BEA-TT

Land Transport Accident
Investigation Bureau

Technical Investigation Report on the Derailment of a Coal Train on 29 July 2010 at Bully-Grenay (62)

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Technical Investigation Report on the Derailment of a Coal Train on 29 July 2010 at Bully-Grenay (62)

List of documentation

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Warning

The technical investigation which forms the subject of this report was carried out under Title III of law No. 2002-3 of 3 January 2002, codified in articles L 1621-1 to 1622-2 of the Transport Code and the Decree No. 2004-85 of 26 January 2004 relating in particular to the technical investigations conducted after a land transport accident or incident.

The sole object of this investigation was to prevent future accidents by determining the circumstances and causes of the event in question and preparing the appropriate safety recommendations. It does not aim to determine responsibility.

Consequently the use of this report for purposes other than prevention could lead to erroneous conclusions.

CONTENTS

Glossary

- **BAL** : Block Automatique Lumineux
- **CF** : Cylindre de Frein
- **CG** : Conduite Générale de frein
- **CODIS** : Centre Opérationnel Départemental d'Incendie et de Secours
- **COGC** : Centre Opérationnel de Gestion des Circulations (SNCF)
- **DBC** : Détecteur de Boîtes Chaudes
- **DFS** : Détecteur de Freins Serrés
- **EDF TL** : EDF Trading Logistics
- **EPSF** : Etablissement Public de Sécurité Ferroviaire
- **LORMAFER** : Société de révision de wagons et d'organes de wagons
- **PK** : Point Kilométrique
- **PN** : Passage à Niveau
- **RA** : Réservoir Auxiliaire
- **RAT** : Reconnaissance de l'Aptitude au Transport
- **RC** : Réservoir de Commande
- **RFF** : Réseau Ferré de France
- **RFN** : Réseau Ferré National
- **RST** : Radio Sol-Train
- **SNCF** : Société Nationale des Chemins de fer Français
- **STEM** : Surveillance des Trains En Marche

Translator's Note

Although equivalents for all these terms have been given above not many of them are currently used in British railway literature

- **ACLB**: Automatic colour light block
- **BC**: Brake cylinder
- **MBP:** Main brake pipe
- **DOCFE**: Departmental Operating Centre for Fire and Emergency Services
- **OCC**: Operating Control Centre (SNCF)
- **HBD**: Hot box detector
- **DBD**: Dragging brake detector
- **EDF TL**: Electricité de France Trading Logistics
- **EPSF**: French Railway Public Safety Organisation
- **LORMAFER**: Company which repairs wagons and parts of wagons
- **KP:** Kilometre post
- **LC:** Level crossing
- **AR**: Auxiliary reservoir
- **RSS**: Recognition of the suitability for service
- **CR**: Control reservoir
- **RFF**: Manager of the Infrastructure for the French National Railways
- **RFN**: French National Rail Network
- **GTR**: Ground-Train-Radio
- **SNCF**: French National Railways
- **MTIS:** Monitoring of trains in service

Summary

On 29 July 2010 at 11.10 am the 19 leading wagons of freight train SNCF 88214 became derailed on line 2 at the entry to Bully-Grenay (62) station. These wagons, loaded with coal, finished up sideways and resting on the tracks just past the station building, blocking the two main lines. They came to rest without causing any injuries but there was serious damage to the railway infrastructure over about 600 m.

The 19 wagons concerned were damaged and at least two of them were irreparable. On the other hand this accident did not cause any damage to the environment. On the first wagon, there were indications of a brake defect as some brake blocks had been discoloured by the heat and were badly worn. The wheels had been very hot and some had very big flats with hollowing of their treads.

The accident was caused by malfunctioning of the brake distributor on the first wagon of the train which resulted in the locking of the first two wheelsets of the train, the hollowing of their treads due to the rubbing on the rail then the derailment on the first switch of Bully-Grenay station.

This malfunction was probably due to the presence inside the distributor of solid particles due to an excess of sealing compound left during the last repair of this part.

Because of the place where the locking occurred and the few visible indications, the anomaly was not detected in time by the railway staff or by the automatic detectors.

The analysis of the causes and the circumstances of the accident resulted in the formulation of three recommendations to do with the following areas:

- the quality of the work done by the workshop which repaired the distributor;
- the skill of the staff who repaired the wagon parts;
- the density and the contents of the system for monitoring and detection of anomalies of trains in service.

1 - Immediate observations and opening of the investigation

1.1 - The accident

At 11.10 am on 29 July 2010 the 19 leading wagons of freight train SNCF 88214, coming from Dunkirk, became derailed on line 2 at the entry to Bully-Grenay (62) station. These wagons which were loaded with coal finished up sideways and resting on the tracks, just past the station building, blocking the two main lines. They came to rest without causing any injuries but there was serious damage to the railway infrastructure.

The two locomotives of the train were not derailed, as the coupling between the second locomotive and the first derailed wagon became uncoupled. On the first wagon, there were indications of a brake defect: some brake blocks had been discoloured by the heat and were badly worn, the wheels had been very hot and some had big flats with hollowing of their treads.

Illustration 1: General view of the accident

1.2 – Emergency services and assessment

The emergency services were called immediately and arrived on the scene at 11.26 am. As there was no risk to people the CODIS* 62* lifted its restriction at 12.01 pm. The accident did not cause any casualties and did not result in consequences for the environment.

The material damage was important:

➢ 19 wagons were damaged of which at least two were irrepairable;
➢ the infrastructure was seriously damaged over about 600 m.

1.3 – Traffic measures adopted after the accident

Bearing in mind the number of wagons derailed, their condition and their load, the lifting was difficult and required heavy equipment. The same was true for the repair of the railway infrastructure. No trains were run between Béthune and Lens for 12 days, and traffic was diverted through Don-Sainghin.

* Term listed in the glossary

Illustration 2: Lifting of the wagons

In view of the indications noted on the derailed wagons, EPSF* [The French Railway Public Safety Organisation] suspended the authorisation to operate wagons of the type involved in the accident on 31 July. This suspension was renewed on 3 November 2010 and was still in force at the date of publication of this report.

1.4 – Opening and organisation of the investigation

In view of the circumstances of this accident and its consequences, the Director of BEA-TT [The Land Transport Accident Investigation Bureau] decided to undertake a technical investigation by applying the second paragraph of Article 20 of Decree No. 2004-85 of 26 January 2004 regarding, in particular, technical investigations after land transport accidents (Annex 1). The investigator had received reports of the work done by the Pas-de-Calais (SDIS 62) Departmental Fire and Emergency Service. He visited the site of the accident to examine the parts of the infrastructure that were damaged and the SNCF Tergnier workshops to examine the wheels and the body of the wagon that caused the derailment.

As expert evidence had been ordered by the TGI (*Tribunal de grande instance*), [Higher Level Court] of Béthune, the investigator assisted by providing certain evidence as far as the requirements of his enquiry were concerned and reconstructions organised in this matter, in particular that concerning the brake at the SNCF Rennes workshop and that relating to the checking operations carried out before the departure from Dunkirk.

* Term listed in the glossary

2 – Background information for the accident

2.1 - The railway line from Arras to Dunkirk

The derailment took place on the line from Arras to Dunkirk, and more precisely on the Lens – Béthune section near the station of Bully-Grenay. The line is double track and carries a traffic of about 60 trains per day in each direction, made up, in particular, of freight trains coming from or going to Dunkirk, regional trains and the TGVs [high speed passenger trains] that run the Paris-Arras-Dunkirk service.

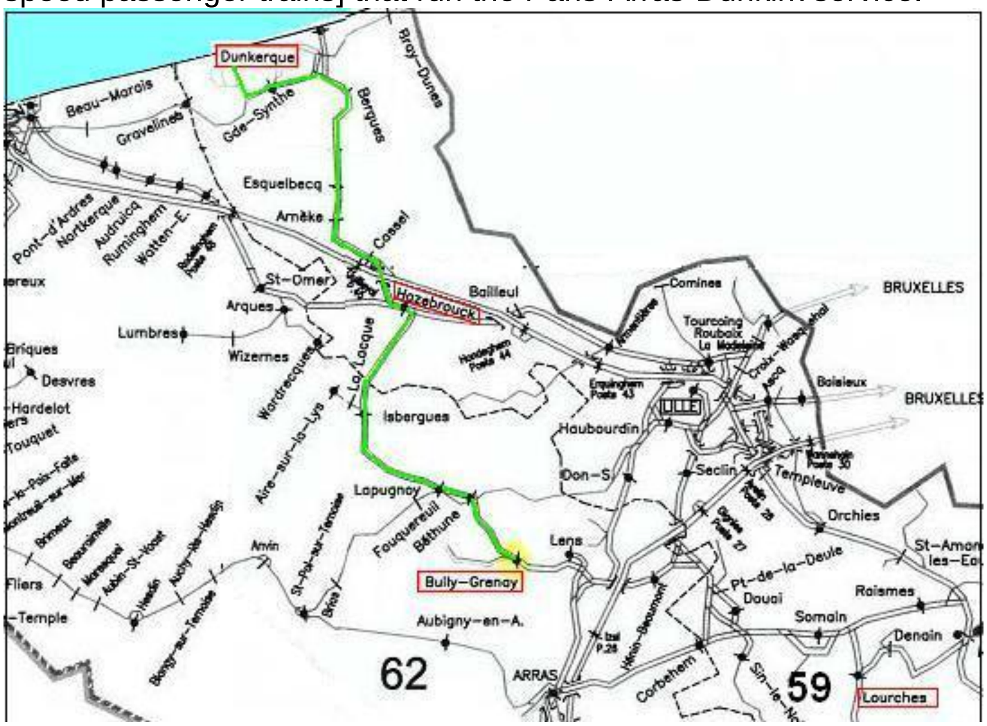


Illustration 3: Railway map

The line is electrified at single phase 25 kV and the maximum speed on the section where the accident occurred was 140 km/h.

The signalling system for the trains is ensured by the *block automatique lumineux** (BAL) [automatic colour light block system].

The line is fitted with *radio sol-train** (RST) [ground to train radio]. It is controlled by the *Centre Opérationnel de Gestion des Circulations** (COGC) [Operations Control Centre] at Lille.

In the zone of the accident the track runs straight in the SE – NW direction.

