KÖZLEKEDÉSBIZTONSÁGI SZERVEZET

TRANSPORTATION SAFETY BUREAU

FINAL REPORT

2008-0446-5
SERIOUS RAILWAY ACCIDENT

Monorierdő
6 October 2008

The sole objective of the technical investigation is to reveal the causes and circumstances of serious railway accidents, accidents and incidents and to initiate the necessary technical measures and make recommendations in order to prevent similar cases in the future. It is not the purpose of this activity to apportion blame or liability.

This present investigation was carried out on the basis of

- Act CLXXXIV of 2005 on the technical investigation of aviation, railway and marine accidents and incidents (hereinafter referred to as Kbvt.),
- In absence of other related regulation of the Kbvt., the Transportation Safety Bureau of Hungary carried out the investigation in accordance with Act CXL of 2004 on the general rules of administrative authority procedure and service,
- MET Decree 7/2006. (II. 27.) on the regulations of the technical investigation of serious railway accidents, railway accidents and incidents.
- The Kbvt. and the MET Decree 7/2006. (II. 27.) jointly serve the compliance with the following EU acts:

  Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on safety on the Community's railways and amending Council Directive 95/18/EC on the licensing of railway undertakings and Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification (Railway Safety Directive)
- The competence of the Transportation Safety Bureau of Hungary is based on the Kbvt. until 31st December 2006 and on Government Decree 278/2006 (XII. 23.) from 1st January 2007 respectively.

Under the aforementioned regulations

- The Transportation Safety Bureau of Hungary shall investigate serious railway accidents.
- The Transportation Safety Bureau of Hungary may investigate railway accidents and incidents which - in its judgement - would have resulted in serious accidents in other circumstances.
- The technical investigation is independent of any administrative, infringement or criminal procedures.

This present final report shall not be binding, nor shall an appeal be lodged against it.

Incompatibility did not stand against the members of the IC.

Persons participating in the technical investigation did not act as experts in other procedures concerning the same case and shall not do so in the future.

The IC shall safe keep the data having come to their knowledge in the course of the technical investigation. Furthermore, the IC shall not be obliged to make the data – regarding which the owner of the data could have refused its disclosure pursuant to the relevant act – available for other authorities.

This present final report

was based on the draft report prepared by the IC and accepted by the Director-General of TSB. The draft report was sent to the relevant parties - defined by law - for reflections. At the same time, the relevant parties and organisations were also informed and invited to the closing discussion of the draft report.

The following organisations were represented at the closing discussion which was held on 30th June 2009:

– National Transport Authority,

– MÁV Zrt.

– MÁV-START Zrt.

– MÁV-TRAKCIÓ Zrt.

– Bombardier MÁV Kft.

– 1 person from the railway staff concerned in the occurrence

ABBREVIATIONS

AS	Automatic LC Önműködő sorompó-berendezés (automata sorompó)
AT	Automatic block signal (automata térköz)
BIG	Safety Directorate (of Máv Zrt.)
CSM	Engine driver on duty on his own in the driver's cab ("Csak Mozdonyvezető" = "Engine driver only")
DB	Deutsche Bahn (German Railways)
EÉVB	Unified Train Control and Vigilance Warning Device
ETCS	European Train Contol System
IC	InterCity
IC	Investigating Committee
Kbvt.	Act CLXXXIV of 2005 on the technical investigation of aviation, railway and marine accidents and incidents
KPM VF BA	Ministry of Transport and Post Services, Railway Department, Automation Section (Közlekedés és Postaügyi Minisztérium, Vasúti Főosztály Berendezés Automatizálási Szakosztály)
MÁV Zrt.	Hungarian State Railways Plc. (Magyar Államvasutak Zártkörűen Működő Részvénytársaság)
ÖBB	Österreichische Bundesbahn (Austrian Federal Railways)
TEB …	Telecommunication, Heavy Current and Signal Box (Távközlési, Erősáramú és Biztosítóberendezési …)
TSB	Transportation Safety Bureau
VBO	The competent Regional Railway Safety Department of MÁV Zrt. Safety Directorate

SUMMARY

Type of occurrence	serious railway accident
Character	collision of trains
Time of occurrence	10:28 on 6 October 2008
Location of occurrence	between Monor and Pilis stations
Type of railway system	national
Type of movement	rolling stock in motion
Fatalities/injuries	4 fatalities 4 seriously injured persons
Extent of damage	the railway track sustained minor damage, the vehicles sustained various damage, two carriages could not be repaired
Registration number of the involved train(s)	2537 és IC 560-1
Infrastructure manager	MÁV Zrt.
Operator	MÁV-Start Zrt.
State of Registry	Republic of Hungary

Location of the occurrence

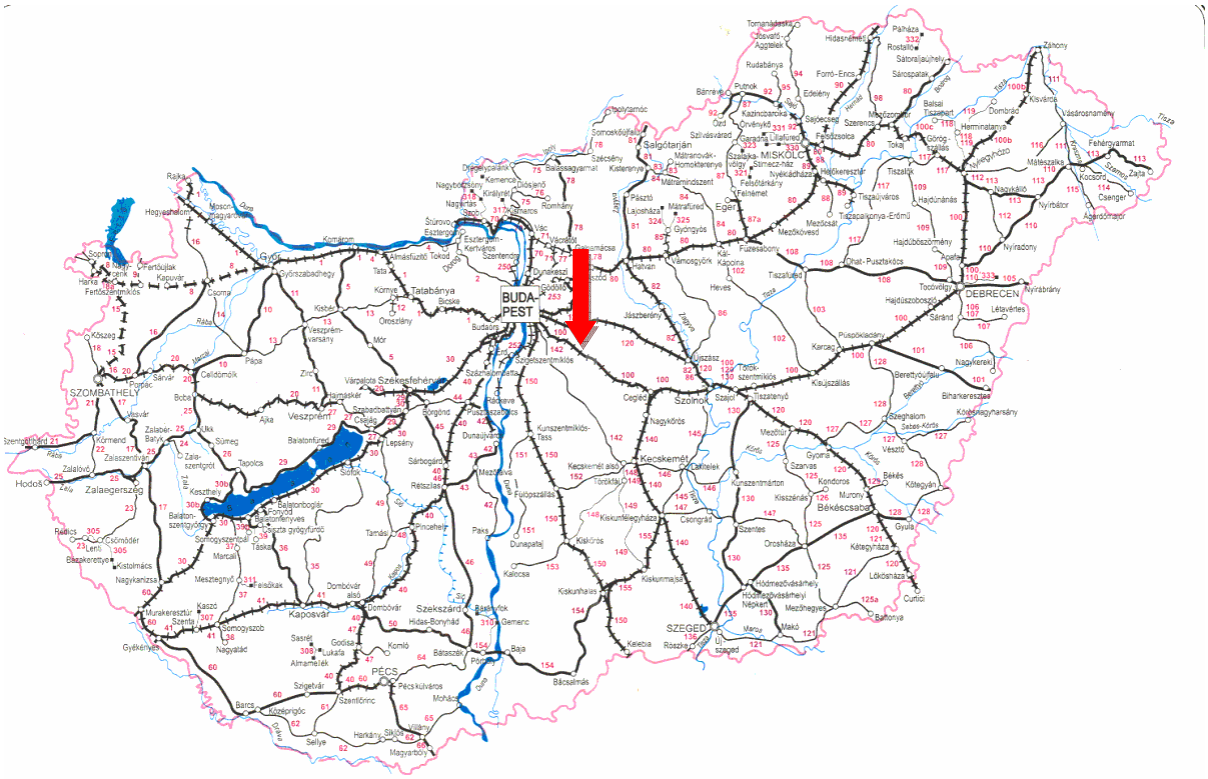


Figure 1.: The location of the accident on the railway map of Hungary

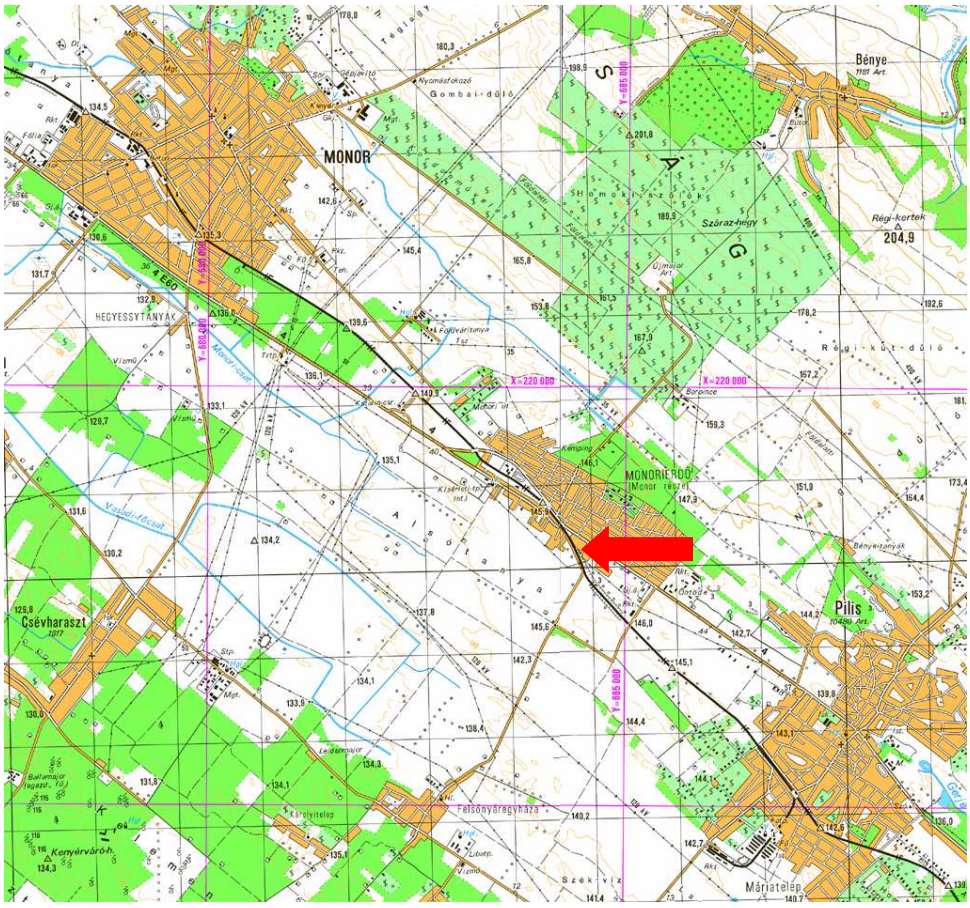


Figure 2: the location of the accident on a more detailed map

Reports and notifications

The head of traffic operations control of MÁV Zrt. reported the occurrence to the TSB duty services at 10 hours 34 minutes on 6th October 2008.

The on duty personnel of TSB reported the occurrence to

– the TSB's head of department on duty at 10:36 on 6th October 2008

– the accident investigator on duty at 10:38 on 6th October 2008.

Investigating Committee

The Director-General of TSB appointed the following Investigating Committee (hereinafter referred to as IC) to investigate the railway accident on 6th October 2008:

Investigator-in-Charge	Gábor Szeremeta	accident investigator
Members of IC	Pál Burda	on-site investigator technician
	Zita Béleczki	accident investigator
	Gábor Chikán	accident investigator
	Róbert Karosi	accident investigator
	Iván Lócsi	accident investigator
	András Mihály	accident investigator
	Éva Prisznyák	accident investigator
	János Rózsa	accident investigator

Gábor Szeremeta, Zita Béleczki and Iván Lócsi resigned from TSB in the course of the investigation, therefore the IC comprised the following members at the completion of the investigation:

Investigator-in-Charge	Gábor Chikán	accident investigator
Members of IC	Pál Burda	on-site investigator technician
	Róbert Karosi	accident investigator
	András Mihály	accident investigator
	Éva Prisznyák	accident investigator
	János Rózsa	accident investigator

Overview of the investigation

The IC conducted a site survey on 6th October 2008.

In the course of the investigation, the IC:

– interviewed the witnesses and persons involved in the accident,

– contacted the injured persons in writing,

– requested and received the necessary documents,

– reviewed the relevant rules and regulations,

– evaluated the strip chart recorder,

– used the opinion of medical experts to compile the final report, and

– issued a safety recommendation on 9th October 2008.

Overview of the occurrence

On 6 October 2008 commuter passenger train No. 2537 and InterCity train No. 560-1, running in the same direction, collided between Pilis and Monor stations. The speeds were 71-78 km/h and 10-12 km/h respectively. The control carriage of the passenger train crashed into the last carriage of the InterCity on an 11-metre-length. Four people died, four people were seriously injured, and forty people suffered minor injuries.

Prior to the accident, the signal box of the track between the given stations went offline due to a shorted cable, and as a result, the block section control system and the signal box of Pilis station became inoperative. The traffic control personnel had the possibility to declare the control system inoperative and change over to station distance traffic. However, they did not do so and the train movements remained controlled by block sections.

The above mentioned control method was allowed by the relevant instructions, according to which the trains had a speed limit of 15 km/h while running through Pilis station and also on the open track, under subsidiary signal. The speed limit is enforced by the train control system installed on engines and control carriages. If the train passes a Stop signal or a Subsidiary signal with a higher speed and there is no signal received from the signal box of the track, the system activates the emergency brakes and stops the train. Due to the faulty signal box the passing trains did not receive signals from the track which would have allowed them to run at higher speed between Pilis and Monor stations.

The InterCity train no. 560-1 sz. was running with that limited speed from the entry signal of Pilis station (and stopped at the station for a short time).

Having passed the entry signal at Pilis station, passenger train no. 2537 - some time after the Intercity - , the speed limiter of the train control system was disabled by the run/shunt switch located in the control car. The passenger train stopped at Pilis station, then departed with a speed of 12-29 km/h (instead of the 15 km/h speed limit) and accelerated to 100-107 km/h on the open track. It passed a dark block section signal (disregarding the specific restrictions the train driver shall observe when passing a dark signal) and an LC with barriers which seemed to be in open position, with the same high speed.

The driver detected the other train on the track ahead while moving on a curved track. The emergency brakes were applied but the collision could not be avoided.

The IC established that

– MÁV regulation E.1. “Regulations for traction vehicle staff” describes in which circumstances the train control system can be deactivated but the guidelines are too general. The IC issued a safety recommendation addressing the issue on 9 October 2008;

– the regulations as to when can block signals be considered inoperative provide too much freedom to the staff in making decisions;

– the staff did not use their scope of authority to declare the block signals inoperative;

– the design and construction of the furnishings of the InterCity carriage – which was damaged beyond repair in the accident – most probably contributed to the severity of injuries of the passengers travelling in the carriage.

In addition to the safety recommendation issued in the course of the investigation, the IC recommends:

– to revise the speed limit of 15 km/h to be observed under subsidiary signal;

– to put more emphasis on passive safety during the design of construction and furnishings of passenger rail carriages;

– to develop regulations and rules which provide basis for making decisions on when can / should block signals be considered inoperative,

– to focus on decision-making during staff training.

1. FACTUAL INFORMATION

1.1 Course of the occurrence

On 6th October 2008 at 9:45, there was a power supply failure in the system powering the 75 Hz circuits of the signal box between Monor and Pilis stations. As a result of the failure, only subsidiary signals could be sent to the main signal of Pilis station, and all block signals turned dark between the two stations. The movements inspectors saw this on the signal boxes as if the arrival tracks of Pilis station and all the block sections between the two stations had been occupied. They did not have information on the actual status of the block signals.

The relevant regulations allow the traffic control personnel to declare the block signal inoperative, and change over to station distance traffic. However, in this case they did not decide to do so.

Train no. IC 560-1 running from Budapest-Keleti station to Budapest-Nyugati station - through Miskolc and Nyíregyháza - approached Pilis station from Albertirsa direction with subsidiary signal at 10 hours 6 minutes. It stopped at the station, then departed under subsidiary signal at 10:08 and ran on according to the rules of block section traffic on the left (correct) track. In this case - as the block sections seemed occupied - the train was allowed to run with a maximum speed of 15 km/h so that it would be able to stop safely at any obstacle. In compliance with this, the train ran with 10-12 km/h speed towards Monor station.

At 10:21 commuter passenger train no. 2537 with a control car on its front running from Cegléd to Budapest-Nyugati was also approaching track III of Pilis station (from Albertirsa direction) under subsidiary signal. While approaching the station, the speed limiter of the train control system located in the control car was disabled (this device detects when the train passes a Stop signal, and prevents the train from exceeding the 15 km/h speed limit). As in the timetable, the train departed at 10:22 towards Monor under subsidiary signal which only allows a maximum speed of 15 km/h until a contrary signal. Having left the station on the left (correct) track, the train, however, accelerated to 100-107 km/h speed.

As a result of the low speed of train no. IC 560-1, LC no. AS 450 - which it passed on its way - became inoperative, as a consequence of which its warning lights towards the road turned dark and its barriers slowly opened. Train no. 2537 arrived at the LC in this state and passed it without braking, with an approximately 100-107 km/h speed.

After passing the LC, the personnel in the driver's cab noticed the rear of the IC train on the track in front of them. Although the engine-driver applied the emergency brakes, the passenger train reached the IC train and its control car collided with the last - first class - carriage of the IC train with 70-78 km/h speed.

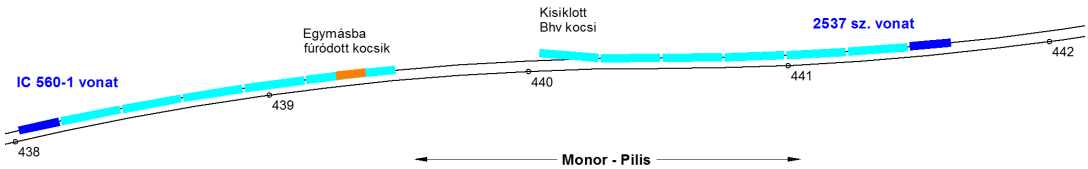


Figure 3: scale drawing of the accident site

As a consequence of the collision, the control car penetrated into the last carriage of the IC on an approximately 11-metre length (See Figure 4). The passenger train got disengaged and its second carriage derailed. Three people travelling in the last carriage of the IC train lost their lives at the site and another person died in the hospital (3 passengers and 1 crew). Four people suffered serious injuries and further 40 were injured.

Figure 4: the site of the accident

1.2 Injuries to persons

Injuries	Staff	Passengers	LC users	Others
Fatal	**1**	**3**	–	–
Serious	–	**4**	–	–
Minor	**1**	**39**	–	–

Three people suffered such serious injures that - according to experts' opinion - they will probably have permanent impairments.

1.3 Damage to railway vehicles

Based on the available preliminary estimations, the damage to the railway vehicles of MÁV-Start Zrt. amounted to 160 million HUF.

Train no. IC 560-1

The scattered pieces of the IC train carriages were found on the rail track from section 440+40 (See Figure 6).

The railway vehicles sustained various damages. The last carriage sustained serious damage, most of its passenger compartment - into which the control car of the passenger train crashed - were destroyed.

In the course of the site survey, the IC established that the overhead luggage-racks in the seriously damaged last carriage broke off, even in parts of the compartment whose carriage-body was not damaged.

