MINISTRY OF
CONSTRUCTION AND TRANSPORT

TRANSPORTATION SAFETY BUREAU

FINAL REPORT

2023-0661-5
(HU-10426)

Railway Accident / Derailment
Tiszatenyő - Mezőtúr, 9th July 2023

Basic principles of the safety investigation

The purpose of the safety investigation performed by Transportation Safety Bureau (TSB) as National Investigation Body of Hungary is to reveal the causes and circumstances of serious railway accidents, railway accidents and railway incidents and propose recommendations in order to prevent similar incidents. The safety investigation is not intended to examine and determine fault, blame or liability in any form.

The findings of the safety investigation are based on an assessment of the evidence available and obtained by the TSB in the course of the investigation, taking into account the principles of a fair and impartial procedure. In the Final Report, the persons involved in the occurrence shall be referred to by the positions and duties they had at the time of the occurrence.

The TSB is obliged to retain and not to disclose to any other authority any data that it has obtained in the course of a professional investigation, in respect of which the data holder could have refused disclosure under the law.[1]

The Final Report shall not have binding force and no appeal proceedings may be initiated against it.

This safety investigation has been carried out by TSB pursuant to relevant provisions of

- Act CLXXXIV of 2005 on the safety investigation of aviation, railway and marine accidents and incidents (hereinafter: Kbvt.);
- Commission Implementing Regulation (EU) 2020/572 of 24 April 2020 on the reporting structure to be followed for railway accident and incident investigation reports;
- NFM Decree No. 24/2012 (V.8.) on the detailed rules of the safety investigation of serious railway accidents, railway accidents and incidents and the inspection of the operator;
- In the absence of other related regulation of the Act CLXXXIV of 2005, the TSB conducts the investigation in accordance with Act CL of 2016 on General Public Administration Procedures.

Act CLXXXIV of 2005 and NFM Decree No. 24/2012 (V.8.) together serve compliance with Directive (EU) 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety.

The competence of the TSB is based on Government Regulation № 230/2016. (VII.29.) on the assignment of a transportation safety body and on the dissolution of Transportation Safety Bureau with legal succession.

The safety investigation is independent of other investigations, administrative infringement or criminal proceedings, as well as proceedings initiated by employers in connection with the accident or incident.

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[1] *On the basis of Subsections (1) and (6) of Section 18 of Act CLXXXIV of 2005 on the safety investigation of aviation, railway and marine accidents and incidents*

DEFINITIONS AND ABBREVIATIONS

470-4	the freight wagon with registration number 3368 4953 470-4
BEATT	the accident investigation body of France (Bureau d'Enquêtes sur les Accidents de Transport Terrestre)
ERA	European Railway Agency
ERAIL	ERA accident database (the ERAIL event identifier is the number in brackets on the cover under the TSB identifier: HU-10426)
ETCS	European Train Control System
ÉKM	Ministry of Construction and Transport
GYSEV Zrt.	Győr-Sopron-Ebenfurt Railways Co.
GYSEV Cargo	GYSEV Cargo Co.
IC	Investigating Committee
Kbvt.	Act CLXXXIV of 2005 on the safety investigation of aviation, railway and marine accidents and incidents
MÁV Zrt.	Hungarian State Railways Co. (At the time the Final Report was issued, already MÁV Pályaműködtetési Zrt (the railway infrastructure manager) was in charge of the railway infrastructure operation.)
MFB	Locomotive On-Board Equipment (with train tracking, data recording, electronic running schedule functions)
Reg. No.	Registration number of rolling stock
TSB	Transportation Safety Bureau, Ministry of Construction and Transport
TSI	technical specification for interoperability
UIC	International Union of Railways (Union Internationale des Chemins de Fer)
VHF	Railway Authority Department, Ministry of Construction and Transport
VTG	VTG Schweiz GmbH (the relevant freight wagon operator in the case)
VTG_{ECM}	VTG Rail Europe GmbH (the organisation responsible for the maintenance of the freight wagon concerned)
VTK	Train load statement (document containing train composition data)

CONTENTS

1. SUMMARY

On 9 July 2023, at 12:17 pm, the third bogie of a wagon of a freight train (No. 48401-2) derailed between Tiszatenyő and Mezőtúr stations, and the train continued to run for about 2 km until it stopped. Before stopping, 8 more wagons derailed and overturned.

There were no injuries, but more than 2 km of railway track and the derailed wagons were damaged, and the cargo spilled hazardous material into the environment.

The investigation found that the braking system of the freight wagon No. 33 68 4953 470-4, which was the second wagon in the train, remained applied 18.8 km before the derailment at the latest. Exposed to continuous friction, the LL IB116* composite brake block overheated the wheels of axles 5 and 6 of the wagon, resulting in

- the resulting sparks caused a fire in the environment and then
- the wheel underwent a plastic deformation, lost its stability and started the process that eventually led to the derailment of 9 wagons.

Causes of the occurrence

a) an undetected, presumably pneumatic, fault in the braking system;

b) the specificity of the wheel/brake block relationship, in that the composite brake block used on the wagon heated the tread to the point of plasticity;

c) maintenance failings of the wagon were identified;

d) the fact that all this was not detectable before the derailment due to the lack of track staff and diagnostic equipment.

Several similar incidents have occurred in Europe in the past, and the results of these investigations have been studied and used by the IC. The European Railways Agency has also investigated these incidents, but has only made substantive proposals in relation to a) and d) above.

In view of this, the IC considers it important to further investigate the interaction between wheels and composite brake blocks.

2. THE PROCESS AND CONTEXT OF THE INVESTIGATION

2.1 Initiation of the investigation

The occurrence was reported by the network manager of MÁV Zrt. to the Call Centre of TSB on 9 July 2023 at 12:23 pm (6 minutes after the occurrence).

The head of the TSB on duty ordered an immediate on-site inspection. On the basis of the findings of the inspection, the head of the TSB decided to open a technical investigation by means of the TSB / 34901 / 2023-ÉKM file on 9 July 2023.

2.2 Grounds for initiating the investigation

Pursuant to Section 7 (1), the Transportation Safety Bureau

1. shall investigate serious rail accidents;
2. *may investigate railway accidents and incidents which, in its judgement, could have led to serious accidents in slightly different circumstances, considering*

a) the seriousness of the accident or incident,
b) whether it is part of a series of events of importance to the system as a whole,
c) the impact on rail safety,
d) requests from infrastructure managers, railway undertakings, national safety authorities or Member States,
e) whether the study can provide lessons on safety.

This investigation was initiated on the basis of Subsection point (1) above (also in accordance with Article 20(1) of the Railway Safety Directive 2016/798 (EU)). The investigation and the lessons learned will allow lowering the risk of accidents in rail transport.

2.3 Scope and limits of the investigation

The aim of the investigation was to identify the chronological sequence of the occurrence, the human, organisational and technical factors influencing the activities of the persons and the operation of the technical equipment, to identify the direct and indirect causes and to present the lessons to learn.

The present study covered the braking equipment of the railway vehicle, lessons learned from previous incidents with the brake block used, measures taken and planned. The investigation did not cover the risk of fire from brake blocks or other hazards associated with the transport of dangerous goods.

2.4 The Investigating Committee

The Head of the TSB appointed the following Investigating Committee to investigate the occurrence:

Investigator-in-charge	Gábor Chikán	Investigator
Member	Bernát Gábor Almási	Investigator

Bernát Gábor Almási's civil service contract was terminated at the time of the investigation, and the head of the TSB appointed Péter Demjén as member of the IC.

2.5 Communication and consultation processes

The IC interviewed the locomotive driver on the spot.

In the course of the investigation, the IC consulted the (ERA JNS normal procedure Consequences of unintended brake applications with LL blocks).

The TSB sent the Draft Report to

- ÉKM Railway Authority Department
- MÁV Hungarian State Railways Zrt.
- GYSEV Cargo Zrt.
- VTG Rail Europe GmbH
- VTG Schweitz GmbH.

The following entities responded in writing to the Draft Report:

- MÁV Pályaműködtetési Zrt, making minor editorial comments;
- GySEV Cargo Zrt. provided detailed, substantive comments;
- VTG Schweiz GmbH, represented by a law firm, made detailed, substantive comments.

On 5 February 2026, the TSB held a final meeting to reconcile the comments received, at which

- ÉKM Railway Authority Department
- MÁV Hungarian State Railways Co.
- GySEV Cargo Zrt.
- VTG Schweiz GmbH (represented by a law firm)

were represented. Those present at the final meeting discussed the comments received. The IC sets out in Chapter 7 the remaining comments and those differing from the content of the Final Report.

2.6 Cooperation

Cooperation with all the organisations present was achieved during the site visit, the subsequent tests and the workshop inspections. In other phases of the study, in particular in relation to data collection and international tasks, cooperation was hampered by the difficulties described in Chapter 2.8.