* Term listed in the glossary

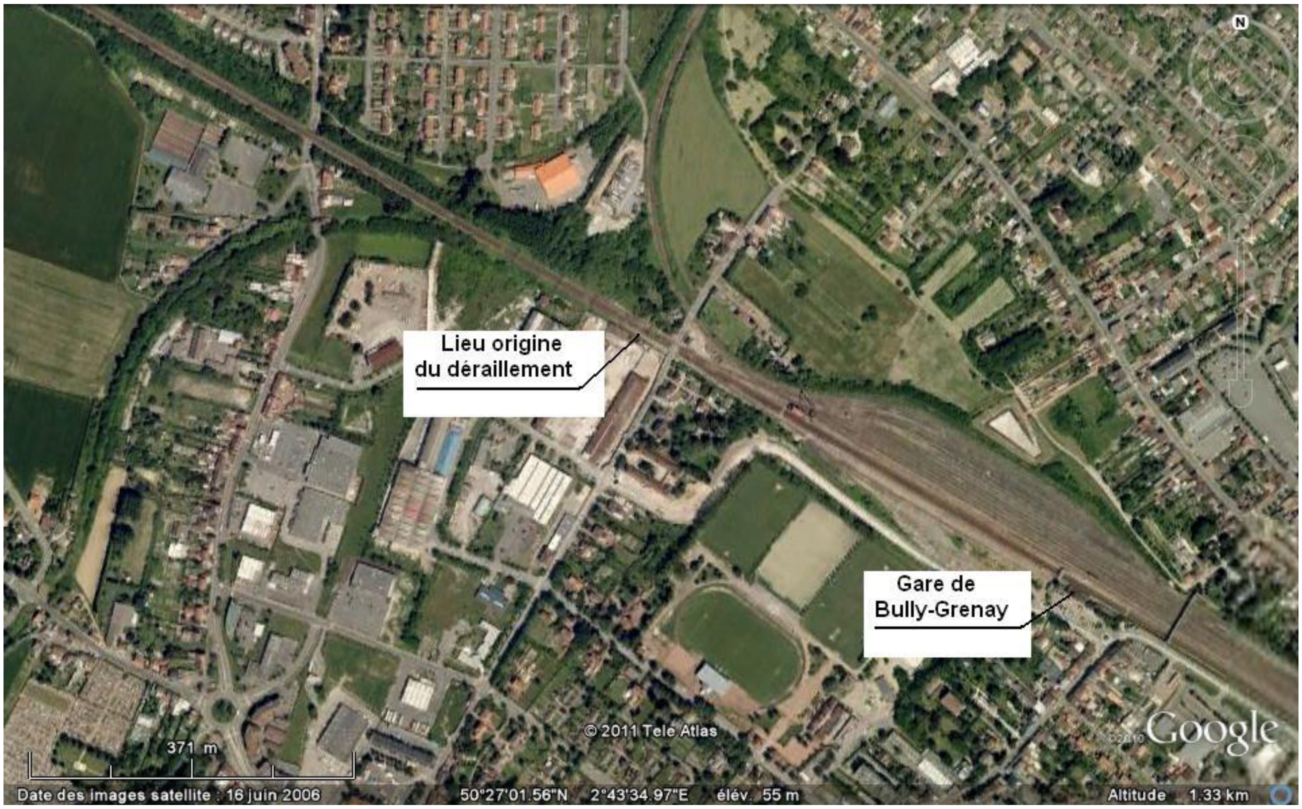


Illustration 4: View on the line close to the station Bully-Grenay

2.2 - Train 88214

Train 88214 was an SNCF freight train running from Dunkirk to Lourches (59). It belonged to the category MA 100 which is defined in the regulation S7A; its maximum speed was therefore 100 km/h and it was braked in the "goods" position.

On the day of the accident it was composed of 44 wagons loaded with pulverised coal for the EDF [*Electricité de France*] power station at Bouchain (59). Its total weight was 3 604 tonnes and its length was 700 m. It was hauled by two type BB 27000 locomotives working in multiple.

2.3 - The wagons derailed

The first wagon derailed in the direction of travel was No. 43 87 6531 611-4. It was the leading wagon just behind the locomotives. On the day of the accident it was loaded with 55.800 tonnes and its total weight was 77.400 tonnes.

All the wagons in the train belonged to EDF Trading Logistics and were of type EFc60. They were hopper wagons, made up of two half wagons permanently connected by a short coupling.

These wagons, designed to carry coal, were built in the years 1950 and 1960 by different manufacturers for private owners who specialised in the transport of heavy goods. They have the following characteristics:

- Tare: 21.600 tonnes
- Maximum load: 58.400 tonnes
- Maximum weight when loaded: 80 tonnes
- Braked weight when in the "loaded" position 48 tonnes

Illustration 5: Hopper wagon EFc60

These wagons have run since May 1989 under a derogation issued by the *Direction du Matériel de la SNCF* [SNCF Rolling Stock Department]. This derogation was necessary because the design features of these wagons required special rules for loading and operation. It was associated with restrictions on their use requiring them to run in block trains on certain services.

This was renewed on 3 July 2008 for the period up to spring 2014 which was the date when these wagons were to be retired from service.

3 - Report of the investigations carried out

3.1 - Summary of the declarations and statements

The summaries given below were prepared by the technical investigators on the basis of the declarations and statements of which they were aware, by selecting the elements that appeared to be relevant to the understanding of the events. It may be that there are divergences between the various statements or with the conclusions put forward by others, or with the description of the facts selected by the investigators such as appears in Chapter 5.

3.1.1 – Statement by the driver of the derailed train

At 11.10 am when running at about 100 km/h, the driver felt a jolt. He looked out of the left side window and saw a cloud of dust. He thought that a coupling had broken. Just at the time when he was getting ready to brake, signal box 2 of Bully-Grenay asked him by radio to make an emergency stop.

He made an emergency brake application and felt a jolt coming from the back. Looking out of his right hand window he saw that the loading gauge of the adjacent line 1 had been fouled. He set off the luminous and radio alert signals and contacted the regulator to ensure that he had activated the protection of this line.

3.1.2 – Statement by the Dunkirk Rolling Stock Inspector

The inspector had carried out the examination of train 88214 to check its ability to transport and the complete brake test with the remote control device, from 6.20 am to 8.00 am, without finding any anomaly.

3.1.3 - Statement by the signalman in signal box 10 at Dunkirk

The locomotives arrived at 9.02 am and were coupled onto the train at 9.05 am by one of his colleagues. The man then went to the back of the train to carry out the brake continuity test.

At 9.36 am he reported to the signalman in signal box 10 that the brake test had been completed. He then returned to the front of the train to tell the driver that the brake test was finished. He gave the starting signal at 9.41 am and watched the train leave without noticing anything unusual.

3.1.4 - Statements by signalmen in the designated monitoring signal boxes

The staff responsible for monitoring the trains in service at signal boxes 1 and 2 at Hazebrouck and at signal box 1 at Béthune watched the passing of train 88214 without noticing anything unusual.

* Term listed in the glossary

3.2 - Examination of the graphical recordings

3.2.1 - Running through the junctions at Hazebrouck

The junctions at Hazebrouck are situated about 45 km before the site of the accident. It was noted that the train was delayed by adverse signals on the approach to Haute-Loge junction and the driver had braked with a depression of 0.8 bar.

A jolt of 2 km/h was noticed just before the junction. This jolt was probably due to a longitudinal reaction of the train. Haute-Loge junction was passed through at less than 20 km/h. Then the speed increased to 60 km/h and then to 100 km/h.

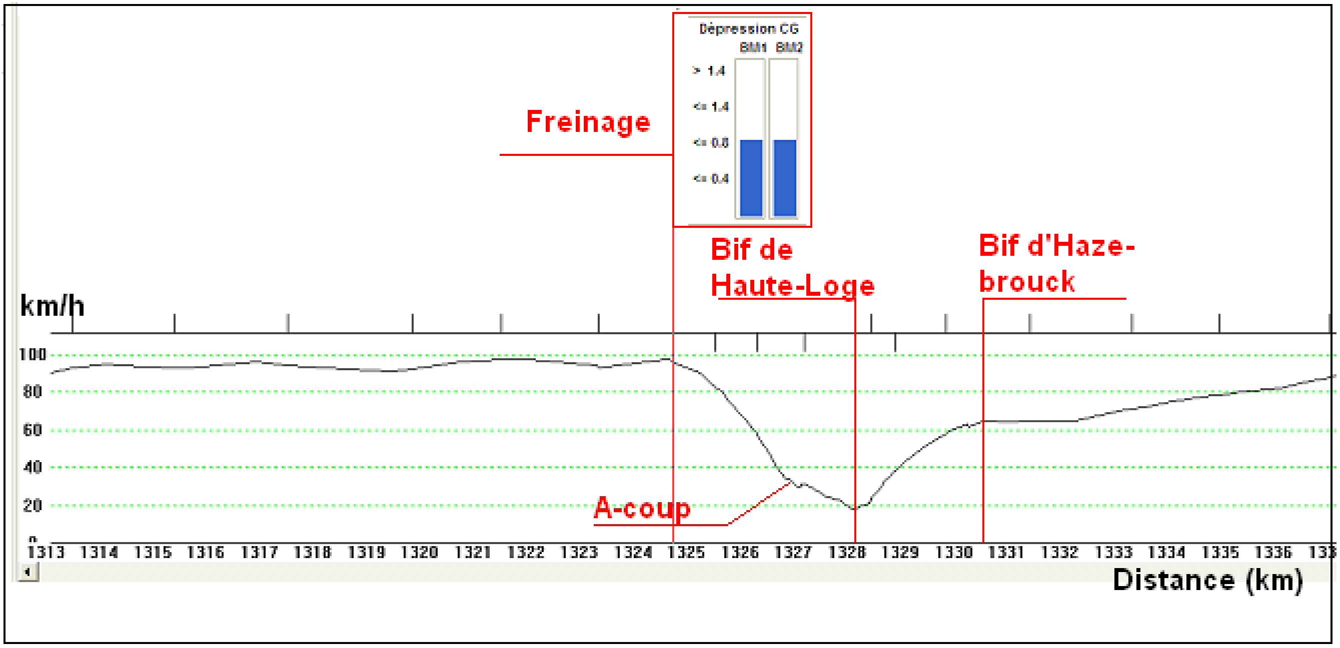


Illustration 6: Junctions at Hazebrouck

3.2.2 - The approach to Bully-Grenay station and the derailment

The speed fluctuated between 80 and 100 km/h. The driver did not use the system of *vitesse imposé* (VI) [imposed speed] in accordance with the recommendations of the *SNCF Direction de la Traction* [SNCF Traction Manager]. At the approach to Bulley-Grenay, it stabilised at 83 km/h. It was at this speed that the derailment occurred.

