High-risk derailment in a city centre

16th March, 1992

Aix-les-Bains (Savoy)

France

Transport of dangerous goods by rail

Ammonia (tanker car)

Dimethylamine (DMA)

Crisis management

Public information

THE FACILITIES INVOLVED


Photo: BARPI (R. R.)

This accident occurred at the Aix-les-Bains train station, located in the city centre. The closest buildings were only a few tens of metres from the railroad tracks.

The freight train was composed of 2 locomotives pulling 28 railcars, of which 3 were carrying hazardous substances:

- √ 1 tanker car containing 20 tonnes of dimethylamine (DMA), which is a toxic and highly flammable liquefied gas (with a smell of ammonia and fish);
- √ 1 tanker car, empty but not yet degassed, that had previously contained methyl ethyl ketone (MEK), a highly flammable liquid;
- √ 1 tanker car containing 44 tonnes of ammonia (NH_3), a flammable, corrosive, toxic and environmentally-hazardous liquefied gas.

The first two railcars were flatbed cars transporting axles and track-related equipment. The 3rd car was an empty, 2-axle grain car intended for the scrap yard; it was followed by a car containing empty barrels, the DMA tanker car, 2 other cars with empty barrels, the MEK-carrying car, the ammonia car and then 17 other empty cars. The last two cars in the freight train were carrying wood. The cars were placed in order depending on their respective destinations. All were equipped with braking systems, except for car no. 3, which had been damaged during a braking-related accident a few days prior and was being transported to the scrap yard[1].

This particular rail line carried heavy freight traffic in the direction of Italy (approx. 8.8 million tonnes / year), which represented nearly 10% of the company's total freight shipments. The track was renovated in 1958 and its grading had been readjusted in October 1988. The most recent track inspection had been conducted on 15th January, 1992 with no anomaly reported (i.e. with track characteristics lying within the tolerance thresholds applied by the railway operating company). According to the accident investigation report, "the track is old, yet remains well monitored and maintained; it is heavily loaded over its curved sections by railcars and has the tendency to be wide-gauged".

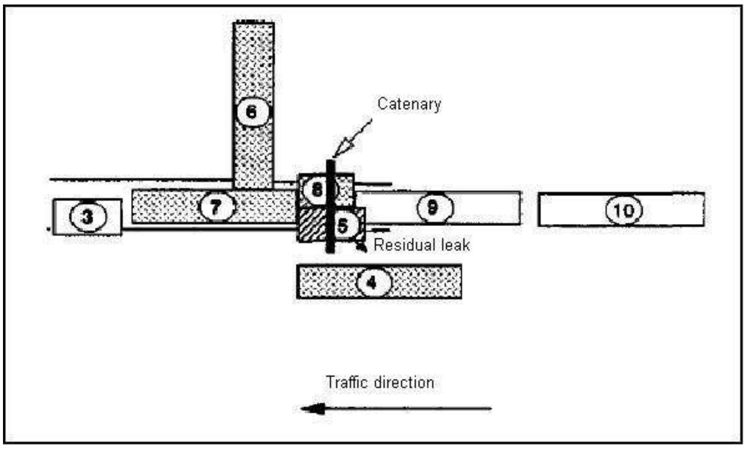
THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

At 2:25 am, le train rolling at 70 km/h derailed at the station entrance. The head of the convoy stopped at the level of the station's passenger terminal building. Both locomotives and the first two railcars did not derail. The convoy became unhitched from cars 3 through 8. Tanker car no. 9 filled with ammonia did not derail either.

The DMA car, which was heavily damaged, lay on its side on the station platform, blocking tanker car no. 8, which had not yet been degassed and had previously contained flammable liquid (MEK). This car no. 8 was pinned under a track signal crane and ignited after the catenary fell. The other tipped railcars blocked the major section of track on the Culoz-Chambery line. Some catenary lines were torn apart, while others were deformed by the heat of the fire.