2.7 Test methods

For the investigation, the IC used

- the findings of the on-site inspection carried out on 9 July 2023;
- the findings of a subsequent on-site inspection carried out on 13 July 2023;
- the locomotive driver's oral report;
- data from the locomotive's recorders;
- recorded running data of other trains, for comparative dynamic analyses;
- measured data of the track;
- as regards the freight wagon with reg. No. 3368 4953 470-4:
  - workshop inspections carried out on 23 August and 11 October 2023;
  - technical expert opinion of its inspection (2.9);
  - workshop test results for pneumatic components (triple valves, linkage adjusters, balancing valves);
- The investigation results of other similar accidents in the Netherlands and France (4.5);
- The final report of the ERA working group on similar events issued on 29 February 2024.

2.8 Difficulties of the investigation

The derailed and damaged wagons released dangerous goods into the environment, which delayed the start of the on-site inspection for the safety of the accident investigators.

It was only after a longer period of time that the police decided not to carry out a pneumatic inspection of the braking system of the wagon with reg. No. 3368 4953 470-4, and therefore, in view of the police seizure, the TSB did not have access to the wreck until then.

The TSB was able to contact the foreign owner of the wagon through their legal representative in Hungary, which slowed down the completion of tasks and legal disagreements slowed down the provision of data and the completion of investigations.

The locomotive's data recorder does not provide sufficiently detailed brake pressure data to allow a possible brake control failure to be reliably verified or excluded.

The resources available to the TSB determined the depth of the investigation.

2.9 Liaison with the judicial authorities

The IC cooperated with the Mezőtúr Police Station that also carried out an on-site inspection on the spot, and during the shop inspection of the wagon with reg. No. 3368 4953 470-4. In the course of the inspection, the IC requested and received the technical expert opinion from the police and provided the police station with photographs.

3. DESCRIPTION OF THE OCCURRENCE

3.1 Description of the occurrence

On 9 July 2023, between Tiszatenyő and Mezőtúr stations, at 12:17 pm, the second wagon of the freight train 48401-2 derailed in section 162, and then 8 more wagons derailed while the train was moving on, before the train stopped in section 184.

There were no injuries, but more than 2 km of railway track and the derailed wagons were damaged, and the cargo spilled hazardous material into the environment.

3.1.1 Occurrence type

Occurrence type: **Serious railway accident**

Nature of the occurrence: **Derailment**

3.1.2 Date and location of the occurrence

Date of the occurrence: **9 July 2023, 12:17**

Location: **national rail network**
Railway line No. 120 Szolnok to Lőkösháza

Section 162, Between Tiszatenyő and Mezőtúr stations

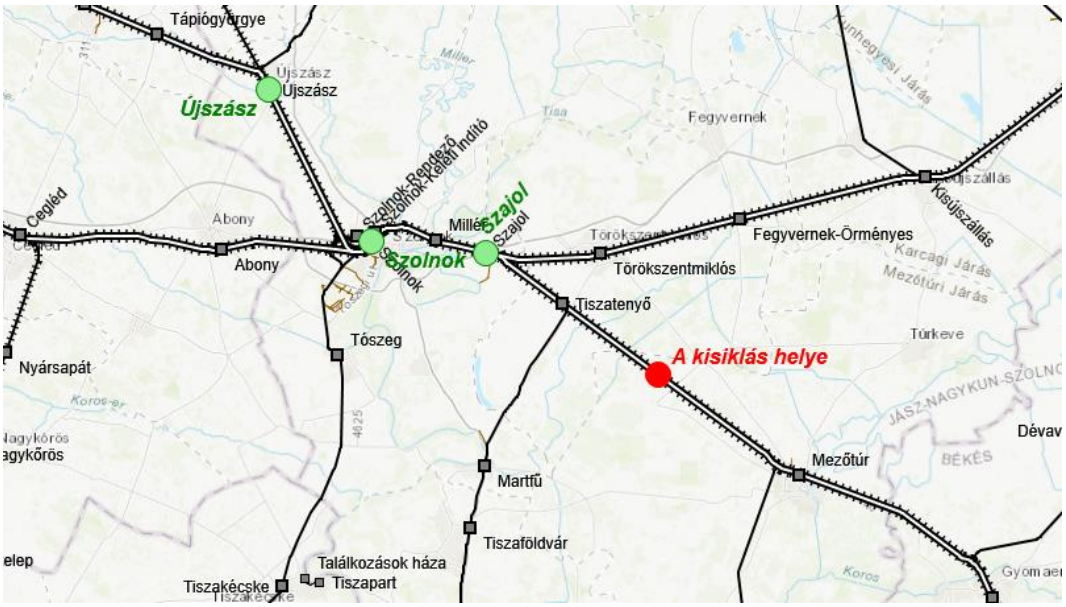


Figure 1: Location of the occurrence and main stations referred to in the Final Report (map: ArcGIS WorldTopoMap)

3.1.3 Location of the occurrence

At the site of the occurrence, the railway track runs straight along the north-eastern edge of Kétpó and crosses the access road to the settlement via the Kétpó level crossing SR2. Kétpó stop is also there.

At the time of the incident, it was a hot summer day with few clouds.

At the time of the incident, there were several brush fires in the vicinity of the railway track, details of which can be found inAnnex 3.

3.1.4 Consequences

Personal injury

Injury	Crew	Passenger	Level crossing user	Foreign	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Light	-	-	-	-	-
Not injured	1	-	-	-	-

Damage to property

Damage to railway infrastructure:

- 200 metres of the left track was partially damaged, 1700 metres of the right track was partially damaged and 360 metres of the track was damaged, requiring the construction of a new track;
- 2 catenary support poles fell down and 9 insulators broke;
- between Sections 162 and 184, the track connection wires were damaged and the 8 fixed balise elements for the ETCS L2 system, which had not yet been in service but had already been installed, were damaged;
- on the passenger platforms along both tracks in sections 177+86 and 180+15, 1 hardened side glass pane of each rain shelter was broken by the crushed stones that had been kicked up;
- the cost of repairing track and other infrastructure damage is HUF 708 million, and the loss of network access fee is HUF 6 million.

Damage to rolling stock:

- Until 17 01 2024, the accident-related damage bills paid by GYSEV CARGO Zrt. amounted to HUF 70 million and EUR 10.8 thousand.
- GYSEV CARGO Zrt. is planning to scrap one Sggmrrs series twin wagon because it cannot be repaired economically and two additional Sggmrrs series wagons will be inspected in a shop, the value of related damage is HUF 35.8 million + VAT.
- VTG has not yet been able to provide a final damage figure, but the preliminary damage is estimated at EUR 583 thousand (10 February 2025).

Significant damage to goods occurred, but the railway undertaking had not provided any data on this by the time the Final Report was prepared.

Environmental damage

From a damaged tank that fell from the wagon 33 68 4964 044-4 with RID 90/3082 hazard label, Genaminox liquid N.O.S. (Amine C12-C18 Alkyl Dimethyl N-oxide, for raw material cleaning agents), hazardous to the health and the environment, was released and it flowed into the agricultural area next to the right track. The Disaster Management Authority had the relevant farmer cut the crop green on about 1 hectare and the NÉBIH ordered him to replace the soil. According to the farmer, the damage was approximately HUF 1 million.

Figure 2: Location of the wreckage (compiled from several images)

3.1.5 Other consequences

Due to the accident, passenger trains were replaced by buses between Szolnok and Mezőtúr stations, and fast and InterCity trains were replaced by buses between Mezőtúr and Törökszentmiklós. The international passenger trains ran via Budapest - Cegléd - Szeged-Rendező - Békéscsaba stations, via a detour.

An emergency capacity restriction has been imposed on freight trains, and the line No. 120 permits have been withdrawn on the section affected.

Delays of trains related to the occurrence:

1103	passenger trains	12854	minutes,
51	freight trains	1072	minutes,
8	other trains	127	minutes.

3.1.6 Organisations and people concerned

The railway infrastructure was operated by MÁV Hungarian State Railways Zrt. at the time of the accident but, by the time of the issue of this Final Report, MÁV Pályaműködtetési Zrt (the railway infrastructure manager) had become the legal successor.

Train 48401-2 was operated by GYSEV Cargo Zrt. and Gartner KgG was the shipper. The entity in charge of maintenance of the second wagon of the train is VTG Rail Europe GmbH (Hamburg, VTG_{ECM}).

3.1.7 The train

The occurrence involved the

freight train No. 48401-2 from Sopron-Rendező to Curtiči (RO), forwarded by locomotive with reg. No. 91 55 0471 500-3:

number of wagons:	17
length:	540m
tonnage:	1,245t

Eight wagons of the train were equipped with K composite brake blocks and nine with LL composite brake blocks.

The No. 33 68 4953 470-4 Sggmrs series freight wagon was second in the train, equipped with LL brake blocks (Knorr Problock IB 116*). The wagon is a so-called twin wagon with 3 double-axle bogies. According to its own numbering, its wheelsets No. 1-2 were in the third bogie in the direction of travel. The Final Report, on the other hand, refers to the bogies in the direction of travel.