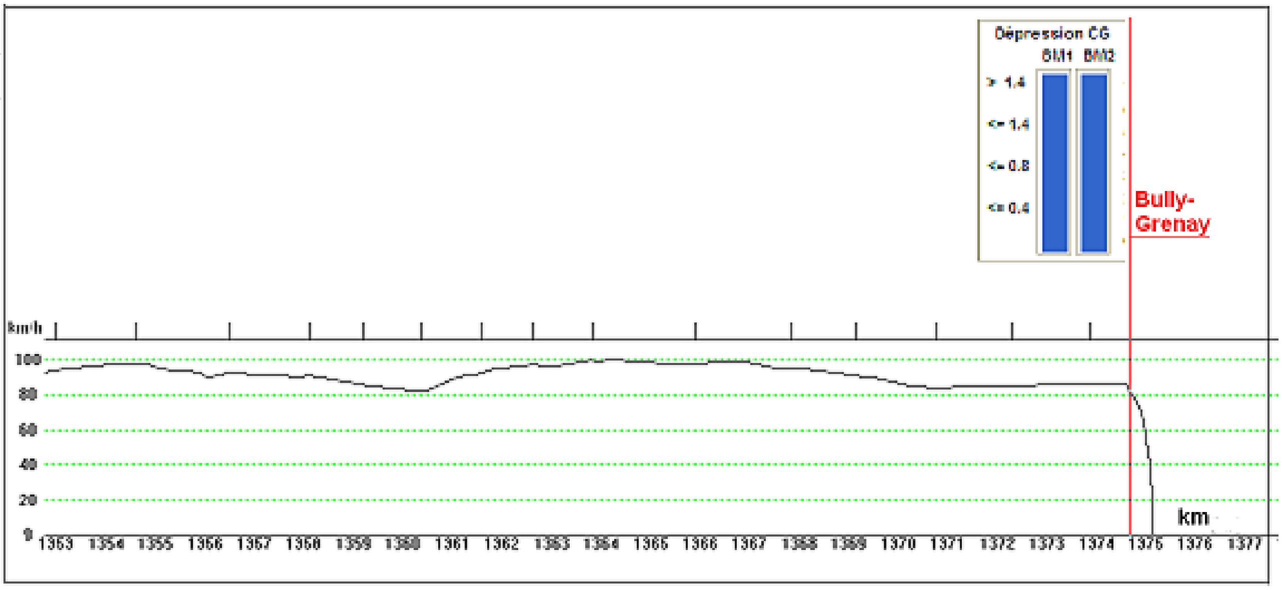


Illustration 7: Approach and emergency brake application at Bully-Grenay

3.3 - The rolling stock


Illustration 8: The first wagon of the rake, lying on its side

3.3.1 - The assessments on the rolling stock

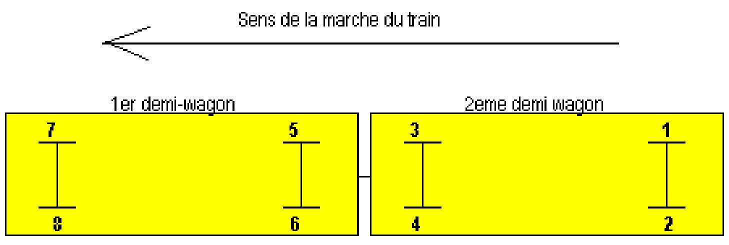


Illustration 9: System of numbering of the wheels and the wheelsets

On the first half wagon
The brake blocks that were still present were in good condition and did not have any indication of overheating. The treads of the two wheels of the wheelset still present (wheelset 5-6) had three very large flats, the longest of which was about 20 cm long. At this size of flats the tread is hollowed at the centre forming a projection near the external side of the tread. By the flat which was the most marked, this projection reached a height of 8 mm.

At the back of these flats in the direction of rotation the metal had flowed and formed waves. The other wheelset of this half-wagon (wheelset 7-8 at the head of this train in the direction of travel) was found later. On the two wheels of this wheelset there was a flat similar to those on wheelset 5-6 but longer (25 cm) and more hollowed with a projection reaching a height of 13 mm. Moreover, one of the wheels of the wheelset had moved and was free on the central part of the axle.

Illustration 10: Wheel of wheelset 5-6 with flat, plastic flow and projection

In view of these indications it was concluded that the rotation of the wheelsets of the first half-wagon had been locked and that they had slid on the track for several dozen kilometres. Wheelset 5-6 had turned on several occasions causing three flats spread around the circumference of the two wheels. Wheelset 7-8 had not turned which explained the presence of a single flat on each wheel but longer and deeper.

It was noted that the brake blocks still present on this half-wagon did not show any trace of heating and were not worn.

Illustration 11: Wheel shifted on wheelset 7-8

On the second half-wagon

The wheelset in position 3-4 was present on the wagon; it had indications of serious overheating (metal blued, paint burnt). The four brake blocks of this wheelset were still in place but showed traces of overheating and heavy wear, the blocks being almost completely worn out.

The wheelset in position 1-2 was missing; it was located and identified. It had the same appearance as the wheelset 3-4. The same is true of the corresponding brake blocks.

It appeared, therefore, that the second half-wagon had run with the brakes applied for a considerable distance causing the overheating of the wheels and the blocks which were almost completely worn out. The absence of a flat on the tread indicated that the wheelsets of the second half-wagon had not been locked, unlike those of the first half-wagon.

Illustration 12: Wheelset 3-4 with its brake blocks very badly worn

On the brake equipments of the first wagon

On the wagons of type EFc60, the brake distributor (see illustration 20) is common to the two half-wagons. It was noted that the distributor isolating cock was in the "in service" position and that the handle of the "empty-loaded" device[1] was on "empty".

On the rest of the wagons

The other wagons did not show any traces of locked wheelsets or of applied brakes similar to those observed on the first wagon. The brake equipments were in the normal position, corresponding to the bulletin of train braking: distributors in service and "empty-loaded" devices in the "loaded" position.

Partial conclusions

The indications observed enabled it to be concluded that there was a malfunction of the brake on the first wagon of the train. This malfunction resulted in a total locking of wheelset 7-8 (situated at the front in the direction of travel), a partial locking of wheelset 5-6 (situated in the second position) and a brake application without locking of the two wheelsets of the second half-wagon.

The position on "empty" of the lever of the "empty-loaded" device observed after the derailment is not compatible with the damage observed on the wheels of this wagon. It was concluded that this lever became displaced when the wagon was lying on its side.

3.3.2 -The maintenance of the wagons concerned

The organisation of the maintenance
EDF TL*, owner of the wagons of which train 88214 was made up, had entrusted the engineering of the maintenance and the implementation of the maintenance schedule for its wagons to the SNCF *Direction du Matériel* [Rolling Stock Department] since 1 January 2007.

This work was the subject of contracts 177/07011, then 177/08007.
These contracts specify that the maintenance should be done according to the rules laid down by SNCF and in workshops approved by SNCF.

1 The "empty-loaded" device aims to reduce the brake power of the wagon when it is empty or lightly loaded in order to limit the risk of locking and damage to the treads (flats) which can result.

* Term listed in the glossary

The maintenance history of the first wagon derailed
It was found that the work was done by companies approved by SNCF. The last repair was that dated 19 December 2007. The bill from the workshops showed that the brake distributor had been repaired on this occasion. The work done on 28 May 2010 concerned the brake rigging. The information supplied by EDF TL showed that the wagon had run on several days in June and July 2010 without problems. It can be concluded from this that the brake had been correctly put back into service after the repair and that this had no connection with the accident.

Entretien réalisé depuis les 5 dernières années sur le wagon N° 43 87 653 1611-4

numéro document	date intervention	entreprise intervenante	lieu de la prestation	prestation réalisée
1	28/05/2010	SNCF	Dunkerque	réformé pour défaut frein "semelle débordante" (voir devis / facture)
2	28/02/2008	SNCF	Dunkerque	réformé pour défaut sur poignée de changement de régime (voir devis)
3	19/12/2007	LORMAFER	Creutzwald	révision complète infrastructure
4	20/09/2006	VFLI CARGO	Freyming	travaux sur la superstructure
5	09/11/2006	LORMAFER	Creutzwald	graissage des commande de trappes
6	25/05/2005	LORMAFER	Creutzwald	révision complète infrastructure

Illustration 13: Maintenance history supplied by EDF TL

3.4 - The railway infrastructure

The first traces of derailment were found on line 2 near the *traversée jonction double* (TJD) [double diamond crossing] 22/23.

3.4.1 – The investigation close to the place of derailment

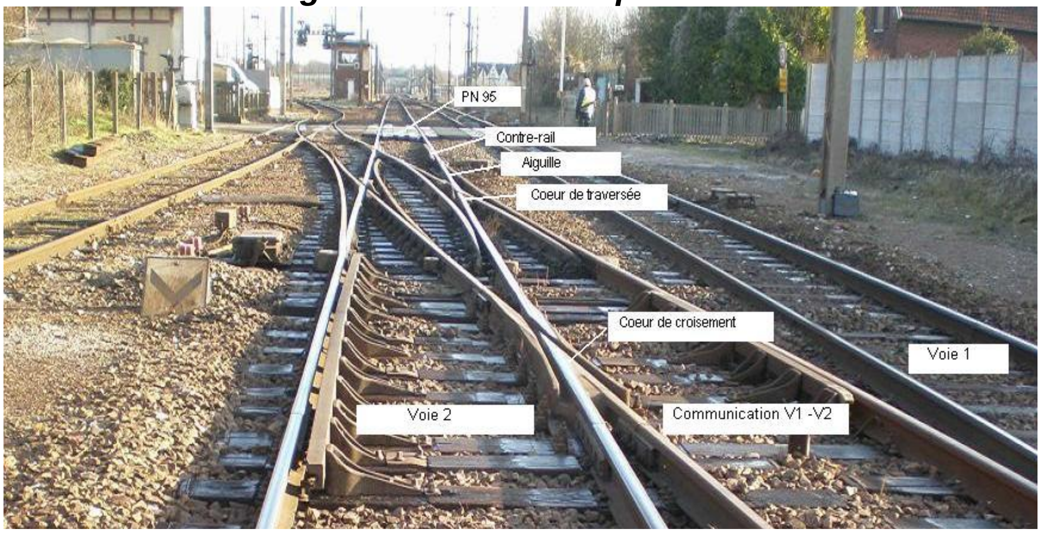


Illustration 14: General view of the double diamond crossing 22/23 on line 2

Longitudinal rubbing marks could be seen on the common crossing and the obtuse crossing corresponding to the projections of the wheels of the first half-wagon.

Illustration 15: Common crossing with marks

Illustration 16: Obtuse crossing with marks

It was noted at the switch that the stock rail had been forced outwards and the chairs were broken.

Illustration 17: View of the switch and the stock rail

On the check-rail there were traces showing that the rail had been displaced towards the outside and that the flange of the wheel bore on the web of the rail and on the fish plate. Beyond the level crossing there were traces of wagons running on the sleepers inside the track and on the outside on the left side indicating that three wheelsets had derailed.

