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TN®106 – IR200: A New Frame without Impact on the Safety of the Package

Benjamin Kerr
AREVA TN, Montigny-le-Bretonneux,
France
benjamin.kerr@areva.com

Thierry Delon
CEA, Cadarache,
France
thierry.delon@cea.fr

Abstract

TN®106 and IR200 packages are type B(U)F packages used to transport irradiated material between research reactors and hot laboratories. They are transported using a customized transport frame.

The ASN (The French Nuclear Safety Authority) required AREVA TN and the CEA (The French Alternative Energies and Atomic Energy Commission) to justify the absence of any impact of the frame on the package safety. A new frame was designed to integrate a non-aggressive geometry (in particular at the interfaces with the cask) and to facilitate the separation of the frame and the package in the event of a brutal shock (mechanical fuse liaison: straps and shearing pins). The new design of the frame was validated by the French Competent Authority in 2014.

This paper will describe the ASN requirements regarding “features added to package” and the approach proposed by AREVA TN and the CEA to meet them. If these requirements are not taken in consideration at the inception of a new package design, performance of the package may be diminished.

Introduction

The TN®106 package is part of a large family of nuclear transport packages developed, licensed and operated by AREVA TN to support research communities around the world. TN®106 package has been extensively used in Europe for transporting materials from experiments between labs since 2002. The TN®106 is based on a modular concept, which allows manufacturing of a series of packages with various useful cavity lengths under the current transport approval. Based on this design, the CEA, with the support of AREVA TN, has developed a version adapted to its specific needs: the IR200.

The TN®106 and the IR200 packages (figure 1) are equipped with a rotating plug to accommodate the connection on the hot cell wall for loading. The package is equipped with four welded trunnions for handling and stowage. The two package models are very similar in shape and design. Differences are related to the material and lifting lug specifically adapted to CEA Needs.

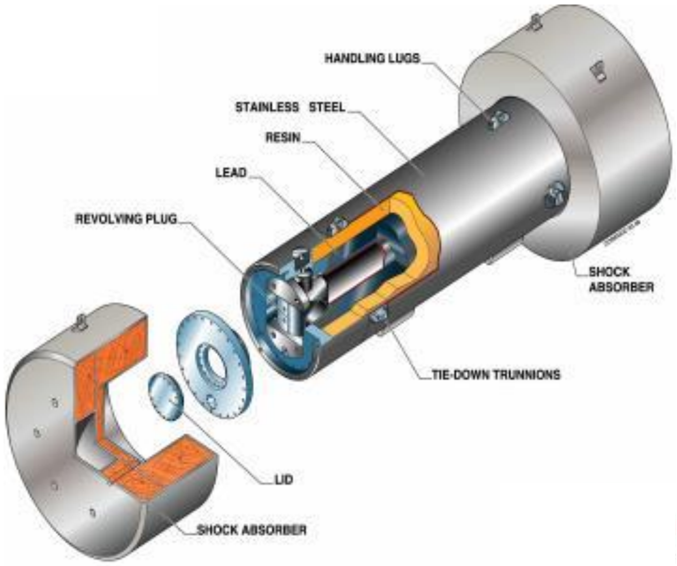


Figure 1 - TN®106/IR200

These packages can be transported by road, sea and rail. They are transported horizontally inside a dedicated 20’ open-top container, can be loaded horizontally as well as vertically after tilting, and can be loaded and unloaded in dry or wet conditions.

Two TN®106 packages and one IR200 package have been manufactured. The first TN®106 package, owned by AREVA TN, has a cavity length of 2,200 mm. The second TN®106, owned by the CEA, has a cavity length of 2,400 mm. The IR200, also owned by the CEA, has a cavity length of 2,400 mm. Two new IR200 packages with the same cavity length of 2,400 mm are currently being manufacturing by the CEA. Table 1 summarizes the main dimensional characteristics of the package.