Figure 5: The inside of the last carriage of train no. IC 560-1 with the torn off luggage-racks

Several pieces of the passenger compartment of carriages further away from the collided carriage also torn off. These are as follows:

– the lavatory door in the front of the first carriage,

– the lavatory door in the front of the third carriage,

– a large wall panel in the kitchen of the fourth (dining) carriage ,

– a wall panel in the passenger compartment of the fourth (dining) carriage (it did not fall to the floor, it got caught on the luggage-racks).

Train no. 2537

The railway vehicles sustained various damages. The control car in the front became unserviceable; its driver's cab and luggage carriage (for carrying bicycles on the train) were destroyed and the second carriage derailed.

Figure 6: The derailed second carriage of the passenger train and some scattered debris

1.4 Damage to infrastructure

The rail track and the overhead contact line sustained minor damage:

– Damage to rail track (estimated): 4 500 000 HUF

– Damage to overhead contact line (fact): 1 126 968 HUF

1.5 Other damage

The IC does not have information on the material and non-material damage to the people travelling on the train(s).

The environment was not harmed.

The railway line was closed on both tracks until 21:45. 19 train services were cancelled, 24 were partially cancelled and 39 trains ran on diverted routes. Altogether 63 trains were delayed by 3360 minutes.

Train replacement buses ran on the Monor-Pilis-Albertirsa route.

Other damage (train replacement, replacement staff, etc) of MÁV-Start Zrt. amounted to 7 845 000 HUF.

According to the available partially estimated preliminary (not final) data, the total amount of the material damage caused by the accident was 173 million HUF.

1.6 Personnel information

1.6.1 Engine-driver of train no. IC 560-1

Age	34 years
Gender	male
Qualification(s)	engine-driver
Medical certificate valid	Group I. December 2011
Last time on duty	06. 10. 2008. 05:19
Route knowledge	OK

1.6.2 Engine-driver of train no. 2537

Age	44 years
Gender	male
Qualification(s)	engine-driver
Medical certificate valid	Group I. January 2009
Last time on duty	2008.10.06. 02:55
Route knowledge	OK

1.7 Train information

1.7.1 Train no. IC 560-1

Train type	long-distance passenger train
Type of traction	CSM
Registration number of locomotive	V43 1030
Owner of locomotive	MÁV-Trakció Zrt.
Owner of carriages	MÁV-Start Zrt.
Number of carriages	5 4-axle passenger carriages
Registration number of carriages	50 55 20-67 072-8 (Bp) 50 55 20-67 082-7 (Bp) 50 55 20-67 074-4 (Bp) 50 55 88-67 018-0 (WRR) 50 55 10-67 019-1 (Ap)
Length of train	139 m
Tonnage	227 t
Total weight	307 t
Braked weight	451 t
Prescribed braked weight percentage	105%
Actual braked weight percentage	146%

1.7.2 Train no. 2537

Train type	commuter passenger train
Type of traction	CSM, control car in the front
Registration number of locomotive	V43 2318
Owner of locomotive	MÁV-Trakció Zrt.
Owner of carriages	MÁV-Start Zrt.
Number of carriages	control car and another 6 4-axle passenger carriages
Registration number of carriages	50 55 80-05 415-1 (BDt) 50 55 20-05 650-6 (Bhv) 50 55 20-05 737-1 (Bhv) 50 55 20-05 814-8 (Bhv) 50 55 20-05 769-4 (Bhv) 50 55 20-05 789-2 (Bhv) 50 55 20-05 618-3 (Bhv)
Length of train	183 m
Tonnage	287 t
Total weight	367 t
Braked weight	397 t
Prescribed braked weight percentage	103%
Actual braked weight percentage	108%

1.8 Description of the rail track and the signal box

1.8.1 Rail track

There is a double-track line at the site of the accident. The track from the last exit signal of Pilis station (in the running direction of the trains) runs as follows:

from 471+90	straight	
from 470+64	left curve	curve radius: 1404 m
from 466+22	straight	
from 458+21	right curve	curve radius: 1496 m
from 454+99	straight	
from 446+24	right curve	curve radius: 1100 m
from 440+50	left curve	curve radius: 1104 m

The accident occurred between the last two curves of the above list, approximately in the inflexion point (See Figure 2).

The track in this section is horizontal after a slight upward slope (the height/elevation of the track had no effect on the accident)

471+90-től	upward slope	2,8‰
470+80-tól	upward slope	3,0‰
468+50-től	upward slope	1,5‰
465+00-tól	horizontal	
458+30-tól	downward slope	0,4‰
454+50-től	horizontal	

LC no. AS 450 (protected by warning lights and half barrier) is situated in section 450+77, approximately 1037 metres from the site of the collision. The platforms of Monorierdő station are in section 435+88, approximately 462 metres from the site of the collision.

The rail track is made of 54 kg/fm rails lying on LM concrete sleepers. The permitted speed from Pilis is 120 km/h. There is no track section here where train shall run with restricted/lower speed. The conditions of the rail track had no effect on the accident, therefore their detailed description is not required.

1.8.2 Signal boxes at the stations

The function of signal boxes at railway stations is to control all movements at the station and prohibit setting routes which can endanger the previously set route (some signal boxes also control shunting movements with signals). The signal box also excludes the possibility of subsequent trains colliding with each other or opposing trains on the same track on open tracks equipped with automatic block signals. Furthermore, it closes LCs when trains run through them.

1.8.2.1 Signal box at Monor station

An ELEKTRA1 type electronic, one-centred signal box operates at Monor station, which is able to control shunting routes and check track and points occupancy as well.

The control area of the signal box

The following signals indicate the control area of the signal box:

– „A” and „B” light signals from Üllő beside the left and the right track,

– „C” and „D” light signals from Pilis beside the left and the right track,

– „J15” and „B15” shunting signals on dead-end track VI. and PGF.

The signal boxes of Vecsés and Üllő stations can be remote controlled from the control panel of the signal box at Monor station. In this case (remote controlling) the control area includes the two above stations.

1.8.2.2 Signal box at Pilis station

A MÁV DOMINO 70V type, one-centred signal box operates at Pilis station which controls train routes and is able to check track and points occupancy.

The control area of the signal box

– „A” and „B” light signals from Monor beside the left and the right track,

– „C” and „D” light signals from Albertirsa beside the left and the right track.

LCs at the stations

There are LCs at the start and end point of the station, which are protected with half barriers and warning lights. The warning lights are dependent on the main signals. The LCs are as follows:

– SR 2 (at the start point))

– SR 1 (at the end point).

1.8.3 Signal box on the open track between Monor and Pilis

The double-track is equipped with automatic block signals (ATs), with 5 block sections per track. These are as follows:

– AT 394/95

– AT 412/13

– AT 430/33

– AT 452/53

Automatic LCs on the open track

AS 413, AS 436 and AS 450 automatic block signals (situated on the open track between Monor and Pilis stations) can be controlled from the control panel of the signal box at Pilis station. These automatic block signals are not able to register operations (and/or faults).

Automatic LCs - with barriers which open up slowly in case of failure - operate between Monor and Pilis stations. They are not dependent on the signals. If the barriers do not open automatically (as in normal operation), after 6 minutes they switch to failure state and then a 3-minute so called “red extension” follows. Subsequently the barriers open up slowly within 90 seconds and stay in open position while the light signals are dark towards the road. The endpoint sensor of LC no. AS 450 (located in section 450+77) is in section 464+32.

1.8.4 Power supply

The PQ type power supply device - protected against short circuit - of Pilis station supplies:

– 75 Hz insulated rails at Pilis station

  - o all four sections turning the entry signals to ‘Stop’ („A/M”; B/M; C/M and „D/M”),
  - o the arrival tracks of the station.

– The line signal boxes between Monor and Pilis stations

  - o automatic block signals (75 Hz, 500V per twin wire),
  - o automatic half barriers and warning lights on the open track (50 Hz, 500V per twin wire).

Feedback signals of power supply

The signal box gives information on the power supply by light and acoustic signals. If operation is normal, there is a white continuous light. If there is any problem, a flashing white light appears on the control panel of the signal box.

„Power supply failure” light (rectangle shape):

– Continuous white light means trouble-free state.

– Flashing white light means power supply failure. There is also an acoustic signal indicating failure.

„Line power supply towards the start point" light (round shape):

– Continuous white light means trouble-free state, thus the sections and the LCs on the line towards the start point (Monor station) are supplied normally.

– Flashing white light means there is a failure in the line power supply system or one of the output circuit breakers is switched off towards the start point. There is also an acoustic signal indicating failure.

The documents of the 500V line cable between Monor and Pilis stations

– The record of cable-layout (500V) between Monor and Pilis stations was made on 11th July 2005.

– The cables were laid by MÁV Transdanubian Telecommunications and Signal box Construction Ltd. (Dunántúli Távközlési és Biztosítóberendezési Építő Kft.) In compliance with Directive 106 448/82.9.D.Sz. of KPM VF BA the cables were laid into an underground protective duct.

– The 500V cable on the line was put into operation on 24th July 2005 (same time as the block signal).

– The cable testing prior to the beginning of the operation was carried out by the specialists of MÁV Zrt. Budapest Telecommunication Operations Sub-department

– Values of cable testing:

  - loop resistance 20.6 Ohm
  - insulation resistance 100 M Ohm volt.

The last inspection of the line signal box was at the time of its installation on 24 July 2005.

1.8.5 The signal box failure and the occurrence of the accident

The events of the signal box failure and the measures taken in response were as follows:

– **9:45 hrs**: according to the records of PQ type power supply device at Pilis station, there was a signal box failure (actual registered time 9:50 hrs).

  - The power supply failure message i.e. light and acoustic signal appeared on the control panel.
  - At the same time, the 75 Hz insulated rails at Pilis station (all four sections turning the entry signals to 'Stop' („A/M"; B/M; C/M and „D/M") became apparently occupied.
  - Five 75Hz block sections of both rails between Monor and Pilis stations also became apparently occupied (this apparent occupancy showed at Monor station as well).

– **Immediately after the failure**: the movements inspector of Pilis station called the section controller of Cegléd whether anything happened to passenger train no. 2532 which had previously left Monor station, because there was a power supply failure at Pilis station and by then the train was running approximately in that overhead contact line supply area. The section controller

said there was no problem. Then the movements inspector said that he would inform the section controller if he receives any information.

– **9:46 hrs**: the movements inspectors of Pilis and Monor stations talked on the phone about the signal box failure. The movements inspector of Pilis station said he thought that train no. 2532 had broken off the overhead contact line.

– **9:48 hrs**: the movements inspectors of Pilis station reported the signal box failure to the signal box dispatcher of MÁV Zrt. Kelet "East" (left side), who gave the 331 code for the failure.

– **9:56 hrs**: IC 612 train departed from Monor station on the right track with subsidiary signal

– **9:58 hrs**: the movements inspector of Monor station reported the apparent occupancies between Monor and Pilis stations. The signal box dispatcher told him that the movements inspector of Pilis station had already reported the error and gave a 331 code.

– **Approximately 9:58 hrs**: according to the signal box dispatcher, he notified (on mobile phone) the signal box mechanic about the failure.

– **Afterwards,** the signal box dispatcher also notified the signal box mechanic at Monor station as well.

– **10:01 hrs**: the movements inspectors of Pilis station asked the section controller at Cegléd to call the engine-driver of IC 612 train on the locomotive radio and ask him what he can see on the line. The section controller immediately called the engine-driver who did not answer the call.

– **10:08 hrs**: IC 560-1 train departed from Pilis station on the left track with subsidiary signal.

– **10:11 hrs**: the movements inspectors of Pilis station talked to the section controller of Cegléd station who said that the engine-driver of the IC 612 train had not yet signed in on the locomotive radio.

– **In the meantime**: the IC 612 train called the section controller of Cegléd station on the locomotive radio and told him that the block signals which he had passed (no. 394 and 402) were dark, there was no signal and that he was running with 15 km/h speed. The section controller told him that there was no train in front of him and at the same time informed the movements inspector of Pilis that the block signals were dark.

– **10:14**: the movements inspector of Monor station talked to the section controller of Cegléd and asked him to call the engine-driver of IC 560-1 on radio. He did so and the engine-driver told him that he was in the first section after leaving Pilis station and he could not yet see the first block signal but would contact him as soon as he sees it.

– **10:20**: the engine-driver of IC 560-1 train reported to the section controller that the first block signal was dark.

– **10:21**: the movements inspector of Monor station called Pilis station and said that he would signal out IC 752 train under subsidiary signal at about 10:23. The movements inspectors of Pilis station also said that train 2537 would depart from Pilis station under subsidiary signal at about 10:22.

– **10:22**: train 2537 departed from Pilis station under subsidiary signal. According to the movements inspector, none of the open track warning lights between Monor and Pilis stations had become inoperable (dark) before he ordered subsidiary signal and signalled out the train.

– **10:23**: IC 752 train departed from Monor station under subsidiary signal.

– **Subsequently,** having left Pilis station and passed its SR 2 half barrier and warning lights, train 2537 gradually accelerated and passed open track LC no. AS 450 (which was not working normally by that time due to the slow running of train IC 560-1 previously) with approximately 100-106 km/h speed.

– **10:27**: the movements inspector of Üllő asked the movements inspector of Monor whether the inoperability of the LC had been registered. He answered that it had not been registered and he as well as Pilis station signalled out all trains with subsidiary signal.

– **10:28**: the engine-driver of train IC 560-1 reported (via mobile phone) to the section controller of Cegléd that an accident had occurred at Monorierdő.

– **Afterwards** the section controller instructed the movements inspectors of Pilis and Monor to press “Block section Stop!” immediately, which they did so. (However, as all block signals were dark between the two stations, this action had no effect.)

1.8.6 Measurements and establishments at the site

By the time the IC arrived at the site, the Error log from the station office had been impounded by the police.

The staff of the signal box services arrived at Pilis station at about 10:15-20 hrs to repair another previously reported fault. They had not begun to search for and fix this signal box problem by the occurrence of the accident. The IC, the signal box mechanic, the accident investigator of the VBO and the leaders of the TEB services went together to the relay room. To enter the room, they needed a key which was kept locked by a leaden seal at the station, which was removed by the signal box mechanic before the IC (according to the regulations in force one shall not enter in the room any other way).

In the relay room, it was read from the PQ power supply inverter that according to the clock of the device, there had been no supply to the line since 9:50 hrs. Having checked the fuses, it was established that none of them had been tripped.

It was measured that towards the start point (Budapest), there was no output power supply on the 75 Hz 500V line (Monor-Budapest) due to a short circuit. The IC asked the leaders of the TEB present to order their cable specialists to the site with a device which can locate and measure the short circuit.

- By late afternoon, the specialists of TEB located the short circuit in the vicinity of AT 394/95 block signal case.
- After opening block signal case AT 394/95, the measurements done on the line cable end towards the endpoint (Pilis station) showed that the short circuit was 3 metres from the cable end and the insulation resistance was 20 Ohm.
- After the measurements, the line cable was excavated before the representatives at present (members of the IC, the accident investigator of VBO, the director of BIG, the department heads of VBO, the leaders of TEB, the prosecutor, the police and their expert).
- After the excavation, the line cable (having pulled out from the protecting tube) was opened at the breakage - approximately 3 metres from the cable end - to locate the short circuit. There was no visual sign of short circuit, therefore the cable was cut.

- The cut cable part was measured again and still showed 20 Ohm insulation resistance (remained short circuited).
- The whole line cable was also measured whose resistance was 168,2 Mega Ohm (after cutting the short circuited piece).
- The representatives established that after cutting the short circuited cable part, the short circuit ceased on the line cable.
- The police impounded the cut cable part for further expert analysis.

– **20:30**: the line cable was switched back on, the power supply failure and the apparent occupancies ended.

– **On 11 November at 9 a.m.**: the cable was measured again at the Transport Automatics Department of the Faculty of Transportation Engineering of Budapest University of Technology and Economics and after establishing the fact that it was short circuited, experts opened it in the presence of the IC.

- After opening the cable, the expert and the members of the IC established that the short circuit of the 75 Hz cable was generated from inside - without outer mechanical input - and was probably caused by inadequate cable core insulation at production

1.8.7 Unified Train Control and Vigilance Warning Device

The locomotives and the control car were equipped with EÉVB. Its functions are as follows:

– Checks the vigilance of the engine-driver: there is a pedal or button that has to be kept pressed continuously and released after every 1550 run metres. If this is not done, the device gives an acoustic warning after which, if the pedal is still not released within 150 metres, the train is automatically stopped. (see also 1.16.6).

– It detects and evaluates the signals of the track circuit and shows - on the screen in the driver's cab - the information appearing on the next signals.

– Recognises and shows if the train passes a signal at danger (Stop) after which - if the train runs with higher than 15 km/h speed - it automatically stops the train.

The condition of the function which gives information on the signals is that the vehicle has to receive signals from the track which can be evaluated, that is, the track should be able to give signals.

The speed limiter and stopping function is triggered if the device detects a Stop signal from the track after which the train arrives at a section where there is no detectable signal. This limit applies until the EÉVB device receives another assessable signal from the track.

The above function can be deactivated if the information on passing a signal at danger is deleted from the device. In this case, the device cannot perform its function any longer - until an assessable signal is again received from the track.

The train control function can be deactivated the following ways:

– interrupting/terminating the power supply (e.g. with on/off switch or a fuse),

– application of "own/coupled" switch,

– application of run/shunt switch.

It should be noted that according to the signal regulations in force, there are three different screens at the driver's cab. In the control car involved in the accident there was a digital screen which shows the information with numbers or letters. As some regulations refer to the signals with the earlier used colours, we will use both the number/letter and the colour codes in this report. These are as follows:

– no assessable sign received from the track: „---" (white)
– train can pass the next signal without reducing speed: „MAX" (green)
– 'Stop!' At the next signal: „0" (yellow)
– Train has passed signal at danger: „●" (red)
– device in shunting mode: „T" (shunting)

The other, not listed signals had no relevance in the accident.

The last functional check-up of the device involved in the accident (train no. 2537) prior to the accident was on 23 January 2008 and the next one, after the accident was on 8 October 2008. According to these check-ups, the device worked normally before and after the accident as well (the measured data is also in compliance with this, see Appendix 2). The monthly, regular and briefer check-up of the device was conducted on 4 October.

1.9 Station information

There were 6 tracks/platforms at Pilis station at the time of the accident, with a few dead-end tracks and unused industrial branches. There were no subways or high platforms, the passengers could access trains from level platforms. The station office is at the end point side of the station.

The railway line and the tracks at the station were being reconstructed (building of subways and higher platforms) at the time of the accident, however, the old track/platform network had not yet been dismantled then.

The parameters of Monor station had no relevance in the accident therefore its detailed description is not required.

1.10 Data recorders of railway vehicles

1.10.1 Data recorder of train IC 560-1

There was a Teloc RT 9 type data recorder on the locomotive (V43,1030) of train IC 560-1 whose measuring limit was 150 km/h so was the measuring limit of the strip chart recorder inside it (see Figure 7).