Illustration 18: Traces of derailment on the check rail

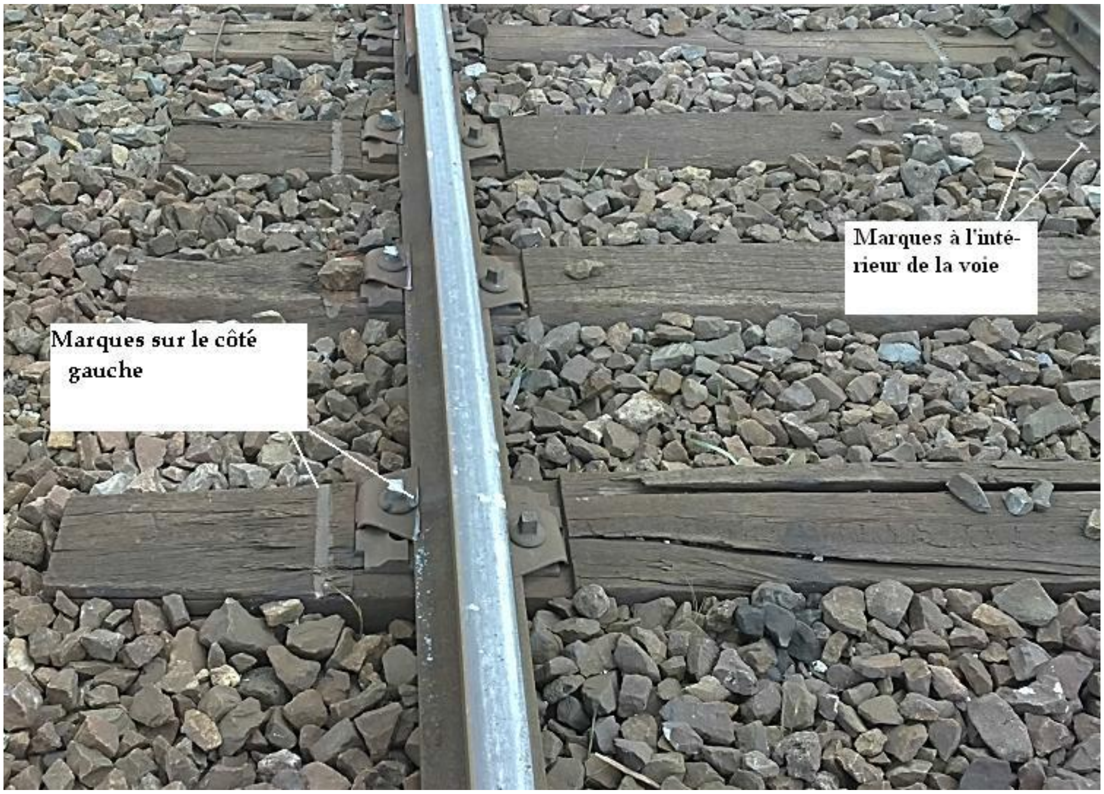


Illustration 19: Marks on the sleepers beyond the level crossing.

In view of the indications that could be seen close to and down line of the diamond crossing 22/23, it was concluded that the wheelsets of the first half-wagon were locked and could not rotate, the projections of the right wheels of these wheelsets were inserted between the switch and the stock rail and spread this rail. These wheels derailed at the tip of the point at KP** 219.375 and they slid between the check rail and the rail spreading the rail and marking its web.

From the decking of level crossing 95 to KP* 219.347, the left wheels of these wheelsets also derailed. Under the effect of the shock against the decking, one wheelset of the second half-wagon derailed. The first wagon, therefore, continued to run with three wheelsets derailed for almost 700 m until a point where the derailment increased and became catastrophic, just after the platforms and the building of the station at about KP* 218.700.

3.4.2 - Investigations up line from the place of derailment

Traces of rubbing on the rail surface were observed during the investigations carried out immediately after the accident, from KP* 219.900, in particular on the expansion joint situated at KP* 219.430.

In the days following the accident SNCF track maintenance staff found traces that might be attributed to the sliding of a wheelset that had a flat and a projection similar to that mentioned in Item 3.3.

These traces were seen on the device 31A at Isbergues (KP* 249.300) as well as at Lillers (KP* 242) and Béthune (KP* 230). After Isbergues traces were also noted of impacts on the insulating joints and the rail connections, proof that the flat was already present. No indication was observed further back than Isbergues and, in particular, at Hazebrouck (KP* 263) which is the preceding station.

3.4.3 - The maintenance of the infrastructure

The track dates from 1980. It is made up of long welded rails of UIC 60 type on wood sleepers. The maintenance is carried out by the track unit "Artois-Douaisis" which is part of the infrapole "Artois-Hainaut" an organisation in the SNCF Infrastructure Activity.

The last recording of the geometric characteristics of the track (Mauzin record) was done on 9 February 2010. A distortion of 9 mm on 3 m was found on the diamond crossing 22/23. This distortion corresponds to a warning level which does not require a speed restriction to be imposed; it was rectified on 1 March 2010. The crossing 22/23 was laid new in 1972. Before the accident the last annual check on its safety dimensions was carried out on 20 January 2010.

* Term listed in the glossary

3.5 - Experience from similar events

Two previous derailments have occurred on the French national rail network due to locking of wheelsets:

➢ the first was on 14 June 1992 at Ambronay in the Ain region; a wagon of train 455559, running between Gevrey and Ambérieu derailed on a switch because of the presence of flats that were 280 mm long with hollows on the treads of wheels 1 and 2. These flats were caused by the locking of the wheelset 1-2 during a braking incident. The wheelset 3-4 had the brake applied but was not locked and its brake blocks were almost completely worn out. The place where the braking incident originated was not determined and the malfunction of the distributor could not be reproduced. (Knorr distributor; wagon registered in Germany).

➢ the second occurred on 14 December 1992 at Macon-Loché in Saône-et-Loire, on the Paris – Lyon high speed line; a bogie of TGV 920 was derailed at full speed, on a switch due to the presence of serious flats and hollows on one wheelset. The locking was due to the failure of the wheelslide protection equipment on one bogie. The place of the locking was determined to be 50 km before the derailment.

4 - Investigations on the brake incident

4.1 - Operation of the railway brake

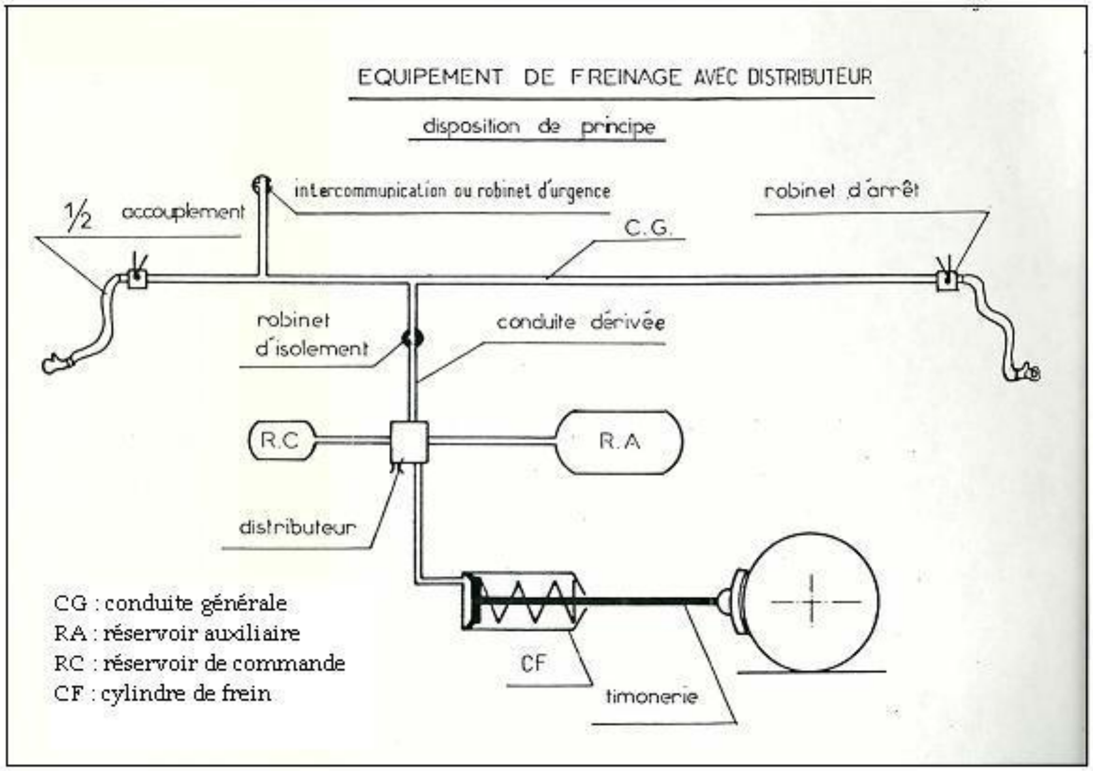


Illustration 20: Schematic diagram of the pneumatic brake of a wagon

The main brake pipe connects all the vehicles in the train to the locomotive. The air pressure in the main brake pipe is controlled by the train driver by means of a device situated in the locomotive and called "the driver's brake valve". When running, in the absence of a braking command the pressure in the main brake pipe is kept at the reference pressure of 5 bar. The driver applies the brakes by reducing the pressure in the main brake pipe.

On the vehicles, the control reservoir, which is quite small, serves to maintain the reference pressure; the auxiliary reservoir, which is bigger, serves to store the compressed air necessary to supply the brake cylinders and operate the brake gear. When running they are in communication with the main brake pipe and their pressure is 5 bar.

When a depression is produced in the main brake pipe the control reservoir remains at the reference pressure and the distributor puts the auxiliary reservoir into communication with the brake cylinders by modulating the pressure admitted to the brake cylinder depending on the pressure difference between the main brake pipe and the control reservoir:

➢ if the depression in the main brake pipe is between 0.2 and 1.5 bar, the pressure admitted to the brake cylinder is proportional to this depression;
➢ for a depression of less than 0.2 bar, the pressure in the brake cylinder is zero;
➢ above 1.5 bar the pressure in the brake cylinder is the maximum. This maximum pressure is determined at the design stage depending on the characteristics of the vehicle and its braking equipment. On the wagons this maximum pressure can be modified depending on the load of the vehicle by operating the handle of the "empty-loaded" device or on certain wagons, automatically by a weighing device.

The type of wagon that was involved in the accident is fitted with a manual "empty-loaded" device; the maximum pressure in the brake cylinder is 3.8 bar in the loaded position and 1.6 bar in the empty position.

4.2 - Technical cause of the brake incident

Brake incidents are not rare events, in particular on wagons. On the French National Network their annual number is thought to be about 500 of which more than 400 involve wagons. These incidents are not events that are very critical, as their consequences are normally limited to superficial damage to the wheels and to the brake blocks, or even the block carriers.