3.1.8 The infrastructure

The railway track at the scene of the occurrence is a double track, straight line, the track structure consists of 60 kg/cm rails laid on reinforced concrete sleepers, the design speed is 160 km/h, the permitted speed is 120 km/h; there was no speed limit at the scene of the incident.

The line is electrified, the track is equipped with an interlocking system and 75 Hz automatic train control, and ETCS L2 trackside elements are installed.

3.2 Timeline of the occurrence

Based on the evidence obtained, the actual course of events can be summarised as follows:

3.2.1 What happened before the occurrence

In order to reduce noise from freight trains, the European Union issued a Technical Specification for Interoperability for the “rolling stock-noise” subsystem, which means that only freight trains that meet these standards and have lower noise levels are allowed to run on many designated railway lines in Europe.

In order to meet these requirements, freight wagon keepers have switched from using cast iron brake blocks to composite brake blocks.

11 2020 The keeper of the freight wagon had the vehicle’s braking system converted from the former P10 cast iron brake block to LL composite brake block. LL brake blocks were installed on every axle of the wagon on 5 December.

28 12 2022 The Sggmrs series wagon (reg. number: 33 68 4953 470-4), equipped with LL composite brake blocks, later involved in the accident, underwent repairs ordered by VTG_{ECM} regarding the braking system (replacement of brake hoses on bogies 1-2, replacement of right rip cord on side 1, replacement of brake blocks (installing LL IB 116*) on axles 3, 4 and 6, replacement of triple valve in wagon part “B”, replacement of relay valve, renewal of the wagon sign). The brake system of part “A” of the wagon, which was involved in the incident, was either not tested or the test was not documented.

30 12 2022 The freight wagon was put into service after brake and wheel repairs. (The freight wagon then covered 22 148 km before the accident.)

08 07 2023, 23:45-0:15 A full brake test of freight train 48401-2 was performed in Sopron-Rendező.

The train passed the dynamic wheel load measuring device installed between Kelenföld and Ferencváros stations on its way, which did not indicate any anomaly.

09 07 2023, 04:59 The train passed through the hot axle box detector near the Újszász - Szolnok station, which did not indicate any anomaly.

05:10 The train arrived at Szolnok-Rendező.

after 08:00 A connection brake test was carried out on the two leading vehicles (the locomotive and the first wagon) of the train (Annex 7).

3.2.2 The course of events

The origin of the trip data is the point of derailment.

11:25:31 [-27.7 km] The freight train departed from Szolnok-Rendező station. In the Szolnok area, the train was travelling at a maximum of 10 km/h and stopped two more times. Meanwhile, as the train approached a ‘Danger!’ signal, it continued to run at low speed over a short section. At this point, the locomotive driver had not yet noticed any irregularities.

11:50:44 [-24.5 km] The train moved on for the second time.

11:57:31 [-22.8 km] A line brake test was performed on the open line from 50 km/h with a deceleration of 0.42 0 m/s^2.

12:01:24 [-18.8 km] After the Tisza Bridge, the train had to be braked due to a speed limit of 80 km/h, the speed was reduced from 90 km/h to 72 km/h with a deceleration of about 0.2 m/s^2.

At this point at latest, the brakes on the last bogie of the second wagon failed to release (fully), the brake blocks constantly scraping the wheel tread.

> The pneumatic brake was not applied after that until the derailment, according to the vehicle's recorded run data.

12:04:30 [-14.9 km] Leaving Szajol, the train slowed down by 0.05 m/s^2 without applying traction, while the train passed in the vicinity of the phase boundary at gauge 14+82.

> This deceleration exceeds the 0.03 m/s^2 typical for other trains of similar configuration on the same track, which can be related to the fixed brake.

It then continued at a steady speed of 90 km/h with automatic speed control.

Exposed to continuous friction, the brake block heated up the bogie wheelsets, and at the same time, glowing pieces of the brake block came off, which ignited the trackside undergrowth and crops in several places starting from section 47 (Annex 3).

The wheels became hot and began to deform.

> The track inspections showed more and more intensive marks of deformed wheels on the rails from section 92 to the derailment site.

12:13:48 [-1.2 km] Near the platform of the Pusztapó stop on section 152+00, a metal lattice built into the inner structure of a brake block was blown away.

> Brake block parts were also found dropped on subsequent sections of the railway track, but all 8 brake blocks were not recovered during the site inspection. Smaller parts may have been lost in the trackside bushes, but it is also possible that the car may have lost such parts earlier along the track.

12:14:34 [0 km] Just before Kétpó, on the 162+88 section, one of the third bogie axles of the second wagon derailed at 90 km/h, crossing the left rail and then running on the concrete sleepers, breaking them. This derailment caused a slight jolt to the train, which the locomotive driver noticed.

12:15:07 [+0.7 km] The other axle of the bogie crossed the left rail in section 170+95. The speed then dropped slightly and began to fluctuate. The locomotive driver noticed the jerk that had occurred but did not attribute any significance to it.

12:15:45 [+1.8 km] The derailed bogie jumped onto the STRAIL elements of the crossing at section 180+51, causing the train to break up.

Figure 3: Part of a frame of a surveillance camera image, showing the derailed bogie reach the level crossing

On the track damaged by the derailed wagon, the following wagons of the train also derailed, and the wagons started to turn across and overturn.

The locomotive driver again sensed the jolt, so he looked out of the window and identified the derailment, and he braked the train.

12:16:06 [+2.2 km] The train stopped.

3.2.3 What happened after the occurrence

12:15-13:12 The Disaster Management Authority received a report of brush fires along the railroad tracks.

13:56 The TSB IC arrived at the scene, started the site inspection, but for the time being away from the wreckage. By that time, the Disaster Management staff had found that the damaged containers of the derailed trucks were leaking hazardous material.

Approx. 17:00 After identifying the hazardous materials and their hazards, the Disaster Management Authority authorised work on the wreckage of the vehicles, with a fire safety warning and precautionary measures.

20:27 The TSB completed its on-site inspection.

15 July, 17:55 The left track was returned to traffic.

11 August, 16:55 The right track was returned to traffic.

4. ANALYSIS OF THE OCCURRENCE

4.1 Responsibilities of people and organisations

4.1.1 Railway infrastructure manager

According to the measured data of the track (4.2.8), the railway infrastructure manager provided the train involved in the accident with a track in good technical condition, and this activity cannot be linked to the accident.

From the infrastructure side, the incident could have been detected by diagnostic equipment or track monitoring by station staff; however, on this occasion

- there was no equipment along the railway track to detect the fixed and overheated brake in time;
- station staff were only present at Szajol, which was still at the very beginning of the abnormal sequence; it cannot be determined whether there were already visible signs of the fixed brake at that point;
- there were no staff at the subsequent stations concerned to monitor the train,

and therefore the infrastructure manager was unable to identify the incipient anomaly and intervene.

Technical inspections of trains in service are carried out before departure; however, given these circumstances, the infrastructure manager has limited ability to identify malfunctions that occur during operation and to prevent the resulting hazards. With the modernisation and centralisation of rail traffic management, the number of stations where staff are no longer on duty is gradually increasing, and the classic system of monitoring trains is gradually disappearing. To compensate for this, technical solutions exist, but they are installed on the national rail network in smaller numbers than desired.

4.1.2 The railway undertaking

The railway company is responsible for the correct and safe assembly and forwarding of its trains. The activities of the company's locomotive driver cannot be linked to the accident, and his influence on the extent of the damage is analysed in Chapter 4.3.

4.1.3 The organisation in charge of the maintenance of the wagon

At the time of the accident, the freight wagon was not suitable for safe driving: as shown in Chapter 4.2, the wagon lost its running safety due to its anomaly and derailed. The VTG_{ECM}, as the entity in charge of maintenance, therefore failed to achieve its objective.

The brake blocks

In November 2020, the owner of the freight wagon had the vehicle's braking system converted from the former P10 cast iron brake block to LL composite brake block. According to the expert opinion obtained, the chosen brake lining complied with the relevant international standards, but:

The maintenance instruction (MI 7.1.004) that came into force on 20 November 2021 stipulated the replacement of the brake block type with the LL J847 composite brake block at the next workshop inspection, and only permitted the installation of the LL IB116* brake block as a secondary option, in the exceptional cases listed. This

subsequent shop inspection took place in December 2022 (3.2.1). Where this type change did not occur, the brake blocks to be replaced were also replaced with the LL IB 116* type.

As a justification for the use of IB116*, the company says that the two brake blocks are equivalent as they are both UIC approved. Therefore, the preference for the J847 type was not related to safety concerns, but rather to the fact that there were significant stocks of this type available at the time. Once these stocks were depleted, the preference for the J847 ceased.

However, given the experiences with brake blocks (4.2.5) and the concerns regarding their testing (4.2.6), it is likely that safety equivalence does not exist.

The triple valves

The last inspection of the triple valve on the wagon involved in the occurrence took place in 2004, and it is permitted to operate for 21 years. According to the company's own regulations, the triple valve must be replaced if the operating life exceeds 21 years by the time of the wagon's next general inspection.