[1] The transport company distinguished between 3 levels of rolling stock scrap. Level 1, for damaged equipment, indicated that the railcar was to be immediately removed from circulation. Level 2, which was assigned to car no. 3, did not include the circulation ban, but still implied the need for emergency repairs. The railcar owner, who possessed a sufficient fleet of cars, had made the decision to remove the 1962-built car from circulation rather than perform the necessary repairs.



Position of the railcars after the accident:

3) Empty, 2-axle grain car destined for the scrap yard

4) Closed car transporting new, empty 200-litre barrels

5) Car containing dimethylamine (22 tonnes of DMA)

6) Closed car transporting new, empty 200-liter barrels

7) Closed car transporting new, empty 200-liter barrels

8) Car containing methyl ethyl ketone (empty but under MEK atmosphere)

9) Car containing liquefied ammonia (40 tonnes of NH_3)

10) Empty flatbed car

Notified 5 min after the derailment, emergency response services were at the scene by 2:37 am. The heat radiating from the fire was intense; 20-m flames could be seen. 50 fire-fighters sought to control the blaze with foam: the fire was eventually extinguished at 3:50 am, but the drift of the ammonia-smelling cloud led local authorities to set up a 400-m safety perimeter, order the evacuation of all nearby buildings and request other neighbours to remain indoors.

The cloud dissipated using a water curtain produced using 2 industrial nozzles, complemented by 2 smaller nozzles, around 5 am. Two members of the chemical emergency squad, equipped with gas-impermeable suits, carried out a reconnaissance mission of the damaged railcars to identify the leak of hazardous substances and then proceeded with explosibility and toxicity measurements using Dräger tubes.

The results of these measurements demonstrated the efficiency of the response: the high-risk zone was limited to approx. 50 meters. The 400-m safety perimeter was maintained. The source of the cloud, which could be detected on the DMA car at around 5 am, was only isolated with precision at around 10 am; the leak stemmed from a suction flange damaged during the derailment and was estimated to be discharging at a rate of 100 g / minute.


Photo: BARPI (R.R)

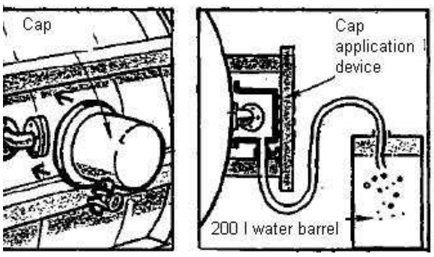
An emergency operational command post was set up at 10:30 am. The task of clogging the residual leak with a new blind flange proved a delicate step, since it could not be carried out with the equipment at hand, hence specialist assistance was sought. The local Prefect activated the TRANSAID procedure, which facilitated the deployment of experts in case of an accident involving the transport of hazardous substances.

In the early afternoon, both the municipality and Prefecture were regularly informing the local population either directly or via the release of bulletins.

The damaged flange was replaced at 5:30 pm, which enabled placing a 95% seal on the leak.

By the end of the day, the 19 railcars at the back of the train had been evacuated.

A customised "cap" was installed at 6 pm the next day in order to control the residual emissions. Sprinkling of the tanker car was then stopped and the DMA captured by this cap could be neutralised by dissolution in water.



With the immediate risk averted and given the accident response imperative, several crisis meetings were held among the various actors assigned to manage this situation.

The rail operator was interested in resuming traffic on the line as quickly as possible, leading to an initial attempt at transferring the tanker car contents onsite. However, given the urbanised setting (3,000 population to be evacuated) and the operation's inherent risks, the Prefect, advised by the Prefecture's technical units (DRIRE) as well as other experts dispatched to the site, decided to move the tanker to a safe place prior to performing any subsequent operation (see below for measures adopted).

Consequences of this accident:

Property damage was extensive: switching facilities deteriorated, the station's track A sustained heavy damage, rails on track B buckled, signalling and catenary installations degraded, 7 railcars seriously damaged.

Thanks to an overall favourable context, coupled with the resistance of these tanker cars and the rapid emergency response, this accident was not responsible for any significant environmental impact. Only the municipal treatment plant was slightly polluted by runoff water through the storm drains from the water curtain used to fight the blaze.

