TN-CIEL: A MOBILE TANK VEHICLE FOR LIQUID SPECIFIC ACTIVITY WASTE

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INTRODUCTION

Transnucléaire has developed a new concept of tank vehicle, named «TN-CIEL », intended for road transportation of low level radioactive waste and potentially corrosive liquids.

The tank vehicle (fig.1.) is licensed with respect to the ADR transport regulation for “class 7” (radioactive materials) but is also designed for “class 8” (corrosive materials).

According to the regulation of transport of radioactive material, this tank is classified as Industrial Package Type 2 (IP-2).

The French authorities, DRIRE (Regional Directorate for Industry Research and Environment), are responsible for licensing tank vehicles. They imposed the following requirements:

- the rolling parts (semi-trailer) of the TN-CIEL vehicle must be checked every year.
- the inside cavity of the tank must be checked every three years with a leaktightness test and every six years with a hydraulic test at a pressure of 4 bars (relative pressure) for this design.

It is now used for the transport of boric acid between the French nuclear power plants and the incineration facility. The tank has been developed specifically for the need of EDF, the French Utility which has participated to the financing of the vehicle.
But Transnucléaire, as owner of the tank vehicle, is in charge of all operational activities including licensing, transport, maintenance and dismantling.

This project illustrates the evolution of the transport in the future: this activity will be more and more outsourced from the main nuclear companies and will be taken in charge by specialized companies for which transport is the core business.

Fig. 1. TN-CIEL tank vehicle in transport condition

EXPLANATION AND CONTEXT

The tank is presently time used, since February 2001, for the transportation of all the concentrate of boric acid neutralized by soda effluents from each of the 18 French EDF nuclear power plants, whatever plant model it is (900, 1300 or 1450 MW), to the waste incineration facility (CENTRACO), which is located close to the nuclear site of Marcoule in south-east of France.

The concentrate is stored in EDF vessels of 5 to 10 m^3 capacity until it is unloaded in the TN-CIEL tank.

These vessels can be located, according to the type of EDF power plants, in elevation at 8 meters up to the ground floor of the TN-CIEL (for all the 900 MW and 1450 MW plants) or underground at – 4 meters down (for the 1300 MW plants).

Before the development and use of TN-CIEL, the concentrate was processed by mixing it with special adapted cement and by pouring the whole into drums, to form concrete shaped cylinders. These drums were then shipped to a French low-level-waste disposal center operated by the French radioactive waste agency ANDRA.

The decision to transport and incinerate the liquid concentrate of boric acid presents the main advantage to reduce significantly the waste volume to be disposed of.

Transnucléaire is now in charge for the EDF client of the loading of the concentrate of boric acid in the tank, of the transport and of the unloading from the tank.

Transnucléaire provide full technical assistance on each operation, which has followed all the required and regular training to intervene on the EDF or CENTRACO site.

Transnucléaire has performed a risk analysis of the tank exploitation on site and has minimized the operators intervention during the loading and unloading.

EFFLUENT DESCRIPTION

This concentrate is obtained from evaporation of wastewaters of EDF nuclear plant including water of the primary system.

This liquid is composed of boric acid (H_3BO_3) neutralized by soda (NaOH) and presenting a various quantity of phosphate (PO_4^-) and calcium. The density of this solution varies between 1 and 1.2.

This mix has been analyzed for the EDF power plants and found as not corrosive according to the transport regulation (“class 8”), when neutralized.

The particularity of this liquid waste mix is to crystallize at ambient temperature. The crystallization process depends also on the ratio soda over boron. Outside a range of soda/boron ratio values, the product starts to precipitate and can become hard as concrete. This chemical reaction is normally irreversible.

The mix of boric acid is therefore kept heated at the NPP at a temperature of about 60°C.

It must be consequently transported at warm temperature (minimum of 60°C).

The TN-CIEL tank allows such a transport by maintaining the inside face of the tank at a constant temperature between 60°C and 70°C. Moreover the TN-CIEL tank is equipped with a stirring machine in order to avoid any “shadow area” with precipitate.

TECHNICAL FEATURES

The TN-CIEL tank vehicle is composed of a semi-trailer with its equipment on which a tank is fixed (see Fig.2).

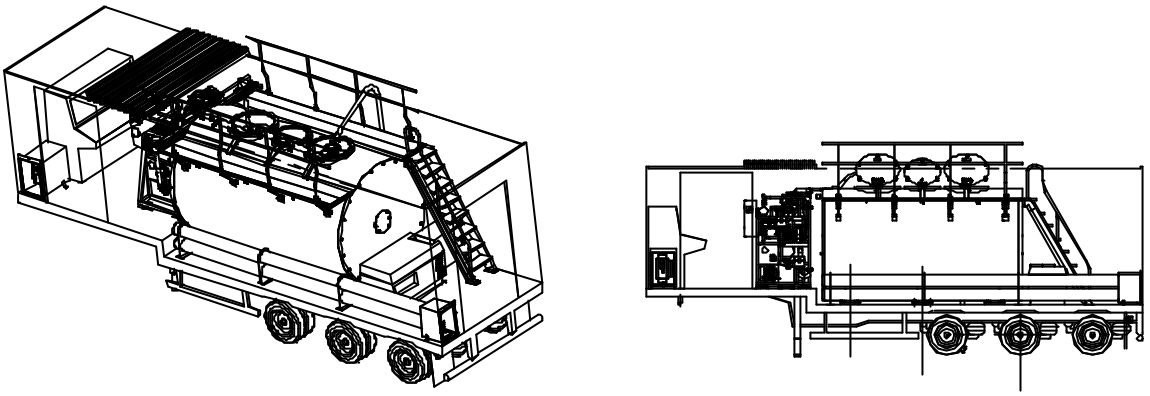

Fig.2. Sketch of the TN-CIEL tank vehicle

The tank is itself composed of an internal high-grade stainless steel shell of 10 mm thickness, which has been chosen to withstand any normal corrosive attack, and a steel external shielding protection of 70 mm thickness.