This replacement did not take place; however, at the time of the incident, the triple valve had not yet exceeded the 21-year service life. The IC therefore does not relate this deficiency to the incident.

4.2 Vehicles and technical equipment

4.2.1 The root cause of the derailment

The wheels of the third bogie of the second wagon (wheelsets 1 and 2 according to the numbering of the wagon) suffered a deformation (Figure 4) that caused them to lose their running safety and leave the track.

Figure 4: The fifth wheelset (numbered 2) of the second carriage in the direction of travel

The derailment is directly attributable to the deformation of the wheel.

4.2.2 Wheel deformation

The rim showed a plastic deformation pattern, which implies a high rim temperature. The rims of the wagon are of type BA004/182K, which reach plastic deformability at 796 °C according to the material quality standard. These indicate that the wheel was exposed to a significantly higher thermal load than typical for service braking.

On the basis of on-site inspections:

a) Only the backing plates of the brake blocks remained in the bogie frame, with skid marks following the direction of rotation of the wheels on them, indicating that their composite body had been lost while running;

b) Brake parts were found on the railway track, metal lattices from brake blocks, already about 3 km before the derailment, with discolouration indicating high temperatures and rotational slip marks, suggesting that the disappearance of the brake blocks was caused by wear over the entire length;

c) Brushfires broke out along the railway track after the train had passed (3.2.3), which is a typical consequence of melt and sparks from a brake block.

All those above suggest that the bogie was running the with brakes on, the friction of the running train heated up the brake blocks and the discs, the brake blocks wore out and burnt, the discs were softened, their shape was distorted by the wheel load and they lost their running stability.

The deformation of the wheel was caused by the thermal load from the brake assembly remaining braked.

During the on-site inspection, a bluish discolouration was also visible on other wheelsets of the wagon, indicating a heating of about 300°C, which suggests that other bogies of the wagon were also braked to a lesser extent.

Figure 5: Discoloured wheel in the second bogie of the wagon with reg. No. 470-4 (contrary to what the picture suggests, the tread is not damaged, there is no external pseudo-marking on the wheel)

The wagon concerned - as a twin wagon - operates as two wagons for braking purposes:

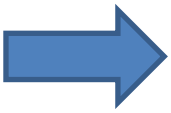
- A KE-GP-A triple valve and a brake cylinder belong to the third bogie (wheelsets 1 and 2), and
- Another KE0 triple valve with two additional brake cylinders for the first and second bogies (wheelsets 3 to 6).

The fault that caused the accident was therefore only seriously present on the third bogie (the brake controlled by the second triple valve), but also to a lesser extent on the first and second bogies (first triple valve).

Design factors affecting the thermal load

Factors that affect the thermal load on the wheel:

- The composite brake blocks used: due to their material, they are less able to absorb and dissipate heat than the cast iron brake blocks used previously, so the kinetic energy converted into heat during braking can only escape towards the wheel disc, heating it to a greater extent;
- Wheel size and wear: if a smaller wheel diameter is used, or if the wheel is more worn and has a smaller rim thickness, the heat-absorbing mass of the wheel is also lower, which also increases the rate of heating. The nominal wheel diameter of the wagon concerned is 920 mm (the same as the wheel diameter required for testing brake blocks), but the last measured wheel diameters of the wheelsets involved in the incident were 878 mm and 868 mm. (Which is smaller than the nominal value, but met the lower limit of 860 mm for wheel diameter.)



The design and condition of the wheelset and braking system increased the risk of excessive heat exposure of the wheel.

4.2.3 Handbrake

The wagon has a handbrake, but it is applied to the front part of the wagon in the direction of travel (wheelsets 3 to 6), and not to the bogie that was involved in the accident. Therefore, the possible applied state of the handbrake cannot be the cause of the incident.

4.2.4 Pneumatic brake

The train's braking system was working properly at Újszász - Szolnok station: the wheel disc temperatures measured by the hot axle-box detector (79-85 °C) indicated that the train was shortly after braking, but they did not show any spike value for any axle (Annex 1), which would indicate a fixed brake block. Subsequently, the train stayed in Szolnok for more than 6 hours (3.2.2), which makes it safe to say that the freight wagon No. 470-4, which became important later on,

- was not yet abnormally braked when shortly before Szolnok, and
- it set off with cold wheels from there.

The pneumatic brake on the third bogie of the car must have remained (at least partially) applied at the latest during the last brake application before the derailment, the line brake test described in the course of the occurrence (3.2.2) or the subsequent restricted speed running, 18.8 km before the derailment.

When the train departed from Szolnok, or at the latest during the subsequent restricted speed running, the third bogie of the wagon remained braked.

Considering that the investigators of the previous incident a year earlier, which caused fire only, identified an abnormal residual brake cylinder pressure of 0.1 bar (4.5.3), this time the wheel deformation on a significantly shorter track section suggests that this time there must have been more than 0.1 bar of residual pressure, and therefore more brake force.

This is definitely due to a fault in the braking system, which could be:

a) a control fault on the locomotive, or
b) a fault in the equipment of the specific wagon.

Ad a)

This case is not considered by the IC as likely or significant, because in such a case the train would have been braked as a whole and it would not have been able to go on. It cannot be excluded, however, that the triple valve of the third bogie of the 470-4 wagon reacted in an extreme way to some indeterminable change in the pressure of the main line, but this also assumes that the triple valve had a fault, i.e. a deviation from other triple valves of the train.

It was not possible to extract from the locomotive's data recorder the kind of mainline pressure data that would answer this question satisfactorily (2.8).

Ad b)

Since the wagon with reg. no. 470-4 was the only one in braked state causing serious wheel damage, it is a certainty that the wagon's braking system had a defect that kept it braked despite the train's brake being released.

It is unlikely that the brake rigging would be pinched, because then the braking effect would have ceased due to wear on the brake block, and the pneumatic system may be able to maintain the force on the brake block even during continuous wear and burn.

However, no fault was detected in the pneumatic elements. The IC had them tested in detail at the manufacturer's workshop 10 months after the accident, and the tests did not reveal any anomaly related to the accident. The minor defects found were of a nature that would not cause unintended braking.

A fault is suspected in the pneumatic components of the braking system of the wagon, but all effort made to detect it during the investigation was fruitless.

4.2.5 The wheel - brake block connection

In the European railway system, there have been several occurrences where wheels braked with LL type composite brake blocks deformed when remaining abnormally braked (4.5), which suggests that this brake block poses a risk to the condition of the wheel used.

All of the occurrences reported to the IC occurred with LL IB116* brake blocks. Despite its request, the IC has not received detailed data on the occurrences reviewed by the European Railway Agency (ERA) (Annex 5.), and therefore it is not possible to take position regarding whether the phenomenon is specific to LL IB116* or to all composite brake blocks.

The LL IB116* brake block - but it cannot be excluded that all composite brake blocks - can pose a risk to the wheel condition if the braking system remains improperly braked ("fixed brake").

4.2.6 The brake block

The brake blocks of the wagon involved in the occurrence, marked LL - IB116*, complied with the Technical Specifications for Interoperability WAG Appendix C.9, which complies with UIC 541-4:2010 (Annex 4.).

During the investigation, neither the freight wagon operator nor the ERA JNS working group (4.4.2), which investigates similar incidents in Europe, identified a testing procedure that would assess the behaviour of brake blocks under conditions similar to those in this case - specifically, the effect of an unreleased brake on the wheel - as part of the brake block approval process.

However, the UIC 541-4 A6 test, which simulates the behaviour of brake blocks in the event of an unreleased (fixed) brake, is similar to this in the approval procedure; however, the issue examined in the test is the wear of the brake blocks

- during continuous braking for 60 minutes,
- at a speed of 100 km/h and
- with a brake block force of 24 kN.

During this time, the wear of the brake blocks must not exceed 16 mm.

The applicability to the occurrence under investigation must be treated with the caveat that the brake block force prior to the accident is unknown. However, the wagon derailed after 24 minutes at a speed of up to 90 km/h, but the brake block had already worn down by more than 1 km before the derailment occurred.

The French accident investigation authority made similar findings regarding the incident they investigated (4.5.2), and the TSB also collected data on a similar incident that did not result in a derailment (4.5.5).

4.2.7 Fire risk

In addition to the derailment risk discussed, a side effect of a fixed brake is the risk of fire: the detached glowing, burning brake block pieces can ignite flammable materials in the environment (see 4.5.3). This happened in this occurrence, and Annex 3 shows the resulting fires.

Regarding the fire risk, the ERA working group issued a statement that LL brake blocks do not pose a higher fire risk than cast iron. The TSB's investigation did not cover the fire risk.

4.2.8 Condition of the track

Prior to the occurrence, on 11 April 2023, a track geometry measurement was made by a measuring train, during which no defect was identified at the incident location, and the track was typically compliant to runs at 160 km/h on the train's route up to that point.

Following the derailment, the track was measured by the track maintenance organisation at the site of the derailment. The gauge varied between 1432 and 36 mm, and superelevation between -1 and 0 mm.