Table 1 - TN®106/IR200 main characteristics

		TN®106 n°1	TN®106 n°2	IR200
Maximum Mass		11.6 tons	12.3 tons	12.2 tons
Cavity Length		2,200 mm	2,400 mm	
Cavity Diameter		Ø 203 mm		
Overall length	without shock absorber	2,978 mm	3,178 mm	
	with shock absorbers	3,624 mm	3,824 mm	
Overall diameter	without shock absorber	Ø 820 mm		
	with shock absorbers	Ø 1,458 mm		

In 2008, the CEA and AREVA TN created a partnership to optimize the control and the management of its package fleet based on two main activities: maintenance, and licensing and design. In the framework of this partnership, and because it was a shared subject, a new frame common to both the IR200 and TN®106 packages has been designed by the CEA and AREVA TN to meet the French Nuclear Safety Authority (ASN) requirements for "features added to the package" and to avoid penalizing the performance of the package.

French Competent Authority requirements about "features added to package"

Based on paragraph 612 of IAEA 2012, [1] "Any features added to the package at the time of transport that are not part of the package shall not reduce its safety." The French Competent Authority requires designers to consider a package frame or transport system (container, canopy, tarpaulin) as "features added to the package." This means package designers have to demonstrate that conclusions of the safety analysis report, generally considered without frame or transport system, remain unchanged in the presence of these features.

Past interpretation of this requirement of the French Competent Authority was generally limited to the thermal aspects. For example, in order to transport a package in France with a significant thermal power (>15 W/m^2) inside a container, canopy or tarpaulin, transport authorization is required. In this case, specific analyses are conducted to demonstrate that container, canopy or tarpaulin does not significantly reduce the thermal power capability of the package due to the decrease of the thermal dissipation. This demonstration has been proven by the IRSN (the Institute for Radiological Protection and Nuclear Safety), the French national public expert in nuclear and radiological risks.

In 2009, interpretation of this requirement by the French Competent Authority was extended to regulatory drop tests in normal and accidental conditions of transport. The ASN now requires applicants to demonstrate that the transport system has no impact on the safety of the package and is not aggressive to the package in the event of accident (drop test). The ASN now requires demonstrations when the frame or transport system is attached or in contact with the package. However, the container, handling pallet, and straps are exempt from the analysis.

In 2010, a preliminary study was conducted for IR200 and TN®106 packages by AREVA TN and the CEA to check if the frame was aggressive to the IR200 and TN®106 packages.

Preliminary study - Issues regarding the previous package frames

<u>Presentation of the previous IR200 and TN®106 frame principles</u>

The previous frames are typical (figure 2). The package was supported by four trunnions on four supports (rep.1) linked together by a welded structure made of a HEB steel section (rep. 2). The frames were bolted (rep.3) inside a specific ISO 20' container. The frame and the package were handled at the same time by using the lifting lugs of the package.

Previous IR200 and TN®106 frame featured:

- A tilting device (by using trunnion support rep. 4).
- Integrated frame support (rep. 5) for transporting the lifting beam.

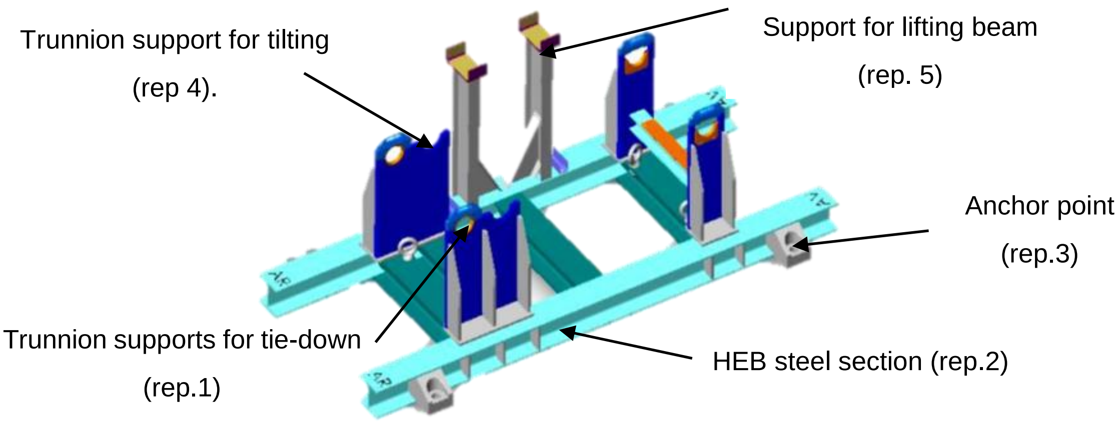


Figure 2 - Previous IR200 frame

Even if the TN®106 and IR200 packages are similar, the frames (figure 3) are different because these packages were not manufactured at the same times (2002, 2005, and 2009) by the same supplier. The design of the frame has also evolved to take in consideration experience feedback:

- Thicknesses of the different parts of the frame (support and HEB profiles) are not the same.
- Distances between trunnions supports have been adapted to the length of the different packages.
- Operation of the tilting differs.

Figure 3 - Comparison between TN®106 n°1 and IR200 frames

Issues regarding the frame used for IR200 and TN®106

Frames are heavy (up to 2.3 t) and rigid compared to the package. In the event of a drop with the package and the frame, the impact of the frame on the ground may result in the following:

- Higher accelerations on the package than those calculated in the safety analysis report may require further safety demonstrations concerning mechanical analysis of the containment barrier, and mechanical integrity of internal arrangements necessary for safety criticality demonstrations.
- High strains and stresses on the trunnions may lead to breaking. . However, in the case of the IR200 and TN®106 packages, the trunnions are welded, thus rupture is difficult to predict. A tear may appear in the external shell protecting neutrophage resin used for safety-criticality demonstration and thermal protection.
- Support for lifting beam may be aggressive to the package.

Because the frames are not similar, it was necessary to conduct not one demonstration but three, and to file two package safety analysis reports. The most economical and least risky solution to meet the ASN requirements was to design a new robust frame instead of providing demonstrations for each frame. Modifications to the previous frames were discussed but did not reveal any significant advantage. Thus, in partnership with the CEA, AREVA TN, decided to design a new frame for the three packages.

Design of the New Frame

Design requirements

The main requirements for the design and the current characteristics for the manufactured new frame are the following:

- The frame is the same whatever the package (IR200/TN®106) and cavity length.
- The new frame is compatible with anchor points inside the dedicated ISO20' container used with the previous frame.
- Packages, frames and containers are inter-operable.
- The frame is capable of tilting of the package.
- Operation time for loading/unloading the package is not increased.
- The frame is not aggressive to the package.
- The new frame design does not necessitate an update of the safety files (which is an issue in a context of international transport where validation of transport approval certificates is required).
- Maintenance is easy.

Principles of the new frame (figure 4)

Fuse links between the package and the frame have been incorporated by AREVA TN and the CEA to avoid any aggression to the package.

- The package (rep.1) is placed horizontally on the support plate (rep. 2).
- The frame is made of two parts (rep.2 and rep.3), with fuse pins between them (rep.4).
- The package is tied-down to the support frame with straps (rep. 5), chains/turnbuckles (rep.6), and an interface piece (rep.7).

