A HEAVY RAILWAY WAGON FOR HEAVY SPENT FUEL CASKS

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INTRODUCTION

Generally, for the transport of radioactive materials the engineering activity concentrates its efforts on the optimization of the package design. In fact, it is very important to consider the whole transport system and in particular the necessary equipment for the transport of the packaging.
The present paper illustrates the global approach in the domain of railway transport.

Transnucléaire is developing new casks designed for the transport of spent fuel (for reprocessing or interim storage) and radioactive waste (for interim storage).
These heavier and bulkier packagings of B(U) type with an increased capacity for loading are designed in conformity with regulations of International Atomic Energy Agency (IAEA).
Therefore, Transnucléaire has identified the need to develop a high performance rail wagon able to transport commercially such heavy packaging with reinforced capacity compared to the wagons of the current fleet for which the packaging weight is limited.

Based on a long experience of radioactive materials railway transport, with an existing fleet of 32 wagons (type Q70), COGEMA as the owner and Transnucléaire have launched the development of a new design of wagon, the Q76 type (fig. 1), which has been certified since June 2000.

Presently, one Q76 wagon is operating and the manufacturing of complementary wagons is scheduled in the near future.

The principal characteristics of the wagon are developed in chapter I.
Chapter II describes all static, dynamic tests and ride trials which were done to validate the performances of the wagon. In France, the engineering departments of the French railway company SNCF are in charge of the technical evaluation and of the application to the French Ministry of Transport who delivers the transport license.
Chapter III presents the range of application of the wagon and some examples of its sales application.

Fig. 1: Q76 rail wagon in transport condition

CHAPTER I: TECHNICAL FEATURES

Use

The wagon series 8387 994, Type Q76 is intended for the conveyance of various type of nuclear packages, with a maximal load of 143 t, between continental countries reactors and the COGEMA La Hague reprocessing plant (France).
It is designed for a track gauge of 1 435 mm, with GA gauge profile in accordance with the UIC[(1)] leaflets 505-1 & 506, and for operating at a commercial speed of 100 km/h (S traffic) in both loaded and tare conditions.

Description

The wagon consists of three polyarticulated underframes, equipped with four bogies.
The design of the wagon consists of a main frame installed on two intermediate frames on which bogies are fixed. See fig.2
A set of two canopies ensures the protection of the packaging against rainwater. Venetian blinds and partial openings of the roof allow dissipation of the packaging heat by natural convection.
The securing of the packaging with or without ship transport frame is done directly onto the structure of the main frame of the wagon.
Internal lower part of the main frame is covered with a pan, used to ensure the retention of drops of water resulting from condensation.
The wagon complies with the UIC and RIV[(2)] leaflets and the French SNCF requirements.