On this basis, track geometry cannot be associated with the derailment.

The condition of the railway track did not affect the occurrence.

4.3 Human factors

4.3.1 Detectability of a fixed brake

A sign indicating that the brake had not been released was that, during the deceleration phase after Szajol, the train slowed down at a rate of 0.05 m/s², which is higher than the 0.03 m/s² typically observed for other trains (3.2.2). However, even though this deceleration rate was mathematically higher than usual, it was actually too low for the locomotive engineer to reliably recognize it as an anomaly. (In normal decelerations based on the locomotive engineer's experience, trains decelerate at least ten times this rate.)

4.3.2 Detectability of the derailment

The locomotive driver detected a jolt resulting from the derailment, but its magnitude was consistent with his experience, as similar jolts frequently occur whilst driving under normal operating conditions; therefore, he saw no reason to regard this familiar phenomenon as an emergency.

Towing the derailed carriage increases the tractive effort requirement; however, due to automatic speed control, the locomotive handles this without any intervention from the driver. The phenomenon therefore remains hidden from the driver. The traction force display can provide information in this regard, but only if the driver has a reliable understanding of the traction force required to move a train of a given weight, technical condition and speed on the track in question, or if they notice a change in the previous value. This cannot be expected of the driver.

The locomotive driver checked his train 33 seconds later, following the second, stronger jolt, by looking out of the window, and identified the derailment accordingly. At this point, the emergency braking he had initiated had no effect on the course of events, because by then the train had begun to brake due to the train breaking up.

In the period between the two jerks, therefore, there was no phenomenon or information – differing from normal driving conditions – on the basis of which the driver should clearly have taken action. There is no explicit requirement for the active, regular monitoring of anomalies (e.g. frequent looking back, checking traction), and such behaviour would also act as a risk-increasing factor by diverting attention from other driving tasks (looking ahead).

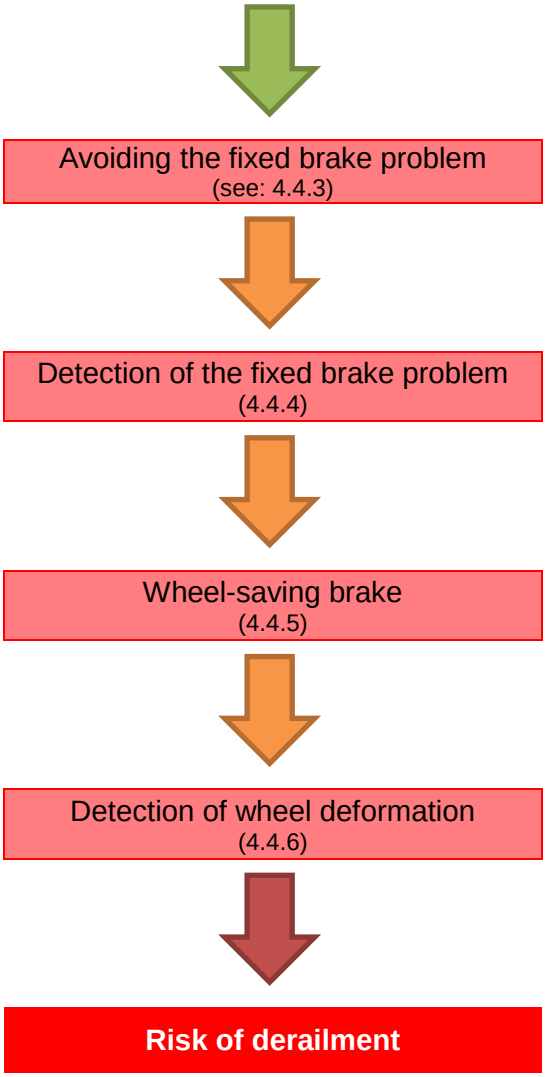
All of this is significant in terms of the consequences of the derailment that occurred. Had the driver identified the derailment sooner and stopped the train, the carriages turning sideways and consequently overturning would probably still have been unavoidable, as the rear of the train would have collided with the derailed carriage at the front, which was slowing down more rapidly; however, the damaged section of track might have been shorter.

Smaller jerks, which are common on locomotives, and automatic speed control make it less likely that the driver will be able to detect the anomaly.

4.4 Safety procedures

4.4.1 Ways to avoid this occurrence

The occurrence is the consequence of a process from a fault to an emergency to an accident, a process that can be stopped at several points by appropriate interventions and safety measures. The points of intervention identified in this occurrence (each option is discussed in more detail in the referenced chapters):



4.4.2 Activities of the European Railways Agency

Following the occurrence near Breda, the Netherlands, on 27 May 2016 (4.5.1), ERA set up a working group to investigate the risks associated with LL brake blocks, but the working group achieved no substantive results.

An investigation into the problem was also initiated by the Dutch authorities.

Following an occurrence near Troyes, France, in 2019, the French accident investigation body BEATT issued a safety recommendation to ERA *to "Re-establish the Joint Network Secretariat «wagon braking systems» working group to define measures to prevent damage to the running surfaces by grooving when braking wagons equipped with LL-type brake blocks."*

The results of the newer working group, established in November 2021, are presented in more detail in Annex 5, and are referred to in the following chapters on a case-by-case basis.

4.4.3 Avoiding “fixed brake”

The design, manufacturing quality, maintenance, operation, etc. of the braking system have a major impact on its reliability and thus on the likelihood of a fixed brake.

The ERA working group has drawn attention to the need for these to be carried out with precision and care, but does not answer why these procedures - which are largely laid down in the rules and applied in professional practice - are not perfectly implemented in practice. On the other hand, it is also noted that prevention of the “fixed brake” problem is not economically and organisationally feasible.

The IC also shares the view that the measures listed by the working group may improve brake reliability - and therefore certainly reduce the likelihood of an accident - but that it is impossible to prevent a fixed brake.

(It is also true in general that the probability of failures can be reduced, but not completely prevented, by spending more resources; that is, there is a level of safety measures where further reducing the probability of failure would require more effort than intervening at other points in the safety process (see 4.4.1))

4.4.4 Identifying a fixed brake

Slow down

An unreleased brake has an effect on the traction force needed to move a train but, according to those set out in Chapter 4.3.1, the braking (not even necessarily complete) of a wagon of a heavy freight train can only be detected with a low probability on such a subjective basis.

Track side monitoring

The hot axle-box detector is suitable for detecting wheel overheating, which occurred as an effect, and the train passed by a measuring device in the Újszász - Szolnok interstation track section (Annex 1), but its data did not show any abnormity. The fault developed only afterwards (3.2.2), but no such equipment was installed in the next section.

As the train travelled just over 20 km between the time of the fault and the derailment, preventing accidents in this way would require a much higher density of gauges to ensure that there is time and a safe way to stop the train after the fault has been signalled. The density of 30-80 km proposed by the ERA working group is therefore insufficient to prevent such incidents.

In the past, a similar function was performed by the obligation for station staff to monitor trains (if there is already a visible sign of a problem, i.e. sparking or smoking), which can be compared to the very densely installed hot axle-box detectors. The serious consequences of the incident referred to in Chapter 4.5.5 could thus be avoided. However, on the railway line where this incident took place, the stations and sidings are now unmanned service stations because of their modern safety equipment.

Vehicle side monitoring

The ERA working group has discussed the possibility of brake monitoring devices integrated into electronic equipment with other functions, which for the time being

exist only as a test system and require further development. In the short to medium term they cannot replace track-side sensor systems.

4.4.5 Wheel-sparing brake

However, in the view of the IC, as outlined in Chapter 4.4.1, investigating and understanding of the wheel vs brake block interaction represent a clear intervention option and cannot be ignored in the search for ways to avoid such occurrences.

The French Accident Investigation Authority has also issued a safety recommendation to the ERA, the UIC and the Bureau de Normalisation Ferroviaire (France) to review the testing procedures for LL brake blocks.

Also in the context of that recommendation, the ERA working group concluded that the requirements for the design of LL composite brake blocks are sufficiently covered by the current legal framework and that the LL IB116* brake block conform to such requirements. However, the report does not address the question of the adequacy of the specifications themselves.

The working group does not consider that a fixed brake poses a major risk of wheel damage and therefore does not see the need for further research on the interaction of composite brake blocks and wheels in the case of a fixed brake, but notes that such studies are ongoing. The IC has not received any answers to its questions from either the ERA or the UIC regarding these investigations.

Based on the accidents that have occurred and the wheel injuries that have been observed, the IC is certain that the risk implied in the of wheel vs brake block contact exists.

4.4.6 Detection of wheel deformation

Dangerous deformation of the wheel can be detected by appropriate measuring equipment or by visual inspection (the ERA working group draws attention to the latter).

However, visual inspection is not possible while the vehicle is in motion, and is therefore not suitable for avoiding such occurrences, and the same, but even less favourable conclusions can be drawn about measuring equipment as mentioned in Chapter 4.4.4: once the wheel is deformed, the vehicle is probably only a few kilometres or a few minutes away from the derailment, at which point there is very little possibility of intervention.

