Design and Manufacture of an Explosive Resistant Container

Elaine Hinman-Sweeney and Lada Osokina
Sandia National Laboratories, Albuquerque, New Mexico USA

Vyacheslav Solovyev, Olga Vorontsova, Anatoly Abakumov and Mikhail Syrunin
All-Russian Scientific Research Institute of Experimental Physics (VNIIEF), Sarov, Russia

ABSTRACT

High Explosives (HE) are categorized as hazardous material. Despite all efforts taken to improve them in terms of safety, the likelihood of an accidental or occasional explosion in the handling of HE-containing items cannot be eliminated. One way to protect the environment from the impact of detonated HE is to confine the explosion inside an explosion-resistant container (ERC). Thus, an item posing the risk of explosion can be placed inside such a container so that if detonation occurs, the explosion products would remain inside the container.

The Sandia National Laboratories (SNL) and the All-Russian Scientific Research Institute of Experimental Physics (VNIIEF) explosive resistant container program consists of several projects performed under a variety of auspices. Early funding was provided by the U.S. Department of State, with follow-on testing work funded through the U.S. Department of Energy's National Nuclear Security Administration (NNSA), and eventually, a partner project via the International Science and Technology Center (ISTC) involving SNL, VNIIEF and the U.S. private corporation NABCO, Inc.

Several designs have been developed under these programs. VNIIEF developed the AT-595 explosive resistant container to meet requirements developed jointly with SNL via the U.S.-Russian Federation Warhead Safety and Security Exchange (WSSX) Agreement. The AT-595 is a cylindrical design with an inner steel liner and an outer fiber-wrapped liner. This design provides total containment of an 8 kg TNT-equivalent explosive detonation surrounded by 35 kg of inert material, and it is significantly lighter and safer than conventional containers. Testing confirmed that the AT-595 was able to contain the explosion, including the resulting shrapnel and gases. The ISTC-sponsored project concentrates on a spherical ERC design with a rapid-closing door mechanism that contains a 5 kg TNT-equivalent explosion.

The explosive containment vessels have potential uses for both safety and security applications, including applications for homeland defense. This paper looks at the technical design, project history, and export and licensing considerations.

This research was sponsored in part by the NNSA Office of Dismantlement and Transparency (NA-241) Warhead and Fissile Material Transparency (WFMT) Program and the NNSA Office of Global Security Engagement and Cooperation (NA-242) Global Initiatives for Proliferation Prevention (GIPP) Program, with support from the International Science and Technology Center (ISTC).

INTRODUCTION

The explosive resistant container (ERC) program began with a paper delivered by the All-Russian Scientific Research Institute of Experimental Physics (VNIIEF) during a meeting in 1994. Various

Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL8500.

studies and container designs have evolved from the initial concept, with funding for early-stage research provided by the U.S. Department of State and later funding provided by the National Nuclear Security Administration (NNSA) under the auspices of the U.S.-Russian Federation Warhead Safety and Security Exchange (WSSX) Agreement. In 2006 NA-242 initiated efforts to commercialize the ERC technology via an International Science and Technology Center (ISTC) partner project between VNIIEF and SNL. Also in 2006, the U.S. private corporation NABCO, Inc. entered into a Technical Assistance Agreement with VNIIEF and Sandia and obtained approval from the U.S. Department of State for the transfer of ERC-related technical information, hardware, and services necessary for the commercial collaboration between the parties in order to develop an ERC prototype.

CONTAINER TECHNOLOGY

Explosion containment requires more than just capturing the detonation within a limited area. It also requires containment of shrapnel and gasses that are products of the explosion. To this end, explosive resistant container designs may include throttles, foam, pressure valves or some combination of these elements. In addition, a container may need to be designed for loading explosive items that have roughly the dimensions of the container inner diameter [1].

AT-595

The design requirements were that the explosive resistant container was able to contain an 8 kg TNT-equivalent HE explosion and all of the products of that explosion. The detonation was to be encased in 35 kg of inert surrounding material.

VNIIEF designed the AT-595 ERC to the requirements above. The AT-595 is a cylindrical design with an inner steel liner and an outer fiber-wrapped liner. The design provides total containment of an explosive detonation and is significantly lighter and safer than conventional containers. The outer layer is made of wound basalt. This layer was made by combined winding of epoxy binder-impregnated bundles with interchanged spiral and annular layers. The inner layer is stainless steel.

The unit has two ports – one on either end. The ports have a working diameter of 430 mm. One is used for loading and unloading the hazardous load and the other is a control port. These ports are hermetically sealed by stainless steel lids. The control port lid has a valve to control overpressure in the inner liner after detonation.

The HE encased in inert material is located inside the container. This area is limited by throttles designed to attenuate shock and the impact of HE gaseous products on the end caps after detonation. These throttles also protect the end caps against fragments. These throttles are made of steel and are welded to the inner surface of the steel shell. Screens further protect the container interior from shrapnel.