Between the two shells, is installed a thermal protection. An electrical resistance guarantees the heating of the internal shell up to a maximum temperature of 70°C (Fig. 3). This electrical resistance is doubled in order to get a security and to minimize the maintenance of the tank, in case of the failure of one of the heating resistance.

Fig. 3. Internal shell with electrical resistance

A pump/compressor, connected to one of the three manholes, allows the loading and unloading of the radioactive liquids in the tank from and to any container. In the case of EDF French plants operation, the pump is used to empty the vessel from boron concentrate possibly for vessel in elevation and normally for underground vessel. The compressor can be used for the draining of the TN-CIEL tank at CENTRACO to push the concentrate into a special vessel on site before incineration.

The filtration system connected to the pump/compressor prevents any release of radioactive gas to the atmosphere thanks to a succession of filters (THE, Active Charcoal). This filtration system itself is heated too, to facilitate filtering of the vapor generated by the loading of warm liquid (Fig. 4.).

In order to perform the loading and unloading of the tank, a hosepipe, equipped at its both extremity with watertight connections (at the tank side with a Zenith connection (aviation type) and at the other side with an Argus connection), has to be plugged in on the rear manhole of the tank. This 5 meters long hosepipe is also heated at a temperature of 60°C to avoid any crystallization of the concentrate after use.

An additional heated hosepipe is also provided. It can be connected to first one in order to increase the pipe total length to 10 meters.

These two pipes are shipped on the semi-trailer in two adapted racks close to the tank.

Fig. 4. TN-CIEL local with the filtration system

The global system is controlled from the front control booth, integral to the semi-trailer, by a power assisted system.

This power assisted control system features several security systems. It controls the opening and closing of the valves or the loading and unloading of the reservoir of the tank by depression of the internal cavity which allows a loading from a 8 m underground vessel or by pressurization of the cavity up ton 1.5 bars.

The control system can be used as external mode without the pump/compressor device, in case of use of external pump as provided on the CENTRACO incineration factory.

In order to guarantee the tank heating during the transport, a 2 kW generating set is included in the vehicle and controlled by this system.

It allows likewise to adjust the cavity tank temperature and consequently the boron concentrate to the required temperature (between 60°C to 70°C in the case of the boric acid solution) during the transportation phase.

The main characteristics of the tank vehicle are:

- total length: 8900 mm,
- total width: 2500 mm,
- total height: 3500 mm
- maximum allowable tank volume: 5 m^3,
- maximum mass of the loaded semi-trailer: 33 t,
- maximum mass of the loaded articulated vehicle: 40 t.

The tank accepts a total content of 5 m^3 of Low Specific Activity of category II (LSA-II) that presents a maximum activity of 20000 Bq/g of gamma emitting nuclides. The total admissible activity in the tank is 0.1 TBq.

Naturally, the average specific activity of the solution does not exceed 10^{-5} A_2/g for the whole nuclides identified in the solution and the total activity is less than the regulatory 100 A_2 for radioactive liquids.

The regular criteria of 10 mSv/h of dose rate at 3 meters from the surface of the unshielded liquid has also been checked for a conservative geometry of the unshielded liquid.

The transportation of the LSA-II liquid is made under exclusive use and the TN-CIEL tank vehicle is classified as Industrial Package Type 2 (IP-2) according to AIEA regulation.

Transnucléaire has provided all the justifications to prove the IP-2 conformity of the tank vehicle loaded with its radioactive effluent, to the last AIEA and ADR regulation in force. These justifications are exposed in a Safety Analysis Report of the IP-2 TN-CIEL tank vehicle model, accompanied with a certificate of conformity.

The total weight of the loaded vehicle which is less than 40 tons allows to transport it as a legal weight truck and not as exceptional convoy and does not need any particular escort for the European transports.

MAINTENANCE AND DOSE INTEGRATION

After each transport of effluent to the CENTRACO incineration factory, the TN-CIEL tank has to be rinsed thanks to a rinsing system consisting of three rotative heads inside the reservoir which can be connected to demineralized water pipe on site. The two hosepipes are also rinsed with water or steam at the end of the loading.

Transnucléaire performs a regular maintenance of the tank and the vehicle which has to be done in a controlled area. The regular maintenance includes an eventual decontamination of the cavity in order to allow the pressure tests imposed by the French authorities (DRIRE):

- Leaktightness of the cavity every 3 years,
- Hydraulic pressure test at 4 bars (relative pressure) every 6 years.

The rolling part (semi-trailer) is also maintained and has to be checked by DRIRE every year.

The design of the tank vehicle has been done taking into account the ALARA requirements for the tank exploitation by the operators so that the level of the integrated dose rate of this operator during one year should be less than 0.5 mSv.

The shielding is designed on the basis of 100% of gamma emitting nuclides (such as Co^{60} and Ag^{110}).

The shielding thickness of the tank of a total of 8 cm of steel is designed with a maximum amount of concentrate and with a conservative activity of 10^{11} Bq.

The first transports which have been carried out show a dose rate at contact and at 1 m very low with respect to the regular criteria.

CONCLUSION

The TN-CIEL is an innovative concept that allows a multi-units NPP operator to optimize processing of its waste, by decreasing both capital costs and volume.

Beyond that, the TN-CIEL also illustrates an approach to outsourcing non-core business: a good part of the optimization is that the operator really acquires a full service, an availability, a license maintenance and dismantling package; it leaves to the transport designer and operator full responsibility on its own core business.

We believe that such a model achieves a good base solution for similar development.