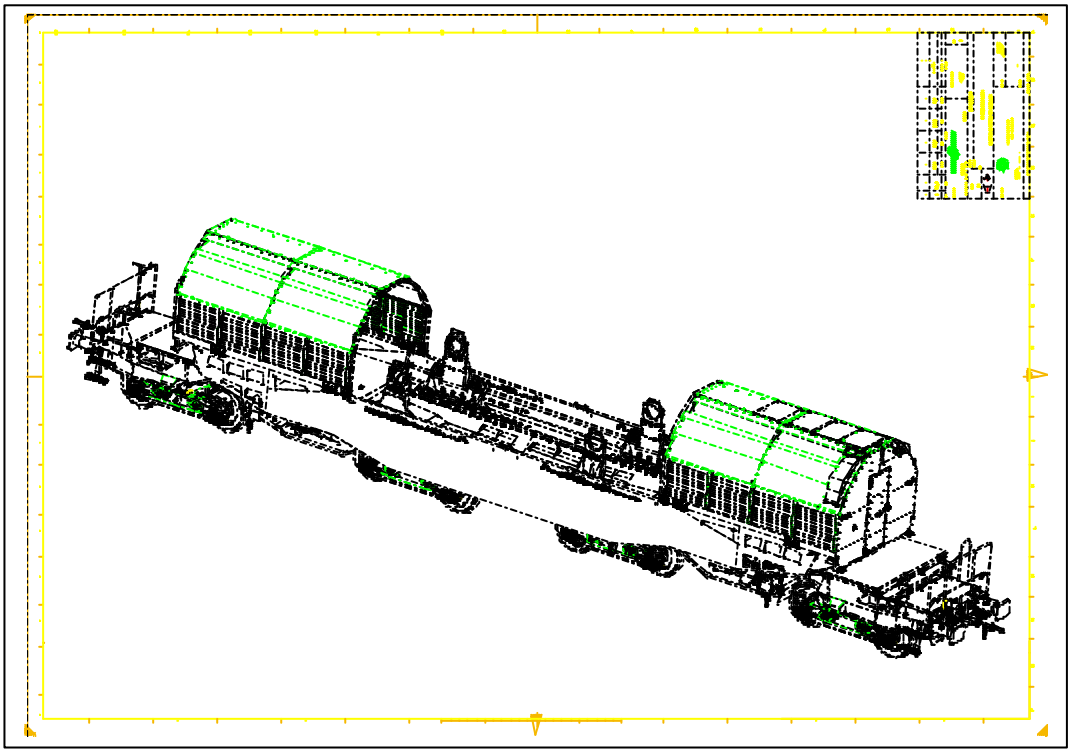

Fig. 2: CAD file of the wagon design

The main dimensions and characteristics of the wagon are given in the following chart 1.

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[1] UIC : International Union of Railway
[2] RIV : Reciprocal use of wagons in International traffic

MAIN FEATURES	
Overall length	22.5 m
Bogie wheel base	2.150 m
Main platform deck height	1.160 m
Buffer height	1.060 m
Overall height	Between 4.300 and 4.528 m
Overall width	Between 3.033 and 3.268 m
Maximal load	143 t
Gross weight (Max) of the wagon	200 t
Loading gauge	GA
Minimum curve radius	75 m, uncoupled wagon
Tare weight	57 t
Weight per linear meter	8 t/m

Chart 1: Main features of the Q76 wagon

Manufacturing

Wagon frames

The main (center) frame is built of fully welded rolled steel sections and plate.
The main frame incorporates mounting positions for the various cask dimensions currently in use by the Nuclear industry, and running rails for 2 moveable canopies provided for cask protection.

Intermediate frames (x 2) as well are constructed of rolled steel sections and fully-welded plate. The frames incorporate the buffing and UIC type drawgear in accordance with UIC leaflets 522 & 530-1.

Furthermore, each intermediate frame is equipped with an air pressure brake and a parking brake. The parking brake operates onto external bogie and is operated from the end platform desk.

The intermediate frame ends are fitted with the handrail footsteps and access to the canopies is done by the end platform desks.

Bogies

The wagon is equipped with four bogies of 2150 mm wheelbase especially designed and qualified for a suitable 25t axle-loads in S traffic (100 km/h) and 970 mm diameter wheels.
The bogies are built in an H-shaped steel frame design, and use a wheel-disc braking system powered by air pressure.

At 25t axle-loads, the Q76 wagon complies with the present ride test criteria given by UIC leaflet 518.

High speed (100 km/h) at heavy axle-load (25 t) brake performances are achieved thanks to wheel-disc braking system technology.

Spherical seating pivots

Two spherical seating pivots connect the main frame with the intermediate frames. Also, included on each intermediate frame, are two spherical seating center pivot casts to UIC design to accept the bogies.

Canopies (covers)

A set of two canopies ensures the protection of the packaging against rainwater.

Canopies are all aluminum frame design and then covered with aluminum steel fixed on. They are moveable on running rails, and can be easily opened manually. At both ends, access door enabling the entry into the inner cover area.

The vertical sidewalls and roof of the canopies have partial openings to allow a flow of cooling air through. In front of each opening, weatherproof top vents and rainwater fences are also incorporated. See fig. 3

The opening design was confirmed by computer simulations in order to have a maximal allowable dissipation of the packaging heat by natural convection. See fig. 4 & 5