The parameters of the explosion-resistant container AT595 include:

- 984 mm outer diameter;
- 3320 mm length;
- Container mass without the transportation support device is 2030 kg;
- Container mass with the transportation support device is ~ 2120 kg.

The hazardous load parameters are:

- 371 mm outer diameter;
- 1100 mm length;
- HE mass is 8 kg TNT;
- Inert casing mass is 35 kg.

Figure 1 shows the design schematic. The outer layer (1) bears the detonation load, while the inner layer (2) prohibits the escape of detonation gases and increases the load-bearing capacity of the outer layer and end caps. The mouth for fastening the hatch is shown in (3). Shrapnel protection is provided by the woven screens (4), and throttles (5) help to decrease the impact from shock and shrapnel on the container ends. Extra protection for the hatch lids is provided by cylindrical steel dampers (6) filled with poly foam (7).

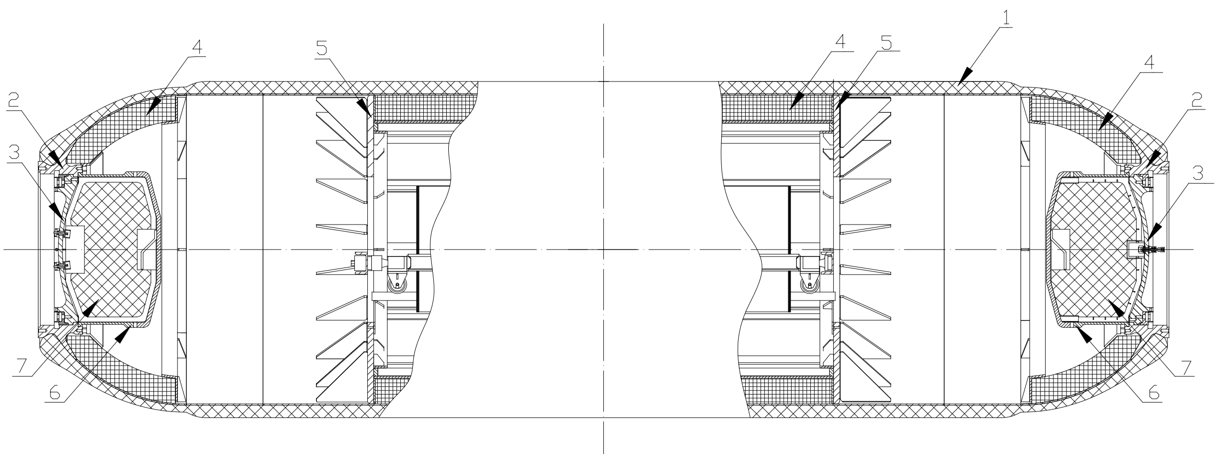

Figure 1. AT-595 Container

The container also has a hand cart for placing hazardous loads into the container. The loading/unloading system is depicted in Figure 2.

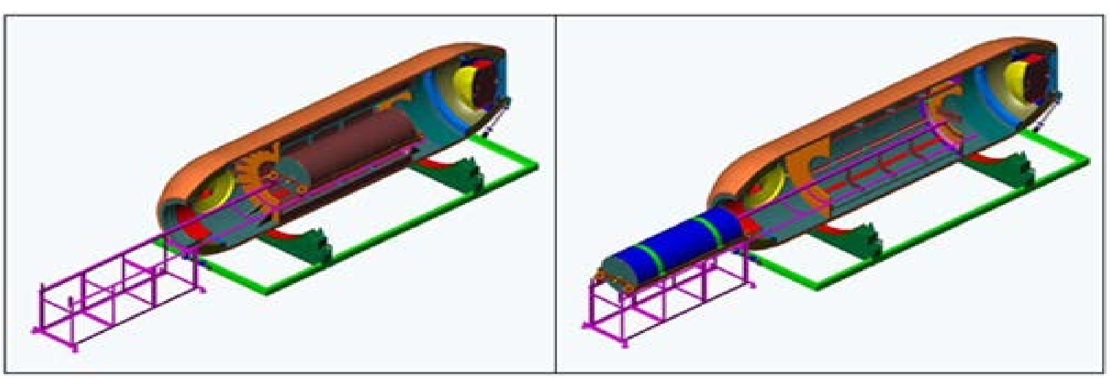

Figure 2. Loading Configuration

The first physical test of the container confirmed that the AT-595 was able to contain an 8 kg TNT HE explosion and preserve its integrity. Prior analyses had been done through simulation and scale-model testing. Results from the physical test matched in large part the predictions of the prior analyses. The dynamic response of the shell and other bearing elements was characterized by a typical transient oscillation curve. The peak dynamic strain over the bearing shell showed the most significant load took place in the central section of the vessel as predicted. The worst damage to the container interior was caused by fragments from the inert casing and the casing holder. The test also showed some gas escaped at the valve on the control end cap due to shearing of the threads. Most likely this was caused by a late modification to the design. This issue is addressed in later designs through the use of a stronger thread.