Attention should nonetheless be focused on the potential disaster of this accident, which was avoided thanks to the efficient tanker car design (specifically its shock resistance). Under the hypothesis of a major break in the ammonia tank, even the least pessimistic models would have forecast fatalities out to 1 or 2 km from the accident (for a 80-mm diameter break and a wind speed of between 1 and 4 m/s).

Photo BARPI (R. R)

The European scale of industrial accidents

By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States' Competent Authority Committee for implementing the '*SEVESO*' directive on handling hazardous substances, and in light of information available, this accident can be characterised by the four following indices:

The parameters composing these indices and their corresponding rating protocol are available from the following Website: http://www.aria.developpement-durable.gouv.fr.

The overall score of the "hazardous substances released" index reached a "2", as the quantity of DMA released could be estimated at 110 kg (i.e. a 100 g/min leak over an 18-hour period), which corresponds to less than 1% of the SEVESO threshold (parameter Q1).

Two fire-fighters, slightly disturbed during the intervention, were hospitalised for testing. Moreover, 700 convention centre attendees had to be evacuated for 5 hours, resulting in a "human and social consequences" index rating of "3".

With no accurate information available on the environmental consequences, the corresponding index was not scored.

Since the amount of damages apparently surpassed the €1 million euros (railcar damage alone was appraised by default at €0.6 million), the "economic consequences" index was assigned a "2" by default.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THIS ACCIDENT

The damage observed on the tracks both leading to the station and at the station itself, as well as observations recorded on the derailed cars, led to forwarding the following scenario: railcar no. 3, the empty 2-axle grain car on its way to the scrap yard, would have left the rails at 1.6 km before reaching the station, as a result of several factors: a track compliant with standards, yet with a tendency for gauge expansion; a damaged car no. 3, rolling empty (12-tonne weight) with 2 axles on the curved part of the track, and framed by much heavier cars (respectively 25 and 35 tonnes) fitted with bogies. Arriving at the station out of alignment, car no. 3 would have struck the cranes supporting the catenary lines and platforms, which in turn would have caused derailment of the subsequent cars.


Photo BARPI (R.R)

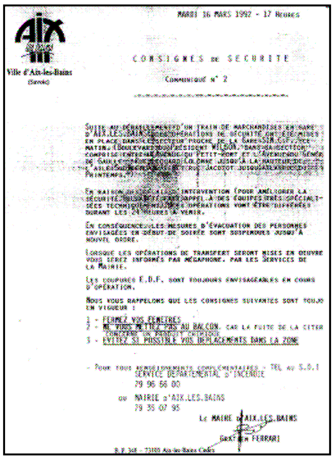
Moreover, the manhole cover on the tanker car that had not been degassed of MEK would not have been completely closed[2], thus making it easier for this highly flammable product to leak out, followed by its ignition, in the presence of a spark. This safety aspect had remained unverified at the time of "train verification prior to departure".

ACTIONS TAKEN

Crisis management

Given the limited local resources available to the freight company for managing this accident, the Savoy Departmental Prefect, joined later by the Ain Prefect (acting in accordance with the prescriptions of an emergency situation), assumed responsibility for coordinating the emergency response, with notable support provided by the Rhone-Alps DRIRE Office.

It was essential to keep the public notified in order to: avoid panic, complete all necessary evacuation operations, and not interfere with the work of responders. Collaboration between the City of Aix-les-Bains and the Prefect proved to be highly efficient: once the event had occurred, the population was kept regularly informed either directly or through published bulletins. A press release, widely disseminated on 16th March at 5 pm, provided a thorough summary of operations already underway as well as all decisions made. It also reminded the population of basic protection guidelines to follow and listed phone contacts to obtain further information.


Ville d'Aix-les-Bains (Savoie)

MARDI 16 MARS 1992 - 17 Heures

CONSIGNES DE SECURITE

Communiqué n° 2

[illegible]

En conséquence les mesures d'évacuation des personnes envisagées en début de soirée sont suspendues jusqu'à nouvel ordre.

Lorsque les opérations de transfert seront mises en oeuvre vous serez informés par mégaphone, par les Services de la Mairie.

Les coupures E.D.F. sont toujours envisageables en cours d'opération.