Fig. 3: canopies partial openings

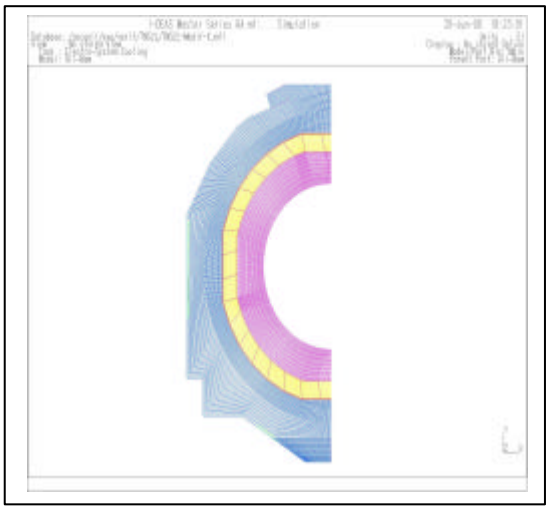

Fig. 4: FEM thermal analysis model

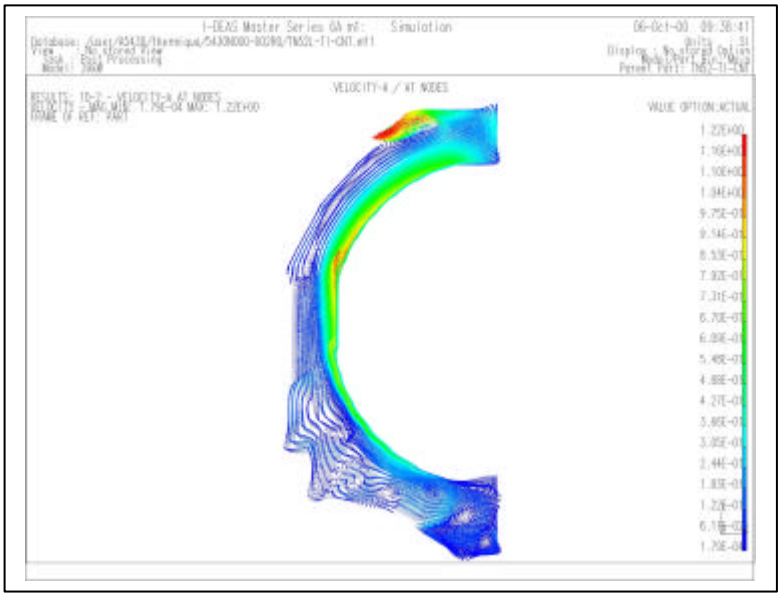

Fig. 5: FEM analysis results of flow cooling air

Canopies structural gauge can be easily modified depending upon the packaging design or transport configuration with or without ship transport frame. Several gauge for the canopies are available onto the wagon.

Type 1 sized within the UIC GA gauge (4 303 mm high and 3 033 mm width).
Type 2 position 2 sized (4 403 mm high and 3 268 mm width) and Type 2 position 3 sized (4 528 mm high and 3 033 mm width) outside the GA gauge. For the Type 2 configurations, gauge studies must be performed in order to validate and allow the planned conveyance.

Maximal packaging dimensions allowable under canopies regarding to UIC requirements are 3 100 mm in diameter and 8 500 mm in length with a maximal high of the Center of gravity (Cdg) packaging from rail level of 2 800 mm.

Real Time Tracking System (RTTS) is integrated into canopies concept. Delivery services are as following: (See fig. 6)

- Calculation of position of the vehicles by GPS satellite.
- Data Transmission by IMMARSAT C satellite to an earth station.
- Receipt of data in the monitoring room.
- Data contain position, speed and some alarms (exceeding speed limit, vehicle stopped, and exceeding inside temperature level…)
- Possibility to recover data with GSM network.
- Operators check continuously itinerary, speed and alarms.

RTTS is designed to be barely visible and free from operational constraints.

The module, on board the wagon, is included an INMARSAT C transmitter/receiver or a GSM modem, an external GPS module and a PC card.

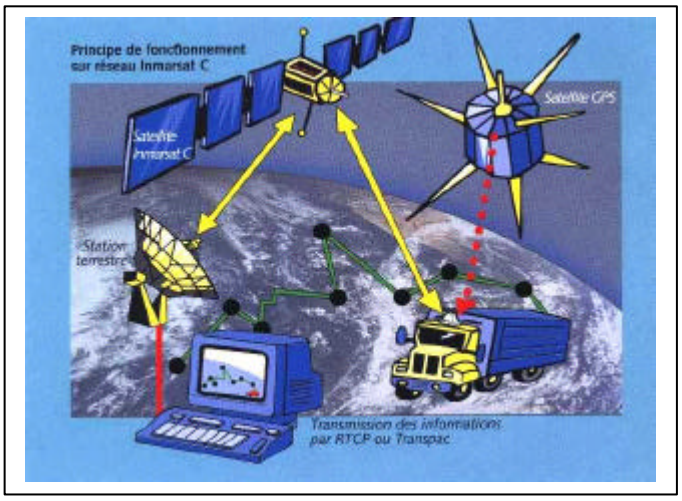

Fig. 6: The principle of the Real Time Tracking System

Anchorage device

The securing of the packaging with or without ship transport frame is done directly onto the structure of the wagon's main frame.
Transnucléaire's packaging concept incorporates directly in the body structure, the trunnions used for loading and transport operations.
For transport, the packaging is put down in horizontal position onto four trunnions metal supports with bronze area for the trunnion area in contact.
Several anchorage-mounting positions are available for the various cask dimensions by using interface parts. See fig. 7