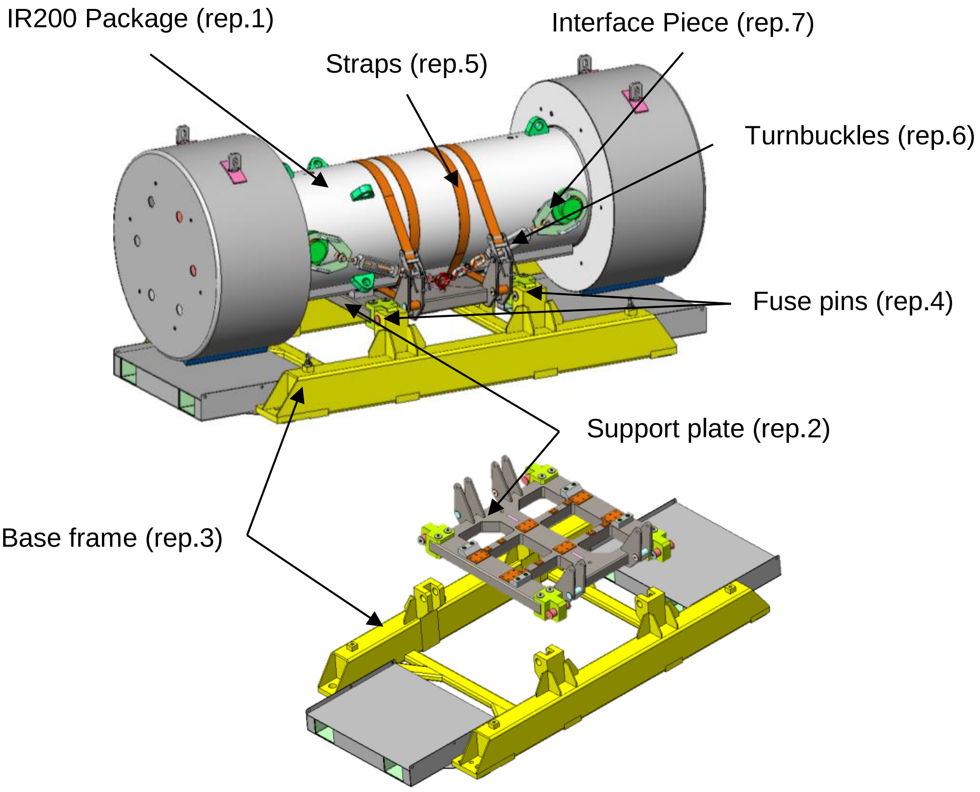
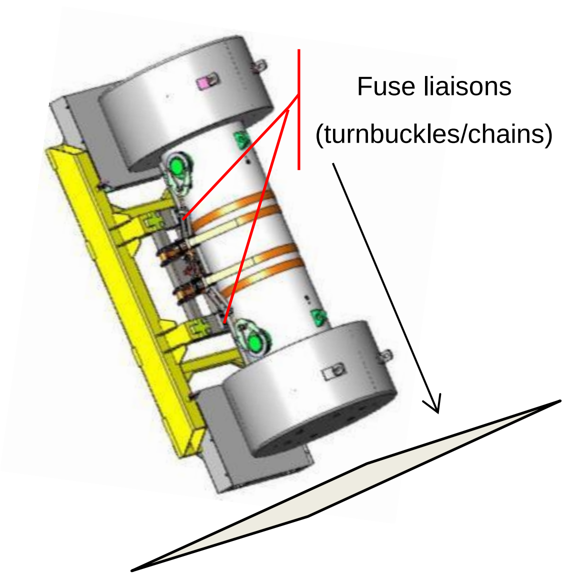


Figure 4 – New IR200/TN®106 Frame

In the event of accident, the breaking of the fuse liaisons would allow the shock absorbers of the package to crush. Fuse liaisons are designed in order to break upon stress thus preventing damage to the package.

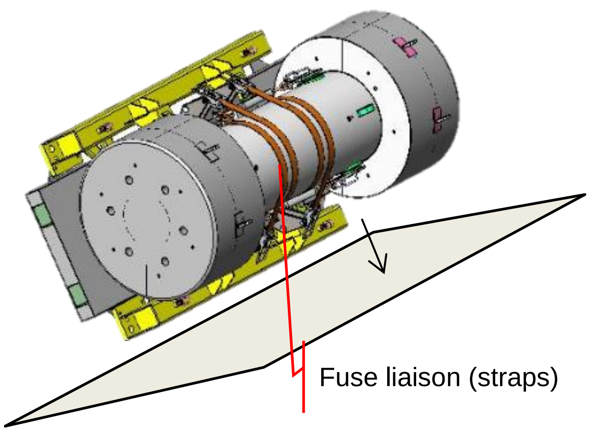
The principle of the frame and the associated safety options were presented to the French Competent Authority and the IRSN, drop test configurations were considered based on the preliminary design of the frame. The French Competent Authority required AREVA TN and the CEA to justify the safety upon impact when the frame hits the target before the shock absorbers. Three main configurations (figure 5) were considered: axial, lateral, and radial drops.