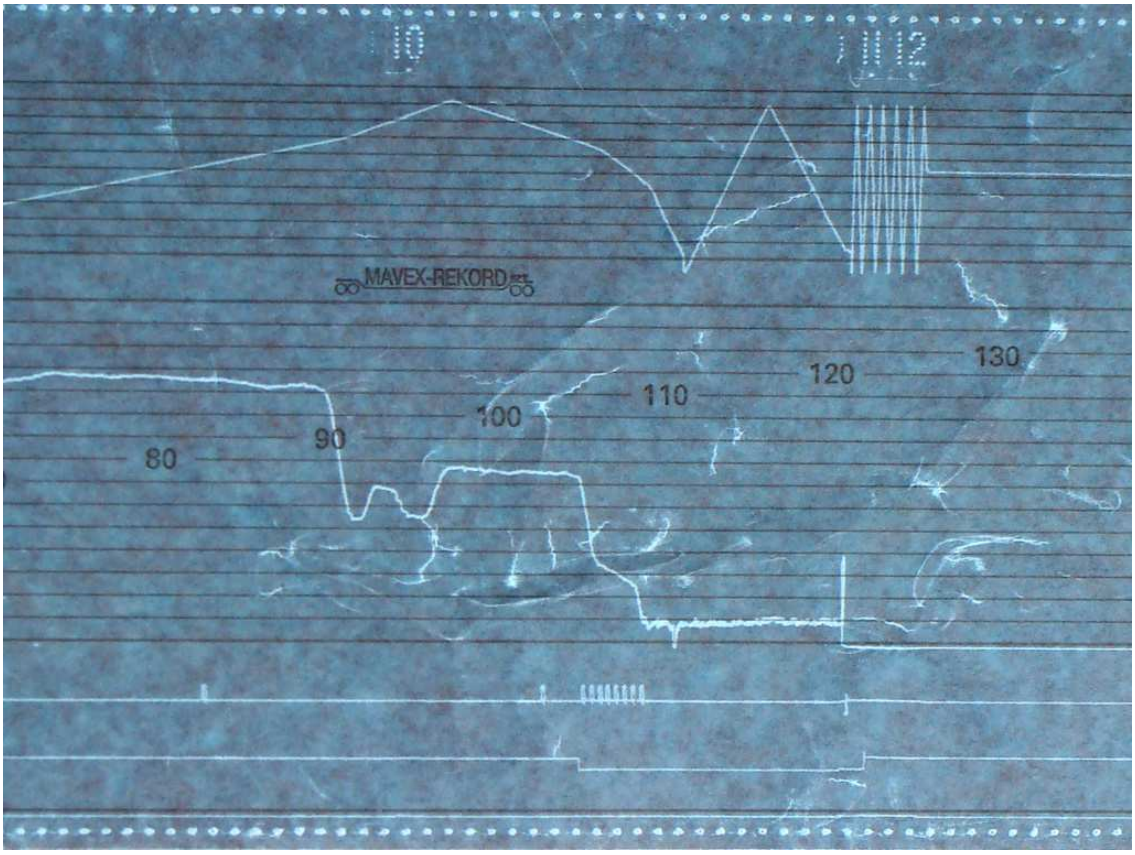


Figure 7: The strip chart recorder of locomotive V43,1030 of train IC 560-1

1.10.2 The data recorders of train 2537

There were two data recorders on train 2537; one Teloc RT 9 type on locomotive V43,2318 in the rear, whose - and the strip chart recorder's - measuring limit was 150 km/h, and another, digital Secheron Tel 1000 type in the control car (the locomotive was driven from the control car).

The strip chart recorder of the locomotive is shown in Figure 8 and the diagram of the control car's data recorder is in Figure 9.

1.10.2.1 The data recorder of the control car

The experts of MÁV Zrt together with the firefighters found the data recorder of the control car among the wreckages and opened it before the police and the IC (see Figure 8).

Figure 8: the data recorder of the control car

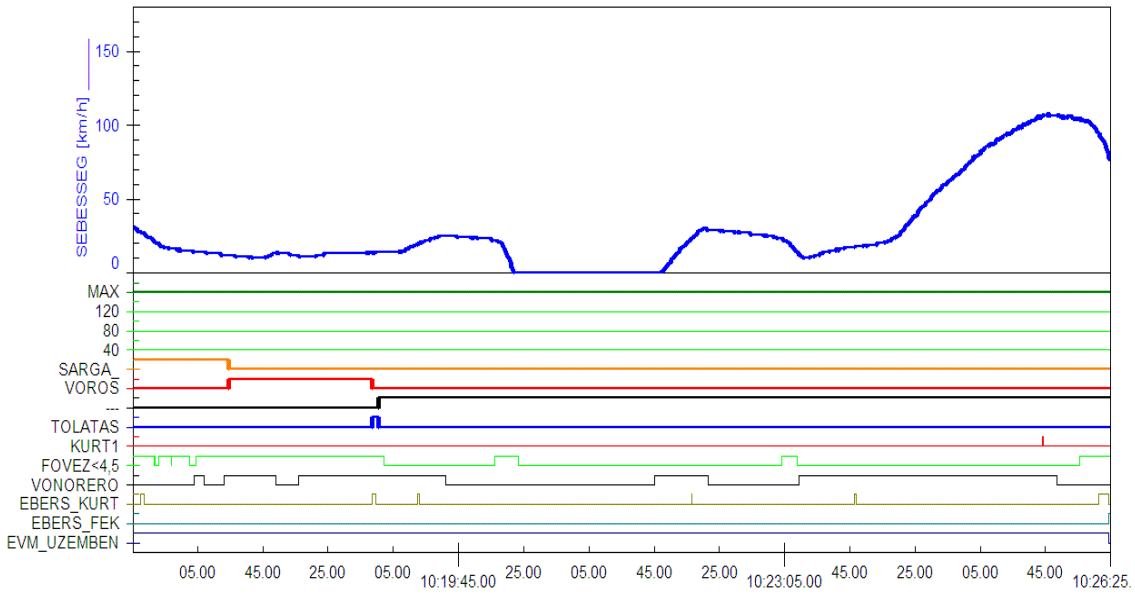


Figure 9: diagram of the BDt 415 control car's data recorder (train 2537)

Excerpts from the relevant points of the recordings, among them the last five registered data (from the STM data storage):

Time *(hr:min:sec)*	Distance *(km)*	Speed *(km/h)*	Signal	Notes
10:14:26	352,27499	79,000	MAX	
10:14:26	352,28599	80,000	0	„yellow” appears
10:17:24	354,06699	12,000	0	
10:17:24	354,06999	12,000	●	„red” appears
10:18:52	354,36499	14,000	T	„red” disappears, „shunting” appears
10:18:56	354,38099	14,000	---	„shunting” disappears, „white” appears
10:19:37	354,58999	25,000	---	the maximum speed while approaching the station
10:20:19	354,83799	0,000	---	stopping at Pilis
10:21:50	354,83799	1,000	---	departing from Pilis
10:22:13	354,93799	29,000	---	the maximum speed while leaving the station
10:23:03	355,31799	23,000	---	main wire pressure under 4,5 bar
10:23:14	355,37299	12,000	---	the minimum speed while leaving the station - traction power already registered
10:25:43	357,43799	107,000	---	reached maximum speed
10:25:43	357,44299	107,000	---	horn sounds
10:25:44	357,48099	106,000	---	horn stops sounding
10:25:52	357,70099	106,000	---	traction power terminated
10:26:06	358,11399	103,000	---	main wire pressure under 4,5 bar
10:26:12	358,27199	102,000	---	
10:26:18	358,45199	93,000	---	vigilance warning acoustic signal sounds
10:26:22	358,53699	85,000	---	
10:26:22	358,53799	85,000	---	
10:26:23	358,56099	84,000	---	
10:26:24	358,58299	80,000	---	
10:26:24	358,60099	78,000	---	last signal, vigilance brake

1.10.2.2 A The data recorder of the locomotive

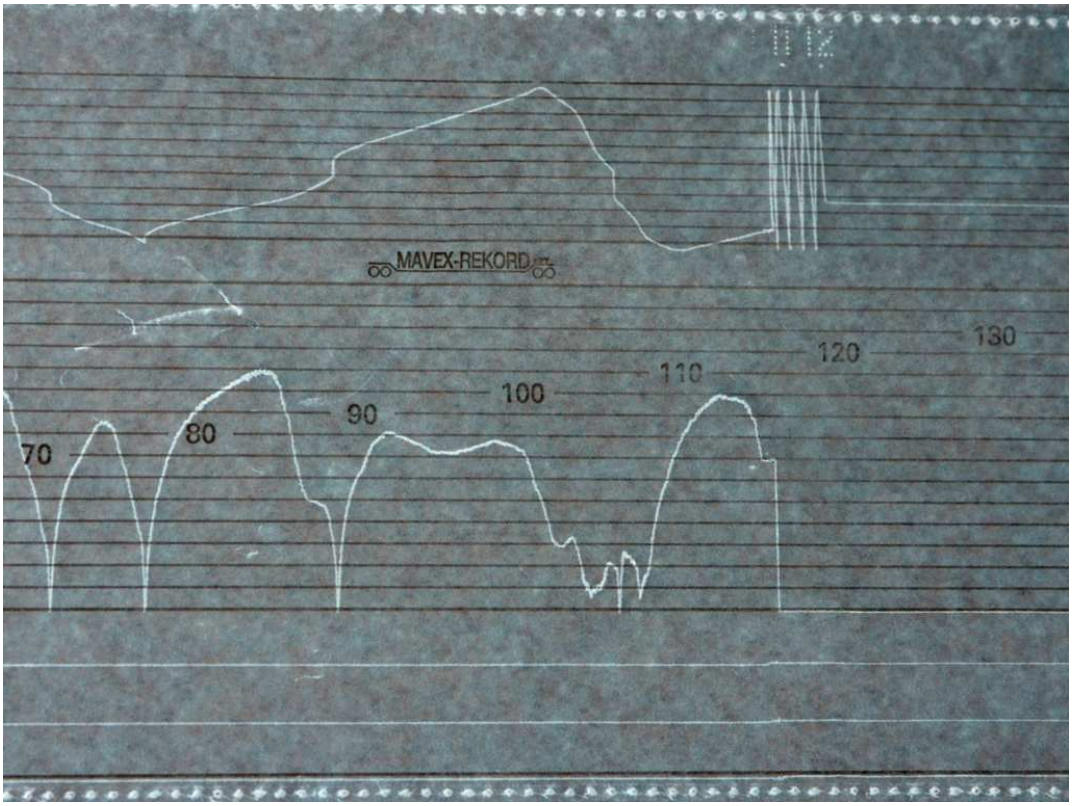


Figure 10: the strip chart recorder of locomotive V43, 2318 (train 2537)

The recordings on the strip chart do not contain the signals of the EÉVB as they can only be detected on the first vehicle. However, the irregular sign due to the collision can be seen on the strip chart recording.

1.11 Communications

At the stations

There is a telephone which the movements inspectors of the neighbouring stations can use.

There is also a separate telephone line for conversations between the movements inspectors and traffic controllers.

There is another telephone which is connected to the national railway telephone network.

Direct communication between the station staff and the train staff is not possible.

On the trains

There was no communications equipment (no radio, telephone or mobile phone) on the control car.

There was no locomotive radio or any other communications equipment on the control car of passenger train 2532 which was running from Monor to Pilis on the right track about 40 minutes before the accident.

1.12 Meteorological information

At the time of the accident there was no rain or any other weather condition (mist, fog, dust, etc) which would have affected visibility. The meteorological weather stations and radars of the area (Pestszentlőrinc, Ferihegy, and Szolnok) reported very good, 30 km visibility, and other related voluntary organisations and stations (metnet.hu, idokep.hu) also reported the same visibility data.

There was ground fog at sunrise at Ferihegy which was also possible at the site of the accident, however this had evaporated by 8:25 (2 hours before the accident). Its height is maximum 2 metres - according to definition - which therefore could not have affected visibility from the driver's cab. Furthermore, the train was running north-westwards, thus the sunshine did not disturb the engine driver either.

The sky was cloudy, the temperature +11-13°C, with 60-70% humidity and light westerly, south-westerly wind.

The weather conditions were normal. The temperature was usual for the season, did not fall below zero at dawn either (+1-3°C). The morning clouds prevented the temperature to rise quickly. The air pressure was around 1015-1016 hPa which is average and only rose slowly and gradually (1 hPa/3 hrs).

In conclusion, there the weather conditions had no effect on the accident.

1.13 Survival aspects

All victims were in the last carriage of the IC train which was substantially damaged by the control car colliding into it. The control car crushed part of the passenger compartment and the victims under itself. Some passengers got stuck and caught in between the jammed furnishings (seats, tables, luggage racks). During the search and rescue, some passengers could only be reached with the use of various tools and technical equipment.

The ambulance was called by more people (eyewitnesses, train staff) immediately after the accident. The Monor Ambulance Services arrived at the site first and then the firefighters and the ambulance helicopters.

One of the seriously injured persons was managed to be pulled out from under the wreckage but he died in hospital subsequently. The persons who died in the accident had had no other illnesses which would have precipitated their death.

1.13.1 The injured persons' position in the trains

The IC sent a questionnaire to the people who injured in the accident - 45 passengers - 20 of which answered. Their positions on the train were as follows:

Passenger train no. 2537

carriage 1.	1 person	was sitting backwards
carriage 2.	3 persons	2 of whom were sitting backwards
carriage 3.	7 persons	
carriages 4-6.	-	
carriage 7. (last)	1 person	

Train no. IC 560-1

carriage 1. (22)	2 persons	one of them was sitting in seat no. 46.and the other was standing in the hallway
carriage 2. (21)	-	
carriage 3. (20)	3 persons	one of them was sitting backwards at a table and the other two opposite each other at a table also
carriage 4. (dining)	-	
carriage 5. (18)	2 persons	one of them was sitting in the middle of the carriage at a table and the other also at a table where the carriage was severely damaged

There was one more passenger who completed the questionnaire but it is not obvious from his answer which train he had sat on, only that it had been in either the 3rd or the 4th carriage.

According to the data received from the railway undertaking, 11 reserved seat tickets had been sold for this part of the journey on train IC 560-1.

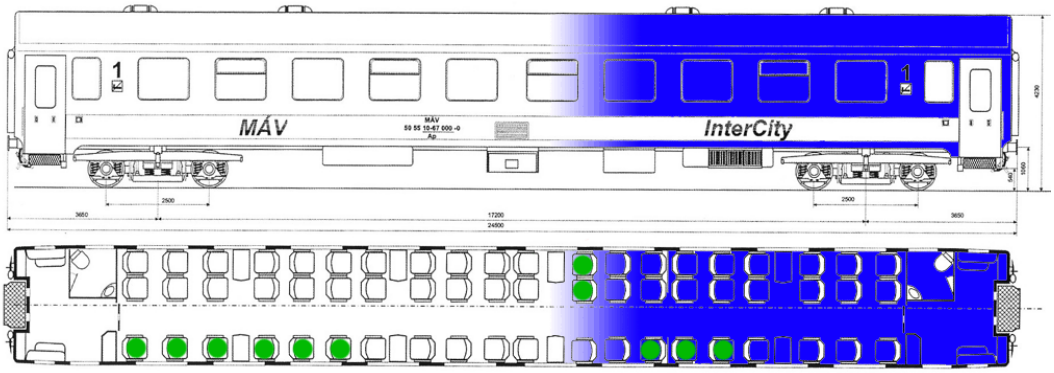


Figure 11: The last carriage of train IC 560-1; the destroyed part of the passenger compartment indicated with blue and the sold seat tickets are indicated with green colour

1.13.2 People in the driver's cab

The people in the driver's cab were in danger in different ways than the passengers of the train. (In the course of the collision it can be seen that if the driver's cab sustains substantial damage, the people in it has very little chance to survive while the result of the damage to the passenger compartments is not as obviously foreseeable.)

In this case, the people in the driver's cab ran backwards to the luggage room of the carriage and through it to the passenger compartment (see Figure 12).

Having made all efforts he could in order to reduce the collision speed, the engine-driver went backwards and waited behind the toilet (in the control car), lying with his back against the wall. He did not suffer injuries. The ticket inspector ran from the driver's cab to the passenger compartment, warned the passengers of the collision and then fell over when the collision occurred and suffered minor injuries. The other ticket inspector in the driver's cab (not on duty) got to the hallway where he suffered injuries at the collision.

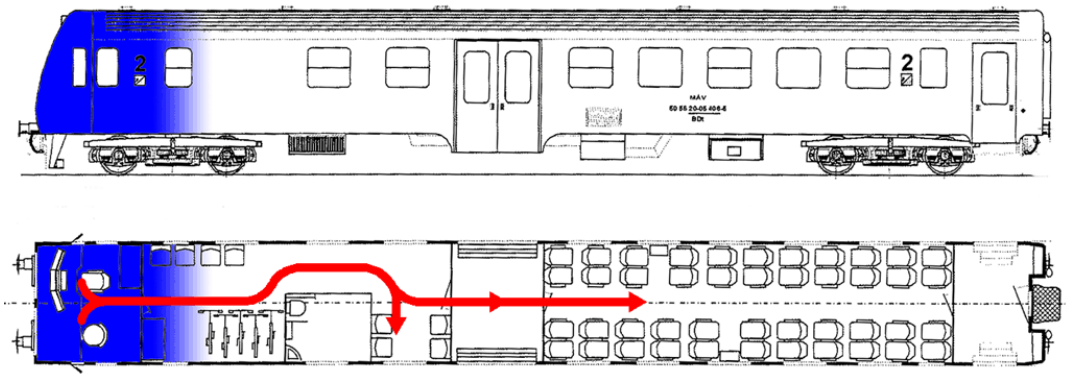


Figure 12: escape from the driver's cab

1.14 Tests and research

In the course of the site survey, the power supply cable of the signal box was measured, in the presence of the IC (for the results, see 1.8.6).

The EÉVB (EVM-120 type) of train 2537 was also examined on 8 October 2008 (Appendix 2).

1.15 Organisational and management information

Inspection of engine-drivers

The work of the engine-drivers of MÁV-Trakció Zrt. is regularly inspected, occasionally during work (when they are on duty) and afterwards, based on the strip chart recorders.

One of the tasks of the traction managers is to check the strip chart recorders. The traction manager in this case (whom the IC interviewed) checks about 20 registers per month - among his other tasks - which is a small number compared to the actual number of recordings done per month.

After the accident, all strip chart recorders were examined with special attention to the deletion of the red signal (which is against the regulations). MÁV-Trakció Zrt. examined almost 50 000 recorders, the results of which the IC received. With regard to the usage/handling of the EÉVB, insufficiency was found in 24 cases, some of which was the deletion of the red signal.

Train staff

Train IC 560-1:

– engine-driver
– chief ticket inspector
– guard
– staff of the dining carriage

Train 2537:

– engine-driver (in the control car),
– chief ticket inspector, on duty in the first three carriages but went into the driver's cab before the accident occurred,
– ticket inspector, on duty in the last 4 carriages.

Not as part of the staff on duty, but another ticket inspector (going home from work) was also in the driver's cab,

1.16 Rules and regulations

See below a summary of the content of the rules and regulations relevant to the accident. Their exact, full version is quoted in the Appendixes (*in Hungarian only*).

1.16.1 Subsidiary signal

F.1. Signal Regulation 2.5.22 applies to the subsidiary signal which is to be used in special cases (e.g. fault/inoperability of the signal box). Under this signal, trains shall run with reduced speed - maximum 15 km/h - so that the train can be stopped safely before an occurring obstacle (see Appendix 1.1).