Fig. 7: making up trunnion metal supports with interface parts

Fig. 8: trunnion metal support with sleeve bearing.

At one end, longitudinal displacement can take into account the thermal expansion effects of the cask. See fig. 8

For some packaging, to be shipped at Cherbourg port the fixture system of the rail-wagon allow the anchorage of the maritime transport frame directly bolted inside the frame of the rail-wagon. In that way the trunnion metal supports are not required and the handling during transfer from rail-wagon to ship cargo holds is simplified.

CHAPTER II: VALIDATION TRIALS

Before introduction of a new type of rail wagon, structural and ride trials must be done on the wagon. Also, the wagon must be designed in a such way that it complies with all the tests described in the UIC leaflet requirements and according to ERRI B12 RP60[3] defining all the condition of tests and allowed stress limits for the structures.
In tare and laden condition means respectively: 57 t, 22.5 t axle-loads and 25 t axle loads.
All the accomplished tests are given in the following chart 2.

TESTS	According to UIC-Leaflet
Traction and compression structural tests under load and fatigue tests at bench (onto wagon frames and bogie frame)	577 OR & 510-3
Torsion stiffness test (main frame and intermediate frames)	530-2
Dynamic buffing test in tare and laden condition	526-3 OR
Lifting and jacking tests	577 OR
Re railing test	577 OR
Running brake test in tare and laden condition	540 & 544-1
Ride trials in tare and laden condition	518 OR
Suitability for twisted track	510-2 & 505-5 OI
Bogie rotational resistance test	518 OR

Chart 2: List of the accomplished tests

[3] ERRI: European Rail Research Institute

CHAPTER III: APPLICABLE FIELD AND DUTY APPLICATION

In the following chart 3 are presented the range of application for the new rail wagon Q76 with reinforced capacity compared to the wagon Q70 of the current COGEMA fleet for which the packaging weight (load) is limited.

Wagon's type and characteristics		Q70 (RIV)		Q76 (GA)	
S traffic without restriction	- Gross Weight (tone) - Load (tone) - Tare (tone)	160 114 46		180 123 57	
Allowed S traffic under restriction	- Gross Weight - Load - Tare		168 122 46		200 143 57

Chart 3: Applicable fields of the wagons type Q70 and Q76

All the existing casks developed by Transnucléaire Group for the transport of spent fuel / or waste can be transported onto the wagon Q76. In the following chart 4 is presented the list of packaging able to be transported by rail, with or without maritime transport frame:

TRANSPORTABLE PACKAGING
TN12-1, TN12-2, LK 100
TN13-2, TN17-2
TN28, TN81
TN52 L
TN112 (new generation cask)
TN24 D, TN24 DH, TN24 XLH, TN24 SH
TN24 G
TN97 L
TN24 BH
TN24 E
TK69
NUHOMS 61B
Maritime transport frame (TN12, TN17, TN28)

Chart 4: Transportable packaging

Some examples of sales application for the Q76 wagon are presented in the following figures:

TN24 G tilting operation (Gösgen) and transfer by road to Zwilag plants (Switzerland)

Ship transport configuration with ship transport frame

CONCLUSION

The Q76 rail wagon is a new and more functional concept with increased load capacities and is a complementary equipment to existing wagons Q70 of the current COGEMA fleet.

Studies have been done with modern tools like Computer Aided Design (CAD) and Finite Element Method (FEM) in order to optimize the design and improve the performances of the wagon under optimal conditions for security and reliability during the transports.

Presently, the wagon is in use for transport of the new generation “dual purpose cask” of the TN 24 family: TN24 G (Gösgen plant) and TN52 L (Leibstadt plant) for Swiss reactors.

After a successful introduction of this high performance wagon Q76, COGEMA intend to launch at least three additional units to be operational in September 2002.