Nous vous rappelons que les consignes suivantes sont toujours en vigueur :

1 - FERMEZ VOS FENETRES
2 - NE VOUS METTEZ PAS AU BALCON, car la fuite de la citerne [illegible]
3 - EVITEZ SI POSSIBLE VOS DEPLACEMENTS DANS LA ZONE

- Pour tous renseignements complémentaires : TEL au S.D.I SERVICE DEPARTEMENTAL D'INCENDIE
79 96 66 00

ou MAIRIE D'AIX.LES.BAINS
79 35 07 95

Le MAIRE d'AIX.LES.BAINS

Gratien FERRARI

B.P. 348 - 73103 Aix-les-Bains Cedex

---

[2] According to the report released by the administrative hearing commission after the accident.

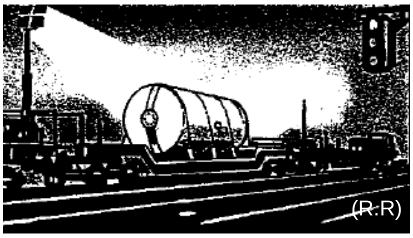
Removal of damaged tanker cars

The reconnaissance missions conducted on 16th March at 9 am did not provide any leads suggesting a rapid solution for the removal of hazardous products. In order to limit the DMA leak, a customised cap was installed during the evening of 17th March on the flange. Connected to a water spraying device, this cap served to neutralise the residual leak.

After a day spent assessing the situation between emergency response, public administration and backup deployment of experts from 5 private firms, the initial idea of performing a material transfer of the tanker cars onsite (in an urban area) was rejected. The decision was made to stand the DMA car up and move it to a safe place for the transfer operation.

Operations were prepared with extreme care: the freight cars blocking the track were removed, the NH_3 car was shifted, and a 200-tonne crane was brought to the site and installed.

On 18th March around 3:30 pm, approx. 700 people were evacuated from the convention centre. The lifting operation began at 4:30 pm. Two hours later, the DMA tanker car was loaded onto a lowered railcar, framed by 2 flatbed cars carrying safety equipment. The entire assembly was hauled as a special convoy to the Culoz marshalling yard, in the Ain Department. Since the convoy exceeded clearance on the left side, it had to circulate on the opposite track (i.e. on the right) to allow passing through tunnels. In all, the trip lasted nearly 3 hours travelling at 8 km/h.


(R:R)

The population was authorised to return to the evacuated zone around 8:30 pm.

The ammonia car, which was only slightly damaged, was pulled until reaching the destination plant in the Maurienne valley, where its contents were transferred without difficulty.

The rail installations were repaired at the same time the derailed cars were placed upright: rail traffic in all directions could resume on 20th March about 6:30 pm.

Subsequent handling of the DMA tanker car

After evaluating a range of technical solutions to drain the DMA car, the proposal from a Dutch chemical company was selected at 5 pm on 19th March. The tanker car would be raised and then emptied in its normal position using a dip tube inserted via one of the taps on the railcar dome. The other solution, which consisted of directly perforating the car, was rejected, primarily on the grounds of an excessive risk of ignition.

Once the tanker car had been placed upright, only after cooling with carbon dioxide (CO_2) in order to balance pressure, the transfer operation could begin on 20th March around 5 am and lasted until near 1 pm.

LESSONS LEARNT

This accident highlighted the need to be able to access at the very least, and as quickly as possible, Specialised Emergency Plans for the Transport of Hazardous Substances, as specified in the regulations (88/404 circular issued on 22nd November, 1988).

France's Transport Ministry assembled a special administrative hearing commission in order to determine / analyse the causes of this accident and draw lessons in the areas of prevention and organisation of systems for transporting hazardous substances by rail. Thirty recommendations (see Appendix) were subsequently submitted to the rail operator in order to:

- implement appropriate preventive measures on the rolling stock and rail track so as to avoid the risks of derailment and detect them in time;
- improve the safety of hazardous substance transport;
- establish how best to determine the factors leading to derailments (theoretical approach and feedback[3]);
- help clarify the responsibilities of the various actors in the handling of serious accidents;
- actively participate in developing emergency plans, within the scope of the initiative launched by the Interior Ministry.

