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Overview of the specification and the organization for the transport of radioactive sources from the CEA

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Abstract

The Commissariat à l'Énergie Atomique et aux Énergies Alternatives (French Alternative Energies and Atomic Energy Commission) occupies a unique position in the French research landscape works, where it is now the major actor in conducting scientific research on low-carbon energy technologies, in addition to the range of missions that had already been assigned to it in the past.

The CEA constantly supports the French nuclear industry through its efforts to optimize existing nuclear reactors and fuel cycles. At the back end, it develops technical solutions for managing radioactive waste. The CEA is responsible for cleaning up and dismantling its own nuclear facilities.

Since 2005, the CEA has initiated a strategy for recovery of radioactive sources located in its different sites in France. Part of this programme has focused on the possibility to return the old sources of Plutonium-Beryllium to the US supplier through the "Off-site Source Recovery Project". This project has provided a solution to the French legal issue for the source recovery strategy.

This paper describes the CEA's experience about the transport of Pu-Be materials used since the sixteen's as radioactive sources for research programmes. In particular, the definition of the need, the specification of the conditioning aspects, of the packaging choices for the multimodal transport, the licensing process in order to obtain the certifications, the off-site transfers from the CEA's sites to the LANL's nuclear facility in USA, are detailed.

Finally, this paper will show the significant experience feedback on the topic taken from: the preparation of the sources, the organization of the operations for gathering the radioactive materials in the CEA sites (In-site and Off-Site transfers), the packaging transport, the logistic for the shipments including many interfaces, the contributions to comply with all the regulatory requirements.

Introduction

Plutonium-beryllium neutron sources were purchased by the CEA from a US Company in the 1960s. These sources were used for research purposes in nuclear facilities and have now been declared ***expired*** under the terms of the French regulatory requirements (Table 1).

As part of the US Government's Off-Site Source Recovery Project, the Department of Energy (DOE) has nominated the Los Alamos National Laboratory (LANL) to take back the Pu-Be sources distributed in Europe, of which there are about 50 in CEA centres (France).
This source recovery was a onetime project presenting specific technical constraints for the CEA facilities: the sources were grouped and specially packed. The shipping campaign transport was based on a multimodal (road/sea/road) logistic organisation involving road haulage operators and a maritime carrier chartering a dedicated ship. It required the use of 15 transport packages (S300), loaded with a special form capsule (model SFC-II) meeting regulatory requirements for ***material in special form*** (Table 1).

This document describes the regulatory, organisational and operational actions carried out by the CEA concerning these sources and their transport.

Expired sealed source	A radioactive source is considered sealed when the radioactive material it contains is not dispersible. Within the meaning of the French Public Health Code, a sealed source is declared expired 10 years at most after its first use, unless its period of use has been extended by the Safety Authority (Art. R.1333-52).
Material in special form	Within the meaning of the transport regulations, either a non-dispersible solid radioactive material, or a sealed source. To be considered as in "special form", the material must comply with additional prescriptions (requirements of ADR, para. 2.2.7.2.3.3). These are, for example, resistance tests to shock, percussion, folding, and temperature stability, which guarantee that the required leaktightness criteria are met. A material in a special form is covered by a unilateral agreement (French TDG Order, Art. 5, para. 3) that allows national and international transport according to this classification of radioactive material.

Table 1: Regulatory definitions

1-Licensing framework

Numerous regulatory and contractual formalities were carried out to obtain ***authorisations*** from French authorities (Safety Authority, Heads of CEA Centres, etc.) and international bodies (Euratom, NNSA/DOE, etc.). These formalities concerned the management of radioactive sources, safety of packages and transport, and security provisions to be set in place by the various agents involved (holder, consignor, carrier, and consignee). Table 2 lists the authorisations issued by the relevant French government departments.
This project started with deliberation on the type of packaging to be used, given the nature of the material to be transported (source, fissile material) and the constraints imposed by the nuclear facilities.
The S300 packaging chosen was a US package model designed for the transportation of material as type A packages loaded with fissile material (IAEA TS-R-1 ed. 2009, § 671 and 814). This material is packed in special form as prescribed by the transport regulations. This technical choice, which escaped the constraints of a type B container, implied additional prescriptions concerning the packaging of the sources.

