

# CONTAINERS FOR THE TRANSPORTATION OF RADIOACTIVE LIQUID WASTES

Jean-Michel Troude  
French Atomic Energy Commission  
CEA, Saclay Research Center

Bernard Vigreux  
SGN, Saint Quentin en Yvelines, France

## ABSTRACT

Since the establishment of the Saclay Nuclear Research Center, the liquid radioactive wastes from the facilities of the Center (laboratories, reactors, workshops, etc.) have been transferred to processing plants using tanker vehicles designed to minimize risks incurred in transport.

The Radiation Protection Branch, which is responsible for the disposal of radioactive wastes at Saclay, has thus designed and put into operation different types of tanker vehicles with or without biological shielding. These vehicles have capacities ranging from 1.3 to 19 m<sup>3</sup>.

The development of nuclear energy in France has made necessary the transportation of radioactive liquids between a number of facilities in different parts of the country.

The experience acquired at Saclay has made it possible to select and develop three tank trailer models approved by the competent authorities (branches of the Ministry of Transport) and used frequently for transportation in France as well as in other European countries. The models are:

- A trailer equipped with a tank with a usable capacity of 4.5 m<sup>3</sup>, for the transport of low-level radioactive liquids,
- A trailer equipped with a tank with a usable capacity of 4.5 m<sup>3</sup> surrounded by a shield equivalent to 50 mm of lead for the transport of intermediate-level radioactive liquids, and
- A trailer equipped with a tank with a usable capacity of 1,280 liters shielded by 150 mm of lead for the transport of high-level radioactive liquids.

## GENERAL DESIGN CONSTRAINTS

To avoid any interruption or stoppage of transport during a journey, it was decided to use coupled assemblies (tractor trailers) in spite of the disadvantages resulting from the coupling system. If the tractor breaks down en route, it can then be replaced.

The total permissible loaded weight (40 metric tons) is an additional reason for this choice. The installation of an electric braking system on the trailer significantly improved the safety of the transport assembly.

### Regulatory and Safety Operating Requirements Applying to the Three Types of Tank Trailers

The handling and transport of radioactive materials are subject to several requirements imposed by:

#### Highway Code Applying to the Transport Assembly

This code specifies:

- Maximum total loaded weight,
- Distribution of the weight on the axles,
- Dimensions of the transport assembly,

- Design of transport equipment specifically for hazardous materials (electrical equipment, signals, and braking), and
- Submission to the Mines Branch (*Service des Mines*) to obtain a certificate of approval for registration.

### Regulation Governing Transportation of Hazardous Materials (Régiment des Transports de Matières Dangereuses - RMTD) of April 15, 1945 (With Numerous Revisions)

These regulations require showing the competent authorities (Ministry of Transport) that the vehicle complies with regulatory requirements concerning the nature of the risks due to the hazardous material being transported (class 7, 4th or 1st and 2nd categories) in order to obtain:

- The authorization for use of the roads (*carte jaune* - special vehicles license) for tank trailers designated "industrial containers," allocated to transport for low-level radioactive liquids (4th category of the RTMD group 70408); radioactivity limited to 100 A2.NOTEBA2 is expressed in Bq or Ci of each radionuclide, section VI, Table I of the RTMDNOTEB. (The special license is issued by the Mines Branch after examination of the technical specifications of the vehicle.)

- The acceptance of the tank as a type B (U) container issued by the Ministry of Transport for tank vehicles designated for the transport of intermediate, high- or very high-level radioactive liquids (greater than 100 A2 per load groups 70201 - 70102 - 70101).

The Transport Safety Commission of the Protection and Nuclear Safety Institute is responsible for submitting the approval request files to the Ministry.

In addition, the RTMD specifies in its articles 792 to 797 the conditions for the:

- Use of containers,
- Shipment of individual loads,
- Maximum authorized dose rates; 1 mGy/h (100 mrad/h) at contact on the accessible walls of the vehicle 0.1 mGy/h (10 mrad/h at 2 meters from these walls,
- Marking and labeling of the containers and
- Shipping restrictions;
- prior notification to the Directorate of Civil Safety for materials in 1st category (high activity),
  - handling,
  - storage,
  - fire precautions,
  - loading and stowing, and
  - marking and signaling of the vehicles (7D sign and an orange rectangle for the 1st and 2nd categories).