On the whole, these plans should provide, whenever necessary, the list of transport companies as well as specialised firms (lifting, drainage, etc.) and the local, regional and national experts to be called. The information documents used as part of the TRANSAID procedure, which also plays a role, should contain the contact details of a greater number of competent actors, especially those handling rarer substances.

As exemplified by the coordination between internal/external emergency plans, these various plans should establish the conditions for triggering the transition from an internal phase to a phase requiring the intervention of outside

[3] Two similar accidents had occurred within the same region during the month of March 1992 alone. Also, the rail operator had not been receiving updated lists of rail accidents involving hazardous substances in France.

professionals, and *vice versa*, while specifying the type, role and location (control post, etc.) of these external actors (e.g. administrative agencies, industrial leaders, elected officials). Within such a framework, the legitimacy of actors and responsibility sharing must both be paid close scrutiny (including legal analysis). Alongside this approach, the eventual compensation remitted to outside professionals, in particular when requisition procedures are implemented, would also need to be explained.

Personnel training

The train conductor had not been instructed or informed of the kinds of products being transported; nonetheless, he did have in his possession a detailed document.

Public information

This accident also underscores the importance of effective information dissemination to the public throughout the crisis management period, in order to avoid panic and complete all necessary evacuation operations without interfering in the work of responders.

BAINS : A 2 H 25 HIER MATIN, ON A FROLÉ LA CATASTROPHE A L'ENTRÉE DE LA GARE

TRAIN DE LA PEUR

Falco.

Sept wagons d'un train transportant des matières dangereuses ont déraillé provoquant un incendie. On ne déplore pas de victime.

Mais, sous le choc, une citerne contenant du diméthylamine s'est fissurée faisant craindre une explosion. La fuite a été réduite, mais le gaz toxique ne pourra être transfér[é] que jeudi.

Photo M. P.

Extracted from "Le Dauphiné Libéré", 17th March 1992 (R.R)

L'EVENEMENT

AIX-LES-BAINS : LE PIRE ÉVITÉ

Un train de marchandises qui **déraille** à l'entrée de la gare, trois wagons de **matières dangereuses** en très mauvaises postures : le cœur de la ville a **tremblé,** hier. On ne déplore heureusement aucune victime

A un wagon du drame

Cet accident pose à nouveau le problème du transport des matières dangereuses

Dépotage

Extracted from "Le Dauphiné Libéré", 17th March 1992 (R.R)

20 years later…

In the area of prevention, the Law enacted on 30th July, 2003 introduced the obligation for transport infrastructure managers (marshalling yards, highway parking facilities, maritime and river ports) accommodating large quantities of hazardous freight to conduct safety reports. A decree issued on 3rd May, 2007 specified the conditions for applying this law, in moving the report submission deadline to May 2010. This decree moreover defined the thresholds at which safety reports were required.

These measures were supplemented by Law No. 2010-788 enacted on 12th July, 2010 (the so-called 'Grenelle 2 Law'), whose Art. 218 empowers the Prefect with additional policing authority to sanction the failure to submit a safety report and, if applicable, to impose operating adjustment measures when necessary in light of the hazard assessment.

Rail transport is also subjected to the Regulation relative to the international transport of hazardous freight by rail. For each type of freight, each railcar must meet a set of specific resistance criteria defined with respect to a given freight category, such as resistance to corrosion or the absence of porosity.

