Type C Package: History and Prospects

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Introduction

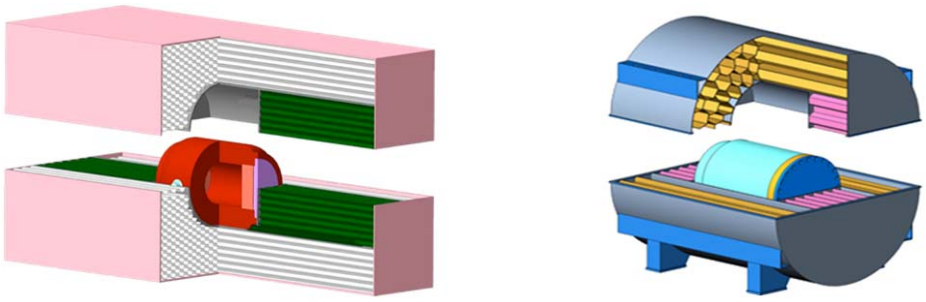
In compliance with the TS-R-1 and NP-053-04 Regulations Type C package requirements are more strict than those for the packages of other types and the most significant test is the impact onto the hard target at the velocity of not less than 90 m/s. Type C package was firstly mentioned in the Russian Federation Regulations for the Safe Transport of Radioactive Material, NP-053-04, which were enforced in 2005. Since then the Sosny Company experts started studying the issues and problems concerning the spent nuclear fuel shipment by air. Many solutions were used during the implementation of the Programme of the Russian-Origin Research Reactors Fuel Return to the Russian Federation (RRRFR). In the new regulatory framework, in 2009, two air shipments in Type B (U) packages of research reactor spent nuclear fuel (SNF) from Romania and Lybia – were performed under the RRRFR Program. Thus the principal possibility of research reactor SNF shipment by air was confirmed. For the purpose of further work on this issue one of the decisions taken at ATOMTRANS-2009 was to develop the Type C package for the shipment of various types of high level radioactive materials by air.

In mid 2009 US DOE/NNSA proposed Sosny Company to assess the possibility to design the Type C package based on the SKODA VPVR/M cask that can accommodate up to 36 research reactor SFAs. In this connection the Sosny Company experts were confronted with the question: “Shall we strengthen the ISO-container to be loaded with the SKODA VPVR/M cask or shall we create a new dynamic protection?” Finally it was decided to strengthen the available SKODA VPVR/M cask with the dynamic protection to suppress the main portion of energy in case of the cask impact onto the obstacle.

History

The Russian and international Type C packages requirements do not impose any additional constraints on the radioactive contents activity, though they demand that the package leak-tightness be maintained after the impact tests at the velocity of not less than 90 m/s and after the fire within an hour.

At the first stage of the development a conceptual decision was taken to create the demountable dynamic protection, which will accommodate SKODA VPVR/M cask without standard absorbers [1, 2]. Moreover, the possible use of an available 20-feet ISO-container filled with the energy absorption materials as the shell for the dynamic protection or as a shell with ISO-container fittings (Fig. 1) was worked through in order to ensure the simplicity and flexibility of transport and handling activities to be performed with the package.



a) b)

Fig. 1. Conceptual option of Type C package:
a – on the basis of ISO-container, b – with ISO-container fittings

The next stage was the selection of material for the dynamic protection. There is a great number of commercial materials which are ranged by their manufacturers as the shock energy absorbing ones. The absorbing material properties were studied and analyzed thoroughly and they can be grouped as follows:

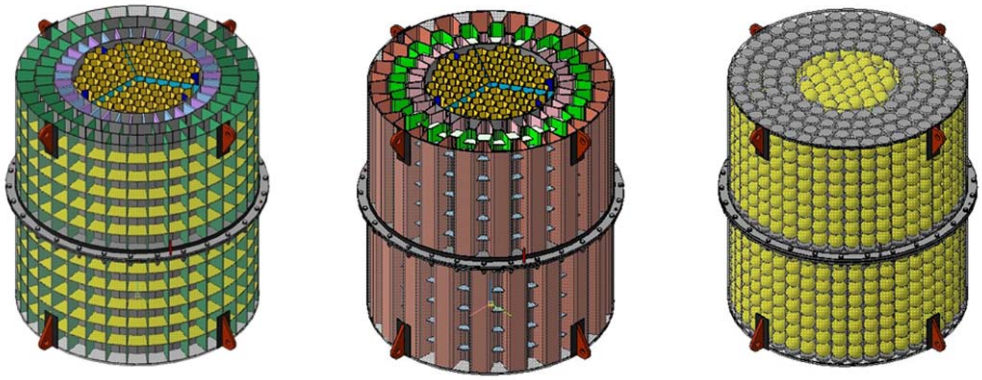
- wood,
- metal honeycomb, and
- foamed metal.

The metal honeycomb and aluminum foam are not strong enough and are considerably inferior to the wood by their strength properties (the pinewood and balsawood data were used for analysis). However, the Type C package with the dynamic protection made of wood would have weighed 42 tons, what is inadmissible for the air shipment. So none of the materials mentioned above can be used for the Type C package dynamic protection on the basis of the SKODA VPVR/M cask.

While studying the strength properties of commercial energy absorbing materials, the work was done to develop the optimal transport and handling scheme for Type C package shipment. As a result, the decision was taken to put the SKODA VPVR/M cask in a vertical position without standard shock absorbers.

Having made sure of the need for the development of the specific shock absorbing system for the SKODA VPVR/M cask, within the period from February to May, 2010 the RFNC – VNIIEF experts have assessed three options of the dynamic protection structure that are provided in Fig. 2:

- "Gussets" – a welded engineering structure made of gusset plates;
- "Channels" – a welded engineering structure made of rolled-formed sections;
- "Spheres" – a composing construction of spherical shock absorbing elements.



a) b) c)

Fig. 2. Type C package options at the stage of the draft design:
a – "Gussets", b – "Channels", c – "Spheres"

Each option thorough analysis has shown that the most promising and technically feasible options are the "Channels" and the "Spheres". The construction strength was calculated for both options. The results obtained using the numerical simulation of the package impact onto the hard obstruction at the velocity of 90 m/s have demonstrated the possibility of creation of the package of such type. One of the most important outcome of the conceptual design stage was the determination of the dynamic protection material – titanium alloy.

In June 2010 after the creation possibility of the transport packaging set for air shipment has been proved, the Technical Assignment on the Type C package design was concurred with all involved organizations of the industry, namely: Federal Service for Environmental, Technological and Atomic Supervision, Emergency Engineering Center of Minatom of Russia, Mayak PA and Volga – Dnepr Airlines. Here the transport packaging set was assigned the identification number TUK-145/C.

The main provisions of this Technical Assignment were as follows:

- possibility of TUK-145/C transportation by all modes, including by air;
- maximum mass of the loaded TUK-145/C shall not exceed 35 tons;
- TUK-145/C shall be no higher than 3,900 mm and no wider than 3,800 mm; and
- SKODA VPVR/M cask shall be vertically loaded into the package.

The conceptual design should have resulted in the selection of one of two layouts: "Channels" or "Spheres".

The further elaboration of the TUK-145/C design options made it possible to define more precise mass-dimensional parameters of the dynamic protection, which became known as the Energy Absorbtion Container (EAC). The numerical simulation of different types of the TUK-145/C impact onto the hard obstruction at the velocity of 90 m/s enabled the obtaining of the EAC stress-strain behaviour data. Table 1 provides the results got for the "Channels" and "Spheres" options.

Table 1. TUK-145/C parameters for the "Channels" and the "Spheres" options

Parameter	**"Channels"**	**"Spheres"**
Overall dimensions, mm	Ø3,000x3,843	Ø3,214x3,065
EAC mass, kg	22,500	19,200
Stress in bolted joints of the SKODA VPVR/M cask lid, kgf/mm^2:		
axial impact;	62	35
lateral impact;	64.5	30
angular impact	60	45

If we compare the data from Table 1 we can conclude that the "Spheres" option is better both in terms of dimensions, mass and strength. This very option was selected for further development.