4.5 Previous similar and related occurrences

The TSB has not investigated a previous incident that could be linked to the present case, but similar cases have occurred in Europe.

4.5.1 27 May 2016 Breda (NL)

A fixed brake on one of the wagons of a freight train equipped with LL brake blocks caused the brake blocks to burn, deforming all 8 wheels of the wagon.

Following that occurrence, the ERA set up a working group to examine the risks associated with LL brake blocks, but the working group did not achieve any substantive results (Annex 5.).

4.5.2 26 July 2019 Troyes (FR)

On freight train 60815, carrying vegetable oil in its VTG tank wagons, a hot axle-box detector installed near Troyes (FR) gave an emergency signal, causing the train to stop.

The French accident investigation body (BEATT) found that a wheelset of one of the freight wagons fitted with LL - IB116* brake blocks was badly damaged (Figure 6), the wagon was missing brake parts, damage was identified on the track and there were several fires along the railway track.

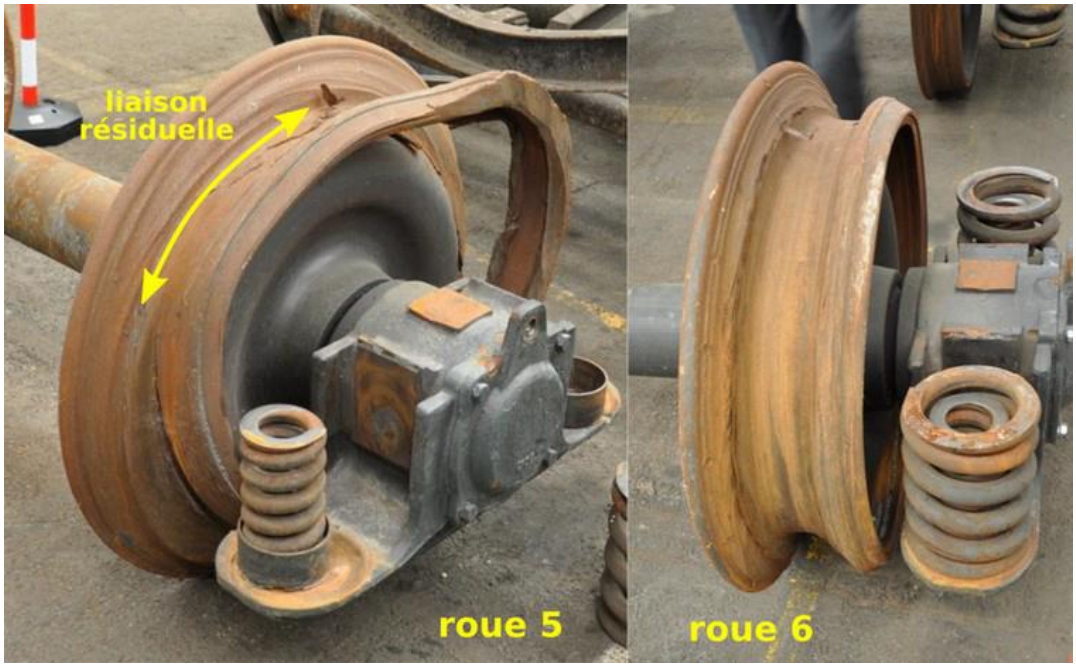


Figure 6: Damage to the wheels (source: French final report of the occurrence)

Following a brake test after starting the wagon, the wagon remained braked due to a pneumatic fault and the LL brake blocks used caused the wheel to overheat.

The report identified the possibility that the approval and testing of the brake blocks may not have been carried out properly, or that the testing used did not adequately model the operating conditions. The behaviour of composite brake blocks, which heat up to high temperatures during continuous braking, has been highlighted by working groups at European level in a number of incidents, but without tangible results and no preventive measures followed.

The body issued safety recommendations:

- to the wagon operator relating to the handling of defects at wagon or main part level and on the quality control of LL brake blocks by the supplier;
- to ERA to re-establish the working group referred to in Chapter 4.5.1;
- to ERA, UIC and the Railway Standards Bureau to review the testing procedures for LL brake blocks.

4.5.3 23 July 2022, Mezőberény - Tiszatenyő, Szolnok (2022-0783-5)

The international freight train No. 48400-1, also carrying dangerous goods, was stopped at Szolnok station because the wooden floorboard of its 19th car was on fire. It was later found that the undergrowth, followed by agricultural land and farm buildings had caught fire in several places along the train's route.

The incident was not investigated by the TSB, but the MÁV Zrt., as part of its corporate investigation, found that the braking system of the sixth freight wagon in the train failed to fully release due to a brake rod and triple valve failure, and that of the 18th freight car due to a triple valve failure. LL plastic brake block pieces and sparks from the brake exposed to constant friction ignited the vegetation and the last (19th) wagon. The brake blocks of the carriage were worn down to the support structure.

The technical investigation concluded that the failure of the brake-gear return failure on wagon 6 was the cause of the fixed brake, and that on the 18th there was 0.1 bar of pressure left in the brake cylinder.

The failure was not detected and dealt with in time because:

- The train also passed over two vehicle diagnostic devices installed on its route (between Kétegyháza and Békéscsaba and between Tiszatenyő and Szajol), which could probably have indicated overheated wheels, but neither of them worked.
- An off-duty worker at Mezőtúr station detected an anomaly (sound and smoke) in the passing train, notified the locomotive driver, but he was unable to identify the fault while the train was moving (neither looking back nor trying to brake).

4.5.4 10 August 2023, Gotthard Base Tunnel (CH)

In the Gotthard base tunnel, a wheel rim of a freight train from Chiasso to Basel broke and 16 wagons of the freight train derailed.

An investigation by the Swiss transport safety authority attributed the wheel rim fracture to excessive heat stress on the wheel caused by the composite brake blocks.

The final report of the occurrence is available on the website of the Swiss transport safety body.

4.5.5 18 May 2024 Nyíregyháza – Hajdúhadház

At the time of the investigation of the present incident, the braking system of several wagons of a freight train remained braked after departure from Nyíregyháza station, presumably due to foreign intervention. After 15 km, at Újfehértó station, several brake blocks of the train were observed to be on fire and the train was stopped.

The wheels of the wagon fitted with LL - IB116* brake blocks were deformed and the brake blocks were largely burnt (Figure 7), while the wheels and brake blocks of the wagon fitted with the similarly braked K brake blocks (also a composite type of brake block) were slightly damaged.

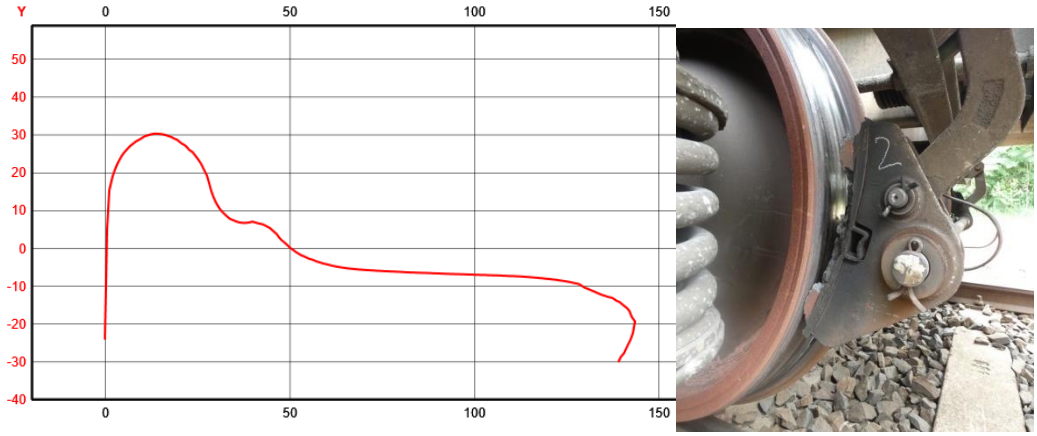


Figure 7: Damaged profile and brake block of one wheel braked with an LL - IB116* brake block

5. CONCLUSIONS

5.1 Summary

5.1.1 Causal factors

Acts, mistakes, events or conditions or a combination thereof the elimination or avoiding of which could probably have prevented the accident or incident:

a) a wheel of the second wagon in the train suffered a plastic deformation to such an extent that it lost its running safety (4.2.1); because
   - after the train had left Szolnok or at the latest during the subsequent restricted-speed running, the third bogie of the wagon was left braked for reasons not revealed during the investigation (4.2.4); and
   - therefore, the heat load from the unreleased brake caused a plastic deformation to the wheel (4.2.2).