The main causes of these incidents are:

➢ driver's error which is especially possible with the old type of driver's brake valve (type H7A). With the modern valves with electrical control (type PBL), the depressions and the re-supply are automatically calibrated, avoiding handling errors;
➢ the malfunctioning of the driver's brake valve which is very rare and results in incidents affecting several vehicles, or even the whole of a train;
➢ the operation of a cock on the main brake pipe which leads to the venting to atmospheric pressure of the main brake pipe at the front (the case of the front cock) or at the back (the case of the rear cock);
➢ the operation of the isolating cock on a vehicle, the closure of which causes the application of the brakes on this vehicle alone;
➢ the malfunctioning of the brake distributor[2] of the vehicle which is the cause of about three quarters of the brake incidents. The distributor is a complex piece of equipment containing pistons, membranes, joints, check valves and pneumatic pipes some of which are of small diameter. It is likely to have continuous and reproducible failures (pierced membranes, leaking joints, etc.) or intermittent failures. These intermittent failures that the maintenance staff are not able to reproduce are not exceptional and can be the origin of repetitive incidents that occur at intervals of several weeks. The presence of foreign bodies in the distributor can be the cause of an intermittent failure.

The train that suffered the accident was hauled by modern locomotives of type BB 27000. These locomotives are fitted with a driver's brake valve of type PBL which prevents the driver making brake handling errors. The incident was limited to a single vehicle, so the malfunctioning of the driver's valve and the operation of a cock on the main brake pipe can be ruled out.

The operation of the isolating cock can also be ruled out since this was found by the investigators to be in the normal position on the wagon in question. In addition, in the absence of a stop on the line it could only have been operated after the brake test and before the departure of the train. Such an operation would have no logical justification. The position of the valve on the frame of the wagon set back from the body makes it very unlikely that it was accidentally operated by a branch or an object that penetrated into the loading gauge. At this stage, a malfunction of the brake distributor of the wagon appears to be the most probable cause.

4.3 - Investigation on the brake distributor of the wagon

On wagon 611-4 the function of the brake distributor is carried out by:

- a Charmilles distributor type C3A LG;
- an adjustable pneumatic relay type A2E to carry out the "empty-loaded" function.

2 On the wagon in question the function "brake distributor" was performed by a C3A LG distributor and a pneumatic relay A2E. In the remainder of the report the term "distributor" refers to this assembly.

4.3.1 - Maintenance history

The distributor was repaired in March 2007 and fitted in the wagon in December 2007 during its last repair. These two operations were carried out by the Lormafer * de Kreutzwald (57) works which is approved by SNCF for these operations. The history of the relay was not clearly established. The last maintenance mark was dated 1992. It was not possible to interpret this.

4.3.2 - Assessment on the test stand

This assessment was done by the SNCF Works (Technicentre) at Rennes.

Assessment of the distributor

The tightness and functioning tests showed non conformities on the supply, application and release times as well as an exit pressure greater than the standard. However, these anomalies are not such as to explain the braking incident. During the dismantling a strip of Loctite orange product was found around the seat of the main valve and particles of this product in the sieve of the interface filter with the auxiliary reservoir on distributor side. Some accumulations of hardened and dried grease were also seen.

* Term listed in the glossary

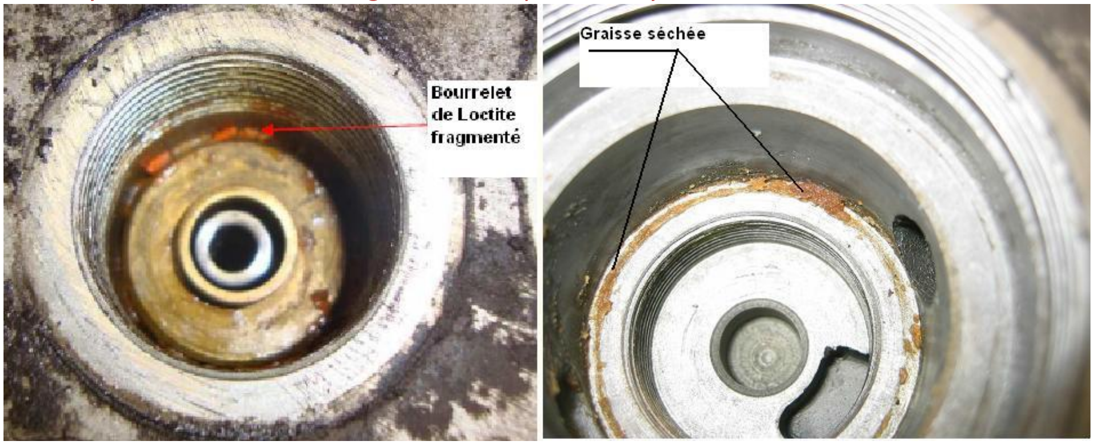


Illustration 21: Dismantling of the distributor

The presence of these materials which are likely to block the pipes of the distributor in an intermittent manner is not normal.

Assessment of the pneumatic relay

The bench tests showed that there was a serious leak and a utilisation pressure slightly higher than normal in the "empty" position. During the dismantling, swarf was seen inside the relay and on the seats of the valves. This pollution explains the leak found on the bench. It probably came from the cutting of the pipes after the accident, during the removal of the relay for it to be sent for assessment. A strip of adhesive was also found around a check valve seat from which fragments might have broken off.

4.3.3 - Scenario of the malfunctioning of the distributor

BEA-TT has worked out a scenario based on the presence of particles in the distributor leading to a feed of 5 bar to the brake cylinders and to the non-release of the brake on the wagon in question. This scenario is presented in Annex 2.

4.4 - Explanation of the locking of the wheelsets

In general a brake incident does not cause the axles concerned to lock; the axles continue to turn and the brake equipment overheats more and more and wears until the blocks or the pads are completely worn away. In the case of an empty or lightly loaded wagon, wheelset locking is possible when the "empty-loaded" device is incorrectly left on "load". In the case of a loaded wagon the locking is very improbable, as the power of the brake is always small compared with the weight. The locking of both axles of the leading half-wagon is a unique case which must be explained.

* Term listed in the glossary

The braking of type EFc60 wagons is controlled by a single distributor feeding two brake cylinders each situated on one half-wagon with the same pressure. Each brake cylinder operates the brake rigging of its half-wagon, applying the cast iron brake blocks on the wheels. The cast iron blocks have a coefficient of friction which is constant at speeds above 50 km/h but which increases markedly at low and very low speeds.

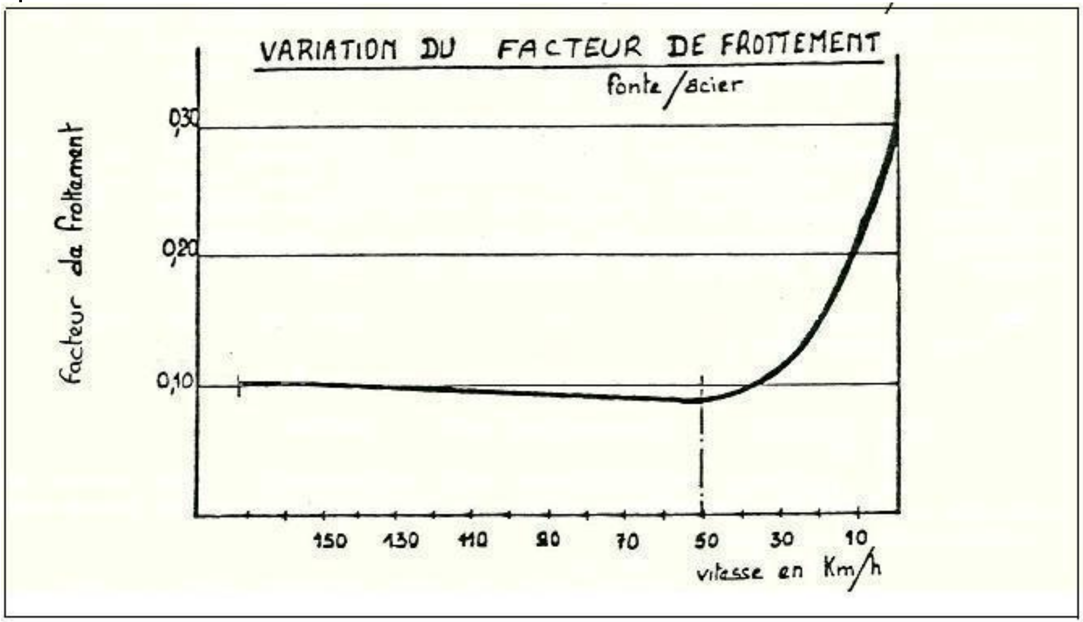


Illustration 22: Variation of the coefficient of friction for cast iron on steel with speed

It, therefore, appears that at low speeds the locking of the wheelsets of a wagon fitted with cast iron blocks becomes possible even on dry rails. Then, once the locking has occurred, if the brakes remain applied the wheelsets remain locked even if the train regains its normal speed.

Examination of the ATESS recording of the train showed that this condition of low speed only occurred on leaving Dunkirk and when slowing at Hazebrouck. When slowing at Hazebrouck, the moderate braking (depression of 0.8 bar) commanded by the driver would not enable the wheelsets to lock even at low speed when the distributor operated normally. The scenario described in Item 4.3.3 shows that a malfunction of the distributor can lead even during moderate braking, to feeding the brake cylinders with a pressure of 5 bar, which is likely to cause locking of the wheelset.

The difference of behaviour of the two half-wagons (locking on the first half-wagon and application of the brake without locking on the second half-wagon) can be explained by different factors which, without presenting abnormal behaviour can, when combined, lead to the difference found. These factors are, in particular:

➢ a difference in the behaviour of the mechanical parts of the braking system connected to the wear and the friction in the articulations:

➢ a non-uniform distribution of the load between the two half-wagons The loading documents transmitted by the port operator Sea-Bulk gave the load per wagon but did not specify the distribution between half-wagons. The wagon 611-4 had a total weight of 77.4 tonnes for a maximum of 80 tonnes; a distribution of 37.4 tonnes and 40 tonnes between the first and the second half-wagon is not impossible nor abnormal at first sight;

➢ a longitudinal compressive reaction of the train causing a slight unloading of the first half-wagon favouring the locking of its wheelsets. Such a reaction is always possible during the braking of a long train like train 88214. It can be felt, in particular, on a vehicle at the front, as locomotives have different braking characteristics to the rest of the train.

4.5 - Location of the brake incident

An untimely malfunction of a distributor may be produced when this is prompted during a braking action. The last braking actions before the accident were:

➢ the slowing down at Hazebrouck, about 50 km before the accident;
➢ the dynamic test of the brake about 80 km before the accident;
➢ the brake test before departure from Dunkirk, about 100 km before the accident.

In view of the intensity of the brake application of the wagon in question necessary to make the wheelsets 5-6 and 7-8 lock, a distance of 80 or 100 km would have caused the total wear of the brake blocks and the attack on the brake block carriers of wheelsets 1-2 and 3-4 which were not locked. The fact that these blocks, although not new when the train departed, were not completely worn at Bully-Grenay (see illustration 12) and the experience from the accident at Macon-Loché, where the distance run with the axle locked was 50 km, showed that the brake incident was probably initiated by the slowing down at Hazebrouck.

This hypothesis was confirmed by the fact that the initial traces of sliding on the rails and the points and crossings were only visible after Isbergues station situated about 20 km after Hazebrouck.