At the preliminary design stage the TUK-145/C design was elaborated in more details (Fig. 3). EAC is a vertical cylinder assembled of two halves with the flange joint in the middle. Hollow titanic spheres, being the absorbing elements, are laid inside each half according to the concrete order.

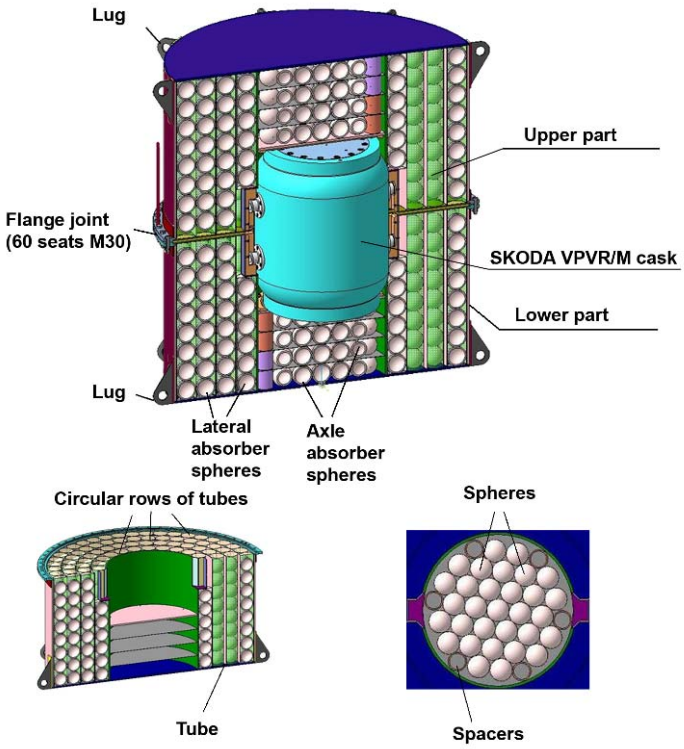


Fig.3. TUK-145/C design (preliminary design stage)

Test preparatory activities and certification testing

According to the TS-R-1 and NP-053-04 Regulations the RFNC – VNIIEF experts carried out the calculated simulation of the following accident situations:

- drop of the TUK-145/C package onto a hard target from the height of 9 m;
- drop of a mass of 500 kg onto the TUK-145/C package;
- drop of the TUK-145/C package onto a pin from the height of 3 m;
- simulated fire for 60 minutes; and
- impact onto a hard obstruction at the velocity of 90 m/s.

The drop of the TUK-145/C package onto a hard target was simulated for the angular impact option, when the TUK-145/C is in the most risky position concerning the integrity of the SKODA VPVR/M cask.

The results of the numerical simulation of accident situations for TUK-145/C have confirmed the safety of its use for transportation by all modes including the one by air.

Since the mandatory requirement when developing the TUK-145/C was the full-scale test for the hard target impact at the velocity of 90 m/s at the completion stage of preliminary designing the Sosny Company experts have designed the TUK-145/C mockup being its reduced copy. The fabrication of the mockup at a scale of 1 in 2.5 was completed in April 2011. By this time the Tests Program has been developed and approved by Rosatom.

The tests committee was established by the Rosatom order and included the representatives from Rosatom Nuclear and Radiation Safety Department, RFNC-VNIIEF, Sosny Company, NCCP, St. Petersburg Emergency Engineering Center, Federal Service for Environmental, Technological and Atomic Supervision, FMBA of Russia and TVEL. Before testing an incoming inspection with the TUK-145/C mockup parameters registration was performed. The tests were held on May 18, 2011 at the VNIIEF rocket sled. On their completion the TUK-145/C mockup was inspected and its condition was analyzed.

The tests results have been recorded in the TUK-145/C mockup fault detection report and the test results certificate approved by the First Deputy General Director of Rosatom. The members of the committee have concluded that the experimental data correlate well with the calculated ones, and the calculation results obtained during the research reactors irradiated SFA-containing TUK-145/C safety justification meet the air transportation safety requirements specified in TS-R-1 and NP-053-04 Regulations.

On successful completion of the TUK-145/C mockup tests the Sosny Company experts have developed work design documentation for the TUK-145/C energy absorption container and initiated the procedure of obtaining a Certificate of Approval for the package design in Russia.