#### Safety of Transfer Operations Required by the CEA Safety Group Regulations

To ensure maximum safety in the filling operations for these three types of tanks, the fundamental basis is transfer under vacuum. The air exhausted from the tank is filtered before being released to the atmosphere. Draining is carried out:

- Under pressure for the low-activity tank (19.5 m<sup>3</sup>) and the high-activity tank (4 m<sup>3</sup>) and
- By siphoning under vacuum for the very high-activity tank (1,280 l).

#### Basic Design and Operating Specifications for Each Type of Tank Trailer Designed by Saclay Center

There is the LR 54 tanker trailer for the transport of low-level radioactive liquids.

There are three units in service: Two since 1985 and one since July 1990.

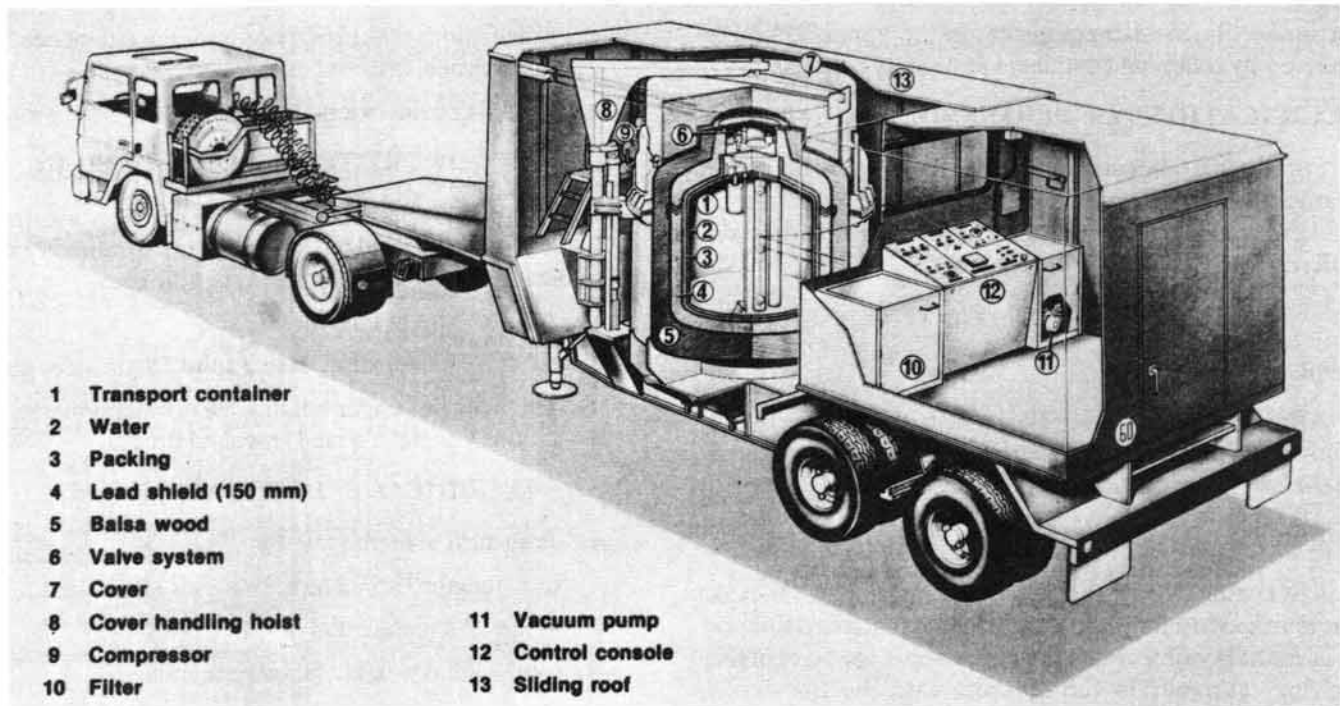
The technical report on the verification by the quality control organization (APAVE), which followed the construction and the authorization for use on the roads (special vehicle license) issued by the Mines Branch, certifies that this type of tank vehicle complies with the RTMD rules specifying the regulations for the construction, repair and use of metal tanks for the transport of group 70408 (low-activity) liquids. In addition to the annual highway code inspections, the special license is renewed every four years after verification tests are carried out by a certified expert (APAVE).

