CALIFORNIUM-252 TRANSPORTATION EXPERIENCE

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ABSTRACT

SSC RIAR is one of the major californium-252 producer in Europe and Asia. Since 1964, practically just after starting in 1962 the SM high flux research reactor facility, RIAR begins to produce artificial elements. After that rapid upsurge of radioisotopes production and application take place, including californium-252, annual yield of which reaches to tens of milligram. Accordingly problems concerned finished products delivery become more intensive. This paper will provide an overview of twenty years RIAR's experience of safe transportation of californium-252.

INTRODUCTION

Special feature of californium-252 as neutron emitter is high fission spectrum neutron flux per mass unit (2.34×10^{6} $s^{-1}\mu g^{-1}$). Depending on source purpose and its design californium content may change from 0.43 to 8600 microgram, and neutron flux from 1.0×10^{6} s^{-1} to 2.0×10^{10} s^{-1} respectively. Thus one can say that we are to transport very compact (D×H= 7.0×25.0 mm) low power nuclear reactor facility. That is proved also by combined flux of ionizing radiation consisting both of gamma quanta and neutrons.

Thus we at RIAR give the special consideration to accident prevention for personnel and environment when transporting californium-252. To transport californium-252 practically through the world during recent years we use all principal transport modes as car, railway, air, and sea, excluding unless transportation through inner water transport and post parcels (Fig.1).

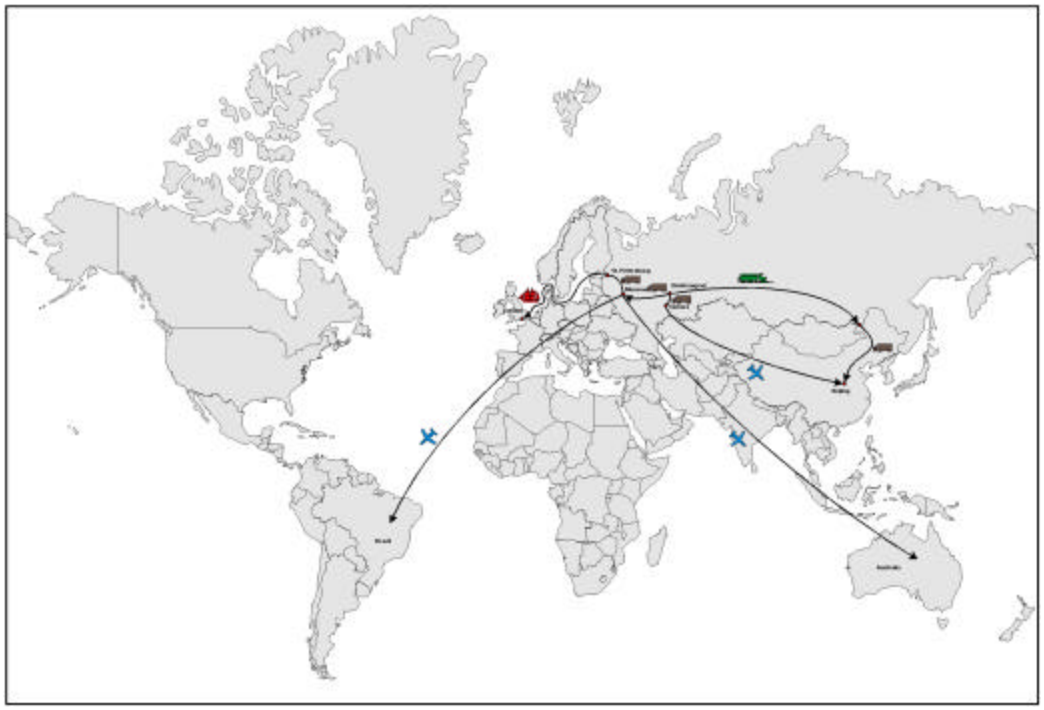

Figure 1, Route card for Californium-252 shipments

BASIC COMPONENTS OF TRANSPORTATION SAFETY

In accordance with the requirements of IAEA regulations for type A packages the limit in respect of californium-252 charging is 0.1 TBq for Special Form Radioactive Material and 0.001 TBq for other materials. The Institute has developed the number of capsules for californium-252 transportation. These capsules passed tests for compliance with Special Form Radioactive Material. Bodies of sealed californium sources are also certified as Special Form Radioactive Material. Thus regardless of the package type, either A, or B, currently californium-252 being transported as Special Form Radioactive Material.
The design of the most typical californium-252 source is shown in Fig.2.

Californium neutron sources are used for radiobiological research, and treatment of malignant tumors as well. They also may be used as start-up sources at nuclear energy facilities. The source itself is sealed double encapsulated structure. Capsules are made of stainless steel and inserted one into another. Californium-252 as oxide is surely fixed inside the primary capsule.