TUK-145/C Certificate of Approval Obtaining and EAC Manufacture

In order to obtain the Certificate of Approval on the TUK-145/C package design the application was sent with the Letter dated October 11, 2011 to the RFNC-VNIIEF Labour Body Deputy Manager and to the Deputy Director of the Nuclear and Radiation Safety, Licensing and Permitting Activity Organization Department. After the application has been accepted and registered the RFNC-VNIIEF experts started the review of the application materials and the expert assessment.

At the same time an application was forwarded to the RF SSC-IPPE Nuclear Safety Department for the transportation nuclear safety substantiation. On completion of basing analysis an "Assessment No. 11-147 of the Nuclear Safety of TUK-145/C for Research Reactors SFA Transportation by Air" was granted.

The Expert Assessment was approved by the RFNC-VNIIEF Labour Body Manager in February, 2012 and then the draft certificate and the Expert Assessment were sent to the Deputy Director of the Nuclear and Radiation Safety, Licensing and Permitting Activity Organization Department for the Certificate to be further endorsed by the Departments of Rosatom, FMBA of Russia and Rostechnadzor.

In the course of the certification process on Rostechnadzor requirement the independent Expert Assessment was issued. All these activities resulted in the granting of the Certificate of Approval on package design in Russia on April 10, 2012.

The energy absorption container was manufactured by VSMPO-AVISMA Corporation in the period from January to June 2012. The manufacturing process was rather labour-intensive, since it is the first time that the item of such design is produced, and the titanium treatment is technologically difficult.

TUK-145/C Dry Run

Within the period of June 26-27, 2012 the dry run including the TUK-145/C handling technique appraisal took place at the Ulyanovsk-Vostochny Airport. The main goals of the tests were as follows:

- demonstrate the feasibility to build up the TUK-145/C package by putting a SKODA VPVR/M cask into the energy absorption container using a truck crane;
- demonstrate the feasibility to load/unload the TUK-145/C package from a truck (a semi-trailer) into/from the AN-124-100 aircraft using a roller system and a truck crane;
- demonstrate the feasibility to load/unload the TUK-145/C package installed on a truck (a hauler with a semi-trailer) in/from the AN-124-100 aircraft;
- identification of the TUK-145/C buildup process specific features;
- identification of the TUK-145/C transshipment from the transport vehicle of one type to the transport vehicle of another type process specific features;
- photographing and video filming of the main stages of activities;
- actions duration timing; and
- verification of the TUK-145/C handling procedure to be efficient for shipments.

On the first day the TUK-145/C was loaded into AN-124-100 aircraft using the roller system and a truck crane (Fig. 4). The total procedure lasted for almost three hours.

On the second day the TUK-145/C being on board the truck semi-trailer loading into the AN-124-100 aircraft was demonstrated (Fig. 5). The total procedure lasted for almost two hours.

The dry run has completely proved the TUK-145/C handling procedure to be efficient for the RRRFR Program.

Fig. 4. Loading the TUK-145/C packaging into AN-124-100 using a roller system

Fig. 5. Loading a truck with the TUK-145/C packaging into AN-124-100 aircraft

Conclusions

The idea to create the Type C package for research reactor SNF shipment by air under the RRRFR Program was rather fast turned into reality. Until 2015 five shipments shall be performed under the RRRFR Program. Various routes and modes of transport are analyzed for the purpose of their implementation and the air shipment is among them.

In future the developed Type C package can be used for other international projects also as a set of equipment for emergency SNF removal in case of any force-majeure situation, such as a war, acts of God, terrorist threat, providing the spent nuclear material shipment from anywhere globally. Now the possibility to use the air shipment for spent nuclear fuel removal from off road sites, such as Bilibino NPP.

Referenses

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[2] V. Shapovalov, A. Morenko, L. Barabenkova, V. Yakushev, “Conceptions of the Type “C” Package for Air Shipment of Spent Nuclear Fuel of Research and Power Reactors”/ XV International Symposium on packaging and transportation of radioactive materials, Miami, Florida, USA, October 21-26, 2007.