#### TECHNICAL SPECIFICATIONS

- Tank trailer
  - Total length: 13.5 meters
  - Total loaded weight: 38.5 metric tons
- Tank
  - Usable volume: 19.5 m<sup>3</sup>
  - Wall and interior fittings in Z1 CNDU I stainless steel (wall thickness: 8 mm),
  - Test pressure: 4.5 bars and vacuum tightness.
- Operating equipment:
  - Transfer arrangements (Fig. 2);
    - filling by evacuation of the tank using an independent compressor-vacuum pump system (extent of filling limited to 93% of the maximum volume),
    - draining by pressurization,
    - self-closing valves for transfer of the waste liquids,
    - constant level controls and alarms,
    - liquid sampling systems,
    - protective shield at front of the tank (12 mm of lead),
    - four independent level alarms,
    - two safety release valves on the compressor-vacuum pump circuit,
    - absolute filters before the exit to the atmosphere,
    - protection against overfilling by a safety volume and level alarm, and
    - control console and signal panel.

The controls, measurements, signals and alarms are assembled in a watertight unit in a compartment in the trailer.

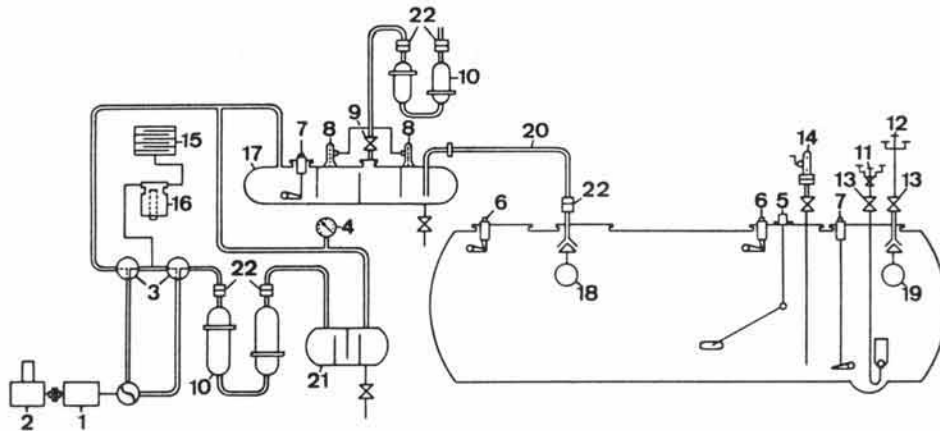
Note that during transport the contents are completely confined (all valves closed). In the event that the trailer is



- 1 Transport container
- 2 Water
- 3 Packing
- 4 Lead shield (150 mm)
- 5 Balsa wood
- 6 Valve system
- 7 Cover
- 8 Cover handling hoist
- 9 Compressor
- 10 Filter
- 11 Vacuum pump
- 12 Control console
- 13 Sliding roof

Fig. 1. LR 54 unit for the transportation of radioactive liquids.

Pumping diagram



- 1 Compressor-vacuum pump powered by an internal combustion engine
- 2 Internal combustion engine
- 3 3-way synchronized motorized valves (... draining - filling)
- 4 Vacuum gauge
- 5 Level indicator
- 6 High point indicator
- 7 Low point indicator
- 8 Safety release valve
- 9 Electrically-operated valve to atmosphere
- 10 Air outlet and aerosol filter
- 11 ZENITH RC 450-02 connector (draining)
- 12 ZENITH AU 650-03 connector (filling)
- 13 Safety valves
- 14 Removable sampling valve on a self-closing connector
- 15 Aerosol filter
- 16 Oil separator
- 17 Water separator
- 18 Automatic shut-off valve
- 19 Check valve
- 20 Flexible removable tubing
- 21 Oil-water separator
- 22 ZENITH self-closing connectors

Fig. 2. Low-activity liquid transport tank.

overturned, the service equipment in the upper section is protected by retaining containers and safety cradles.