5.1.2 Contributing factors

Acts, mistakes, events or conditions which influenced the occurrence by increasing its probability, accelerating the effects or the severity of the consequences, but the elimination of which would not have prevented the occurrence:

a) the design and condition of the wheelset and braking system increase the risk of excessive heat stress on the wheel (4.2.2);
b) the organisation responsible for maintenance did not fit the carriage with a brake block in accordance with its own specifications – as it considered the one actually fitted (IB116*) to be equivalent to the prescribed one (J847), and furthermore, it cannot be verified that it had fully satisfied itself as to the operational capability of the braking system (4.1.3);
c) the driver did not detect the derailment in time, which had the effect of aggravating the consequences (4.3); the minor jerks that occur on other locomotives and the automatic speed control make it less likely that the driver will be able to detect the anomaly (4.3);
d) and, in conjunction with the introduction of unstaffed stations on the section in question, no track-side diagnostic equipment capable of detecting faults of this nature had been installed (4.1.1).

5.1.3 Systemic factors

Causal or contributing factors of organisational, management, social or regulatory nature which are likely to have an effect on similar or related occurrences, particularly including regulatory framework conditions, the design and use of the safety management systems, the skills of the personnel, the procedures and maintenance:

a) the LL brake block – though it cannot be ruled out that this applies to all composite brake blocks – may pose a risk to the condition of the wheel if the braking system remains abnormally engaged (4.2.5);
b) although several accidents and studies (4.5) have drawn attention to the potential risks of composite brake blocks, no conclusive studies have been carried out (4.4.5).

5.2 Actions taken

The organisation in charge of the maintenance of the wagon has not taken any action until the final report is drawn up, as - according to their information - the official and clear reason is not yet known and the organisation cannot yet carry out an analysis of the repairs.

5.3 Additional notes

Risk-increasing factors that are unrelated to the occurrence of the occurrence:

a) the maintenance documentation for the wagon is incomplete as regards the brake test data for the wagon section “A” (4.1.3);
b) there were faults in the wagon’s braking system that were not linked to the accident (4.2.4).

5.4 Proven procedures, good practices

The IC identified no factor that helped to reduce the consequences of the occurrence and avoid a more serious outcome.

5.5 Lessons learnt

There are several ways to avoid such occurrences, as described in detail in Chapter 4.4.1. Among these, avoiding or detecting a fixed brake and detecting an overheated wheel are well known possibilities in the railway industry, but they also have limitations.

On the other hand, as regards the interaction between composite brake blocks and the wheel, the IC has also encountered open questions in international organisations, so no conclusions can be drawn at this stage on the possibility of intervention and possible limits in this area.

6. SAFETY RECOMMENDATION

Due to obstacles in carrying out the investigation in sufficient depth (2.8), the IC is unable to issue a well-founded safety recommendation.

However, the IC points out that, as the experience of the study suggests that composite brake blocks may cause damage to the wheel tread in the case of unintended braking, further investigation into the wheel/brake block interaction could be warranted.

7. DISSENTING OPINIONS

No dissenting opinion was expressed by the members of the IC. Those involved in the occurrence requested the publication of the following differing opinions:

7.1 The dissenting opinion of the VTG

Regarding the possibility of detection of emergency situations by train drivers (4.3):

"29. With regard to the obligation to look back, we note that

(i) the fire caused by the incident affected 7 kilometres of undergrowth along the railway line from Szajol to Kétpó, with 10 hectares (!) of crops burnt in one place; and

(ii) the fixed brake probably also caused smoke to form.

Therefore, the VTG's position is that a look-back by the train driver or the responsible crew could have prevented the accident, or at least significantly reduced its consequences.

30. It is unreasonable to claim that there is no need whatsoever for active monitoring of the train if the locomotive is equipped only with a rear-view camera that must be switched on manually. In such cases, internal instructions should actively require the locomotive driver (or any other staff member performing monitoring duties, if applicable) to switch on the rear-view camera regularly."

In relation to the conclusions (the reference now applies to point 5.1.2.b. following an amendment to the Draft Report).

"32 The list of factors contributing to the incident set out in section 5.1.2 should be amended as follows:

- point 5.1.2(c) should be deleted, as the use of the IB116 brake block instead of the J847 brake block was in accordance with the relevant maintenance instructions, and the Report did not detail any distinguishing characteristics of the IB116* brake block compared to the J847 brake block that could have had a relevant impact on the incident. See paragraphs 9–13."*

VTG expressly draws attention to the fact that

“[…]

(iv) we dispute that, based on the maintenance instructions in force at the time, it would have been mandatory to switch from the IB116 to the J847 type brake block;*

(v) we dispute that the test in accordance with UIC 541-4:2010 (Annex 4) / UIC 541-4 A6 has any relevance: as the brake pressure at the time of the accident is unknown, the results of the standard test cannot therefore be compared with the behaviour of the brake blocks during the accident.”

Budapest, 20 March 2026

Gábor Chikán Investigator-in-Charge	Péter Demjén IC Member

ANNEXES

Facts that had a material bearing on the occurrence and/or its investigation and were not otherwise presented in the final report.

Annex 1 Essential characteristics of the rolling stock

The freight wagon with reg. no. 3368 4953 470-4 passed through the dynamic wheel load measuring device installed between Kelenföld and Ferencváros stations at 3:20 am. The measured data and evaluation provided by the equipment are shown in the table below:

Axle	VTK				Measured data				Asymmetry		
	No.	Wagon ID	Licence	Axle load	Left	Right	Axle	Total	R/L	R/L, Wagon	Front/ Back
11	3	3368 4953 470-4	None	9.4 t	2.3 t	2.2 t	4.4 t	53.1 t	6.3 %	6.7 %	120.0 %
12				9.4 t	2.4 t	2.3 t	4.7 t		5.5 %		
13				9.4 t	4.1 t	3.4 t	7.5 t		17.5 %		
14				9.4 t	3.6 t	3.5 t	7.2 t		2.3 %		
15				9.4 t	7.8 t	7.2 t	14.9 t		8.0 %		
16				9.4 t	7.3 t	7.1 t	14.4 t		1.8 %		

At 4:59, the train passed over the hot axle-box detection equipment installed at Újszász - Szolnok station, which also measures wheel rim temperatures. According to its data, the temperatures of the train's wheels were 79 to 85°C, while the temperature of the wheelsets involved in the accident was 85°C.

Note: the data measured by the equipment is incomplete: wheel rim temperatures are only provided for the left side, bearing temperature only for the right side.

Annex 2 Data recorders of railway vehicles

Data recorders of railway vehicles

The data read out from the locomotive's travel data recorder is illustrated in Figure 8. The times of the running data had to be corrected by 7203 seconds to synchronize with the MFB data.

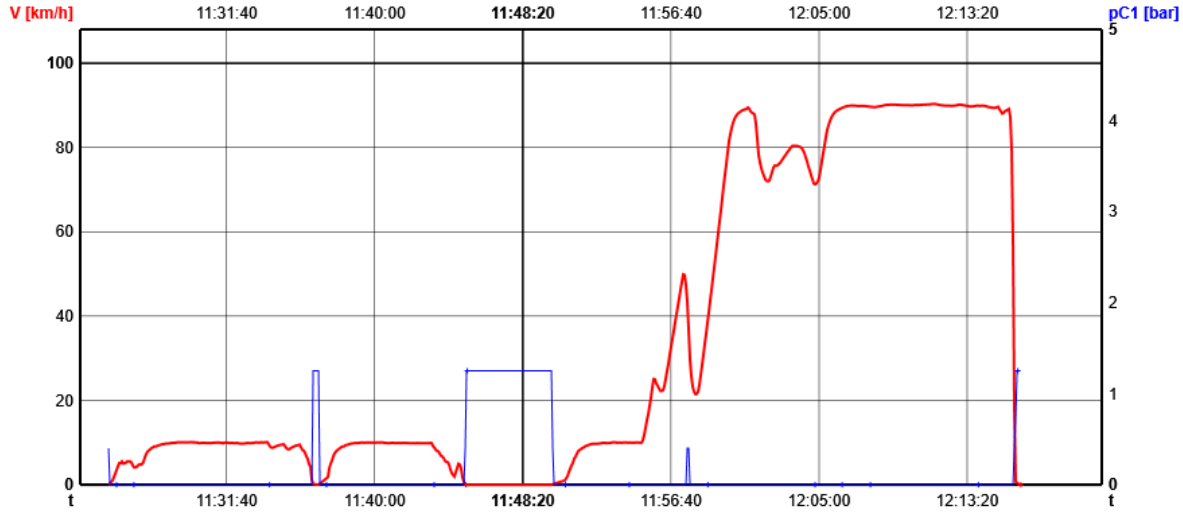


Figure 8: locomotive running data
red: speed
blue: locomotive brake cylinder pressure band

Annex 3 Fires along the track

The Jász-Nagykun-Szolnok County Directorate of Disaster Management provided the following information about the time of the fire (9 July 2023 in all cases):

- 12:15:33
- 12:18:52 - Tiszatenyő;
- 12:27:21 - Tiszatenyő;
- 12:42:36 - Kétpó;
- 12:51:09 - Tiszatenyő;
- 12:52:03 - Kétpó;
- 12:55:39 - Tiszatenyő;
- 13:12:18. - Kétpó.