Authorisation	Domain concerned
Authorisation for export	Radioactive sources
Authorisation to export radioelements	Radioactive sources
Certificate of transport approval for S300	Transport
Validation of loading plan	Transport
Execution agreement issued to carrier	Transport
Authorisations for in-site transport	Transport
Authorisations to hold sources	Radioactive sources
Export licences for customs	Tax
Certificate of financial guarantee under the terms of the Paris Convention	Insurance
Civil liability insurance	Insurance

Table 2: Authorisations issued by French government departments

The S300 packaging (Figure 1) is cylindrical, and is composed of a standard steel drum acting as an outer container, a shock absorbent layer, a flanged inner cylindrical container and a high density polyethylene (HDPE) shielding insert. It is designed to transport a single ***special form capsule*** (SFC, Figure 1) of plutonium-beryllium (Pu-Be). Its maximum gross weight is about 218 kilograms.

The SFC Model II capsule, which is housed inside the shielding insert of the S300, meets the regulatory requirements for radioactive materials in special form (IAEA TS-R-1 ed. 2009, § 415 and 804). This model of capsule is covered by a conformity certification (USA/0696/S-96) for radioactive material in special form. Issued by the US Department of Transportation (DOT), this unilateral certification is recognised by the French competent authority (ASN), in application of Article 5 of the French Order of 29 May 2009 concerning the transport of dangerous goods by land.

The ***main safety functions*** of this packaging are :

- Confinement, ensured by the sealed SFC-II capsule;
- Radiological protection, ensured by the steel and polyethylene structures;
- Criticality safety, ensured by the SFC-II capsule;
- Protection against shock, ensured in particular by sugar cane fibre, the body and the lid of the packaging;
- Thermal protection, ensured by sugar cane fibre.

After examining the model S300 package, the ASN did not validate the US certification (USA/9329/AF-96), but issued a special arrangement with additional compensatory measures (stated in Section 4), to take into account:

- The potential danger of fire, because the demonstration of the behaviour of the package in the regulatory fire test (800 °C for 30 minutes) was ruled incomplete;
- The uncertainty of the mechanical behaviour of the package model in accidental conditions of transport, because the safety demonstrations assessing the robustness package in such conditions of transport were ruled incomplete.

The organisation of such transport, which required compliance with both international and national regulations, entailed verifying the consistency of different requirements.

For instance:

- Example 1: the special arrangement applied only to the French road transport, because the model S300 package is certified by the US authority for US territory.
- Example 2: there is some overlap between the IAEA Code of Conduct and French regulations.

  The IAEA Code of Conduct recommends a prior D−8 notification before shipping, transmitted to the exporting state (France) "at least 7 days before shipping". This recommendation also exists in the French regulations, under information requested as part of the notification for "notice of road transport" (TDG Order and provisions of certificate F/857/X). Thus all the information requested in the Guide to the Code of Conduct (§12.b) was sent to the French authorities.

  For this transport campaign, the importing state (USA) within the meaning of the Guide of Conduct, was represented by the DOE/NNSA. The importing state was therefore a party to the process as beneficiary, which simplified the information process as regards the Code of Conduct formalities.

Figure 1: Packaging of a radioactive source (a and b), loading of the capsule into the S300 packaging (c and d), and loading into the ISO 20 ft container (e)

2- Transport preparation

Specific documents were drawn up by the consignor (CEA), the designated carrier / freight forwarder (AREVA/TNI) and the consignee (LANL). Some were linked to the contracting of the project, others concerned its operational implementation: modalities of recovery of sources and associated liabilities, liabilities of the people involved, transfer of liability among the different transport actors (CEA as consignor, road haulier in France, maritime carrier, road haulier in the USA, consignee), provision of packaging and associated equipments, source transfer authorisations, documentation dedicated to project steering, etc.

Packaging of radioactive sources in SFC-II capsules and their loading into packagings

Each SFC model II capsule contained 1–3 radioactive sources made of PuBe alloy, according to the quantity of fissile material (maximum 300 g in accordance with certificate F/857/X). In all, 15 SFC-II capsules were packaged (Table 3) in the various CEA facilities by a LANL team, using their own specific procedures.