4.6 - Non-detection of the brake incident

4.6.1 - Non-detection by the system for monitoring of trains in service (STEM)*

Article 502 of the Regulation S2C "Running of Trains"[3] stipulates that *"Whenever they are not prevented by the execution of their normal duties, sedentary staff who are involved with the running of trains as well as the staff working on the lines [...] shall observe the trains passing by in order to detect any dangerous deficiencies for safety […]"*.

Moreover on certain lines, a regional instruction designates the signal boxes and stations responsible for carrying out the systematic monitoring of trains passing by. The spacing of these monitoring points is dealt with in the General Notice S2C (DCO 1515) and is summarised in the table below.

Tonnage journalier total brut moyen remorqué (T) sur la section de ligne (2 sens réunis)	Distance entre deux points de surveillance successifs quel que soit le côté des voies principales où s'effectue la surveillance	Distance entre deux points de surveillance successifs situés d'un même côté des voies principales
T > 60 000	60 km	120 km
30 000 < T ⩽ 60 000	70 km	140 km
T ⩽ 30 000	80 km	160 km

For the Dunkirk – Arras line, the regional instruction DCO 0208 specifies:
- ➢ monitoring on the left side by P2 at Hazebrouck, 55 km from Dunkirk;
- ➢ monitoring on the right side by P1 at Hazebrouck, 58 km from Dunkirk;
- ➢ monitoring on the right side by the P1 at Béthune, 90 km from Dunkirk;

The rules of the General Notice S2C are therefore complied with.

Illustration 23: View of signal box 1 at Béthune; line 2 is in the foreground

[3] Reference DCO 1514 and published by the order of 23 June 2003 concerning the regulation of safety applicable to the national rail network.
* Term listed in the glossary

In view of the train noise produced by heavily loaded hopper wagons passing, the noise produced by a brake incident would hardly be noticeable by sedentary staff. Staff can probably only detect the problem by seeing any sparks that may be produced by the rubbing and the smoke given off by the brake equipment when it reaches a very high temperature. Now the rubbing on the rails of the wheels of a locked wheelset causes only a few sparks and little smoke. On the other hand application of the brakes without locking as on the second half-wagon is normally more visible.

In view of the estimated place where the brake incident occurred, the overheating of the wheels and the brake gear was still insufficient to be visible from Hazebrouck signal boxes. Béthune signal box 1, which is more than 30 km from the start of the brake incident, was geographically better placed to detect the anomaly. However, it is about 30 m away from line 2 and the vision of the lower part of the wheels is hindered by the presence of a platform.

4.6.2 - Non-detection by the rolling stock anomaly detectors

The national rail network is equipped with a network of hot box detectors* (HBD) some of which are connected with a dragging brake detector* (DBD). Currently, apart from the high speed lines there are 263 HBD*s of which 150 have a DBD*. There are no other types of detectors on the conventional lines of SNCF, unlike other railways which have installed detectors for excessive load, infringement of loading gauge, wheel impacts, etc.

In France there is no maximum distance between HBD*s on lines where the maximum permitted speed is less than or equal to 160 km/h. Only the document EPSF* SAMI D001[4] recommends on these lines a mean distance between HBD*s of 65 km with a maximum of 150 km. The deployment of DBD*s is not specified. SNCF specifies in the Directive MA0078, that freight trains should pass a HBD* between 50 and 250 km after their departure and then every 450 km.

There is no HBD* between Dunkirk and the site where the derailment took place. The first HBD on the itinary of the train would have been that at Bully-Grenay situated 102 km from the starting point of the train, 500 m after the place where the accident occurred. Overall the train concerned observed the Directive MA0078, and the installation of the HBD* on the route taken meets the recommendations. However, the distance of the order of 100 km without a HBD between Dunkirk and Bully-Grenay, is considerably greater than the mean for a line with heavy freight traffic.

[4] A technical document the provisions of which are not mandatory

* Term listed in the glossary

5 - How the accident developed and the emergency services coped with it

5.1 - Formation of train 88214 and running up to Hazebrouck

On 28 July 2010, the wagons of train 88214 were loaded with coal at the Sea-Bulk dock of Dunkirk West Port. This train was formed of 44 double wagons of type EFc60. At 10.50 pm it was put into track No. 17 of Dunkirk signal box 10 where it underwent an inspection on 29 July from 6.20 am to 8.02 am to see that it was fit to run followed by a complete brake test by an SNCF Rolling Stock Inspector. No anomaly was found in the course of these operations.

After locomotives BB 27068 and 27076 had been coupled in multiple at the head of the train, a continuity test was carried out at 9.36 am. The test was satisfactory. The signal to depart was given at 9.41 am; the train passed in front of the operator man of signal box 10 who did not detect any anomaly.

During the phases of increasing the speed, coasting and during the dynamic brake test carried out at 10.05 am at a speed of 80 km/h the driver did not experience any abnormal behaviour from his train. He then ran at a speed which varied between 85 and 95 km/h. At 10.31 am, at the approach to Hazebrouck, the driver saw adverse signals and made a moderate brake application with a depression of 0.8 bar. During this braking the distributor of the first wagon malfunctioned and caused a brake application on this wagon with a pressure of 5 bar in the brake cylinders.

In the section before the junction the driver reduced his brake application and only left a depression of 0.4 bar. The first wagon remained strongly braked. As the speed of the train reduced, the braking of the first wagon intensified (see article 4.4) and when the speed dropped to less than 20 km/h at Haute-Loge junction, the wheelsets of the first half-wagon locked.

When, after this junction, the driver released the brakes and applied power again the brakes of the first wagon remained strongly applied with the wheelsets of the first half-wagon locked.

5.2 - Journey to Bully-Grenay and derailment

The train picked up speed and ran at 60 km/h to Hazebrouck signal box 1, then its speed varied between 80 and 100 km/h. The treads of the wheels of the first half-wagon became hollow as they rubbed on the rail. A flat was formed with a projection near to the external side of these treads. These projections began to mark the switches at Isbergues and continued to grow in thickness. The wheels and the brake blocks of the second half-wagon overheated as they wore. Béthune station was passed at 11.02 am. The staff at signal box 1 did not detect the braking incident.

By the time the train had reached Bully-Grenay station the projection on the front right wheel had reached a height of 13 mm. When passing over the first switch in the station (double diamond crossing with slips 22/23) the projection inserted itself between the switch and the stock rail causing this to deflect and the front right wheel to derail then the back right wheel of the first half-wagon.

When passing the level crossing 50 m further on, the wheels derailed striking the decking violently and as a result causing the derailment of the left wheels of these wheelsets and probably the derailment of a third wheelset of this wagon.

At 11.09 am the operating member of staff in Bully-Grenay signal box 2 saw the derailment and ordered the driver of the train to stop by ground-train radio. Simultaneously the driver felt a jolt and looking back at his train saw a cloud of powder. He then made an emergency brake application. During this time the train continued to run with three wheelsets derailed on the first wagon. This wagon progressively moved away from the track, then struck a fixed obstacle or under the effect of the braking it became sideways onto the track causing a series of collisions and the derailment of the first 19 wagons.

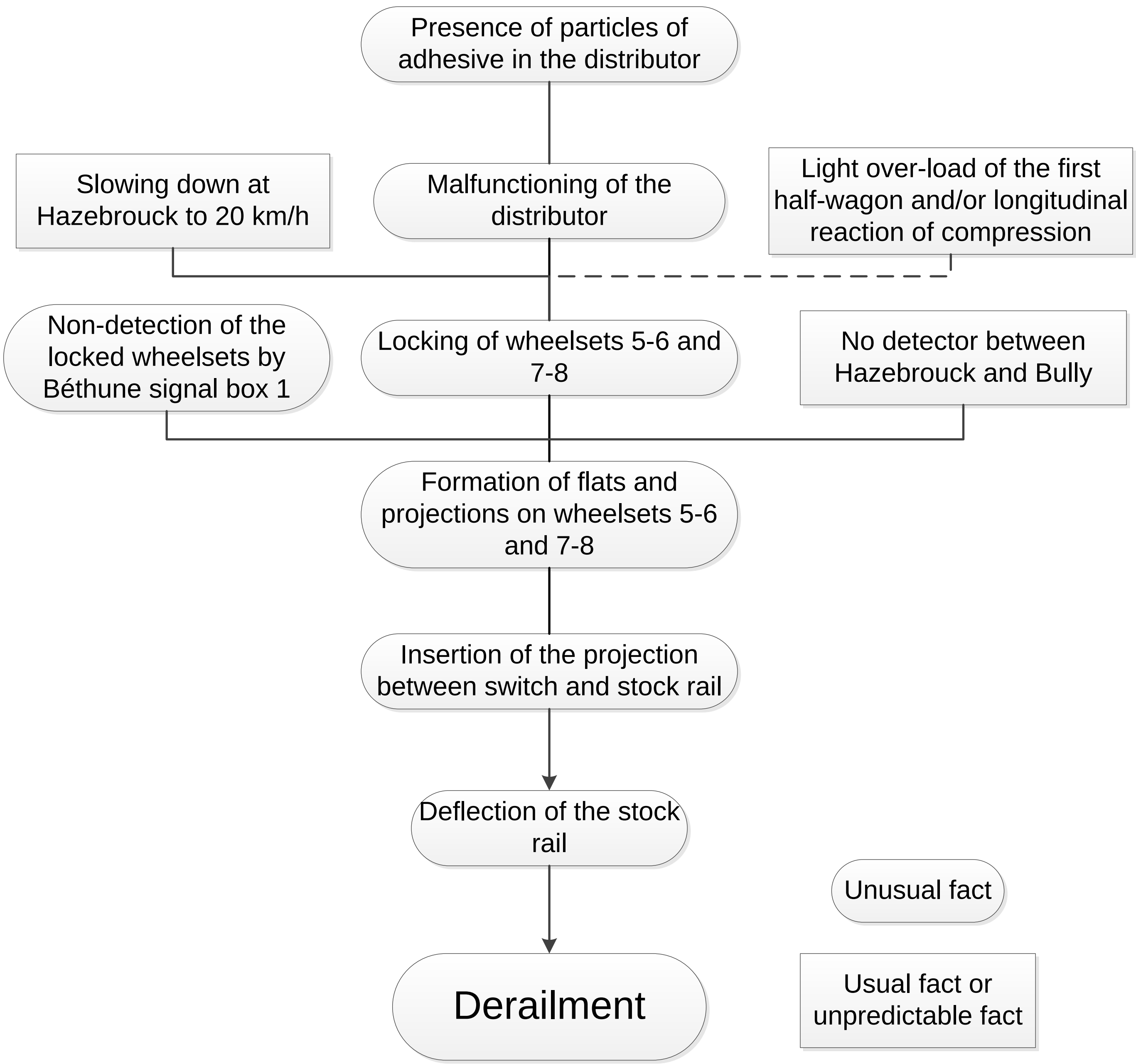
5.3 – Alerts and emergency services

Seeing the derailment and the blocking of the adjacent track, the driver set off his radio and light alert signals. After the stopping of the radio alert signal, he contacted the regulator to ask for the protection of line 1. When leaving the cab to inspect his train he found some catenary supports flattened. He therefore asked for the emergency procedure to switch off the traction current to be activated.