1.16.2 Course of action if the lights on the signal are inoperative

According to F.1. Signal Regulations 8.7, if the engine-driver sees a main signal (among them a block signal) whose lights do not light, he shall to stop the train - unless he had been previously informed in a written order about the failure of the signal.

Pursuant to F. 2. Traffic Regulations, in case of dark block signals if it is not possible to check whether the block section is occupied, running further on is only permitted only after 2 minutes and with the maximum speed of 15 km/h. If the train finds another train in the following block section, it shall stop or the other train shall only be followed with at least 200 metres distance kept.

The other condition of running further on is that 'Stop' should appear on the main signal - which gives preliminary signal to the given block signal - , otherwise running forwards is only permitted based on a permission given via telephone.

(Appendix 1.3)

1.16.3 Inoperative automatic block signal

According to F.2. Traffic Regulations 15.4.2.1, on tracks built for block section traffic, if the block signal is inoperative, a changeover shall be made to station-distance spacing order.

One of the conditions of the inoperability is that either the signal box services or the traffic controller (in agreement with the signal box dispatcher) shall declare the device inoperative. The regulations do not describe aspects based on which the device should be declared inoperative.

According to F.2. Traffic Regulations 3.3.3, if the automatic block signal is inoperative, the open track warning lights (LCs) shall be closed manually before signalling the trains into the given block section, unless otherwise instructed by the signal box dispatcher. (Appendix 1.5)

1.16.4 Traffic while the main signals prohibit running forward

According to F.2. Traffic Regulations 15.19.1.8., if trains are signalled out onto tracks equipped with automatic block signals but there is no line clear (run forward) signal on the exit signal,

– In case of normally operating EÉVB, trains may run based on its signals, except if the given track at the station is not built for giving signals and the white light („---") remains on the screen in the driver's cab because in this case the train shall only run with 15 km/h until the first block signal. In this case, the movements inspector shall not signal out the train (if he can check the actual occupancy of the first block section).

– If the EÉVB does not operate normally, and the movements inspector has no possibility to check the occupancy of the block section, while maintaining the 15 km/h speed, the engine-driver shall also be informed about this by a written order. In case of subsidiary signal, the reduced speed shall only be maintained until the subsidiary signal is annulled or until the following block signal.

(Appendix 1.6)

1.16.5 Procedure when the warning lights are inoperative

If the warning lights indicate fault - if there is no train on its way towards the LC and the section is clear - troubleshooting shall immediately be started. In order to do this, the section between the two given stations shall be cleared even if trains are delayed. (1.7)

1.16.6 Unified Train Control and Vigilance Warning Device

The regulations on the operation/usage of the EÉVB are included in Appendix 2 of E.1. Regulations (for traction vehicle staff). Its parts relevant to the present accident are as follows

Point 3: describes the vigilance warning/checking function, detailed in **Hiba! A hivatkozási forrás nem található.** of this report.

Point 4.1: describes its function on track sections which can control trains as well as the signals on the driver's cab screen. Among them, it contains the regulation according to which if a train passes a main signal indicating 'Stop!', a red signal appears on the driver's cab screen and in case of exceeding the 15 km/h speed limit, the device automatically stops the train.

Point 4.2: contains the rules of running at 'Stop' signal. Among them:

– 4.2.1: If the **block signal** indicates 'Stop!', (red signal on the driver's cab screen) after passing the signal, the maximum speed is 15 km/h. Deactivating this controlling function is **prohibited**.

– 4.2.2 If the **entry signal** indicates 'Stop!', after passing the signal, the train control function **shall** be deactivated after stopping at the designated place at the station.

(Appendix 1.8)

According to F.2. Traffic Regulations 1.2.139., the train control function is efficient if both the track and the vehicle are equipped with the required devices and they operate normally. (Appendix 1.4)

1.16.7 Driver's cab signal

Chapter 3 of F.1. Signal Regulations also contains the signals appearing on the screen in the driver's cab. In case of white „---" signal,

– the device is inoperative or

– the train arrived at a track section able to give signals and control trains but it is occupied or

– the train arrived at a track section which is unable to give signals and control trains.

(Appendix 1.2)

1.16.8 Accuracy of speedometers

No. 100124/1996.GF.A. Regulation of MÁV Zrt contains regulations on the handling and inspection of speedometer recordings. The permitted inaccuracy of speedometers is as follows:

– Electronic speedometers: ±1%,

– Strip chart speedometers: ±5%.

Verification is to be done with a stopwatch based on the run distance.

1.17 Additional information

The IC did not receive any additional information and does not with to publish any other information apart from the above information and data.

1.18 Previous occurrences of a similar character

There had been several similar occurrences (collision due to one train reaching another) in the previous few years on the Hungarian national railway lines.

1.18.1 29 August 1998 between Nagymaros and Szob stations

On 29 August 1998 at 15:51 hrs, train no. 2144 collided with approximately 68 km/h speed with the rear of standing train no. IC 310 between Nagymaros and Szob stations in railway section 575+79.

The engine-driver of train no. 2144 died in hospital a few days after the accident.

The cause of the accident was that while train IC 310 was running on the open track between Nagymaros and Szob, the signal box was being repaired and the power supply of the open track signal box was partially terminated (cables were cut). Subsequently - disregarding the relevant regulations -, they changed over to station-distance traffic and then train no. 2144 was signalled out from Nagymaros station in spite of the fact that there had not yet been feedback message on the train running in front of it.

1.18.2 26 October 2001 between Monor and Pilis stations

On 24 October 2001 at 15:55 hrs, train no. 6016 collided with approximately 32 km/h speed with the rear of train no. IC 706 (running with 15 km/h) on the right track between Monor and Pilis stations in section 427. 36 people were injured in the accident, (11 of whom suffered injuries of over 8 days recovery time). The trains did not derail, however, locomotive (reg.no. V43,2355) of train no. 6016 became unserviceable.

Prior to the accident, (since 15:32 hrs) there was a signal box fault due to voltage failure, which was reported to the dispatcher. The movements inspectors of the stations - as they were not able to check the signals of the block signals between the two stations and the signal box services had not yet arrived at the site to repair the fault - did not declare the line block signal inoperable (based on F.2. Traffic Regulations) thus they still allowed block section traffic.

Trains IC 706 and 6016 were signalled out from Monor station with subsidiary signal. Having passed the exit signal, red light appeared on the screen in the driver's cab of the locomotive of train 6016. According to this, the train ran with 15 km/h. As the train accelerated and reached a speed of over 15 km/h in the first block section, the EÉVB automatically stopped the train. Having re-activated the EÉVB and after 30 seconds, the train ran on. The engine-driver noticed that the first block signal was dark and tried to call the traffic controller on radio but could

not reach him. Then he turned off the red light by applying the “run/shunt” switch and therefore the light turned to white. As this way the speed checking and train control function of the EÉVB was deactivated, the train was able to accelerate to 92 km/h. In the meantime, train IC 706 was running with 15 km/h in front of train 6016 in a 1000-radius-left bend - the engine-driver therefore was unable to notice it in a safe distance - and the collision was unavoidable despite the application of emergency brake.

1.18.3 6 February 2007 between Almásfüzitő felső and Komárom stations

This occurrence was investigated by TSB and a Final Report was published with file number: 2007-047-5.

On 6th February 2007 at 18 hours 43 minutes, between Almásfüzitő and Komárom stations at section no. 998+42, EUREGIO passenger train no. 9438 running from Tatabanya to Wien Südbahnhof (Vienna Southern Railway Station) with a speed of approximately 101 km/h collided with freight train no. 45224 which was running in front of the passenger train in the same direction with the speed of 9-10 km/h.

The engine driver of the passenger train died at the site of the accident, two passengers suffered serious injuries, another four passengers, the chief ticket inspector of the passenger train and the engine driver of the freight train suffered minor injuries. The electric locomotive (registration number 1116-017) of the passenger train owned by ÖBB sustained serious damage. 5 cars of the DB-owned freight train derailed, 4 of which sustained serious damage. The right track of the railway line sustained serious damage in approximately 120-meter-length, while the left track sustained less serious damage in approximately 30-meter-length. The catenaries over both tracks broke and two catenary supports fell.

It was found in the course of the investigation that the line signal box between Almásfüzitő and Komárom stations did not operate normally and the block signals were dark at the time of the accident.

The direct cause of the occurrence of the accident was the switching the “EVM 120 vigilance warning and train control device” of the locomotive of train no. 9438 over to shunting mode and back to run mode. As a result of this action, the train control device stopped functioning as a speed limiter and therefore the train exceeded the speed limit six-sevenfold.

The indirect causes of the occurrence of the accident were the following:

The battery charger of the power supply installation was not switched back on (after maintenance works).

The traffic regulations in force at the time of the accident did not permit the switchover to ’station-distance traffic’ which would have been safer in the given situation

Actions taken

TSB issued a safety recommendation in which it recommended the modification of the regulation on the inoperability of block signals in F.2. Traffic Regulation. MÁV Zrt. complied a new regulation which was put into force on 6 April 2008.

The IC issued another safety recommendation as follows:

The IC recommends railway undertakings operating traction vehicles to work out a solution to be able to check switchovers from run mode to shunt mode on train control devices of locomotives and other traction-vehicles, as this way, engine drivers would be obliged to operate the device as prescribed.

The IC did not receive any response as to whether this recommendation was implemented or not.

2. ANALYSIS

The IC covers the following points in the analysis of the occurrence (after describing the running of trains involved in the accident):

as processes directly connected to the occurrence

– failure of the signal box

– applied traffic technology

– ineffectiveness of the train control device of the control car

– running of train 2537, applied speed

– injuries to persons in the passenger compartments

as 'sidelines' of the occurrence

– problems of open track warning lights

– traffic regulations in connection with train control.

2.1 Overview of running of trains

2.1.1 Strip chart recorders

Photos of the strip chart recorders can be found in point **Hiba! A hivatkozási forrás nem található.** (Figures **Hiba! A hivatkozási forrás nem található.**. **Hiba! A hivatkozási forrás nem található.** and **Hiba! A hivatkozási forrás nem található.**), of this report.

2.1.1.1 Data recorder of train IC 560-1

The strip chart recorder of train IC 560-1 is shown in Figure 1.

According to the digital photo of the strip chart, the 0-150 km/h speed range corresponds to 305 pixels vertically (measured at that section of the chart which indicates the moment of collision). The slow speed which was registered after the train passed the entry signal of Pilis station is represented by a record at heights between 20-25 pixels. Based on the above, the calculated slow speed is:

150/305 x (20-25) = 10-12 km/h.

Due to the collision, the train gained speed. The recorded line is at 81 pixels, therefore the acquired speed is:

150/305 x 81 = 40 km/h.

Due to limitations of the strip chart technology the speed values can be calculated only with a certain precision (rounded to the nearest whole number).

The chart also shows the train's stopping at Pilis station. On the time recording 10 minutes corresponds to 153 pixels, while the stopping is represented by 18 pixels (the almost vertical line, recorded before 10:10 according to the recorder's built-in clock). Based on the above, the calculated stopping time is:

10/153 x 18 = 1,2 minutes.

The moment of the collision was recorded 21 pixels ahead of the direction shift of the time recording writing head which was set to 10:30. Therefore the collision took place

10/153 x 21 = 1,4 minutes

before 10:30, in other words, at 10:28:30. The recorder of the control car of train 2537 shows a moment two minutes earlier, that is, 10:26:30 as the time of the collision.

There are two writing heads inside the strip chart recorder which receive signals from the train control device and write the strip chart. The two recordings shall be evaluated together according to the table below:

		position of the lower head			
		down		up	
position of the upper head	down	„●”	(red)	„0”	(yellow)
	middle	„MAX”	(green)	„40”	(yellow-green)
	up	„T”	(shunting)	„---”	(white)

The lower writing head recorded only a zero signal which means that it was inoperative. Because of the faulty lower head, the evaluation of the recording produced only partial results. It was established that the train control device received signals as follows:

until the last block signal before Pilis station

– „40” (yellow-green), or
– „MAX” (green);

after the above block signal until the collision

– „0” (yellow) or
– „●” (red).

The „40” (yellow-green) combination can be excluded because it is impossible in that track block. The actual movement of the train corresponds to the second possibility: „0” (yellow) signal until the Pilis entry signal (set to STOP) and „●” (red) thereafter.

2.1.1.2 Data recorders of train 2537

There were two data recorders on train 2537. The recordings of the data recorder installed on the V43,2318 locomotive in the back of the train are shown in Figure 4, while the recordings made by the control car's digital data recorder are in Figure 3.

According to the digital photo of the strip chart taken from the locomotive's recorder, the 0-150 km/h speed range corresponds to 310 pixels vertically (measured at that section of the chart which indicates the moment of collision). The maximum speed prior to the collision is represented by 207 pixels. Based on the above, the calculated speeds are:

speed at collision: 150/310 x 146 = 71 km/h;
maximum speed: 150/310 x 207 = 100 km/h;
minimum speed recorded while the train was leaving Pilis station:
150/310 x 18 = 9 km/h.

On the time recording 10 minutes corresponds to 154 pixels. The moment of the collision was recorded 20 pixels after the direction shift of the time recording writing head which was set to 10:30. Therefore the collision took place:

10/154 x 20 = 1,3 minutes

after 10:30, in other words, at 10:31:15. This time is approximately 5 minutes later than the time recorded by the control car's data recorder.

The data from the control car's data recorder directly can be used for further analysis.

2.1.2 The position of the trains

Due to the fact that the internal clocks of the data recorders were not synchronised, the recordings show different time for the moment of the collision. In order to use the available data for the analysis, it was necessary to adjust the recorded times to compensate for the discrepancy. The compensation was made based on the clock of the digital data recorder of the control car of train 2537.

Figure 13 shows the position of trains and the status of LC AS 450 in the last 30 minutes prior to the collision.

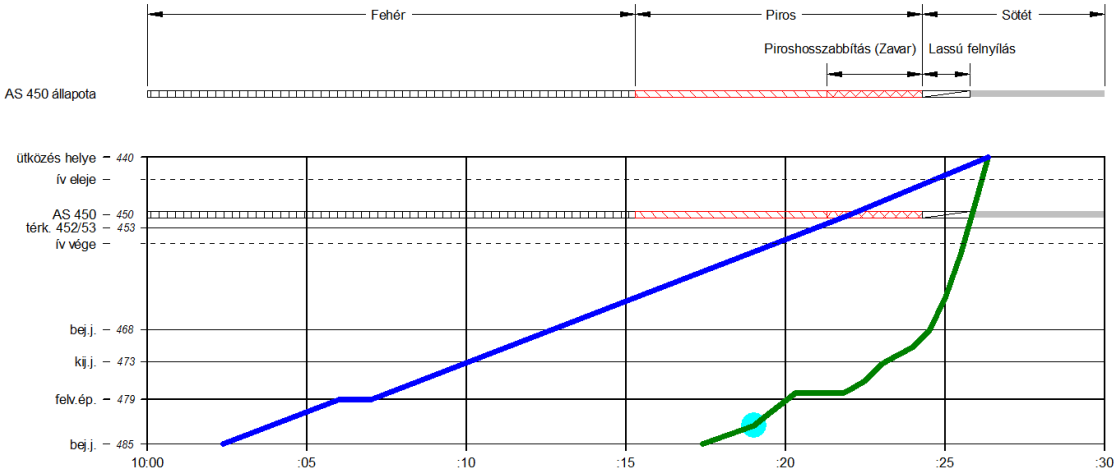


Figure 13: the distance-time diagram until the collision and the state of LC AS 450 (**bej.j.**: entry signal, **kij.j.**: exit signal, **felv.ép.**: station office, **térk.**: block signal, **AS**: LC on the open track; **green:** train 2537, **blue:** train IC 560-1; **light blue dot:** EÉVB place of deactivation)

The light blue dot in Figure 13 indicates the moment when the EÉVB of the control car was deactivated. It is visible from the breakage of the green line that after deactivating the control function, the train ran on with higher speed.

It is also visible that the slowly travelling IC 560-1 train turned LC AS 450 dark (as a result of staying longer than usual) (At this time train 2537 had already been waiting to be signalled out at Pilis station.) but it reached the LC while it was still red towards the road (due to the so called "red extension" (see 1.8.3.). Subsequently, the barriers of the LC slowly opened and train 2537 ran through it when it was already open and its warning lights were dark.

Another unfortunate factor was that the track is straight on a 875 metre length before the site of the collision. It was a question of only 30 seconds that the engine-driver of train 2537 did not notice the IC train running in front of it on the straight track.

Significant moments before the accident

In the below Figures (14-18) the position of the trains and the signals are shown. (not to scale).

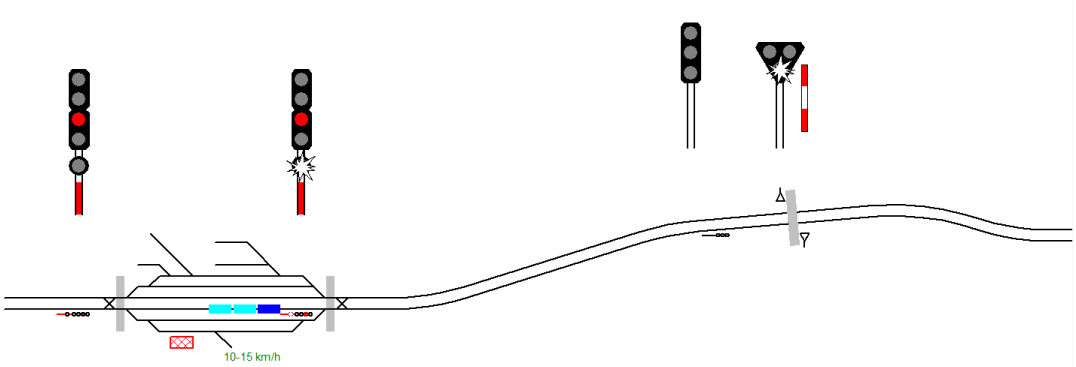


Figure 14: 10:13 hrs

At 10:13 hrs: train IC 560-1 departed from Pilis station onto the left track under subsidiary signal.

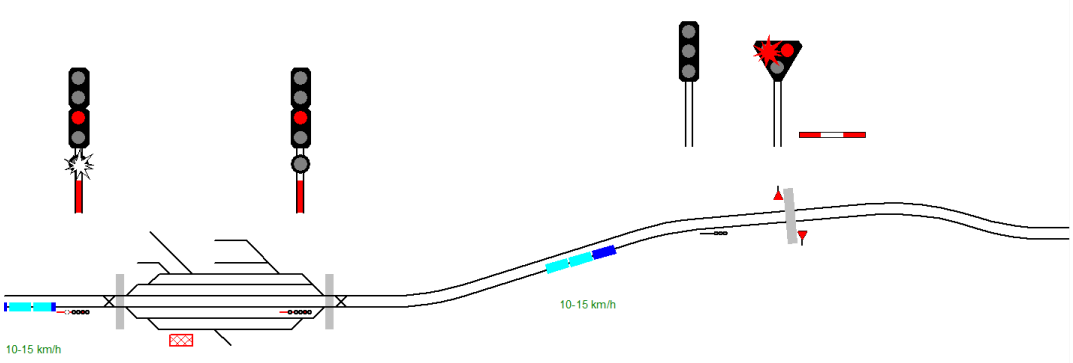


Figure 15: 10:17 hrs

At 10:17 hrs: the passenger train received subsidiary signal on the entry signal and while approaching the station, the train control device of the control car was deactivated. In the meantime, IC train was running slowly on the open track towards Monor, having closed LC AS 450 by this time.