Axial drop



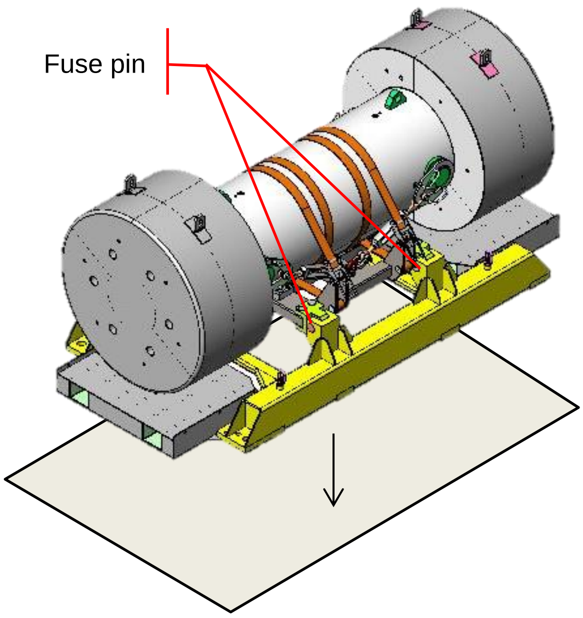
Frame is not aggressive to the package because of fuse liaisons with the trunnions (chains). Package and frame will be dissociated.

Radial drop



Frame is not aggressive to the package because of fuse liaisons of the straps. Package and frame will be dissociated.

Lateral drop



Frame is not aggressive to the package because of pin fuse liaisons. The frame will be dissociated in two parts, and shock absorbers will crush.

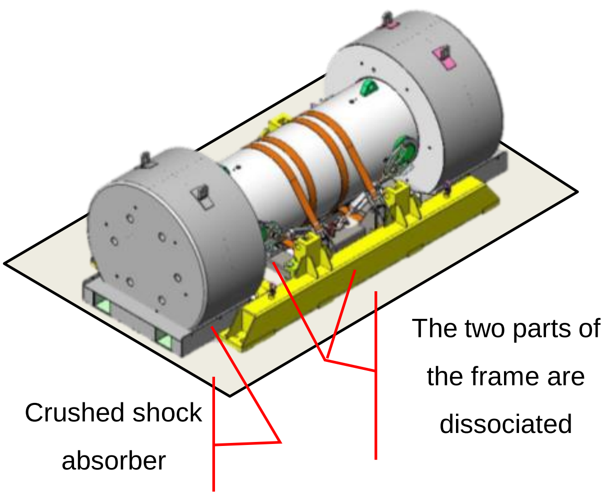


Figure 5 - Drop configurations

Designing the frame

The frame was designed (figures 6 and 7) to avoid operational error. AREVA TN and the CEA had to be sure that the package could be easily and quickly tied-down on the frame to limit dose rates received by operators: stowage accessories (straps, chains, turnbuckles) were implemented on the frame after feedback from users and the accessories supplier recommendations; the trunnion interface piece was designed to be as light as possible to facilitate handling by operators.

However the main challenge of such a frame design is to 1) guarantee an effective liaison while being submitted to transport accelerations, and 2) at the same time, to enable the separation of the frame so as to avoid any impact on the safety of the package. These two characteristics are contradictory. Under routine conditions of transport, the frame is designed to be compatible with INF requirements allowing transport by sea, rail, and road.

A fatigue analysis was conducted on the entire structure of new frame and especially the welding. Even more difficult was the design of the pin between the two parts of the structure. AREVA TN and the CEA paid a careful attention so as to avoid any pin breaking during routine conditions of transport by considering very penalizing loading cases. The influence of different parameters on the stress level inside the pin (mainly friction coefficient and tolerance between pins and upper and lower part of the frame to have a safe and robust design) was verified by numerical calculations. In the same way, AREVA TN and the CEA checked resistance of the frame structure to high solicitations during a drop test without significant deformation until the breaking point of the pin fuse liaison.

Subsequently, AREVA TN and the CEA demonstrated that the breaking of the fuse liaison is compatible with demonstrations in the safety analysis report. There was no significant deformation on the body of the package and the deceleration was compatible with the demonstration of the mechanical integrity of the internal arrangement during the ACT (Accidental Conditions of Transport) drop test.

The frame design, expertised by the IRSN, was validated by the ASN.