For example, the level of leaktightness required for the capsule implied certain precautions in the assembly of the closure elements. Measurement of the final leaktightness was carried out by metric checking of the tightening system, to provide proof of the certification compliance of the source in special form. The capsule with its closure system (Figure 1) is covered by a US patent.

Before encapsulation, each source was identified by a visual check and measurement of its surface non-contamination. A non-contamination check was then done on every capsule before loading it into the S300 container.

Number of sources per SFC-II capsule	Activity (GBq) loaded per capsule	Number of S300 packages	Number of road haulage runs
1	*441*	*2*	*1*
3	*406*		
1	*367*	*2*	*1*
2	*367*		
3	*257*	*2*	*1*
2	*367*		
4	*262*	*3*	*1*
4	*257*		
4	*257*		
2	*404*	*3*	*1*
3	*266*		
4	*112*		
2	*404*	*3*	*1*
4	*220*		
5	*184*		
TOTAL	*4571*	*15*	*6*

Table 3: Distribution of sources and activity per capsule, number of S300 packages per vehicle.

In site and Off site transports for grouping

Preparatory to final transport, the CEA organised, between 2010 and 2011, the grouping of the sources (i) to group them at the smallest number of centres, and (ii) to store them in a limited number of installations. This grouping entailed making transport runs on public roads to four centres (Cadarache, Marcoule, Saclay, and Fontenay-aux-Roses). In site transport was then organised between installations in accordance with the General Rules for Internal Transport (RGTI) applicable to the CEA centres.

Examples:

- The Atalante installation was the grouping point at the Marcoule centre.
- At the Saclay centre, the sources were grouped in two installations, in compliance with the limits set by the regulations for holding this type of source.

3- Implementation of road and maritime transports

Consignment of packages in shipping containers

This transport campaign required multimodal organisation logistics with successive road/sea/road modes, which entailed choosing:

- A road haulier operating with real-time monitoring;
- A seaport in France, with a dedicated terminal allowing the transloading of packages in compliance with the specific provisions of the special arrangement;
- A maritime carrier chartering a special ship that was INF-2-certified (code IMDG);
- A road haulier for US territory to carry the packages from the port of arrival (Savannah) to the LANL site (New Mexico).

Measures of physical protection were taken as prescribed by the application of the French Order of 08 August 2010 concerning the protection and monitoring of radioactive materials during their carriage (for materials of Category II). These measures demanded provisions to ensure the protection of vehicles by the services responsible for the safety of transport inside France (validation of route, real-time monitoring of progression of vehicles, etc.).

On leaving the centres, the S300 packages containing the sealed sources were prepared by the CEA, which was responsible for shipping to the USA. Accordingly, the transport offices of the CEA were involved in the operational organisation at the installations to carry out the various inspections:

- Verification of conformity of the S300 packages with the requirements of the official certification and additional associated measures of use;
- Validation of compatibility of the package with the authorised content;
- Assistance lent to the nuclear facilities to vouch for the packing list, check shipping declarations, and verify the correct blocking and stowage of the packages in the shipping containers;
- Completion of administrative formalities before shipping jointly with the logistic organiser AREVA/TNI selected by the CEA.

The CEA drew up a list of inspections to be carried out before shipment, established from the conditions of use of the packages and the criteria stated in the special arrangement. Below are some of the verifications carried out on the components of the package*:*

- Check of the external surface state of the outer container;
- Examination of the internal package components, e.g. the polyethylene structure;
- Visual inspection of the state of the screw systems, joint, lid and shielding insert, etc.

For dose rate monitoring, cumulated measurement of gamma radiation and neutrons in dose rate was made in contact with each package and 1 metre away, before loading it in its ISO 20 ft shipping container.

We note that in the authorisation, a special provision requires the yellow III label (7C), even though the dose rate measured before shipment at distance 1 metre from the package called only for a yellow II label (7B).

Additional measurements arising from the special arrangement

The S300 packages were loaded into an ***ISO 20 ft maritime shipping container*** in a configuration such as to minimise risks of perforation during transloading operations.

A special provision in the special arrangement required the loading and securing plans for the S300 packages to be validated by ASN before shipment was undertaken.