“The fire affected 7 kilometres of typical undergrowth in patches along the railway tracks leading from Szajol towards Kétpó. In one place, 10 ha of standing wheat was on fire.”

A more precise location of the first origin of the fire: from Szajol station towards Tiszatenyő station, starting from about section 47, it was on the right side of the train’s direction of travel.

Annex 4 Extract from the UIC 541-4 Decision

German version of the UIC Decision (November 2020)

A.6.1 - Prüfprogramm A6

V-BKS-Material	organisch oder gesintert
Art des Bremsklotzes pro Rad	2 x Bg (2 Sohlen x (320 x 80 $\binom{+1}{-2}$ mm)) oder 2 x Bgu (4 Sohlen x (250 x 80 $\binom{+1}{-2}$ mm))
Radtyp	Konform mit *UIC-Merkblatt Nr. 510-5*, Radkranzvolumen gem. Punkt A.14 - Seite 116
Nominal wheel diameter	920 mm, Durchmesser des Prüfrades gem. Punkt A.14. Der genaue Raddurchmesser ist im Prüfbericht anzugeben.

Bremsung Nr.	V	F_B	θ_0	Bemerkungen
	[km/h]	[kN]	[°C]	
ES (Einschleifen)	70	-	20-80	Einschleifen Simulation der Gefällebremsung mit einer Leistung von 26 kW bis min. 80 % Tragbild (in Zyklen von 45 min pro Zyklus)
BS (Bremsstörung)	100	9 kN (K) 24 kN (LL)	20-60	Simulation der Gefällebremsung bei konstanter Anpresskraft über 60 min.

Annex 5 Findings of the ERA working group

The *Joint Network Secretariat "wagon braking systems"* working group, set up in December 2021 within the ERA analysed 19 European occurrences, of which 10 incidents involved tread deformation (but no information is given on how many involved derailment). The main findings are summarised below, translated and extracted by the TSB.

The original document was available at the time of compilation of this Final Report: https://www.era.europa.eu/system/files/2024-03/JNS%20NP%20LL%20brake%20blocks_Final%20report_v2.0.pdf

Unreleased ("fixed") brakes are a phenomenon that occurs regardless of the type of brake block. However, when the LL composite brake block was introduced in the European Union in the early 2010s, the consequences were already different from those of cast iron brake blocks:

a) flaming brake blocks, causing fires in vehicles and the environment;

b) an increased likelihood of tread deformation, causing a risk of derailment.

> Both possible consequences are linked to this occurrence, as firstly there were several fires on the track section preceding the derailment, which could be linked to the train (4.2.7), and then the train derailed due to the deformation of four wheels (4.2.1).

The cases show that their occurrence cannot be linked to the type of wagon, type of locomotive, position of the wagon in the train, season, gradient ratio, speed control, or brake mode.

As risk management measures, the working group identified the following main lines of action:

a) avoid the fixed brake situation
b) detect fixed brakes
c) detect deformed tread

The points and possibilities of intervention identified by the Task Force are summarised in the following sub-chapters.

Ad a) Avoid fixed brakes

The ERA working group identified the following as possible ways to avoid fixed brakes:

a) as regards personnel training and activity: proper preparation of the braking equipment, performing brake test, attentive and professional work during brake tests, brake handling, use of pressure adjustment, knowledge of hand brake handling on different types of wagons, compliance with loading rules;

b) as regards the locomotive driver's work: use automatic traction and brake force control only if the dynamic brake is sufficient for speed control;

c) use the right amount of antifreeze (not too much) in the braking system, and ensure good air quality;

d) in maintenance and vehicle design: triple valves made before 1982 should be replaced; environmental conditions and traffic performance should be taken into account when designing the cycle; the brake rigging should be lubricated and brake strokes should be properly adjusted; air tightness should be ensured; in terms of vehicle design: water trap-free brake hose tracking; use of parking brake indicators; use handbrake with handbrake wheel only;

e) proper design of the braking equipment of locomotives (in terms of preparation, overloading, automatic speed control functions).

The working group noted that a complete elimination of the fixed brake problem is not feasible economically and organisationally.

Ad b) Detection of a fixed brake

The ERA working group has identified the following as possibilities for detecting an unreleased brake in relation to the resulting deceleration:

a) carry out a test start

meaning that the train is started at low speed with the driver's cab window open, and after the traction is released, the train is observed to see if the wagons are jammed up on the locomotive, if there is excessive deceleration, jerking, abnormal noise.[2]

b) Overheating and burning caused by the brake

a. Detection of overheated wheels by hot axle-box detection devices installed every 30-80 km, stopping trains in case of alarm;

b. Detection of a flaming brake block by train or track crew;

c. Discoloration of brake block or wheel, detection of brake block burnt condition

d. Standards and recommendations for hot axle-box detection equipment should be developed.

c) Installation of brake monitoring systems on wagons, capable of detecting fixed brakes (integrated in electronic equipment with other functions).

Such systems exist only as test systems, which require further development and cannot replace trackside sensor systems in the short and medium term. (Test systems are also present on some wagons of the railway company involved in this occurrence.)

Ad c) Detect deformed tread

According to the final report of the working group, dangerous deformation of the wheel can be detected by visual inspection of the tread.

Other

The ERA working group has concluded that the requirements for the design of LL composite brake blocks are sufficiently covered by the current legal framework (the Interoperability Directive, the Technical Specifications for Interoperability which require the application of the UIC 541-4 decision). The IB116* brake block involved in this occurrence complies with these requirements.

The ERA JNS concluded that a fixed brake does not pose a major risk of wheel damage and therefore the working group does not see the need for further research on the interaction of composite brake blocks and wheels in the case of fixed brakes, but they note that:

- there is an ongoing WP1.2 UIC project on the subject, the outcome of which is awaited;
- the conditions under which a fixed brake situation can lead to tread deformation and that deviations in the manufacturing process of composite

[2] The working group notes that the method is also suitable for detecting shoes left under the wagon.

LL brake blocks can have unintended consequences will be further investigated in the industry project “brake block vs wheel interaction”;

The working group also made recommendations on the subject:

a) modifying several regulations (standards, TSIs, UIC decisions) by reorganising their content;

b) brake blocks not complying with the above rules must be subject to a risk assessment and vehicles fitted with them must be authorised separately by each railway authority.

Fire risk

As regards fire hazard, the ERA working group found that

- LL brake blocks produce less high-energy sparks, the risk of fire is not greater than with cast iron brake blocks;
- the technical specifications for interoperability do not contain requirements for spark arresters and hot-wheel detection systems for freight wagons.

On this basis, a proposal for the regulation of spark arresters has been formulated.

Annex 6 Commission Regulation (EU) No 1304/2014

Commission Regulation (EU) No 1304/2014 of 26 November 2014 on the technical specification for interoperability relating to the subsystem ‘rolling stock – noise’ amending Decision 2008/232/EC and repealing Decision 2011/229/EU provides for the following:

„7.2.2.2. Wagons operated on quieter routes

Wagons belonging to one of the categories below can be operated on the quieter routes within their area of use:

- Wagons holding an EC declaration of verification against Commission Decision 2006/66/EC,
- Wagons holding an EC declaration of verification against Commission Decision 2011/229/EU,
- Wagons holding an EC declaration of verification against this TSI,
- Wagons equipped with any of the following:
  - friction components for tread brakes with EC declaration of conformity according to this TSI,
  - friction components for tread brakes listed in Appendix G.
  - disc-brake as service brake,
- Wagons fitted with composite brake blocks listed in Appendix E for the service brake function. The operation of these wagons on the quieter routes shall be limited in accordance with the conditions described in this appendix.”

Annex 7 Rules for the connection brake test

MÁV Zrt. Brake Instruction No. E.2. stipulates the following regarding the connection brake test:

„**3.4. A The K brake test**

3.4.1. Scope of the **K** brake test

During the **K** brake test, it must be verified that:

- the continuity of the train's main brake pipe has been restored,
- the condition and operation of the braking systems of vehicles newly connected to or newly incorporated into the main line comply with the requirements set out in points 2.2.-2.3.

3.4.2. A brake test must be carried out if:

- the main line of the train or part of the train has been without compressed air supply for a period not exceeding 3 hours, and the direction of charging remains the same,
- during the train's journey, the brake valve controlling the train's brakes is changed for any reason, but the direction of charging remains the same,
- vehicles have been added to the train and the direction of charging remains the same,
- vehicles with braking systems previously taken out of service are brought back into service and the direction of charging remains the same,
- the continuity of the train's main line is interrupted at any point for any reason, following restoration.

3.4.3. Performing the **K** brake test

The **K** brake test consists of a braking and release test on two air-braked vehicles following the establishment of a new main line connection in the train.

3.4.4. Performing the **K** brake test when fitting brakes to newly registered vehicles or vehicles with previously deactivated braking systems:

- A train integrity check must be carried out.
- The braking and release test shall be carried out only on newly classified vehicles with newly fitted air-brake systems and on the two air-brake-equipped vehicles following them."