<u>Tilting</u>

Tilting of the package can be achieved by the addition of a specific feature (figure 8) which can also be used to support the lifting beam during transport. The tilting device is not attached to the package frame during transport, only when required within the loading/unloading facility.

Figure 6 - IR200 cask with the new frame

Figure 7 - TN®106 cask with the new frame

Figure 8 - IR200 cask and frame with tilting device

Lessons learned and perspectives

Design

The principle of the frame with fuse liaison is patented. AREVA TN and the CEA plan on using this frame design for other packages.

Manufacturing

The manufacturing of the frame has not revealed specific difficulties, despite the mechanically constrained assembly (the two parts of the frame are linked by four pins which is a statically indeterminate configuration). The schedule was tight, but the first frame was delivered in time to conduct interface tests (with package and transport container) and to execute the first shipment scheduled with the new frame.

Operational

Three frames are currently in use, and two other frames are going to be manufactured for the two new IR200 packages.

The use of the frame has proven to be easier and more simple than expected. The time required to operate the frame is very similar to the time required with the previous frame. This point was not obvious considering the apparent complexity of the tie-down of the package with the new frame. AREVA TN and the CEA have been able to increase the safety of the transport without increasing the dose rate received by operator, which was an important requirement.
However, the use of the frame requires a special attention regarding the straps, if the package is not laid horizontally on the frame with care, there is a risk of deterioration to the straps. Some improvements are under investigation to resolve this point.

Inspection

After one year of use, AREVA TN conducted the first inspection of a TN®106 frame. The frame was disassembled and a liquid penetrant test was conducted on the welding and on the fuse pins (figure 9). No negative indication was revealed, confirming the excellent behavior of the frame during transport.

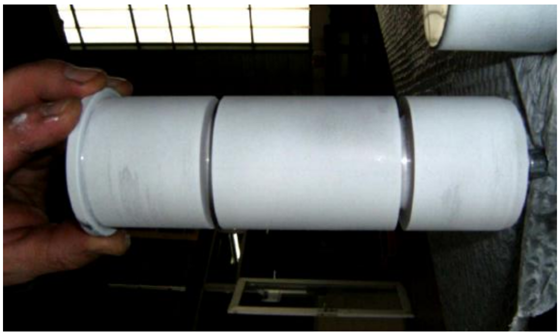


Figure 9 – Penetrant test on fuse pin

<u>Safety</u>

In 2016, requirements of the ASN have evolved regarding “features added to the package” and expectations are increasing [3]. Now, it is not only required to demonstrate that the frame is not aggressive to the package, but the ASN has also required new drop configurations where the mass of the frame is to be considered in addition to the mass of the package to ensure that the frame does not impact the safety of the package. The frame is practically considered as a part of the package model.

New configurations where the shock absorbers hit the ground before the frame will be required to be studied (figure 10).