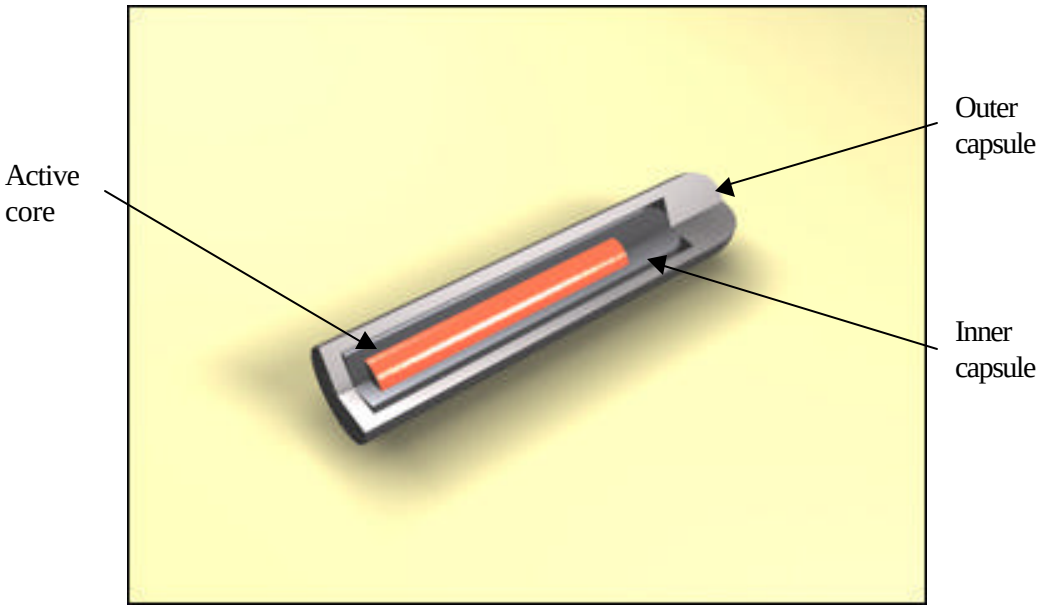

Figure 2, Californium-252 double encapsulated source

SHIPPING PACKAGE SET DESIGN

The package must be safety sealed, quite enough to attenuate the radiation, and economically reasonable shielding being able safety disperse thermal energy. Let us consider, how these requirements are realized in the design of packages used by RIAR to transport californium-252. RIAR container stock is equipped with type A packages, as well as type B ones. Their design was developed in cooperation with VNIITFA (Moscow) experts. All these packages have been tested and certified by the Competent Authority of Russia - Ministry of Russian Federation for Atomic Energy. Standard dimensions are submitted in that way, that it is possible to choose necessary and sufficient shielding for the amount of californium-252 to be transported. General features of packages are shown in table 1.

Table 1

Package features

Package code	Diameter, mm	Height, mm	Mass, kg	Maximum neutron flux, s^{-1}
UKTIIA-1	487	562	92	$4.0 \cdot 10^{7}$
UKTIIB-1	644	754	225	$5.0 \cdot 10^{7}$
UKTIIB-2	920	990	550	$3.0 \cdot 10^{8}$
UKTIIB-3	1310	1280	1650	$2.5 \cdot 10^{9}$
UKTIIB-4	1960	1730	4600	$2.0 \cdot 10^{10}$

As the example the sketch of UKTIIB-3 shipping container is shown in Fig.3.