A procedure for mitigating risks at their source for this type of accident entails:

- the reliability of rolling stock, whose improvement depends on the efforts of: public authorities, responsible for establishing construction standards; contractors implementing these standards; certified maintenance workshops assigned to oversee equipment maintenance, railcar owners, responsible for the cars' state of repair; and the shipping industries, responsible for load contents;
- adoption of this procedure by certain rail operating companies and, as of a few years ago, by hazardous substance transport experts in each region of operations, in order to improve risk management at heavily exposed sites. These experts are assigned to identify, share and manage potentially hazardous situations in collaboration with material loaders and emergency response services. Another one of their missions is to complete personnel training in the field and monitor procedural efficiency;
- authorisation, for all rail transport of hazardous substances, to circulate within a pre-established rail corridor, along with a specific transport plan designed for radioactive materials. The continuous monitoring of hazardous substances should normally enable knowing at all times the type and location of risks incurred, with the rail infrastructure manager required to keep all relevant information updated and available;
- signalling, with orange signs affixed to the railcars displaying the identification numbers for both the type of hazard and material, making it possible to identify the product being transported as well as the hazard present, while relaying the corresponding safety fact sheets. In addition to this information, the police authority can call on technical assistance from the shipper, who remains responsible for the product until acceptance by the recipient. The TRANSAID protocol (signed in 1987 between the Interior Ministry and the Union of Chemical Industries) also provides the emergency services with recourse to the input of competent technicians located at chemical facilities nearest to the accident for the purpose of obtaining qualified assistance for several hundred different chemical products, in the form of information, advice and/or assistance and direct intervention at the accident scene;
- lastly, specific rules relative to the International Transport Regulation focusing on circulation and parking of tanker cars on rail network lines: parking time limited in the transport plan established by the facility manager (Art. 2.3.1.1 of the order on hazardous substance transport), parking in designated zones.

With regards to the protection at the national level, the facility manager is to prescribe measures to be adopted in the event of an accident or incident by type of rail operations. The manager also introduces in each marshalling yard a Hazardous Freight Plan, which, as a decision-making tool for crisis situations involving an accident / incident, is intended to:

- ensure efficient notification of emergency services;
- prepare emergency intervention conditions ahead of time;
- depending on the seriousness of the accident situation, take into account the safety of individuals present onsite or accompanying the train (partial or entire site evacuation);
- also pay attention to informing passersby at the site and employees engaged in permanent activities, by means of disseminating warning messages, in addition to informing train conductors concerned by specific measures.

These plans undergo coordination with emergency response services. Their efficiency necessitates a thorough understanding of the site's local specificities: type of hazardous substances, traffic, quantities, layout, and any unique vulnerabilities (urbanised area, water table, etc.). This requirement induces differentiation in the Hazardous Freight Plans across sites, while aiming for the same safety objectives. These plans pertain to all site activities, practiced on either a permanent basis (workshops, depots, etc.) or more temporary (trains passing through, temporary construction projects).

In all other rail stations, the facility manager has the opportunity to implement Local Hazardous Freight Plans, which set guidelines for assigning each entity's missions (personnel, public safety). These local plans overlap with existing departmental-level emergency plans in effect at the periphery of each considered site, thus providing additional assistance to public safety professionals throughout the crisis.

Periodic exercices are organised once a year in order to test the efficiency of these plans, while allowing emergency services teams to better comprehend the local context and its evolution over time.

APPENDIX

30 proposals issued by the Administrative Hearing Commission on the Aix-les-Bains accident