**SPECIFICATIONS OF PERMISSIBLE CONTENTS**

Permissible contents and associated dose rate limits are given in above § "Regulation governing transportation of hazardous materials (Règlement des Transports de Matières Dangereuses - RTMD) 1945."

**OPERATION (Fig. 2)**

**Filling**

After connection of the filling tube to the transfer outlet of the unit with the wastes generated, the tank is evacuated and the exhaust air is filtered and released.

**Draining**

After connection with the INB35 transfer inlet, the tank is pressurized to a limit of 0.8 bar in order to initiate siphoning, as far as possible, when the unit is above the level of the receiving reservoir. In the opposite case the transfer is carried out at less than 0.8 bar.

**LR 56 Transport Assembly for Intermediate-Level Liquids (Type B [U] Container)**

Figure 3 illustrates one unit in service. The technical specifications for obtaining certification as a type B(U) container submitted to the Ministry of Transport led to the certification F/309/B/(U) F.

**DESCRIPTION OF THE PERMISSIBLE CONTENTS**

- Acidity limited to 50% for sulfuric acid and 30% for nitric acid,  
Concentration of Cl<sup>-</sup> ions less than 1 g.l<sup>-1</sup> and F<sup>-</sup> less than 10<sup>-1</sup>.l<sup>-1</sup>,
- Authorized radioactivity;
  - group 70201 limited to 3.10<sup>3</sup> A2 or 3.10<sup>4</sup> Ci,
  - group 70102 if greater than 70201 and as far as the dose rate limits are observed. The power of the contents is limited to 10 W and the fissile material to 200 g of <sup>239</sup>Pu.

**TECHNICAL DESCRIPTION RELATING TO OPERATIONAL SAFETY**

*This concerns the following main points:*

- Quality control of the construction,
- Analysis of the structural strength,

- Calculations of the behavior under accident conditions, drops, fire, and immersion, and
- Shielding calculations.

**REPORTS OF THE TESTS SCHEDULED IN RTMD APPENDIX III**

These tests are carried out on a mockup to demonstrate containment integrity under accident conditions:

- After a drop of nine meters and
- After a 1-meter drop onto a solid 15-cm steel pin.

The behavior under heating and immersion conditions was determined by calculations.

**TECHNICAL SPECIFICATIONS**

- Transport assembly;
  - total length: 13.5 meters,
  - height: 3.4 meters and
  - total loaded weight: 38.5 metric tons.
- Tank:

Type B (U) container for 1st and 2nd categories liquid radioactive material,

- Usable volume: 4 m<sup>3</sup> (88% of total available),
- Tank and interior fittings in stainless steel,
- Shielding: Equivalent to 50 mm of lead,
- Mechanical and thermal shielding (balsa wood and redwood) ,
- Testing pressure: 4.5 bar and vacuum tightness, and
- Operating equipment (Fig. 2);
- Transfer arrangements identical to those of LR 54.

**OPERATION (Fig. 2)**

The filling and the draining are carried out using the same transfer system as that of LR 54.

**LR 44 TRANSPORT ASSEMBLY FOR HIGH- AND VERY HIGH-LEVEL RADIOACTIVE LIQUIDS TYPE B (U) CONTAINER (Figs. 4, 5 and 6)**

There is one unit in service since 1978. As for the LR 56, the file for the application for certification as a type B (U) container and including the same requirements resulted in certification No. B/F 230 issued by the Secretary of State for Transport on June 22, 1978. The latest renewal was authorized in December 1990.