The emergency services received the first call at 11.14 am and the first vehicles from the Bully-les-Mines were on the scene at 11.26 am. As there were no casualties the emergency service stood down at 12.01 pm.

6 - Analysis of the causes and associated factors, preventative measures

6.1 - Causality tree



The investigations carried out resulted in the causality tree above. They led to the investigation of the causal factors and preventative recommendations in the following fields:

- the quality of the repairs of the brake distributors;
- the system for monitoring and detecting anomalies in trains in service.

6.2 - The quality of the repairs of the brake distributors

Although the causal connection between the particles of adhesive in the distributor and the brake incident on the wagon at Bully-Grenay was not formally established, it can be said that such particles are likely to cause at any moment a total or partial blockage of a calibrated orifice, a leak on a check valve or other malfunctions which may have serious consequences. It is important, therefore, that at any time, in operation, in current maintenance and during the repair of wagons, precautions are taken to avoid the introduction of impurities in the pipes and the brake equipment.

These precautions are even more essential during the repair operations for distributors because in this case the interface filters cannot protect the internal parts of the device against the penetration of these particles. The detection during the inspection of the C3A distributor of a strip of adhesive fragmented and liberating particles is a quality defect during the repair of this equipment. The elimination of surplus adhesive and sealing products is included in the procedure that the staff who repair distributors must apply and which the managers and the quality services of the repair workshops must check.

Recommendation R1 (LORMAFER)
Explicitly state in the repair documentation for brake distributors that it is necessary to avoid any excess adhesive or sealing products, and any excess should be removed before reassembling the device. Distribute these documents and ensure this instruction is implemented.

This event shows the level of technical skill and care necessary for certain maintenance work and the seriousness of the potential consequences if the work is not done correctly. This level can only be obtained in certain establishments that have high quality staff, technical equipment and organisation. Now the European Regulation of 10 May 2011 regarding the certification of firms responsible for the maintenance of wagons does not impose any obligation on the workshops that do work for the account of the firms mentioned above.

Recommendation R2 (DGITM)
Contribute on the European level to the creation and introduction of an obligatory system of qualification and monitoring of the workshops that work on brake distributors, and more generally on the assemblies that are most critical for safety.

6.3 - The system of monitoring and detection of anomalies of trains in service

The current system based on the monitoring of trains in service (MTIS*) by the staff and on the system of hot box detectors (HBD*) and dragging brake detectors (DBD*) was not able to spot the defective wagon before the derailment. This is explained by the fact that in spite of the time and the distance between the incident and the derailment (about 35 minutes and 50 km) this type of anomaly did not become visible for a member of staff and detectable by a DBD* and possibly a HBD* when the wheels or the brake blocks had reached a sufficiently high temperature.

The locking of wheelsets is particularly difficult to detect visually because any sparks due to the wheel-rail contact are hardly visible and as the increase of temperature of the wheels is localised, the release of smoke is reduced. The automatic detectors DBD* and HBD* are also not very effective because the zones aimed at are a long way from the point of contact rail-wheel. These zones only slowly reach a temperature that is sufficiently high to set off an alarm. To be sure to detect such a locking and before it becomes dangerous, it would be necessary to have such specialised detectors spaced at intervals of not more than 40 km. It is not certain that such an installation could be justified by comparison with other safety investments.

* Term listed in the glossary

However in view of the changes in the distribution of tasks of the sedentary staff members and the maintenance staff likely to carry out MTIS*, in view also of the introduction of the *Commande Centralisé du Réseau [*Network Centralised Control project] (CCR) and the resulting abolition of signal boxes, the efficiency of the current monitoring system is likely to be diminished and must be compensated by additional automatic detectors. Moreover, it can be seen that new detectors are being developed and installed in other countries (impact detectors, anomaly of load detectors, detectors to check that the loading gauge has not been infringed) although they have not yet been introduced to the RFN*.

Recommendation R3 (RFF*)
Carry out a survey on the principle European railways of the contents, density and quality of the monitoring and detection systems for trains in service (except high speed lines) and study innovative systems that are projected or under development. By sharing the results with the principle parties responsible for safety on the National Rail Network obtain the necessary information to equip this network:

* Term listed in the glossary

7 - Conclusions and recommendations

7.1 - Causes of the accident

The accident was caused by a malfunctioning of the brake distributor on the first wagon of the train which resulted in the locking of the first two wheelsets of the train, the hollowing of their tread by rubbing on the rail then the derailment on the first switch of Bully-Grenay station. This malfunction was probably due to the presence inside the distributor of solid particles coming from an excess of sealing compound left during the last repair of this part. Because of the place where the blockage occurred and the few visible indications, the anomaly was not detected at the time by the railway staff or by the automatic detectors.

7.2 - Recommendations

The analysis of the causes and the circumstances of the accident resulted in the formulation of recommendations to do with the following three areas:

➢ the quality of the work done by the workshop which repaired the distributor;
➢ the skill of the staff who repaired the wagon parts;
➢ the density and the consistency of the monitoring and detection system for anomalies of trains in service.

Recommendation R1 (LORMAFER)
Explicitly state in the repair documentation for brake distributors that it is necessary to avoid any excess adhesive or sealing products, and any excess should be removed before reassembling the device. Distribute these documents and ensure this instruction is implemented.

Recommendation R2 (DGITM)
Contribute on the European level to the creation and the introduction of an obligatory system of qualification and monitoring of the workshops that work on brake distributors, and more generally on the assemblies that are most critical for safety.

Recommendation R3 (RFF*)
Carry out a survey on the principle European railways of the contents, density and quality of the monitoring and detection systems for trains in service (except high speed lines) and study innovative systems that are projected or under development. By sharing the results with the principle parties responsible for the safety on the National Rail Network obtain the necessary information to equip this network:

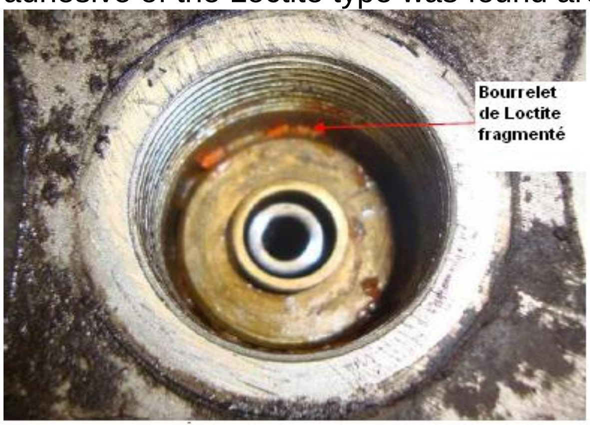
* Term listed in the glossary

ANNEXES

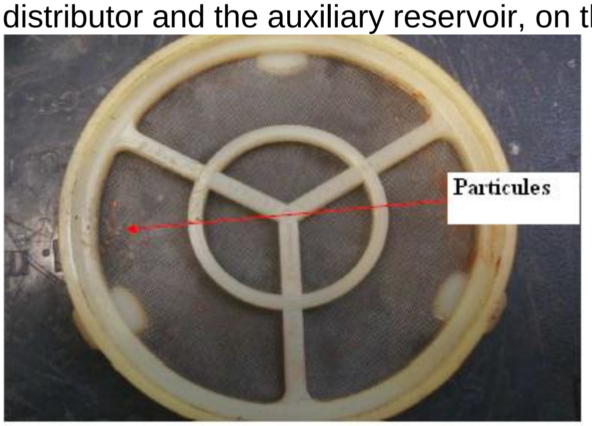
Annex 1: Decision to start an investigation

Annex 2: Hypothesis on the failure of the distributor

During the dismantling of the brake distributor from wagon 43 87 6531 611-4 on 26 November 2010 at the Technicentre of SNCF Rennes, the remains of a strip of adhesive of the Loctite type was found around the seat of the main check valve.



Some particles from this strip were found in the sieve in the interface between the distributor and the auxiliary reservoir, on the distributor side.



The brake distributors are known to be sensitive to the penetration of solid particles likely to compromise the tightness of their check valves and their valves and to block the orifices or small diameter pipes, causing unpredictable and intermittent incidents. Moreover the locking of the wheelsets of the first half-wagon suggests that the brake cylinder had been subjected to a pressure much higher than that delivered normally from a distributor as a result of the driver braking at Hazebrouck.

The scenario on the malfunction of the distributor chosen by BEA-TT is based on two solid particles coming from the strip of adhesive mentioned above:

➢ initially a particle came to rest on the face of the main valve;
➢ secondly, a particle which blocked the orifice which vents the distributor to atmosphere. The drawing of the distributor shows that these two places are physically very accessible to a particle coming from a strip from the seat of the main check valve:
➢ the seat of the main valve is very close to the strip of adhesive;
➢ the orifice of the vent to atmosphere is directly accessible from the intermediary of the hollow shaft of the main device.