1. Promote research that enables defining the set of deterministic criteria that delimit potentially hazardous configurations (e.g. track-railcar interaction, train formation) in order to prevent the hazard from arising by means of adopting appropriate procedures.
2. Integrate new factors onto the strip chart, such as brake control activation, and improve document legibility by modifying the scales.
3. Improve feedback, by systematically combining and interpreting the detailed accident reports on freight trains, especially those in which an empty railcar with axles is assumed to have caused the derailment.
4. Establish an accident typology, conduct a risk evaluation using causal trees and failure trees, review the investigation data sheets on the basis of risk factors, build a detailed statistical database of freight train accidents that enables applying a probabilistic approach to the phenomenon.
5. Evaluate the feasibility of a robust system that serves to detect, on the main track, the simple derailment of an axle ahead of track switches, located within densely populated zones, with the capability of stopping the train before switching tracks; and develop the actual system adopted.
6. Evaluate the feasibility of railcar equipment along with a system that activates air depressurisation within the primary braking line once the offset of a derailed car with respect to the track axis is such that clearance of the opposing track may be encroached.
7. Assess the effect of lubricating pads, in a convoy capacity that features a non-homogeneous composition, on negotiating curves and eventually propose procedures for inclusion in the set of safety rules.
8. Improve the procedure for monitoring physical railcar condition and pay special attention to requesting written decisions from owners regarding maintenance operations.
9. Reassess tolerance limits for the determinant criteria relative to both track and rolling stock. On this topic, the Commission noted that since the accident, the SNCF Railway Company has already made such an assessment on the track spacing criterion and moreover, by circular dated 21st April, 1992, has notified its regional units of a decision to lower speeds to 80 km/hr for all "HA" and "ME" designated trains in all zones where the average spacing measured over 100 m is at least 1.455 m. This step must be taken while awaiting remedial works that the company has commissioned, in assigning the regions a deadline of 2 to 3 weeks.
10. Prohibit the insertion of empty railcars rolling on axles between the head of the convoy and railcars transporting hazardous substances.
11. Measure the advantages and disadvantages of separating homogeneous tanker cars when transporting hazardous substances.
12. Allocate several buffer railcars between those transporting hazardous gases and the other hazardous substance cars. This measure might not be applied to trains offering terminal service due to practical implementation constraints.
13. From this perspective, standardise the set of rules already applicable to railcars loaded with explosives.
14. Introduce an effective adversarial procedure for verifying the compliance of railcars transporting hazardous substances in bulk. Special attention must be paid to verifying the closure of all valves and manholes while under SNCF Railway responsibility after a junction with a private line.
15. Pursue efforts to generalise the conductor's access to clear indications of the names of hazardous substances being transported in bulk in addition to the hazard codes and material codes, as was the case in this accident.
16. Improve and generalise awareness and training campaigns relative to the characteristics and risks specific to hazardous substances among all personnel involved in the transport chain.
17. Consolidate, over the short term, the project to create a specific hazardous substances control centre within the SNCF company, by clearly stipulating objectives, including the establishment of closer ties with the chemical industry on the topic of material risks along with resources for coping with accident scenarios and the eventual reliance on input from specialists.
18. Review the procedure for accessing current databases in order to shorten the time required to meet the eventual needs of response teams, especially for information of a commercial nature.
19. Conduct a study and produce an inventory of potential accidents involving hazardous substances and likely intervention scenarios.
20. Create a database on the scenarios available for handling accidents involving hazardous substances. Be sure to provide database access to partners and response teams.
21. Incorporate the previous point in all departmental emergency plans focusing on rail accidents, with priority given to those departments crossed by major hazardous substance transport corridors.
22. Actively participate in Prefect-backed efforts to draw up Specialised Emergency Plans dedicated to the Transport of Hazardous Substances as well as External Emergency Plans.

23. Clarify the respective roles and responsibilities of the operating companies and loaders in the event of an accident, in addition to assessing the coordination with Prefectural authorities and departments under their authority when crafting the various emergency plans, including the specialised plan for hazardous substances and the external intervention plan.
24. Emphasise the level of coordination between the different levels of emergency plans: ORSEC Civil Safety (its appendix specific to rail), emergency plans relative to rail traffic, Specialised Plans for Transporting Hazardous Substances and External Intervention.
25. Officially assign the DRIRE Office to intervene, under Prefecture authority, whenever rail accidents involving hazardous substances occur.
26. Organise throughout the SNCF network intervention drills simulating the handling of hazardous substance transport accidents within a dense urban environment.
27. Develop and then generalise the application of safe systems for blocking vent closing mechanisms. As an example, a pin-based system could serve to ensure and maintain correct screwing of the butterfly clamps on the manhole cover. Moreover, it can be easily verified by simple visual observation by inspectors during surveys of convoy transport capacities or during technical inspections.
28. When selecting opening control mechanisms for internal valves, only accept devices that are insensitive to accidental external loadings (e.g. pneumatic type controls).
29. Gradually replace, during fleet renewal, railcars with axles by bogie-equipped cars offering better stability, beginning with those cars transporting hazardous substances.
30. In this accident, the tanker cars' shock resistance served to avoid exacerbation of the consequences. The commission recalled that the stiffness of tanker car cribbing was also a critical and determinant factor.