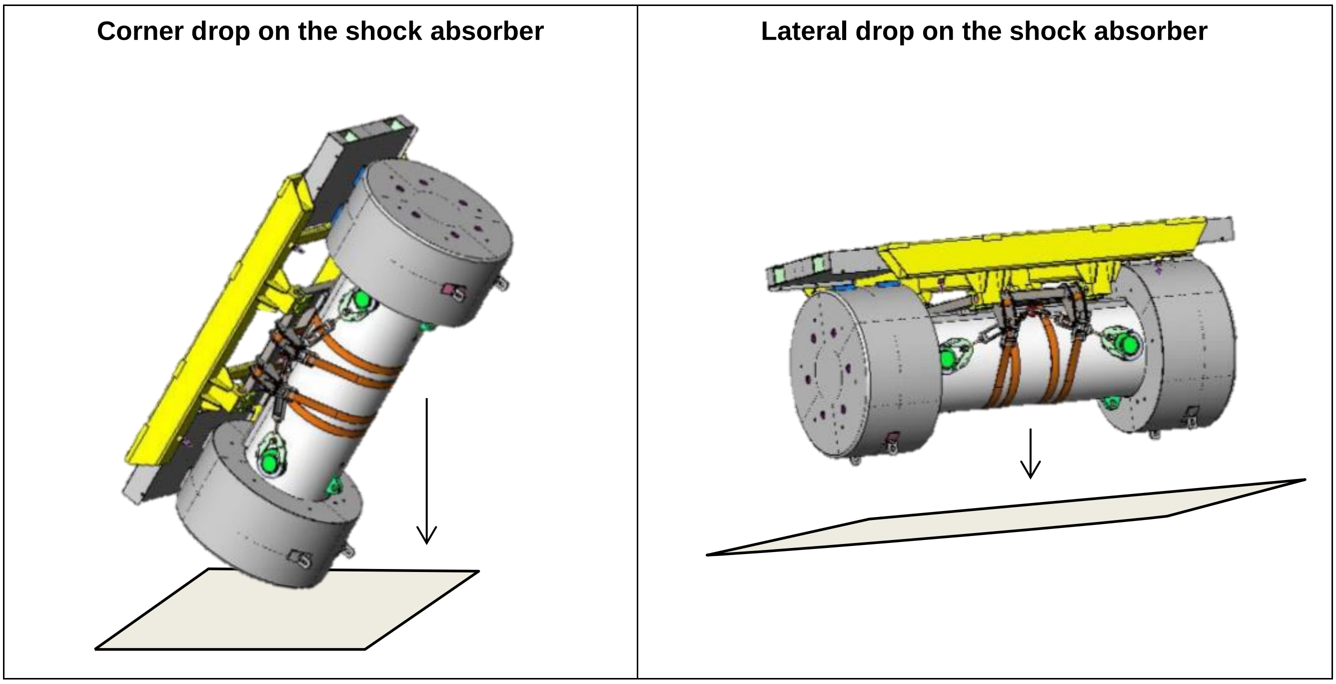


Figure 10 - New drop configurations with frame

In these configurations, the frame is not directly aggressive to the package, but the consideration of the mass of the frame will increase the crushing of the shock absorbers and may have a consequence on safety if there is no, or not enough, margin. The French Competent Authority considers that these configurations should be studied when the mass of the frame is significant compared to that of the package (> ~10 %). This new requirement seems to be troublesome mainly in cases when the package has a mass of less than 10 t. In this event, the frame often has a significantly higher mass compare to that of the package.

Moreover, the FCA now requires combining both NCT (Normal Conditions of Transport) drops and ACT drops for fissile packages in these new configurations, even if in real transport conditions, it is totally unrealistic to imagine that the transport would continue after an NCT incident in this configuration with the frame.

As AREVA TN and the CEA designed the new frame of TN®106 and IR200 packages to be as light as possible, this new requirement should not be a challenge thanks to the margin and the risk analysis conducted at the beginning of the design phase.

Conclusions

Requirements of the ASN regarding "features added to the package" are more and more exigent and precise. The French Competent Authority now practically considers frames as a part of a package model:

- The frame or transport system must not be aggressive to the package when it is attached or in contact with the package.
- The mass of the frame is to be considered in addition to the mass of the package to verify that the frame has no impact on the safety of the package.

For a new package, it is important to consider these requirements in designing the frame and the package. If these requirements are not taken into consideration at the beginning of the design, they may diminish the performance of the package. They may have a significant impact on the design of the package, especially on the shock absorbers. With these new requirements, safety under ACT is increased. However such unrealistic drop conditions with the frame could consequently increase of the complexity of the loading and unloading operations.

In the case of the IR200 and TN®106 packages, the tight partnership between the CEA and AREVA TN has led to the success of the new frame design: each partner transmitted its own experience regarding operations of the package, design and licensing. Such collaboration between the CEA and AREVA TN was important in finding new solutions in resolving this challenge. AREVA TN and the CEA are able to quickly adapt the new frame design to other packages with the same principle based on the experience acquired.

References

[1] IAEA, "No. SSR-6," *Regulations for the Safe Transport of Radioactive Material* (2012)

[2] ASN, "ASN/DIT/0063/2009*," Transport de matières radioactives, impact des châssis/dispositifs d'arrimage et de manutention* (January 28, 2009).

[3] ASN, *Transport à usage civil de substances radioactives sur la voie publique*, Tome 1, *Demandes d'agréments et d'approbations d'expéditions*, GUIDE N° 7 - Révision 2 (February 15, 2016).