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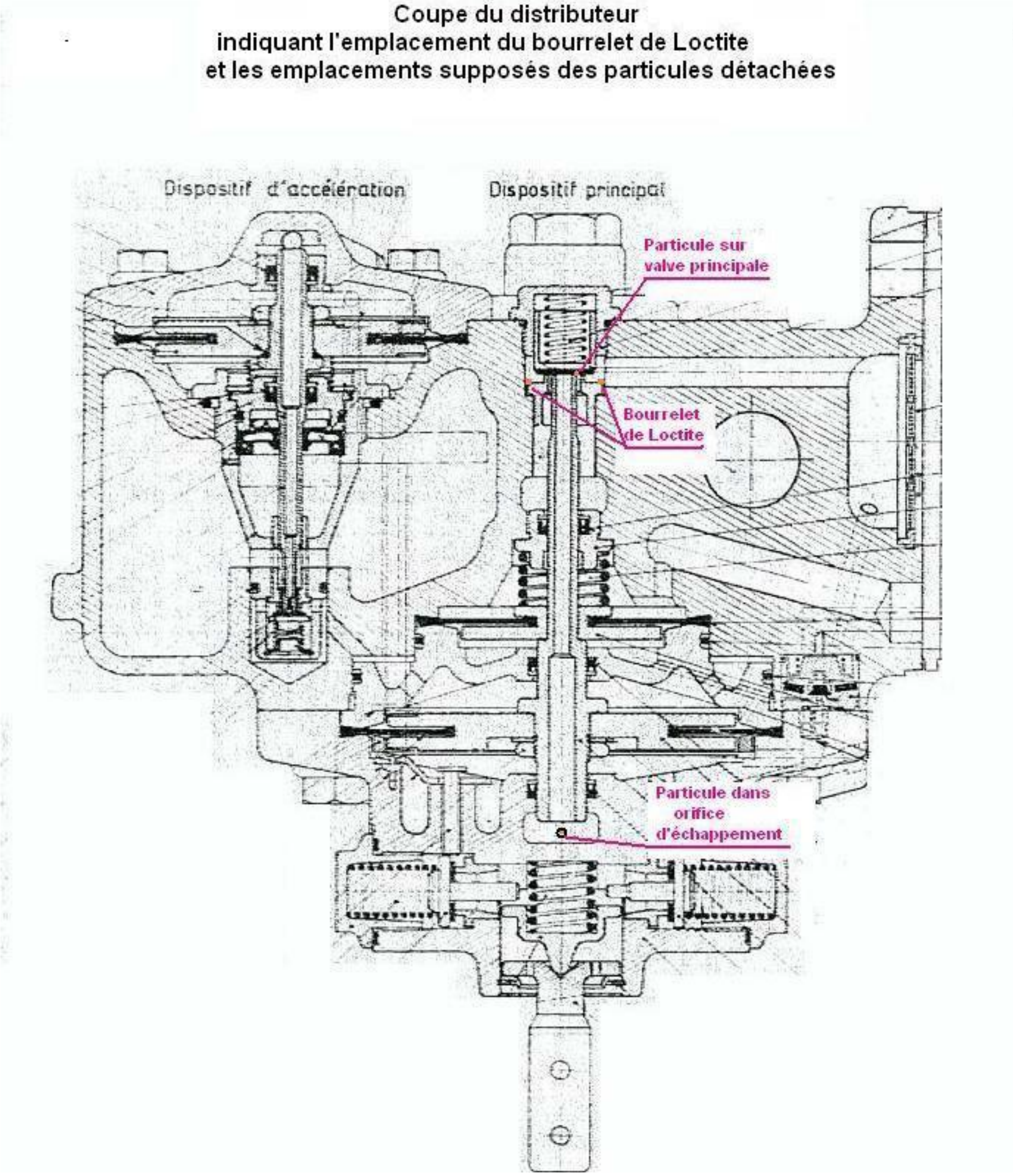
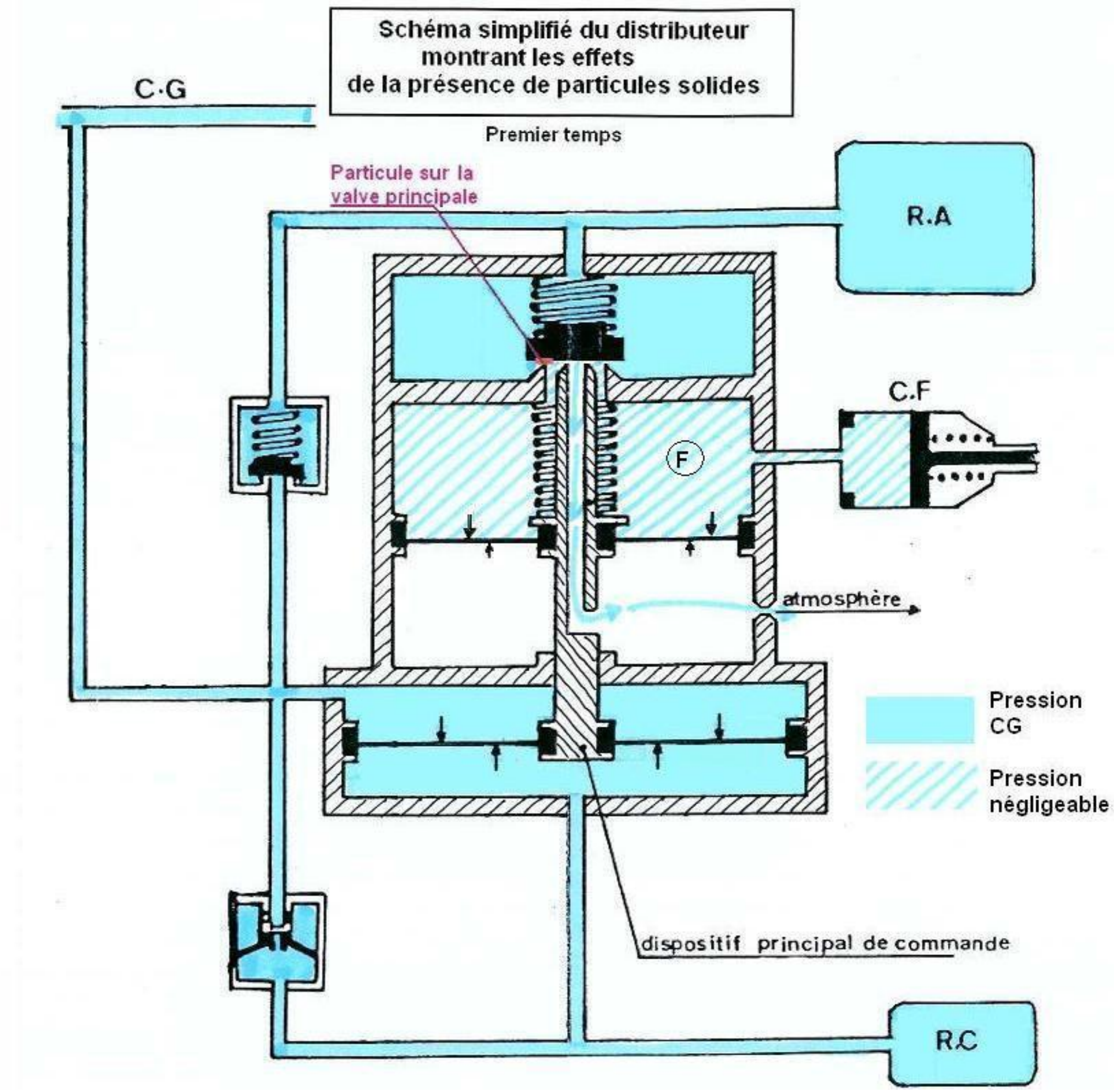


Explanation of the scenario:

Initially

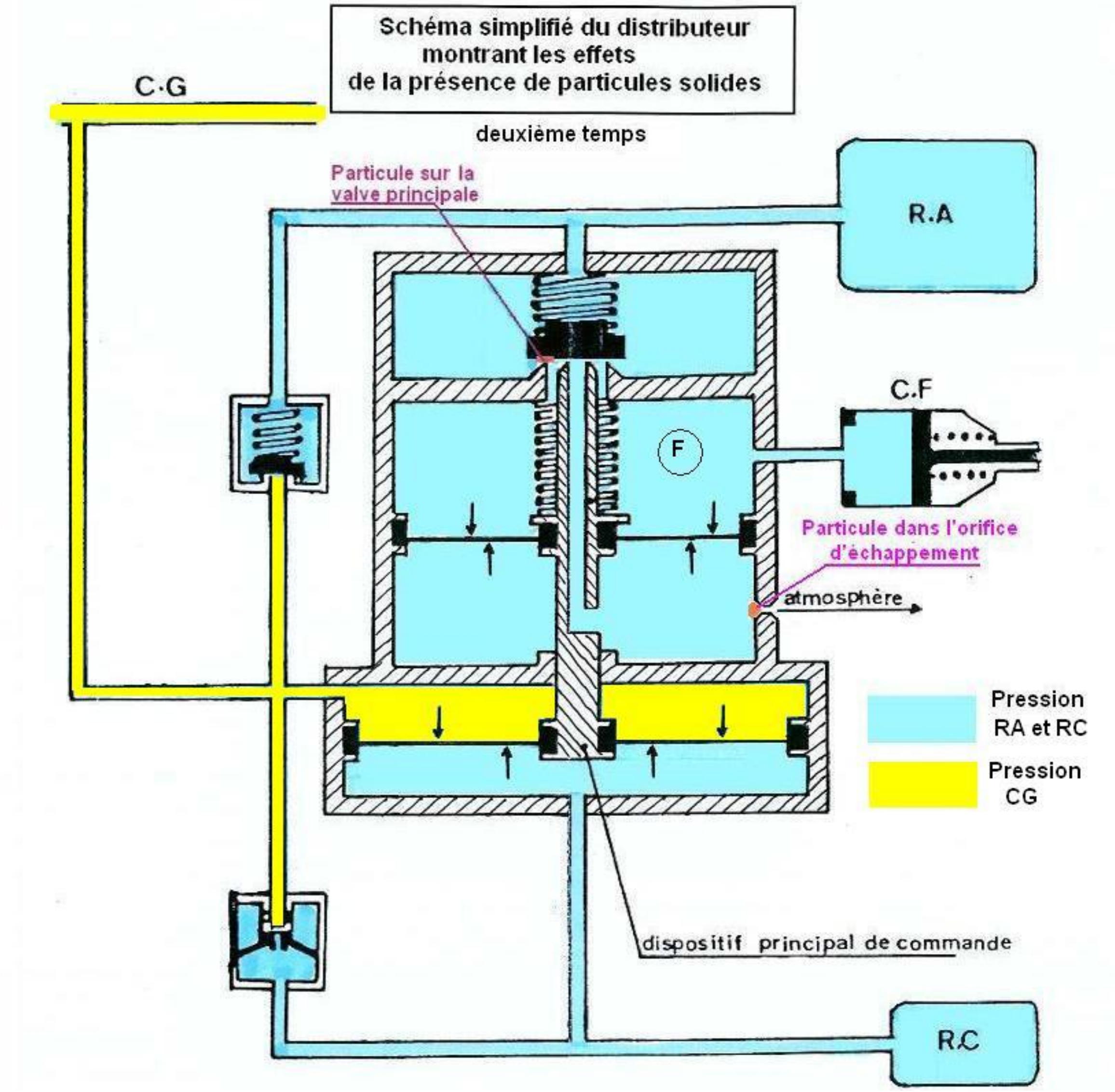
A particle came to rest on the face of the main valve; the air of the auxiliary reservoir entered the chamber F but, as soon as the pressure in this chamber increased the pressure on the membrane caused the hollow shaft of the main device to move down and the air escaped to the atmosphere.



At this stage the malfunction just resulted in a slight leak which remained within the tolerances of the brake tests. This situation could last for an indeterminate time without being detected.

Afterwards

During the braking carried out at Hazebrouck, a second particle, drawn by the air flow, obstructed the orifice for venting to atmosphere, the diameter of which is about 1 mm.



The air in chamber F and the brake cylinder increased in pressure to 5 bar, exerting a very high braking force. As the air could not escape, the wagon brake remained applied with a pressure of 5 bar in the brake cylinder regardless of the pressure in the main brake pipe. Such a pressure in the brake cylinder is 30% more than that of a maximum service brake application or an emergency brake application which is 3.8 bar.

This abnormally high pressure, associated with the slowing down to 20 km/h of the train enables the locking of the wheels of the two leading axles of the wagon to be explained.