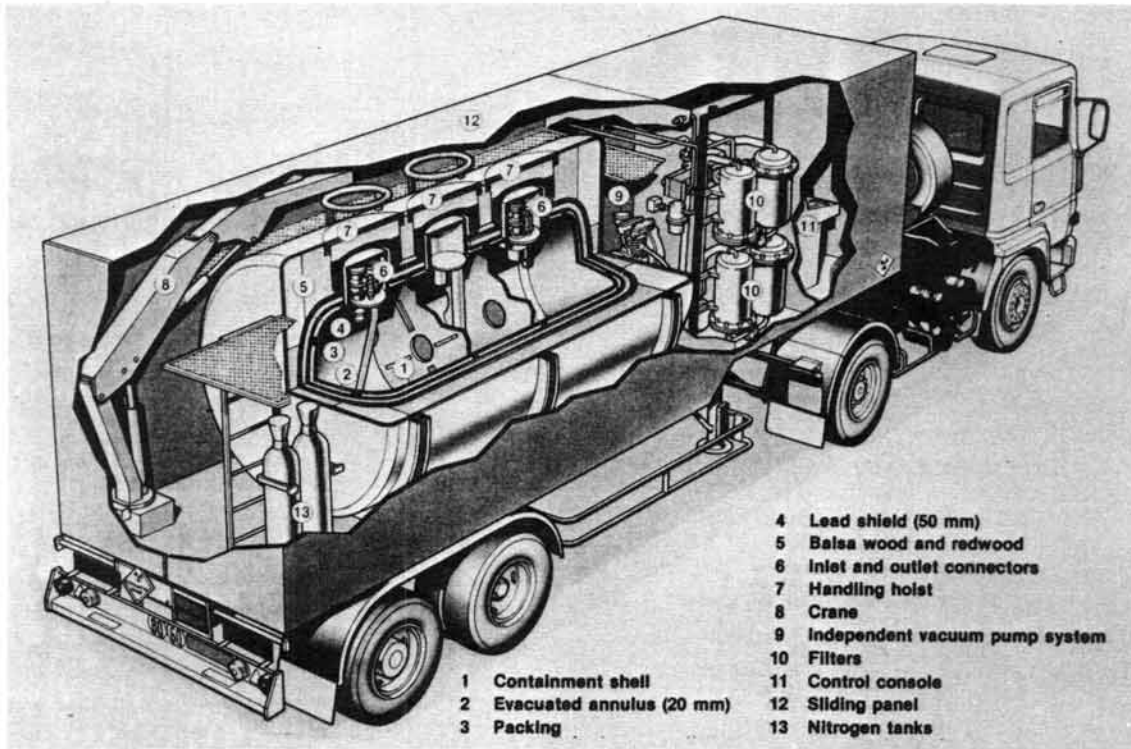


Fig. 3. LR 56 unit for the transportation of radioactive liquids trailer equipped with a type (B) U tank.