A picture of the AT-595 container is shown in Figure 3. This was the unit delivered to SNL as described in the paper section on Export Control.

Figure 3. AT-595 delivered to Sandia National Laboratories

<u>ISTC</u>

For the ISTC project, a spherical container design is being developed. This ERC is required to contain a 5 kg TNT-equivalent detonation. The vessel is designed for confining the detonation of a compact HE charge or an explosive item that can also carry a surrounding package of inert material.

The design criteria include the following:

1. Full containment of the detonation of an emergency explosive item for the energy equivalent to 5 kg of TNT.
2. Possibility to load an explosive item with up to 1.5-2 kg of inert material.
3. Widen the opening diameter to allow loading of an explosive item with inert material package into the inner vessel.
4. Bleed-off and filtering of gases produced by accidental explosion.
5. Leak-tightness or isolation of hazardous materials from environment in subsequent long-term storage.
6. Transportability by railroad, water, aircraft, and trucks.
7. Reduced container sealing time.

To meet these criteria, a spherical fiberglass plastic ERC was proposed. The container design ensures confinement of the explosive load with the HE center of mass positioned in the geometrical center of the inner vessel. An electrically driven mechanical system is designed to enable a rapid placement of the load into the container. A major advantage of the proposed container over the designs developed and used earlier [2-5], is that it uses innovative engineering solutions that increase the container safety and reliability with smaller size and weight [6,7]. One of these engineering solutions is to use composite material for the load-bearing layer.

EXPORT CONTROL ISSUES

The United Nations Security Resolution 1540, adopted by the Security Council in 2004, identified export control as a major issue that all countries needed to address. Specifically, the Security Council called upon all States to promote dialogue and cooperation on non-proliferation and to further counter the proliferation threat by taking cooperative actions to prevent illicit trafficking in weapons of mass destruction (WMD), their means of delivery and related materials [8]. International regimes concerned with specific types of WMD have adopted lists of specific controlled items.

Export control refers to formal efforts to control international access to certain commodities and associated technology that are useful in military and WMD programs. Basic research information is not export-controlled; however, specific materials, equipment, and technology (know-how) that are useful for military programs and proliferation of WMD are controlled. The U.S. Department of State controls military items, and the Department of Commerce controls “dual-use” items and technology. “Dual-use” means having legitimate commercial uses as well as military or WMD proliferation uses.

Controlled commodities require an export license prior to export. In addition, an export license is required for all commodities going to certain listed countries, end uses, and end users as well as known or suspected proscribed activities (e.g. state weapons programs). Exporters must apply to the jurisdictional agency for an export control license prior to export. Each application is reviewed for proliferation concerns by the subject matter experts.

In receiving the AT-595 unit VNIIEF sent to SNL, the company Agility Logistics (SNL contractor) handled the logistical arrangements, and SNL’s Export/Import Control organization ensured the import requirements were met. The shipment went smoothly between VNIIEF and SNL.

CONCLUSIONS

VNIIEF has successfully designed an explosive resistant container that contains the products of an explosion including shrapnel. This type of container may have areas of application in safe transportation of damaged munitions, mitigation of terrorist devices, and demilitarization of conventional or chemical weapons.

The ERC program has brought together several US entities, including the Departments of State and Energy, the Russian laboratory VNIIEF, the ISTC, and NABCO as a commercial partner, during its course. Sandia National Laboratories and NABCO are in the process of developing a CRADA to provide NABCO with access to VNIIEF engineering capability, and to enable the two entities to work together toward future designs.

REFERENCES

1. A.I. Abakumov, E. D. Vishnevetskij, A. L. Mikhailov, P.N. Nizovtsov, V. N. Rusak, V. P. Solov’ev, M. A. Syrunin, A. G. Rdeorenko, V. A. Chernov, Container for Localization of Explosion, / RF Patent 2257537, publ. 27.07.2005, bulletin #21.
2. K.Carbiener, A. York. Description of accident-proof containers / The Symposium on Accident-Proof Containers and Ensuring Transportation Safety. USA, Albuquerque, 26.09.93-02.10.93.
3. B.T. Rogers, R.W. Taylor, D.Venable Confinement system for high explosive events / US Patent 3820435, filed May, 11, 1972, appl. #252171.
4. W.B. Benedick, C.J. Daniel Explosion Containment Device / US Patent 4055247, filed Oct. 22, 1976, appl. # 734834.
5. V.I.Tsypkin, L.M.Timonin, N.N.Moskvitchev et. al. An Explosive Device Container / RF Patent 20878448, publ. 20.08.97, bulletin #23.
6. A.I.Abakumov, D.V.Grigoriev, O.B.Drennov et.al. Explosion Containment Device / RF Patent 95114809, publ. 27.10.97 bulletin #30.
7. D.V.Grigoriev, V.P.Zhogin, A.V.Ivkin et.al. A Device for Containing Detonation Products / RF Patent 2130563, published 20.05.99 bulletin #14.
8. UN Security Council Resolution 1540, April 28, 2004.