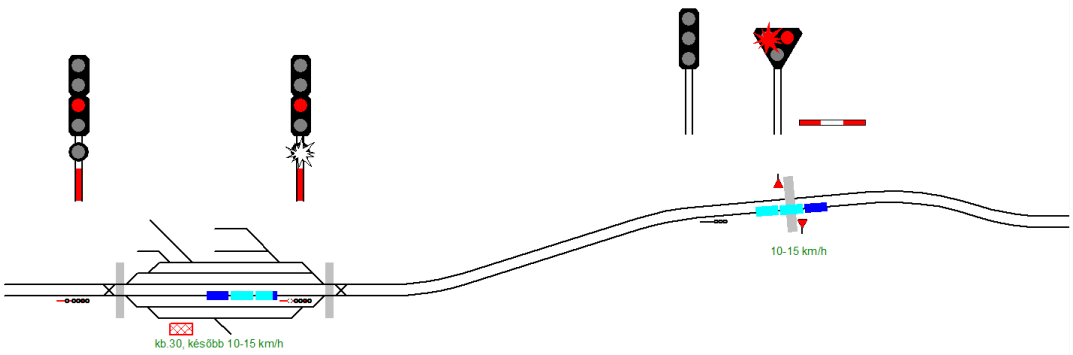


Figure 16: 10:22 hrs

At 10:22 hrs: the passenger train departed from Pilis station onto the left track, also under subsidiary signal while the IC train was passing LC AS 450. However, by this time the LC (its warning lights) became inoperative as the train was running too slowly (the LC was closed for too long time), but it still indicated Stop towards the road due to the so called “red extension” (see 1.8.3.)

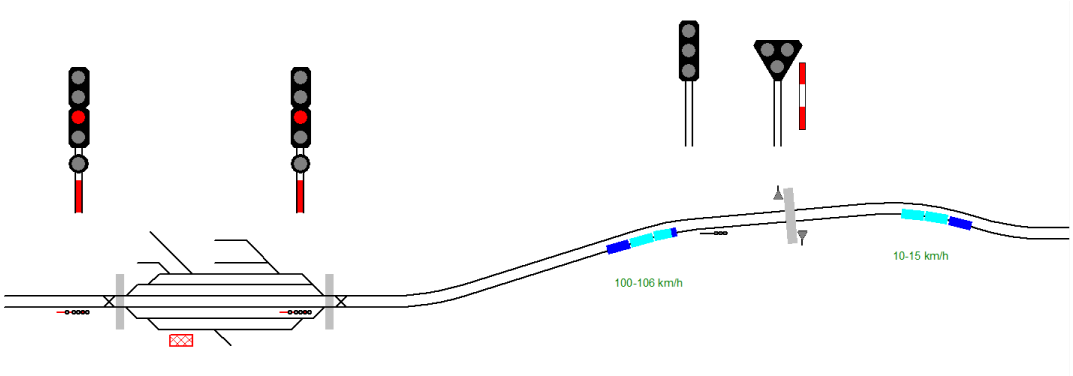


Figure 17: 10:25 hrs

At 10:25 hrs: the passenger train passed the dark block signal with high speed and was on its way towards the LC which by this time had become inoperative (was in failure state). It also sounded its horn. Unfortunately, the IC train had just left the straight section of the track before the passenger train arrived there, therefore the engine-driver of the passenger train had no chance to notice the danger.

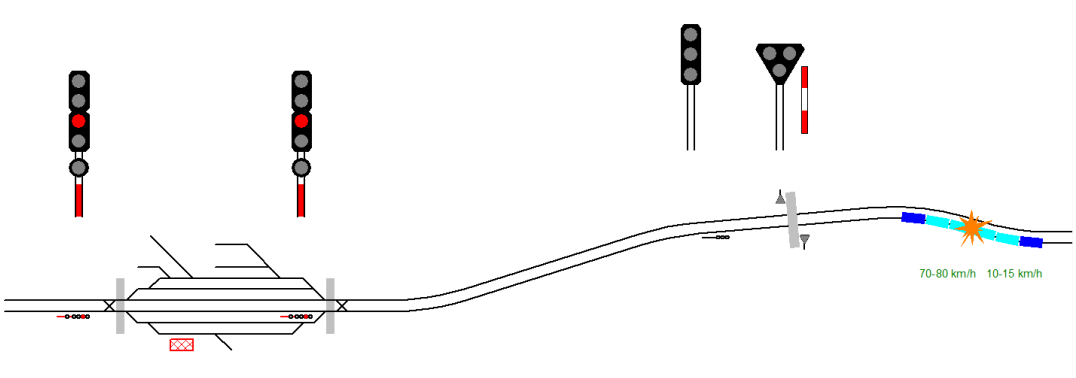


Figure 18: 10:26 hrs

At 10:26 hrs: the trains collided with each other.

2.1.3 Events and actions taken prior to the accident

The below table shows the events in chronological order and by locations based on the recordings of the voice recorders, interviews and strip chart recorders.

Abbreviations used in the table:

Pilis, Monor… the stations or their movements inspector
sb. signal box
mi. movements inspector
2532, IC 612… engine-driver of the given train

Time	Trains	Signal box and dispatcher	Section controller	Pilis station	Monor station
9:45		sb. failure according to the register of the power supply device of Pilis			
	2532 travels from Monor to Pilis		Pilis inquires whether there is any problem with 2532 as there is power supply failure. The section controller says there is no problem.		
9:46				Mi. talk about the sb. failure. Pilis thinks 2532 might have torn the overhead contact line.	
9:48		Pilis reports the failure to the sb. dispatcher.		Mi. reports the failure to the sb. dispatcher.	
9:50	2532 arrives at Pilis			2532 arrives at Pilis	
9:56	IC 612 departs from Monor under subsidiary signal onto the right track.				IC 612 departs under subsidiary signal onto the right track.
9:58		Monor reports the apparent occupancies. The sb. dispatcher says he has already been informed about it from Pilis.			Mi. reports the apparent occupancies. The sb. dispatcher says he has already been informed about it from Pilis
9:58		The sb dispatcher informs Cegléd and Monor sb mechanic about the failure.			
10:01			Mi. requests the section controller to ask IC 612 what he can see on the line.		
			The section controller calls the engine-driver who does not answer.		
10:06	IC 560-1 arrives at Pilis under subsidiary signal where he is informed (verbally) about the situation.			IC 560-1 arrives at Pilis under subsidiary signal where he is informed (verbally) about the situation.	

Time	Trains	Signal box and dispatcher	Section controller	Pilis station	Monor station
10:08	IC 560-1 departs from Pilis under subsidiary signal onto the left track.			IC 560-1 departs from Pilis under subsidiary signal onto the left track	
10:11			Mi. talks to the section controller who says IC 612 has not yet answered.		
	see section controller >>		IC 612 calls and reports that - The passed block signals are dark, - There is no signal, - He is running with 15 km/h.		
			The section controller tells the mi. that the block signals are dark.		
10:14	see section controller >>		The section controller talks to Monor. The section controller calls IC 560-1 who answers that he is in the first block section, cannot see the block signal yet but will call as soon as he sees it.		Mi. requests the section controller to call IC 560-1 on radio.
10:20	see section controller >>		IC 560-1 reports to the section controller that the first block signal is dark.		
10:21	2537 arrives at Pilis under subsidiary signal.			2537 arrives at Pilis under subsidiary signal.	
10:21				Monor calls Pilis and says that IC 752 will depart at about 10:23 hrs under subsidiary signal.	
				Pilis says that 2537 will depart from Pilis at about 10:22 hrs under subsidiary signal.	
		LC AS 450 becomes inoperative due to the slow running of IC 560-1			
10:22	2537 departs from Pilis under subsidiary signal.			Mi. signals out 2537. (According to him, before he ordered subsidiary signal and went out to signal out 2537, none of the open track LCs had become inoperative.)	

Time	Trains	Signal box and dispatcher	Section controller	Pilis station	Monor station
10:23	IC 752 departs from Monor under subsidiary signal.				
10:24	2537 accelerates after station LC SR 2 and passes the open, inoperative LC AS 450 with about 106 km/h.				
10:25				Mi. returns to the station office and notices that LC AS 450 is inoperative.	
				Monor reports that IC 752 has departed under subsidiary signal.	
10:27					Üllő asks Monor whether the sb. failure has been registered in the log. He says no, it has not, both him and Pilis signal out all trains with subsidiary signal.
10:28	IC 560-1 reports to the section controller that an accident has occurred at Monorierdő.		IC 560-1 reports to the section controller that an accident has occurred at Monorierdő.		
			The section controller ordered Pilis and Monor to press 'Block Section Stop'. (As all block signals were dark, this had no effect.)		

2.2 The course of the occurrence

2.2.1 Signal box failure

The process leading to the accident began with the failure of the line signal box. Based on the facts in 1.8, the following can be established with regard to the failure:

– Since 9:45 hrs (the time of the power supply and signal box failure), there was no 500V, 75 Hz line power supply between Pilis and Monor stations until 20:30 hours when the power supply restarted.

– During the above mentioned time period, all block signals on the open track between Monor and Pilis stations were dark and no signals were sent to the trains.

– Due to the apparent occupancy of the open track block sections, trains departing from Pilis and Monor stations could only be signalled out with subsidiary signal.

– The subsidiary signal could not be revoked as the conditions for it were missing (two block sections should have been clear to be able to do so).

– LC AS 450 became inoperative (turned to 'failure state') as train IC 560-1 passed it too slowly (with 15 km/h).

– The open track LCs could not be declared inoperative as the conditions for troubleshooting were missing i.e. there were still trains between the two stations.

The failure was caused by the short circuit of the cables supplying 75 Hz, however, the cause of the short circuit was not found. The insulation of the wires in the cable was damaged to such an extent that it was impossible to determine whether the damage was a consequence of the short circuit or it had been damaged earlier.

Figure 19: the burn mark on the surface of the faulty cable

Figure 20: the wires of the opened cable with the burnt insulation

2.2.1.1 The possible appearance of the signal permitting running forward on the open track

The following question arose in course of the investigation: Is it possible that green light appeared on the first block signal and “MAX” (green) sign on the screen in the driver’s cab after train 2537 left Pilis station?

The IC believes that for the above to occur:

– the power supply of the signal box should have been started again, which is technically impossible because of the failure (short circuited cable);

– the power supply device would have registered this, however, there was no such data found;

– in case of the restart of power supply, the construction/signals of open track signal boxes exclude the possibility of the green light to appear in the given traffic situation as in this case a red light appears due to the occupancy of the block section after the block signal (which train IC 560-1 passed);

– in case power supply is restored, the whole track (section) between the two stations ‘revive’ i.e. is supplied again, which would have been perceived and registered by the data recorder of EÉVB of train IC 560-1;

– the prerequisite for signals permitting running forward is the operation of track circuits, which signal the strip chart recorder would have recorded, however there is no such signal visible on the chart.

These factors exclude the possibility of the occurrence of the above hypothesis.

2.2.2 The applied traffic technology

Due to the failure of the signal box, the usual traffic control procedures could not be used. In such cases, there are special rules and procedures to be followed. In the view of the IC, these rules are not always unambiguous and sometimes give alternative possibilities which had not been examined from safety point of view (which procedure is more favourable in which situation).

2.2.2.1 The possibility to change over to 'station-distance spacing order'

Rules and regulations

The track section between Pilis and Monor stations is equipped with automatic block signals. If they operate normally, trains shall run in block section spacing order and if they do not operate normally, trains shall run in station distance spacing order (only one train at a time between two stations). While in the former case, the second train can be signalled out even when the first train is still on the open track (as the block signal ensures safe traffic), in the latter case, the second train can only be signalled out when the first train has arrived at the next station and the movements inspector has reported its arrival.

It shall be noted that in case of failure or operation problem, the maintenance of block section spacing order is not necessarily unsafe as other rules prescribe lower speed on this occasion.

The inoperability of automatic block signals is described in 15.4.2.1 of F.2.Traffic Regulations, according to which the block signal is inoperative if either the signal box services or the traffic controller (in agreement with the signal box dispatcher) declares it inoperative (see 1.16.3).

The background of this regulation is that after the accident occurred on 6 February 2007 between Almásfüzitő and Komárom stations, TSB issued a safety recommendation suggesting the modification of the relevant previous regulation which had made it rather complicated to declare block signals inoperative.

The modified, new regulation, however, only gives the possibility to make the decision (changeover to station distance spacing order) but does not cover in which cases under what conditions the decision should be made. Furthermore, no handbook, training manual have been compiled or guidelines laid down which would help the concerned staff make the right decision.

It is not stated either which staff member should initiate the decision (even though the decision depends on the agreement of two staff members). Thus it can happen that despite both of them is aware of the dangerous traffic situation, they wait for the other to initiate the decision which may not be made in the end.

Actions taken

At the time of the signal box failure, train 2532 was still on the line (from Monor to Pilis), and the traffic control staff suspected that the train had broken the overhead contact line. However, they were unable to contact the train (See **Hiba! A hivatkozási forrás nem található.**).

After 10 o'clock, the traffic controller contacted the engine-driver of train IC 612 which was between Monor and Pilis stations at this time, who told him that the block signals he had passed were dark. He also called the engine-driver of train 560-1 via radio, who told him that he had passed one dark block signal (this was the first one he passed - 453a - between the two stations).

The following can be established:

– After the power supply failure, a perilous, uncertain situation came about; there was no information (on the signal boxes) in either station on the occupancy of the block sections and the status of the block signals were yet unknown - however, according to the opinion of the IC, the latter can be deduced (e.g. by a signal box specialist) based on the known failures.

– The gradually obtained information (from the trains) made the railway staff think that the block signals were inoperative (dark).

– The traffic controller had certain information based on most of the signals on the signal box - before signalling out train 2537 - that it did not function normally. However, there were still some uncertainties.

The information available for the traffic control staff changed by time as follows:

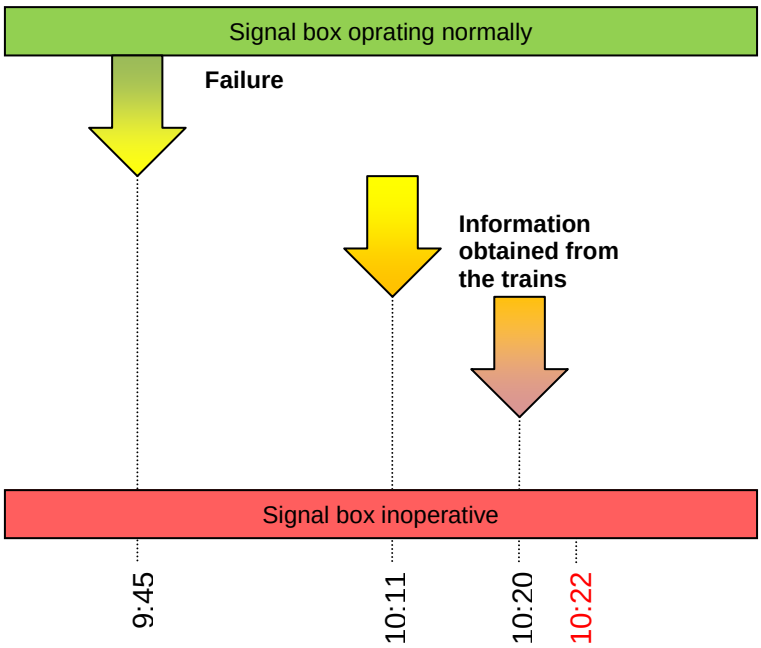


Figure 21: changing information on the status of the signal box (10:22 – train 2537 departs)

The staff was uncertain whether the line signal box failed completely or only parts of it became inoperative. In such an uncertain situation, to assume the worst and act accordingly is the safest until one can ascertain the actual facts. The traffic regulations however, do not prescribe the above, and the staff did not act accordingly, therefore they applied the usual technology and procedures.

The traffic controller and the signal box dispatcher did not contact each other to find solutions for the situation, they did not talk about declaring the device inoperative and ordering station distance spacing. The traffic controller:

– had not initiated changeover to station distance spacing order prior to the accident,

– thought it would not be reasonable as he did not receive information from the signal box dispatcher that the block signal was inoperative. Furthermore, it was not defined on what conditions such changeover shall be made.

The F.2. Traffic Regulations in force does not define the conditions in case of which the device shall be declared inoperative. It only prescribes who can order station distance spacing and how it shall be done, leaving the decision entirely to them.

Quite a lot of time passed after the failure, which may be required to obtain the necessary information to be able to decide, however, the concerned staff members were unable to tell what this necessary information were. This fact also indicates the above mentioned lack of trainings, handbooks, guidelines, sufficient education of railway staff.

2.2.2.2 Efficiency of regulations, suitability of railway staff

The general philosophy of regulations is that they regulate the procedures in as much detail as possible requiring almost 'machine-like' actions from the railway staff. However, in this case, the lack of detailed regulations caused problems (regarding the inoperability of block signals).

As the technical problems can be of very different character and can occur unexpectedly, it is impossible to compile regulations which would cover all cases and prescribe detailed procedures to follow. Therefore, the endeavour for completeness and thoroughness may result in dangerous situations.

However, it is possible to compile a framework of rules, principles and perhaps list examples as a basis for decision-making. Furthermore, the ability to make decisions, the required professional knowledge and suitability are essential as well as the acceptance of the decision-making rights/entitlements.

The principles assisting decision-making should also be taught at training courses, providing the concerned railway staff with the relevant competencies and preparing them for decisions to be made in various situations.

2.2.2.3 Trains arriving and departing from Pilis station

Train IC 560-1 arrived at platform III of Pilis station (from Albertirsa) at 10:06 hrs, under subsidiary signal. The train stopped at the station, approximately opposite the station office. The movements inspector told the engine-driver that probably all the block signals until Monor station will be red. He did not say anything else, neither did he give a written order; he signalled out the train under subsidiary signal. (The red signal at that time was only an assumption. Within the following 5 minutes, the movements inspector was informed about the dark status of the block signals.)

15 minutes later, train 2537 coming from Albertirsa arrived at platform III under subsidiary signal. The stationmaster saw/received train 2537 when it was approaching the platform. The train stopped at platform III at 10:21 hrs. The control car stopped approximately 100-150 metres beyond the station office. The movements inspector did not talk to the train staff. He signalled out the train under subsidiary signal, watched the train (which kept the speed limit when arriving and departing from the station) and the construction work at the station for a short time (about 3 minutes) and then returned to the station office.

To summarise the above:

– Train IC 560-1 was **informed** informally (verbally) about the assumed status of the block signals (red signal) between Pilis and Monor stations. This train stopped approximately parallel with the station office.

– Train 2537 **was not informed** about the problems in the block section between Pilis and Monor stations. The control car of the train stopped approximately 100-150 metres beyond the station.

