy (MINATOM) of the Russian Federation Concerning the Safe and Secure Transportation and Storage of Fissile Material Through Provision of Fissile Material Containers, dated 17 June 1992 as extended May 1996.

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