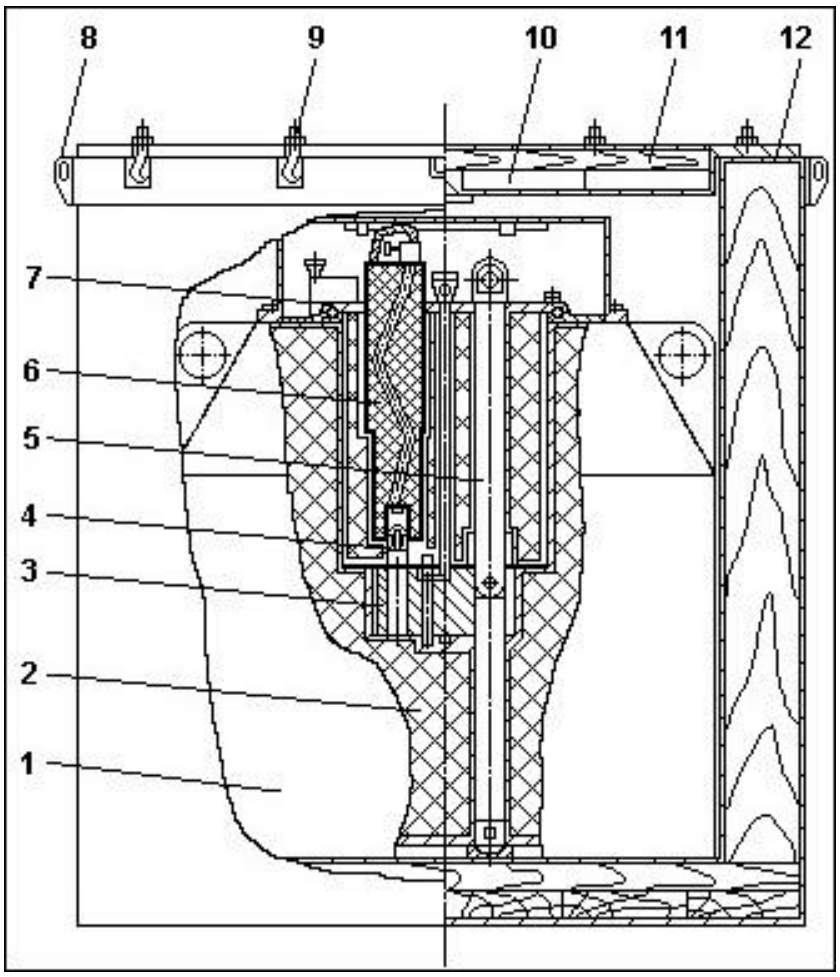

Figure 3, UKTIIB-3 shipping container

It is B(U) type package consisting of the protective case (12) and the shielding container itself (1). The protective case consists of the body and the cover (11). The protective case has lifting devices outside (8). The cover is fixed to the body with bolts (9). There is the pocket documents

inside the cover for. The body and the cover of the protective case are filled with wood impregnated with the special fire proof composition.
The shielding container is a drum type multicavity one consisting of cylindrical body filled with neutron absorbing radiation protective material (2) and a cover (7). The containers are provided with some accessories for loading and unloading sources, such as holding plug (6), grip (4), rotary drum with cavities for source replacement (3), and rod (5). Radiation protection is homogenous mixture of equal in volume parts of paraffin as a moderator, and boron as neutron absorber. The effectiveness of selected radiation protection is proved by some special test. Table 2 shows the results of separate measurement of Exposure Dose Rate for neutron and gamma fields at the surface of three different packages.

Table 2

Results of EDR measurement at the package surface

Package No.	1	2	3
Neutron EDR, mSv/h	0.080	0.035	0.014
Gamma EDR, mSv/h	0.055	0.056	0.020

As one can see from the table 2, EDR for neutron and gamma radiation are of the same order of values and make approximately equal contribution to total EDR value. It means that the radiation protection is balanced, and to increase protective properties in respect of one of the radiation mode is to no purpose.
To decrease overall dimensions and mass of packages, and sequent improvement of portability one may reach by increasing the hydrogen nuclei content in radiation protection body. Among the materials with these properties may be used either silicon or ethylene-propylene, as recommended [1].

ADMINISTRATIVE MEASURES

The sequence of lading, transportation and storing of packages with radioactive content is described in the Quality Assurance Program, where step by step the operating order and responsibility of personnel are determined.
Transportation of RIAR radionuclide products is performed by RIAR own special vehicles equipped in accordance with the Europe Agreement on International Transportation of Dangerous Goods by Road (Fig.4). Covered body is provided with special equipment for fastening packages, completed with emergency facilities, as well as facilities for initial fire-fighting. The front wall of the body is provided with facilities for installation of the screen of extra radiation protection to assure the exposure dose rate in the cab not more than 0.02 mSv/h. Every year both drivers and convoy study special training course in respect of the regulations for safety transportation of class 7 dangerous goods. Besides prior every run they get the instructions on safety handling radiation packages and their control under the way.
The vehicle loaded and fastened with packages is inspected by the commission of experts in radiation control, motor transport, and safety, afterwards the protocol about the vehicle readiness for shipment is issued.
The routes are agreed with the State Inspection for the Safety of Road Traffic.
Prior every shipment RIAR informs Dimitrovgrad Branch of the State Nuclear Inspection.

Figure 4, Special vehicle for transportation of radioactivity

Personnel activity in the case of possible accident are determined by the "Direction for warning on accident and fire and elimination of their consequences", as well as b of measures for warning and elimination of possible radiation accidents when transporting radioactive materials". Special trouble crew consisting of experts very much aware of radioactivity feature, and another properties of materials transported, package design and taking direct part in their loading, as well as radiation control expert.

SUMMARY

Among total amount of californium-252 containing packages the share of type A packages was 90%, and type B –10% in 1998. RIAR experience, regulations being in force, as well as personnel qualification and technical conditions of containers allow to perform accident-free shipment during last 20 years. Since this period none of radiation accident, or unrestricted personnel and habitants exposure took pla ce. At the same time RIAR container stock for neutron source shipment needs an improvement, in general in respect of materials for radiation protection providing effective attenuation of neutron and gamma radiation under minimum overall dimensions and mass of package.

REFERENCES

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