15.19.1.8 section of F.2. Traffic Regulations is not obvious with regard to this question. 2.a. subsection reads that the engine driver shall be notified in a written order. (For he relevant section of the Regulations see chapter 2.3.2 of this report.)

The failure of LC AS 450

Prior to the accident, LC AS 450 (which reports back to Pilis station) became inoperative due to the slow running of train IC 560-1. In this case, no other train shall be signalled out into this track section as the 'failure state' can only be terminated when the track section is clear (by the station staff). In order to clear the section, trains may be delayed.

The LC, however, became inoperative when the subsequent train (2537) was at Pilis station, thus there was a possibility to delay it. By this time, the movements inspector was outdoors and therefore could only be informed about the failure after signalling out the train when he returned to the station office. (However, this would not cause direct accident risk if the 15 km/h speed limit is kept.)

2.2.3 The ineffectiveness of the train control device of the control car

While applying the usual traffic control procedures and maintaining the block section spacing order - with consideration to the status of the signal box - trains could only run with 15 km/h speed. The train control system of the locomotive (the control car in case of train 2537) oversees the compliance with this, which automatically stops the train if the speed limit is exceeded - except when this function is deactivated.

According to the strip chart recorder of the control car (reg.no. BDt 415) of train 2537 (see chapter 1.10.2), the train control device detected the following signals:

Time *(hh:mm:ss)*	Position of train	Speed *(km/h)*	Signal	Note
10:14:26	before Pilis on the open track	79	MAX	
10:14:26	before Pilis, at the block signal	80	0	„Yellow" appears
10:17:24	Pilis entry signal	12	●	„Red" appears instead of „Yellow"
10:18:52	Pilis, points zone	14	T	„Shunting" appears instead of „Red"
10:18:56		14	---	„White" appears instead of „Shunting"

The correct operation of the train control device was checked after the accident as well. The check-up did not show any error on the device, the measured data was in harmony with the measurements done 9 months before the accident.

Towards Pilis station

In the last block section before Pilis station, the train was approaching the station's entry signal indicating 'Stop'. Therefore '0' (yellow) signal appeared on the screen in the driver's cab.

Approaching Pilis station, speed limiting function

After passing the signal (permitted by the subsidiary signal appearing on it) „●" (red) appeared on the screen in the driver's cab. Under such signal the train control device prevents the train from running with more than 15 km/h speed (if

the train exceeds this limit, the device automatically stops the train). It should be noted that this speed limit is set so strictly in practice that trains usually run with no more than 12-14 km/h to avoid the automatic braking.

This signal - and the speed limiting function - ceases only when the train control device receives assessable signal from the track circuits. As in this case, the track circuits were not power-supplied due to the signal box failure (see chapter 1.8.5) between Pilis and Monor stations, the device could not have received such signal, therefore the train would not have been able to exceed the 15 km/h speed until Monor. (Train IC 560-1 ran accordingly, with 10-12 km/h speed from the entry signal.)

Deactivation of the speed limiting function

The speed limiting function can also be deactivated in the following ways:

– application of “own/coupled” switch,

– removing or switching off the fuse,

– interrupting/terminating the power supply (e.g. with on/off switch),

– application of run/shunt switch.

As ways of deactivation, E.1. Regulations prescribe the first three possibilities which cannot be done while the train is en route. The fourth option has the same effect and can be done while the train is running with low speed. (Appendix 2 of E.1. Regulations do not contain that the application of run/shunt switch deletes the „●” (red) signal and deactivates the speed limiting function.)

In this case - as the train passed the red light of the entry signal when approaching Pilis station - according to Appendix 2 of E.1. Regulations 4.2.2, it was obligatory to change the „●” (red) signal to „---”(white), i.e. to deactivate the speed limiting function.

The prescribed deactivation was done, however:

– not by one of the three solutions prescribed in E.1. Regulations but the run/shunt switch was applied (the same actions were taken at the accidents described in chapter 1.18 - at Nagymaros, Monor and Almásfüzitő).

– not after stopping at the designated place but while approaching the station. The recordings of the data recorder prove this: it detected the shunt mode for 4 seconds while the train was running with 14 km/h speed.

The non-compliance with these rules is not relevant to the occurrence of this accident as they had no effect on the actions taken after stopping at Pilis station.

Having switched back from shunt mode to run mode, the device ‘forgets’ that the train has previously passed a ‘Stop’ signal and therefore its speed limiting function remains inactive - until an assessable signal is again received from the track circuit (this would only have been possible at Monor station the nearest, due to the signal box failure).

Departing from Pilis station

From Pilis station onwards, - due to the above described processes and actions taken - the train control device no longer functioned as a speed limiter, it only checked for vigilance.

Thus the device was unable to prevent over-speeding and the accident as its consequence.

Non-compliance with the rules for safety reasons

The engine-driver of train IC 560-1 did not act as prescribed in E.1 Regulations, i.e. he did not deactivate the speed limiting function, for the sake of higher safety.

2.2.4 Analysis of the movements of train 2537

2.2.4.1 Traffic at the station

The train travelled until Pilis station as scheduled, however, it was delayed by 4 minutes due to its arrival under subsidiary signal.

Reconstruction works had begun at the station the day before the accident. Such works may require some signal box restrictions and the risk of faults / occurrence of technical problems are also higher (e.g. cutting cables).

Train 2537 approached the entry signal as well as the exit signal under subsidiary signal, which may indicate problems with the station signal box rather than the signal box on the open track. The reconstruction works at the station also reinforce this assumption. (In this case, both signal boxes had faults as they were power-supplied from the same source.)

In such circumstances, an engine-driver may think that the restrictions are due to some technical problem at the station. This accompanied with the impatience caused by the delays increase the chance that the engine-driver wants to leave the station as soon as possible to avoid any danger and he may also misinterpret some pieces of information relating to the restrictions.

The depth of the information the traffic controller gives to the train staff has a significant role in such unusual situations. If the reasons for an applied traffic method differing from the usual are known, misunderstandings and non-compliance are less likely. On the contrary, if there is no sufficient information, one may think there is no danger. Therefore, any methods differing from the usual (and their necessity) shall be communicated and emphasised.

When departing from the station, the train did apply reduced speed with consideration to the subsidiary signal, however, it only kept the 15 km/h speed limit in the points zone, and accelerated to 29 km/h on the station track.

2.2.4.2 Traffic on the open track

If a train runs with 15 km/h in the full length of the section between the two stations, it covers 10.7 km in at least 43 minutes (this is 33 minutes more than according to schedule) which may result in yet more frustration.

Having left Pilis station, train 2537 accelerated to 100-107 km/h which is in compliance with the 100/120 km/speed permitted for the train but it does not comply with the regulation stating that the speed restrictions given by the signals shall also be kept. In this case, they were the following:

– subsidiary signal **received** from the exit signal,

– **no signal received** indicating the termination of the subsidiary signal (on the back of the entry signal),

– **no signal received** which would permit running further on, (on the screen of the driver's cab).

The train passed the inoperative (dark) 453a block signal with this speed. The fact that the signal was dark should have been interpreted as a 'Stop' signal (see 1.16.2) as the engine-driver had not received a written order informing him about its inoperability. (The IC excluded the possibility of the „MAX" (green) light

appearing on the screen in the driver's cab as well as on the block signal based on the facts described in 2.2.1.1.)

The people in the driver's cab saw that the half barrier of the LC after the block signal was in open position. They planned to report this but they did not reduce speed (they would not have been able to do so until the LC as the distance was too short). Despite the multiple signs of danger (especially after the subsidiary signal and the dark block signal), they still not realised it.

Passing 453a block signal

The block signal was dark, and in this case - if the train control device does not operate normally - the train has to stop before the signal. It may only run further on if the engine-driver receives a permission via telephone to do so.

The reason of this restriction is that subsidiary signal was on the main signal (preliminary signal to the next block signal), that is on the exit signal of Pilis station, which does not indicate that the train should stop. Thus in this case, 15.19.2.2. of F.2. Traffic Regulations applies (see chapter 1.16.2 and appendix 1.3). The other condition of passing the signal without stopping is that the train control device shall operate normally.

Train IC 560-1 did not comply with this regulation either; it passed the signal without stopping (see 2.3.2.2).

2.2.4.3 Prior to the collision

The location and the moment of the collision

See below the last five registered signal of the data recorder of train 2537 (excerpt from the table at 1.10.2):

Time *(hh:mm:ss)*	Distance *(km)*	Speed *(km/h)*	Signal	Note
10:26:22	358,536	85	---	
10:26:22	358,537	85	---	
10:26:23	358,560	84	---	
10:26:24	358,582	80	---	
10:26:24	358,600	78	---	Last signal before the collision, emergency (vigilance) brake

Based on the above values, it is estimated that the collision occurred at 10:26:25 in between sections 358.610-630 with approximately 75-76 km/h speed. (The collision may have occurred a few tenths of seconds before the last registered time, however it is not likely).

Hereinafter we regard the moment of the collision as the last data. The possible evaluation error has no effect on the drawn conclusions.

Based on the scattered debris and the derailment marks on the rail track, the collision occurred between railway sections 440+30 and 440+50. Hereinafter we regard section 440+40 as the location of the collision. The possible deviation doest not affect the analysis.

When evaluating the following distance data, however, the IC took the 1.4 % inaccuracy of the registered data into consideration (see 2.4.3).

Moments before the collision

The below figure shows the moments before the collision. The trains are shown (with light blue colour) in the position when the engine-driver noticed the IC train in front of him.

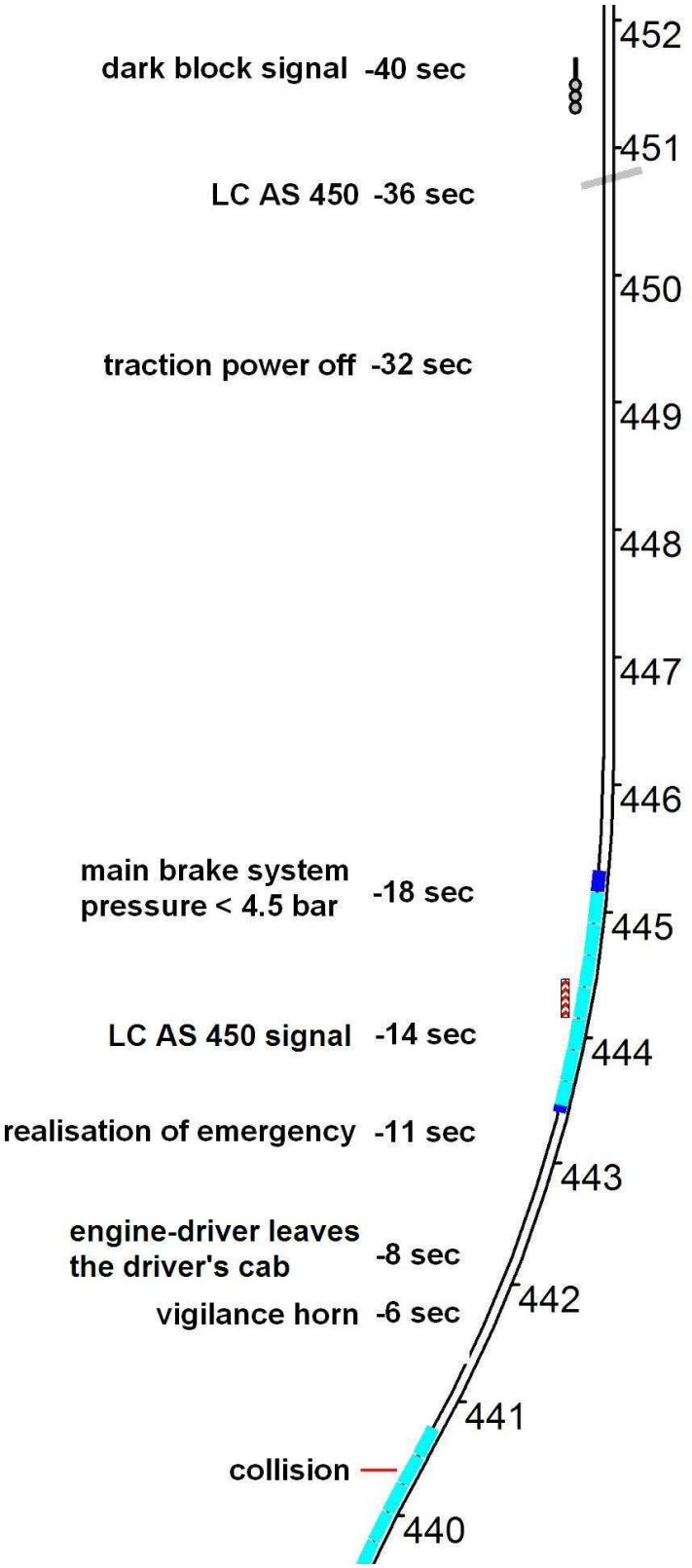


Figure 22: the moments before the collision and the actions/events of train 2537

Based on the registered data (data recorder of the control car) and on the interviews, the following happened prior to the collision:

– **1142 metres from the site of the collision (-41 seconds):** the engine-driver sounded the horn,

  Presumably, its reason is that the train was approaching an LC (105 metres away).

  According to the recordings, the length of this acoustic signal (horn) was 1.3 seconds (35 m at 107 km/h).

– **1130 metres (-40 sec):** the train passed the dark block signal, which - according to 8.7 of F.2. Regulations - should be interpreted as 'Stop'. The train, however, did not reduce speed.

– **1037 metres (-36 sec):** the train passed LC AS 450 whose barriers were in open position, which was noticed by the staff in the driver's cab.

  In actual fact, it was a failure which cannot be ascertained seeing it from the train.

– **888 metres (-32 sec):** the engine-driver turned the traction power off.

– **480 metres (-18 sec):** the main brake system pressure was reduced below 4.5 bar,

  which indicates that the brakes were applied a few seconds before but the brake effect was rather little. The IC has no information on why the brakes were applied. The engine-driver was unable to give an explanation. It is not likely that he applied the brake because of the next station - Monorierdő - as it was still 1.1. kms away.

– **375 metres (-14 sec):** passed a signal indicating (for trains running in the opposing direction) that an LC is near. The engine-driver looked back at the LC from the mirror to read and remember its number (450) and to report that the LC was in open position.

– Afterwards, approximately 200-300 metres from the collision site, the staff in the driver's cab noticed the IC train on the track in front of them.

  This was **11 seconds before the collision (and 297 metres before it)**, counted based on the previous and subsequent actions (realisation of emergency, braking, leaving the driver's cab). At this time, the rear of the IC train was (approximately 37 metres - 12 km/h x 11 mp) before the site of the collision.

  Based on this estimation, there was still a 260 metre-distance (297-37) between the two trains at this time, which is in harmony with the statements of the train staff.

  Train 2537 was running with 101 km/h speed. The actual braking distance from this speed would be twice the distance between the two trains.

– The engine-driver applied the emergency brake

  which was actually the continuation of the previously started braking.

– **196 metres (-8 sec):** the engine-driver left the driver's cab in order to save his life. He would not have been able to do anything else to avoid the accident and reduce its consequences even if he had stayed there. This way, however, he had the possibility to warn the passengers of the expected collision.

– **147 metres (-6 sec):** the vigilance horn sounded.

  The previous data on the engine-driver leaving the driver's cab was deducted from this fact. The basis of the deduction is that the vigilance horn sounds even when the vigilance pedal is continuously released on an at least 50-metre-distance (see 1.8.7).

– **0 metres, that is at the collision:** the vigilance brake came into operation automatically.

  If the engine-driver does not step on (or press) the pedal despite the sounding of the vigilance horn on a 150-metre-distance, the device automatically stops the train. In this case, 149 metres was registered (147 meters actual distance).

The summary of the above mentioned series of events (distance and time in relation to the collision):

Event	Distance *(m)*	Time *(mp)*	Location *(section)*
Horn sounding	-1142	-41	451+82
Dark block signal 453a	-1130	-40	451+70
LC AS 450	-1037	-36	450+77
No traction power	-888	-32	449+28
Main brake system pressure < 4.5 bar	-480	-18	445+20
LC signal (other direction)	-375	-14	444+15
Realisation of emergency (estimated)	-297	-11	443+37
Engine-driver leaves the driver's cab	-196	-8	442+36
Vigilance horn	-147	-6	441+87
Collision	0	0	440+40

2.2.4.4 Time of action

Based on the series of events prior to the collision, it can be counted that at the time of the realisation of emergency, there was approximately 260 metres between the two trains. The line of visibility extends (approximately 7-9 metres) towards the middle point of the curve of the track (The basis of the 2 metre uncertainty is that the visibility depends on which part of the driver's cab the engine-driver is and how much of the IC train he can see.)

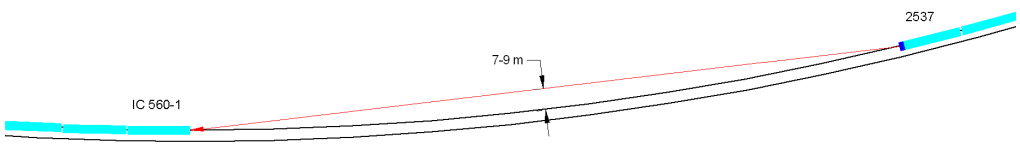


Figure 23: realisation of emergency

When these calculations were made, (in wintertime) the trees along the rail track were bare, therefore the IC was unable to examine the visibility conditions present at the time of the accident. As the area along the rail track is woody and bushy, it is likely that the visibility was hindered in October.

Thus, the engine-driver had no chance to realise the emergency earlier. He was only able to act within the above described timeframe. Therefore the IC believes that he did not delay the necessary actions but did his utmost in the emergency situation.

2.2.5 Injuries to persons in the passenger compartments

The IC examined how the construction and design of the furnishings of the trains contributed to making the consequences more or less serious (injuries to persons - using doctors'/medical experts' opinion -, damage to property).

2.2.5.1 The design of the luggage racks

In the course of the site survey, the IC established that in the last carriage of train IC 560-1, the overhead luggage racks broke off, separated from each other and their parts/pieces fell in between the seats (Figure 18). These may have caused further injuries to the passengers. Some injuries most probably caused by the sharp edge of the fallen luggage racks were life-threatening.

Figure 24: Torn down, broken luggage racks in between and on top of the seats

Figure 25: the luggage rack penetrating the wall of the toilet

It is visible in Figure 5 and 25 that the luggage racks fell as a result of the collision, however, they themselves remained in one piece, were not damaged or broken.

This fact indicates that the luggage racks are very rigid while their fittings and the inner wall/ceiling panels are not as solid. As a result, the longitudinal force from the collision does not deform the luggage racks but their fittings break and they fall off, which increase the risk of further injuries.

2.2.5.2 The position of the passengers

Quite a lot of people were injured in the third carriage of the passenger train (see 1.13.1). It is partly because more people were travelling in this carriage than in the others.

The position of the passengers in the last carriage of train IC 560-1 is shown in Figure 26.

– The green points indicate the seat reservations (sold tickets), however the actual position of the passengers may have been different (they do not always sit where their tickets indicate).

– Orange X indicates where the passengers who answered to the IC's questionnaire were sitting.