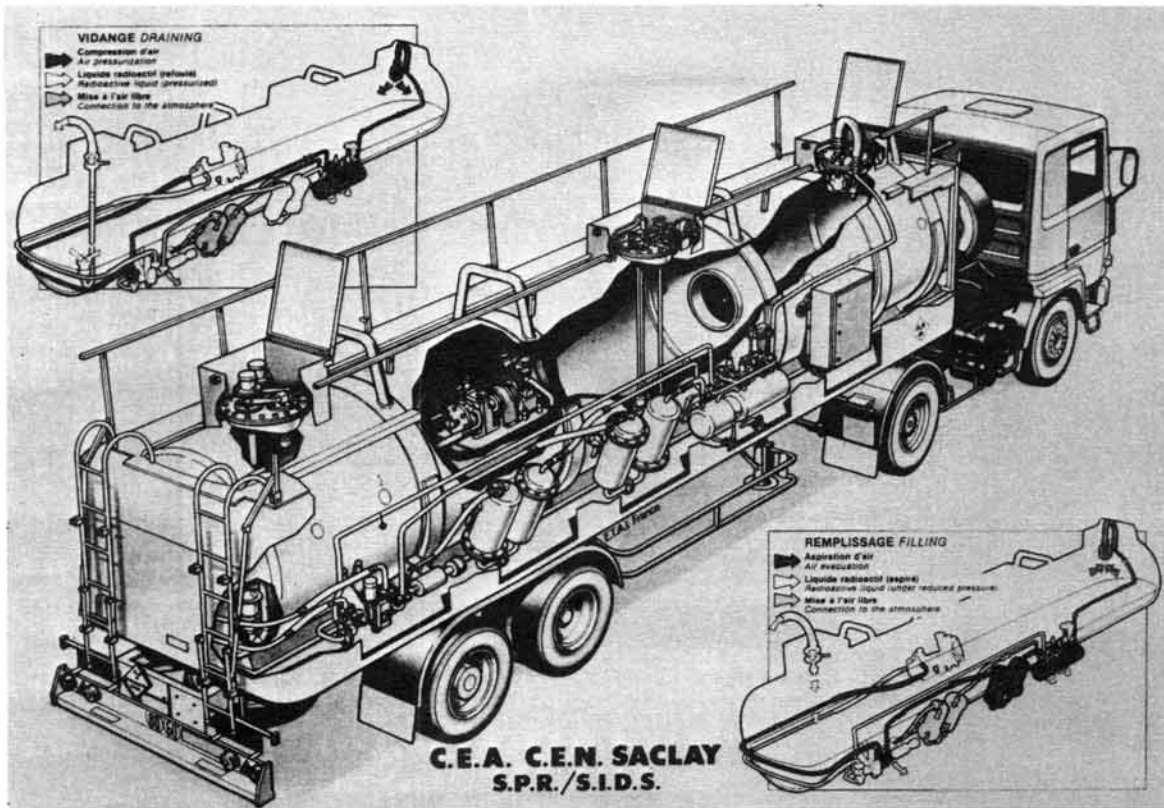


Fig. 4. LR 44 unit for the transportation of radioactive liquids trailer equipped with a type B (U) 230 tank.

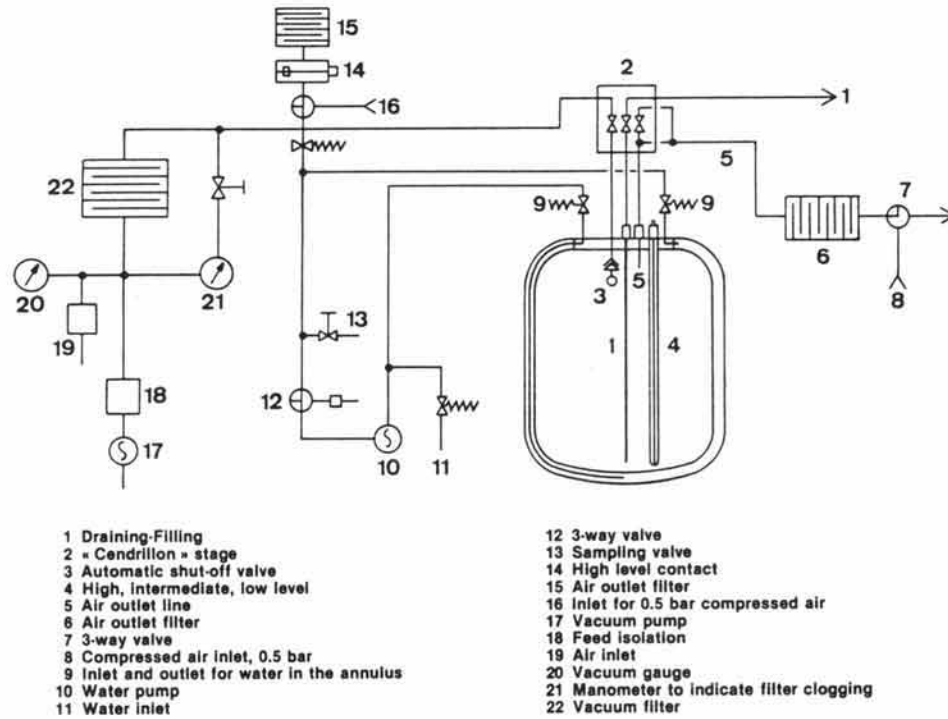


Fig. 5. LR 44 - flow diagram.