The blocking and stowage configuration for S300 into the ISO 20 ft maritime shipping containers took into account the stress envelope, based on the recommendations of the INF code. Maritime accelerations are greater than those undergone during road transport. Operationally, the principle of stowage was based on a method for harnessing the different elements (the S300 package and its handling pallet, and this combination into the ISO 20 ft shipping container) that guarantees a securely attached "S300-pallet" unit.

Other additional operational provisions were applied, in particular:

- For road transport:
  - Choice of favourable weather conditions: no snow, fog, black ice or heavy rain;
  - Provision of an escort vehicle equipped with additional firefighting means in addition to those required by the regulations: doubling of the number of extinguishers relative to the regulatory quantity on each vehicle containing packages, and ten 10 kg extinguishers for the escort;
  - Driving speed limitation according to the category of road taken: for example, maximum 80 km/h on motorways;
- For maritime transport:
  - When containers were being transloaded into the ship's hold, precautions were taken in handling the containers, for example: hoisting of other goods above containers was forbidden, and operations were carried out and checked by a mandated representative from the consignor (CEA);
  - The presence of other dangerous goods in the ship's hold was forbidden. Means of fire detection with a remote alarm at the navigation station were available, and the containers were checked for radioactivity and secured;
  - Labels forbidding stacking were placed on each container.

The 15 S300 packages were distributed in six 20 ft shipping containers used both for road haulage to the chosen seaport, and for subsequent maritime transport.

In all, six trucks travelled on public roads, each carrying a container loaded with 2 or 3 S300 packages. The operational logistics of the transport were steered by AREVA/TN International, which oversaw planning of the operation from the CEA centres until arrival in the USA, mobilising its transport teams (LMC) and means dedicated to monitoring.

All the transloading operations were carried out at a dedicated quayside terminal in the port of Cherbourg. The ship, the INF-2 certified Atlantic Osprey, has safety provisions that exceed those of a conventional ship; in particular, the container stowage deck is equipped with a fire detection and extinction system. The ship's crew had received training in radioprotection and in emergency systems, given the special nature of the cargo. Lastly, all the formalities for departure to the US port were carried out by International Nuclear Services (INS), jointly with TNI and the US authorities.

Conclusions

The shipping campaign took place from 20 June 2011 with the departure of the trucks from the CEA centres. The ship left the French port on 28 June 2011. The packages arrived at Los Alamos on 22 July 2011.

The implementation of this operation required close coordination among the various actors: consignor, road haulier and logistics teams at the seaports, ship owner and crew, consignee.

In addition, a determining role was played by the French and US authorities, with which contacts were initiated far upstream of the project (authorities concerned by transport, management of sources and nuclear material). This enabled us to develop the concertation necessary for the technical and administrative files to be processed in the time allotted.

Lastly, several inspections were carried out during this operation, concerning: the preparation of the shipment of the S300 packages on leaving CEA Saclay (ASN), management of nuclear material at CEA Marcoule (Euratom), safety provisions implemented by the haulier on leaving CEA Fontenay-aux-Roses (EOT), customs inspections, etc.

This onetime CEA project achieved the return to their country of origin of old neutron sources that were no longer in use, in compliance with the French regulations (Table 4).

Duration of project	**5 years**
Number of authorisations	12 (processing: 2 years)
Number of shipping centres	4 CEA centres
Number of sources	44 sources
Number of capsules	15 SFC-II
Number of packages	15 S300
Road transport in France	18 phases / 6 trucks
Inspections by competent authorities	ASN/EOT/Euratom /customs
Operational phase	3 months (of which 1 month for transport)

Table 4: Review of operation

Acknowledgments

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References

[1] The French order of 29 May 2009, as modified, concerning the transport of dangerous goods by lan (“arrêté TMD modifié”)

[2] The IMDG code concerning the rules for the international maritime transport of dangerous goods including

[3] The INF code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships

[4] The General Rules for Internal Transport applicable to the CEA centre (CEA RGTI)

[5] The S300 package design certificates: the US approval certificate USA/9329/AF-96 and the French approval certificate under F/857/X

[6] The special form radioactive certificate USA/0696/S-96 for the SFC model II S300 source capsule

[7] The AIEA Code of Conduct on the safety and security of radioactive sources and the Supplementary Guidance on the Import and Export of Radioactive Sources