– Red + indicates the seats where the two deceased persons most likely sat. As the part of the passenger compartment indicated with blue colour was destroyed, the IC only assumes the seating arrangements based on the injuries to the deceased passengers and their position in the damaged compartment. It was not possible to make such assumptions with regard to the other two victims.

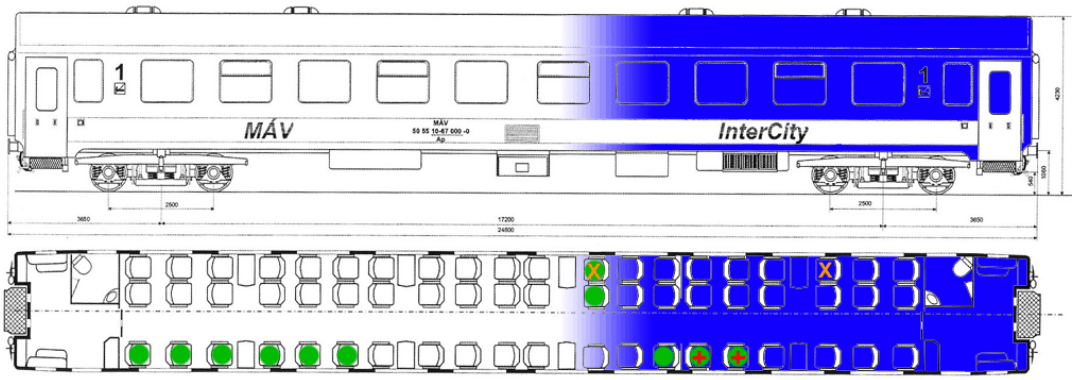


Figure 26: the position of the passengers in the last carriage of train IC 560-1

2.3 Connecting problems

2.3.1 LC control

2.3.1.1 In case of block section spacing order

If the block section spacing order is maintained when train are only permitted to run with 15 km/h speed - as in the present case -, the passed LCs turn to 'failure state' (as the first train keeps it closed for too long time). Subsequently, all the trains having departed from the station before this time - in block section spacing order - pass the (dark) LCs already in failure state. LCs with their half-barriers in open position may be interpreted by road vehicles as open/clear LCs and thus they can cross them regardless of the dark warning lights.

Further trains cannot be signalled out afterwards (in order to terminate the failure state - see 3.4 point of F.2 Regulations and 1.16.5 of this report).

This regulation results in a special, dual traffic - partly block section, partly station distance spacing order. Depending on how far the first automatic LC is, some trains can be signalled out to run in block sections with reduced speed, but after them further trains can only be signalled out when the track between the two stations have been cleared (which takes quite a long time with this reduced speed). Therefore, the maintenance of the block section spacing order decreases capacity as well.

The 'failure state'

Theoretically it is possible to avoid the failure state of the LC if the train moves with a speed close to the maximum allowed 15 km/h. In reality, however, the failure state of the LC can hardly be avoided because of three reasons. One of them is an addition to the regulation concerning train movements, which states that trains should move with such a speed (up to the maximum allowed speed) at which they are able to stop before any obstacle. Another reason is that the settings of the EÉVB also make it doubtable. The third reason is that long trains travelling with low speed always set the LC to failure state.

The distance of the trigger switch (see also in 1.8.3) from the LC is:

464+32 - 450+77 = 1355 m.

In case of the set 6-minute delay before the LC switches to failure state, the minimum required average speed of the front of the train at which the LC does not yet enter the failure state is:

1355 m / 360 mp = 13,6 km/h.

The above calculation presupposes a zero-length train (practically a locomotive). If and when the engine-driver decides to keep the maximum allowed speed of 15 km/h due to lack of restricting conditions, then the train travels a distance of:

360 mp x 15 km/h = 1500 m

in 6 minutes. In order to avoid the failure state, the end of the train should pass the release switch of the LC before the 6-minute delay elapses. Based on this condition, the maximum train length is:

1500 m – 1355 m = 145 m.

In reality, when taking the sensitivity of the trigger and release switches and their exact location and the factual speed into consideration, the maximum train length which does not yet put the LC in failure state is even under the calculated value.

Therefore the occurrence of the failure state at low train speeds is practically guaranteed. Movement inspectors can even be trained to handle the LC failure state routinely; if a train travels with low speed they can almost be certain that the LC switches to failure state. The engine-drivers, on the other hand, can safely assume whenever they pass an open LC that it is in failure state due to a slow train which had passed the LC.

2.3.1.2 Changeover to station distance spacing order

If the block signals are declared inoperative and changeover is made to station distance spacing order, a different LC controlling method is applied.

In this case, the open track LCs shall be closed manually (unless otherwise ordered by the signal box dispatcher) before trains are signalled out to the given track (between two stations - see 1.16.3). They can only be opened when the train has arrived to the next (second) station. Furthermore, the movements inspectors shall inform each other about the manual control. The manual opening of LCs is included in the instruction manual of the signal box.

So the LC is closed as long as there is a train on the given track section, either before or after the LC. When the LC is controlled manually, even if it is held closed for a longer time, it does not turn dark i.e. into failure state. In this particular track section, the LC should be kept close for approximately 8 minutes when an IC train passes it, and 10-11 minutes when a passenger train runs through it. It should also be taken into consideration that it is a double-track railway line, thus the LC should be kept close while trains run on either track, which would result in a rather long closure time-period.

In this case it is more likely that the drivers of road vehicles become impatient and disregard the Stop signal, bringing about possible new dangers - while trains run without speed limit.

Thus the possible changeover to station distance spacing order - under the current system technology and regulations - would have induced other safety risks for whose avoidance there is no routine, unified, practiced procedure or issued guidance. There is no such traffic control method either which would synchronise traffic on the two tracks and would ensure the periodic opening of the concerned LCs.

2.3.2 Traffic regulations in relation to train control

2.3.2.1 The operation and the failure of the EÉVB

After the „●” (red) signal was deleted on the train control device of the control car when approaching Pilis station, a „---” (white) signal appeared. This signal was on until the collision, therefore it was still on when passing the exit signal (subsidiary signal).

4.1.6 point of E.1 Regulations prescribes what the „---” (white) signal can mean (see 1.16.1):

– The train runs on a track section which is unable to control trains, or

– The EÉVB is not functioning, or

– The train has arrived at a track section which - though able to control trains - is occupied.

(This is also prescribed in 3.2.6 of F.1. Signal Regulations, with some minor differences - see 1.16.6 “no assessable signal is received from the track”.)

When the EÉVB is deactivated (no matter how), it technically creates the same effect as the last in the list (even though this is not what actually happened). Furthermore, in this present case, the EÉVB malfunctioned as well.

It should also be taken into consideration that the EÉVB should be considered faulty also when the fault is in the track as one of the conditions of the train control is that the track should operate normally (i.e. transmit signals).

2.3.2.2 Information available for the railway staff

15.19.1.8. of F.2. Traffic Regulations states that the method of traffic depends on whether there is a normally operating train control device and it prescribes the tasks of the movements inspectors accordingly.

The question is whether or not the movements inspector is actually in possession of the information concerning the good operation of the device:

1. is the traction vehicle equipped with the required devices?
2. do they operate normally?
3. is the track able to transmit signals?
4. is the transmission operating normally?

1. Movements inspectors do not usually have such information (unless the movements inspector of the previous station signalling out the train towards him has the information and tells him about it). Considering the ever more varied rolling stock, this problem arises more and more often these days (however this had no effect on the present accident).
2. It is only the engine-driver who knows whether the device operates normally or not, thus the movements inspector can be informed by him only.
3. this is the only fact and obvious answer as all railway staff on the line shall know the facilities/structure of the line - the open tracks connected to their stations.
4. It depends on the knowledge of the movements inspector on the signal box whether he draws the right consequences from the signals appearing on the signal box (e.g. power supply failure, apparent occupancy, signal transmission error, etc) They can only assume a possible danger and act according to the regulations and choose the least risky procedure.

There is a similar problem concerning the engine-driver who cannot always answer to the 4th question. The „●” (red) signal in certain circumstances can mean normal operation but in other specific circumstances it may also mean faulty operation and the actions to be taken differ accordingly - see 15.19.2.2 of F.2 Traffic Regulations.

They engine-driver would only know about this if/when he is informed (based on the found failures).

Although in this present case, the 4th question was the most important, another question arises: can we talk about normal operation after the „●” (red) signal has been deleted?

> If the device operates normally - for what purpose it was designed - it should show „---” (white) signal until it receives the next assessable signal from the track.

If we extend the term ‘normal operation’ to its usage as well, we can only talk about normal operation until it is used/operated in compliance with the regulations.

Movements inspectors are not obliged to know E.1. Regulations, therefore they cannot assume that the „●” (red) signal has been/is going to be deleted.

2.3.2.3 The obligations of the movements inspector

In this case, the failure was on the ‘track side’ not the device itself was faulty - therefore we cannot talk about **normal operation**. Subsection 2 of 15.19.1.8 of F.2. Traffic Regulations (chapter 1.16.4 of this report) point c. prescribes that trains shall only run with the maximum speed of 15 km/h until the first block signal.

According to point a., if the movements inspector cannot ascertain the occupancy of the block section, - which was the case at this accident - he should inform the engine-driver in a written order about the obligations prescribed in the Signal and Traffic Regulations. In this case, the movements inspector did not do so. (It can be assumed that when writing point a. the editor of the Regulations only thought about the case when subsidiary signal cannot be ordered.)

2.3.2.4 Other observations

There is an inconsistency in the first subsection of 15.19.1.8. of F.2. sz. Traffic Regulations. It is valid if there is a normally operating train control device, whose condition (outlined above) is that the track is able to transmit and does actually transmit signals. However, the second paragraph of the same subsection mentions tracks which are unable to transmit signals - which thus cannot be a condition of a normally operating train control device.

2.4. Remarks

2.4.1. Regulation conformity problems

Points 4.1.1-4.1.6 of Appendix No. 2 to E1 Regulations,– albeit partially and with minor differences – repeat the provisions of Chapter 3 of F.1 Regulations regarding the various signals. Explanation of the same topic by several documents with slight differences may pose a safety risk. It may be worth issuing an unanimous regulation which at the same time would be easier to read and understand.

E.1 Regulations lists the signals with colours only. The technical realisation of indication in the driver’s cab, however, can also be purely numerical (as it was the case in the driver’s cab of the second train) or combined (colours and digits on an ETCS display).

F.1 Regulations describes the indication of signals as follows: „The next **signal** is set to […] status.” This expression is misleading because the indication shows the status of the next **main signal** ahead, while it does not work with signals from subsidiary signals, shunting signals, or other types of signals.

2.4.2. Allowed speeds under subsidiary signal

The regulations in force state that in case of an accident or under subsidiary signal trains should run with such speed (up to 15 km/h maximum allowed speed) at which they are able to stop safely before any obstacle.

Provided that the speed limitation is in effect due to a malfunction of the open track signal box between Pilis and Monor stations, the train should run 10.7 km with a speed of 15 km/h which takes approximately 43 minutes. (The longest open track in Hungary is 16.4 km, and that distance would take 66 minutes to cover with this low speed.) The train control systems are often set to brake the train at 12-14 km/h resulting even longer travel times.

The engine-driver's experiences can be described with the following conditions while the train is travelling on an open track under subsidiary signal, with a speed of approximately 15 km/h:

– the speed is boringly low,

– it takes a very long time to cover distances,

– the train control device immediately brakes the train if the speed is slightly increased, which is stressful,

– there are no dangers on the track, and under good visibility conditions the engine-driver can see much further than the braking distance.

In addition, open tracks do not usually have points which would require special attention from the engine-driver and otherwise would pose a danger under subsidiary signal.

The above conditions may cause a stressful situation for engine-drivers which make them want to "get out of it" as soon as possible. The current speed limit itself may mean a frustration to them as it hampers their "escape". This phenomenon might explain the fact that the train approached the station with 20-25 km/h (instead of 15 km/h, once the speed limiter of the train control device had been deactivated) and also left the station in a hurry: the engine-driver wanted to "escape" from under the pressure of the speed limit.

Another side effect of the 15 km/h speed limit is that trains travelling on open tracks switch all LCs to failure state with high certainty (see 2.3.1.1).

Raising the speed limit, especially on open tracks, could mitigate the stress caused by the extremely low speed, thus lower the probability of non-compliance with the rules (which in turn lead to dangerous situations). At higher speeds, however, the breaking distance would also grow, together with the associated safety risks.

The origin of the 15 km/h speed limit can be traced back to the age of steam locomotives and hand brakes. The ergonomics and engineering solutions have undergone major improvements since then. Modern trains can be controlled (driven, accelerated, slowed down) and obstacles can be noticed far more easily these days.

The general rule is that trains shall run with such speed under subsidiary signal which allows the driver to stop the train before any obstacle. The speed limit is the maximum allowed speed, the safe speed may be lower than that.

Based on the above, the IC recommends the moderate raise of the speed limit, in accordance with the European general practice. It is also advisable to test engine-drivers with regard to their reaction to monotony and stressful situations.

2.4.3. Accuracy of the speedometers

Authentication of track lengths

With regard to the accuracy of the data recorder of train no. 2537, the IC found the following:

The control car of the train completed a Szolnok-Budapest Nyugati leg in train no. 2739 prior to the accident. According to the data recorder, the distance (km) counter was at 155,949 at departure and at 257,802 at arrival. The travelled distance is calculated as the difference, that is, 101.853 km. The nominal distance between the two stations along the track is 100.4 km. The measured distance was 1.453 km more than the nominal; it is a 1.4 % relative error.

The nominal and the actual distances can differ a few hundred metres, depending on the actual departure and stopping location. The IC believes that in the accident case the absolute and relative errors resulting from the accuracy of the distance counter do not exceed 500 metres and ±0,5% respectively, and do not have a significant effect on the outcome of the analysis of the accident.

Accuracy

There were two independent data recorders installed on train no. 2537 (one in the control car, the other in the locomotive). The recordings were generally similar with the exception of the speed values. The maximum speeds were 100 km/h and 107 km/h, the collision speeds 71 km/h and 78 km/h, the speeds at leaving Pilis station 9 km/h and 12 km/h respectively.

The relative difference in the range of higher speeds varies between 6.5-9.0 % which is over the relevant accuracy limit (±1 and ±5%; see 1.16.8)

According to the relevant regulations, the control measurement should be conducted with a stopwatch, using the speed calculated from the travelled distance. Therefore the accuracy depends on the speed. The above speed accuracy includes the effects of the wheel wear, the wheel-track connection and other factors.

The wheels of the locomotive through which the traction is transferred to the track always slip (it is called microslip). This slip can result in a 1% difference between the theoretical speed measured on the driven wheels of the locomotive and the actual travelling speed (which is lower). The effect of microslip makes the recorded speed values for the locomotive even lower. However, this error does not have effect on the results of the analysis and does not diminish the effect of the fact that the train was travelling with high speed at the time of the collision.

The superimposed recordings of the two data recorders are shown in Figure 27. The two stopping locations, the scales of the strip chart data recorder and the digital data recorder and the zero-point error were considered while compiling the diagram.

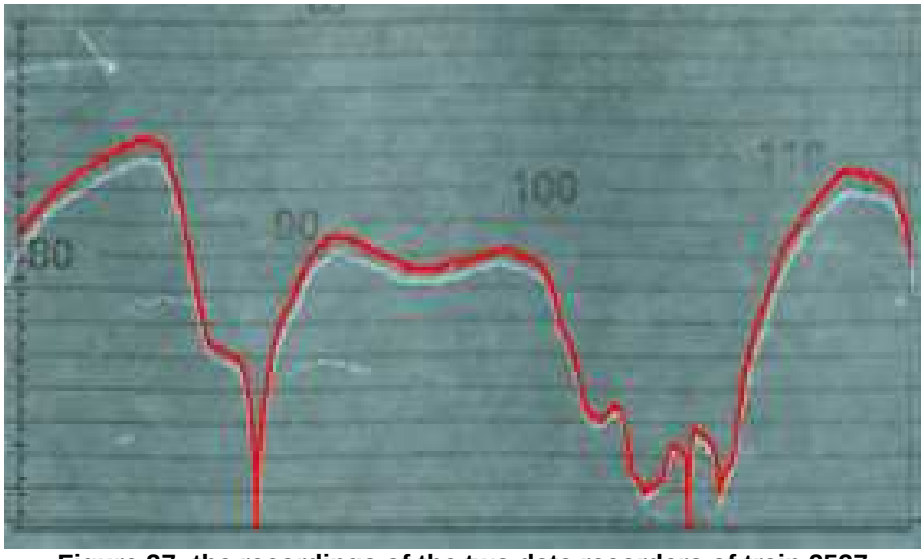


Figure 27: the recordings of the two data recorders of train 2537 (red line: the digital data recorder)

2.3.3 Communications equipment

The control cars involved in the accident were not equipped with locomotive radio, neither was any other communications equipment suitable for communication with the traffic control staff.

At the time of the failure, in the absence of communications equipment, there was no possibility to ask train 2532 whether or not the overhead contact wire had been torn off. The staff had to wait until the train arrived at Pilis station.

It was also difficult to use the radios on other trains; the traffic controller tried for 10 minutes until he was eventually able to contact (via locomotive radio) the engine-driver of train IC 612 running between Monor and Pilis stations to ask him about the status of the block signals he had passed.

The lack of communications equipment (or their insufficient operation) makes it difficult to obtain information required to make traffic-related decisions and to inform the concerned staff.

3. CONCLUSIONS

3.1 Factual statements directly connected to the occurrence of the accident

Train 2537 exceeded the 15 km/h speed limit significantly. Its precondition was that the train control device of the control car was unable to perform its speed limiting function as it had been deactivated.

The train passed a dark block signal (to be interpreted as 'Stop') at which it should have stopped according to the relevant regulations.

3.2 Factual statements indirectly connected to the occurrence of the accident

The fault of the signal box between Monor and Pilis station was such that neither the station staff nor the engine-driver had information (on the signal box and on the block signals) on the position of the first train. In such cases, decision can be made to change the traffic method taking the circumstances into consideration, however, the persons entitled to make such decision did not do so. It is not obvious from the traffic regulations when - in what situations - such decisions should be made.

The open track signal box did not function due to the defective cable. This does not necessarily lead to an accident, though it was a basis of the unusual and dangerous situation.

The engine-driver of the passenger train neither knew what the cause of the subsidiary signal was nor that another train ran in front of him on the open track. (According to the regulations in force, he did not have to know about them.)

3.3 Risk factors not connected to the accident

There was subsidiary signal on both the entry and the exit signal of Pilis station, besides, construction works were in progress at the station. This may have led to the assumption that the signal box failure was caused by the construction work at the station and the danger is not on the open track.

The control car of train 2537 was not equipped with locomotive radio therefore there was no possibility to inform the engine-driver about the traffic situation. The other trains equipped with radio could only be reached with difficulties, therefore the staff entitled to make decisions in this case were informed about the signal box failure with delay.

The regulations with regard to this traffic situation are rather complicated, yet they do not have prescriptions for a number of possible situations, and some regulations are contradictory. It is questionable whether in a stressful situation coupled with technical problems the right decision can be made within a short time.