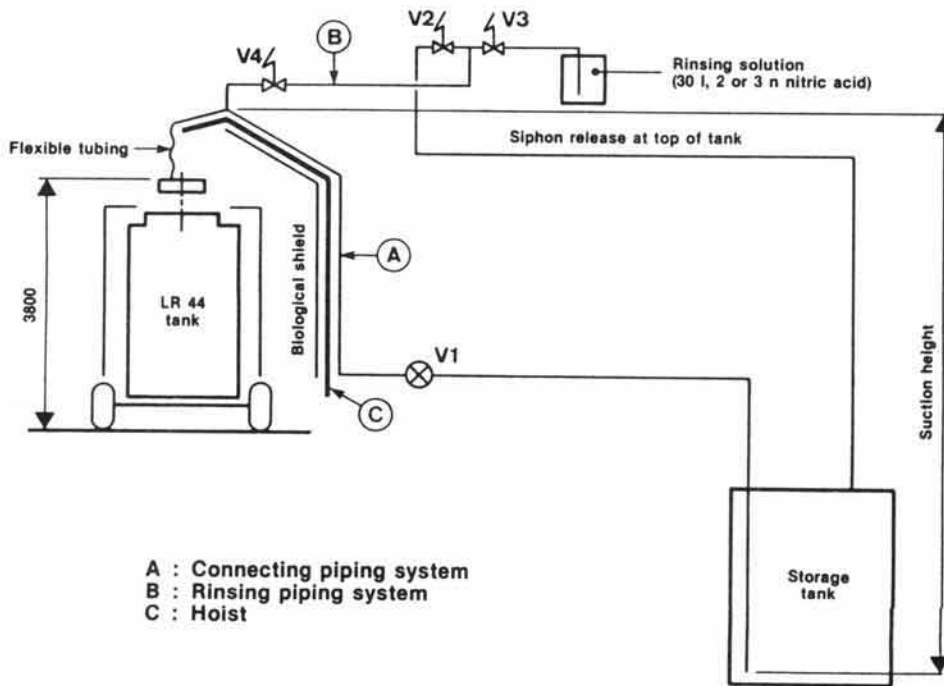


Fig. 6. Diagram of LR 44 storage tank connections.

### DESCRIPTION OF THE PERMISSIBLE CONTENTS

- Acidity limited to the same values as those for the LR 54.
- Radioactivity authorized;
  - group 70201 if limited to  $3.10^3$  A2 or 1,000 TBq ( $3.10^4$  Ci) and
  - group 70102 if greater than 70201, (for example, 1,000 TBq of  $^{60}\text{Co}$ ).
  - Insofar as dose rates cited are not exceeded, the power level of the contents is limited to 100 W without a preliminary test and to 400 W after a preliminary test showing that any radiolysis does not lead to a risk of over-pressurization.
  - the amount of  $^{239}\text{Pu}$  fissile material is less than 200 g.

### TECHNICAL SPECIFICATIONS

- Transport assembly;
  - length: 12.8 meters and
  - total loaded weight: 38.5 metric tons.
- Tank;
  - Double wall of Z 3 CNDU 17/16 stainless steel 10 mm annulus filled with water,
  - Usable volume: 1,280 liters (88% of total available),
  - Shielding: Equivalent to 150 mm of lead,
  - Test pressure: 3 bar at vacuum tightness, and
  - Thermal and mechanical shielding by 200 mm of balsa,
- Operating equipment (Fig. 4)

#### Transfer arrangements;

- immersed pipe for filling and discharging,
- "Cendrillon" type connection,
- pipe with float and safety plug for evacuation, and
- pipe leading to air outlet filters.

Note that during the transfer operations, all the connections with the vacuum system are made using hoses with self-closing connectors.

- Safety measurement and alarm equipment;
  - continuous and discrete level indicators (high, intermediate and low levels, preliminary and final alarm),
  - system for circulation of water in annulus with a sampling valve.
- Control compartment comprising a:
  - pumping system (vacuum pump powered by an electric motor),
  - filtration line for the exhaust air from the reservoir filter),
  - connection to the atmosphere with a second filtration line, and a
  - control console and indicator panel.

### OPERATION

The filling and draining are carried out only under vacuum after connection to a loading unit, shown schematically in Fig. 4.

### OPERATING RESULTS AND CONCLUSION

The handling and transport of liquid radioactive materials requires taking stringent precautions in the design, construction and operation of the vehicles to be used. The Saclay Nuclear Research Center is faced with these problems and operates under tank transport vehicles safety regulations using a specially trained staff. Since they have been put into service, the LR 44 has made 200 trips for facilities within and outside of the CEA. There has been  $33.10^3$  TBq ( $9.10^5$  Ci) transported over 170,000 km. The three LR 54 type units have transported 111 TBq (3,000 Ci) over a total distance of 300,000 km. The LR 56 has transported 50 TBq (1,350 Ci) over a total distance of 10,000 km.

All of these operations have been carried out without any significant incident involving the hazardous material transported.