4. SAFETY RECOMMENDATIONS

4.1 Safety recommendations issued in the course of the investigation

The IC issued the following safety recommendation on 9 October 2008:

BA2008-0446-5-01.: The IC recommends MÁV Zrt. to revise 4.2.2. of the Appendix of E.1. Regulations for traction vehicle staff and consider narrowing its scope, and initiate its modification accordingly.

The justification of the safety recommendation:

In the view of the IC, the current regulation is too general and prescribes the deactivation of the speed limiting function of the train control device in situations where the circumstances do not require to do so, moreover, in situations where the maintenance of this function would be strongly justified.

4.2 Further safety recommendations

BA2008-0446-5-02: The IC recommends the NTA to review the regulations as to when can block signals be considered inoperative, and how these regulations are implemented. The IC also suggests that the NTA should examine whether the concerned staff are prepared for decision-making and should consider improving the relevant education, compiling guides and checklists, or further specifying the current regulation.

The justification of the safety recommendation:

The regulations on declaring the block signals inoperative only give the possibility of decision-making but there are no exact guidelines, decision-making aspects.

BA2008-0446-5-03: The IC recommends the NTA to revise - with the cooperation of railway undertakings - the questions of speed limit applied in case of subsidiary signals, with special regard to:

– technical circumstances having changed since its introduction,

– psychological effects on engine-drivers,

– active and passive safety risks deriving from the applied speed.

The justification of the safety recommendation:

The permission of higher speed (adequately and reasonably prescribed) may reduce the urge to disregard the speed limit, and this way LCs turning to failure state could also be avoided.

BA2008-0446-5-04: The IC recommends the NTA to obligate the usage of communications equipment (locomotive radio, mobile phone, etc) for the communication between traffic controllers and engine-drivers while the train is running, and regularly examine that the equipment is operating normally and is used.

The justification of the safety recommendation:

The lack of communications equipment which hinder/delay decision-making contributed to the occurrence of this accident.

BA2008-0446-5-05: The IC recommends - via the European Railway Agency (ERA) - manufacturers of vehicles to re-examine certain equipment, installations and furnishings of vehicles manufactured or redesigned by them (e.g. luggage racks, lights, windows, doors, etc.) with regard to risk factors in a possible accident. When designing the vehicles, they should choose solutions which decrease the extent of injuries to persons to the possible minimum in case of such occurrences.

The justification of the safety recommendation:

As it was found in the course of the investigation, the luggage racks are very rigid but are fitted inadequately and thus they can easily fell off in case of accidents causing or making injuries more serious. Other parts/fittings of carriages breaking off in the course of the collision may also pose similar risks.

4.3 Measures taken

In response to safety recommendation **BA2008-0446-5-01,** E.1 Regulations was amended and was approved by the NTA (on file no. s KH/KV/NS/A/79/1/2009) on 6 May 2009.

4.4 Observations and opinions

MÁV Zrt., MÁV-TRAKCIÓ Zrt. and Bombardier MÁV Kft. sent their written reflections on the draft report, which were discussed by the participants of the final discussion held on 30 June 2009. The IC made modifications to the final report accordingly.

Reflections on safety recommendation **BA2008-0446-5-02:**

The representatives of MÁV Zrt. expressed its belief that the changeover to station distance spacing order does not necessarily mean safer traffic.

The IC emphasised that it did not consider this changeover as the only solution but also the importance of creating a reliable, unambiguous and efficient decision-making procedure in this regard (which may also be possible with the maintenance of block section spacing order). The IC made modifications to the final report accordingly.

Reflections on safety recommendation **BA2008-0446-5-03**:

According to the observations heard at the final discussion, the re-examination of the 15 km/h speed limit to be applied under subsidiary signal had been proposed previously and the technical possibilities had also been examined. Due to the technical barriers/limitations, a rise to 20 km/h could be executed; over this speed it would be problematic. Therefore, the participants no longer talked about this issue and no measures were taken afterwards.

The IC considers it important that - according to the safety recommendation - a concept should be created on which future technical decisions can be based as the present technical barriers/limitations can only be abolished this way.

Reflections on safety recommendation **BA2008-0446-5-04**:

In the opinion of the representatives of MÁV-TRAKCIÓ Zrt., the establishment of a GSM-R telecommunication system could solve the problem, which however, is yet waiting for ministerial approval and requires a significant amount of financial resources and time.

The IC agrees with the necessity of establishing a GSM-R system but also thinks it is important to find a temporary solution until it is done so that the engine-drivers and the traffic control staff can get in touch with each other while the train is en route if needed (e.g. via locomotive radio or mobile phone).

Reflections on safety recommendation **BA2008-0446-5-05**:

Bombardier MÁV Kft. had chosen the design of the luggage racks (glass plate) in the passenger compartments according to the demands and requests of the customer. These luggage racks pose less risk from property protection/security point of view (non-ferrous parts are often stolen). Of course there are possibilities to present other safer solutions and designs in their offers which are not or only slightly more expensive.

Passing block signal no. 453a (2.2.4.2):

In the opinion of the representatives of MÁV Zrt. - the regulations should be interpreted as follows: after passing a main signal indicating ‘Stop’, engine-drivers should prepare for the next signal indicating ‘Stop’ as well. Therefore, trains approaching block signals indicating ‘Stop’ can run based on the signals of the preliminary signal (and according to the relevant regulations). This is also the routine on this railway line.

However, the IC emphasises that the text of the regulations is not unambiguous and one may not necessarily interpret it as above (the actually wording of the regulation and the routine differ). Therefore the procedure detailed in 2.2.4.2 of this report is to be followed.

5. APPENDICES

Appendix 1:

Excerpts from the regulations relevant to the occurrence *(in Hungarian only)*

Appendix 2:

Protocols on the functional inspection of EVM-120 type unified train control and vigilance warning device (EÉVB) *(in Hungarian only)*

Budapest, 7th May 2010

Gábor Chikán Investigator-in-charge	Róbert Karosi Member of IC
András Mihály Member of IC	Éva Prisznyák Member of IC
János Rózsa Member of IC	Pál Burda On-site investigator technician

NOTE:

This present document is the translation of the Hungarian version of the Final Report.

Although efforts have been made to translate it as accurately as possible, discrepancies may occur.

In this case, the Hungarian is the authentic, official version.

1. APPENDIX

Ezen melléklet tartalmazza az esemény szempontjából érdekelt utasítások, szabályzatok szövegrészleteit.

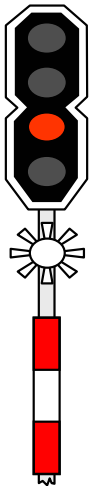
1.1 Hívójelzés

F.1. sz. Jelzési Utasítás 2.5.22.

2.5.22. Hívójelzés.

Villogó fehér fény a főlap alatt külön jelzőlapon és egy vörös fény a főlapon (1. ábra).

Hívójelzés mellett a forgalmi utasításban szabályozott módon lehet közlekedni olyan sebességgel (legfeljebb 15 km/h), hogy a vonat a jelentkező akadály előtt megállítható legyen.



1. ábra: Hívójelzés

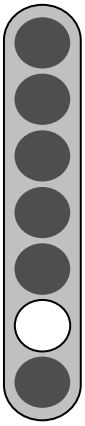
1.2 A vezetőállás jelző

F.1. sz. Jelzési Utasítás, 3.2.6.

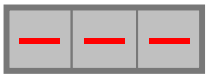
3.2.6. A pályáról kiértékelhető jel nem érkezik.

Egy fehér fény (2. ábra). Digitális vezetőállás jelzőn három vízszintes vonal (3. ábra). ETCS vezetőállás jelzőn fehér alapon három vízszintes fekete vonal (4. ábra).

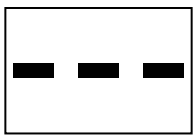
A berendezés használhatatlan, vagy a vonat vonatbefolyásolásra ki nem épített pályaszakaszról vonatbefolyásolásra kiépített, de foglalt, illetve a vonat olyan pályaszakaszra érkezett, amely nincs kiépítve vonatbefolyásolásra.



2. ábra



3. ábra



4. ábra

1.3 Eljárás, ha a jelző lámpája nem világít

F.1. sz. Jelzési Utasítás 8.7.

8.7. *Ha a közlekedő vonat mozdonyvezetője megállapítja, hogy*

- [...]

- valamely fény főjelző lámpája nem világít és a jelző használhatatlanságáról a mozdonyvezető nem kapott Írásbeli rendelkezést, akkor köteles a vonatot a főjelző előtt megállítani, s onnan csak az F.2. sz. Forgalmi Utasításban szabályozott módon szabad elindulni és továbbhaladni.

F.2. sz. Forgalmi Utasítás 15.19.2.2.

15.19.2.2. *Ha önműködő biztosított térközjelzőkkel felszerelt pályán a vonatszemélyzet nem kapott Írásbeli rendelkezést a biztosítóberendezés használhatatlanságáról és a vonat Megállj-jelzést adó vagy jelzést egyáltalán nem adó fehér árbocú önműködő biztosított térközjelzőhöz érkezik, akkor:*

1. […]

2. ***Ha nincs jól működő vonatbefolyásoló berendezés****, akkor a vonatot a Megállj-állású önműködő térközjelző előtt meg kell állítani és megállás után az alábbiak szerint kell eljárni:*

a) ha megállapítható, hogy a következő térköz foglalt, akkor a vonat csak a térköz felszabadulása után közlekedhet tovább;

b) ha a térköz foglaltsága bármely ok miatt (sötétség, távolbalátás vagy szabadlátás korlátozottsága) nem állapítható meg és a megállástól számított 2 percen belül a térközjelzőn nem jelenik meg továbbhaladást engedélyező jelzés, akkor a mozdonyvezető a megállástól számított 2 perc eltelte után a következő főjelzőig — függetlenül annak jelzésétől — figyelmesen közlekedhet olyan sebességgel, hogy a vonatot a jelentkező akadály előtt minden körülmények között meg tudja állítani. A továbbhaladás sebessége a legjobb látási viszonyok esetén sem lehet 15 km/h-nál nagyobb. Ha menet közben nem jelentkezik akadály, de a következő főjelző sem ad továbbhaladást engedélyező jelzést, akkor a jelző előtt meg kell állni. Fehér árbocú főjelző mellől az előző bekezdésben szabályozott módon, fehér-vörös árbocú főjelzőtől pedig az F.1.sz. Jelzési Utasításban szabályozott módon szabad továbbhaladni;

c) ha a Megállj-jelzést adó vagy sötét, fehér árbocú önműködő térközjelzőtől a megállástól számított 2 perc eltelte után elindult vonat a következő térközben vonatot talál, akkor a vonatot meg kell állítani. Ha az előtte levő vonat elindul, akkor azt legalább 200 m távolságot tartva követheti a következő főjelzőig. Ha a következő főjelző nem ad továbbhaladást engedélyező jelzést, akkor előtte meg kell állni és csak a fenti a), illetve b) alpontban szabályozott módon szabad tovább közlekedni attól függően, hogy a főjelző fehér, vagy fehér-vörös árbocú.

Az 1., 2.b) pont szerinti továbbhaladásra vonatkozó előírás csak akkor alkalmazható, ha a térközjelző előtti előjelzést is adó főjelzőn a megállásra utaló előjelzés volt. Ellenkező esetben a vonatot azonnal meg kell állítani és továbbhaladni csak a rendelkezésre álló értekező berendezésen kapott engedély alapján szabad.

1.4 Jól működő vonatbefolyásoló berendezés

F.2. sz. Forgalmi Utasítás 1.2.139.

„jól működő vonatbefolyásoló berendezés” *kifejezés azt jelenti, hogy a mozdony rendelkezik jól működő vonatbefolyásoló berendezéssel és a pálya – folyamatos vagy szakaszos – jelfeladásra kiépített, és mindkettő üzemszerűen működik*

1.5 Az önműködő térközbiztosító berendezés használhatatlansága

F.2. sz. Forgalmi Utasítás 15.4.2.1.

15.4.2.1. *Az önműködő térközbiztosító berendezés használhatatlan, ha:*

- [...]

- a biztosítóberendezési szakszolgálat vagy a forgalmi vonalirányító a biztosítóberendezési diszpécserrel történt egyeztetés alapján a vonali berendezést használhatatlannak minősítette, és erről a forgalmi szolgálattevőt bizonyíthatóan (előjegyzés a Fejrovatos előjegyzési naplóba, vagy hangrögzítő berendezéssel ellátott értekező berendezésen történt közlés) értesítette.

Az önműködő térközbiztosító berendezés használhatatlansága esetén a vonatokat mindkét közlekedési iránynak megfelelően állomástávolságban kell közlekedtetni [...]

F.2. sz. Forgalmi Utasítás 3.3.3.

3.3.3. Önműködő térközbiztosító berendezéssel felszerelt vonalakon a térközbiztosító berendezés használhatatlansága esetén — ha a biztosítóberendezési diszpécser eltérően nem intézkedik — az állomásközben lévő nyíltvonali fénysorompókat mindkét közlekedési iránynak megfelelően a közlekedő vonat előtt kézi kezeléssel le kell zárni. A szomszéd állomásra visszajelentett nyíltvonali fénysorompók lezárására a szomszéd állomás forgalmi szolgálattevőjét utasítani kell.

Ilyen esetben a vonat mozdonyvezetőjét csak akkor szabad felhatalmazni az indításra, ha a szomszéd állomás forgalmi szolgálattevője az állomására visszajelentett fénysorompókat kézi kezeléssel lezárta és erről, valamint a számlálók állásáról a vonatot indító állomás forgalmi szolgálattevőjét értesítette, aki ezt a Fejrovatos előjegyzési naplójában előjegyezte, továbbá a hozzá visszajelentett fénysorompókat is lezárta.

1.6 Közlekedés továbbhaladást tiltó főjelzők mellett

F.2. sz. Forgalmi Utasítás 15.19.1.8.

15.19.1.8. *Ha önműködő biztosított térközjelzőkkel felszerelt pályán a kijárati jelzőn nem jelenik meg továbbhaladást engedélyező jelzés — szükség esetén a vonatszemélyzet megfelelő értesítése után — a kihaladást követően a vonatok közlekedhetnek:*

1. Jól működő vonatbefolyásoló berendezés esetén:

- *ha a vonat által használt állomási vágány is ki van építve jelfeladásra, a vezetőállás jelzőn kapott jelzések figyelembevételével térközben;*
- *ha a vonat által használt állomási vágány nincs kiépítve jelfeladásra, ugyancsak a vezetőállás jelzőn kapott jelzések figyelembe vételével térközben, de, ha a vezetőállás jelző fehér fénye nem változott (a térköz foglalt), akkor az első önműködő térközjelzőig mindenkor csak olyan sebességgel, hogy a jelentkező akadály előtt bármikor meg lehessen állítani. Az alkalmazott sebesség ilyenkor a legjobb látási viszonyok mellett sem lehet nagyobb, mint legfeljebb 15 km/h. Ha a forgalmi szolgálattevő a térköz tényleges foglaltságáról meg tudott győződni, nem indíthat vonatot.*

Ugyanez az eljárás, ha az állomásköz egy térköznek minősül.

2. Nincs jól működő vonatbefolyásoló berendezés:

a) ha a forgalmi szolgálattevő a térköz foglaltságáról nem tud meggyőződni, akkor a vonatszemélyzetet a kijárati jelző használhatatlanságán kívül értesíteni kell arról is, hogy az első térközjelzőig mindenkor csak olyan sebességgel szabad haladni, hogy a vonatot a jelentkező akadály előtt bármikor meg lehessen állítani. Az alkalmazott sebesség azonban a legjobb látási viszonyok mellett sem lehet nagyobb, mint legfeljebb 15 km/h. A következő térközjelző mellett való elhaladásra és a továbbhaladás sebességére a térközjelzőn kapott jelzés a mérvadó.

A mozdonyvezető az első térközjelzőig az előző bekezdésben szabályozott sebességgel köteles haladni akkor is, ha Hívójelzés mellett haladt ki az állomásból;

b) ha a vonat olyan állomásról halad ki Hívójelzés mellett, ahol a Hívójelzés feloldása-jelzés kivezérelhető:
a vonat a következő térközjelzőig a vonatnál alkalmazható legnagyobb sebességgel közlekedhet, ha a vonat utolsó járműve is meghaladta már a kijárati Hívójelzés feloldása-jelzést;

c) ha a vonat olyan állomásról haladt ki Hívójelzés mellett, ahol a kijárati Hívójelzés feloldása-jelzés nem vezérelhető ki:
a vonat a következő térközjelzőig az előzőekben előírt csökkentett, legfeljebb 15 km/h sebességgel közlekedhet.

1.7 Eljárás a fénysorompók zavar állapota esetén

F.2. sz. Forgalmi Utasítás 3.4.

***3.4.** A nyíltvonali fénysorompó berendezés zavarjelzése esetén a két szomszédos állomás forgalmi szolgálattevője köteles egymást értesíteni. Ha a visszajelentő készülék nyíltvonali szolgálati helyen van, akkor a felügyeletével és ellenőrzésével megbízott dolgozó köteles a zavarról mindkét állomás forgalmi szolgálattevőjét értesíteni.*

A zavar feloldását azonnal meg kell kísérelni, ha a nyíltvonali fénysorompó berendezés kezelője előzetesen meggyőződött arról, hogy az útátjáró felé vonat nincs útban, illetve az állomásköz felszabadult.

A zavarjelzés feloldása érdekében az állomásköz felszabadulását a vonat feltartóztatásával is biztosítani kell és vonatot csak akkor szabad indítani mindkét állomásról, ha a zavar feloldás eredményes volt, vagy használhatatlanság esetén a vonatszemélyzetet értesítették.

[…]

1.8 Az egyesített éberségi és vonatbefolyásoló berendezés

E.1. sz. utasítás (a vontatójármű személyzet részére) 2. melléklete

3. A berendezés működése, kezelése vonatbefolyásolásra ki nem épített pályán (vágányon)

3.1. Bekapcsolt berendezésnél a vezetőállásjelző fénye fehér, ekkor 15 km/h sebesség felett útarányos éberségellenőrzés történik. A berendezés kezelést csak 15 km/h sebesség felett igényel. A pedált vagy nyomógombot folyamatosan lenyomott helyzetben kell tartani. Ilyen esetben 1550 m megtett út után szólal meg az éberségi kürt. Felengedett pedál mellett a kürt már 50 m megtett út után megszólal. A kürt a pedál, illetve a nyomógomb egyszeri kezelésére elhallgat, mely kezelésnek a kürt megszólalását követően 150 m megtett úton belül kell megtörténnie.

Ha a kezelés 150 m-en belül nem történik meg, akkor a berendezés leold, azaz a vonóerő megszűnik, és vészfékezés következik be. A leoldással egyidőben a kürt elhallgat. […]

3.2. Az éberségi kürt megszólalása a pedál, illetve nyomógomb előkezelésével (az 1550 m út befutása előtti kezelésével) megelőzhető.

4. A berendezés működése, kezelése vonatbefolyásolásra kiépített pályán (vágányon)

4.1. A 2. pontban előírtak szerint üzembe helyezett berendezés vonatbefolyásolásra kiépített pályaszakaszon kapcsolatot tart a mozdony és a helyhez kötött főjelzők között, és 15 km/h sebesség felett útarányos éberségellenőrzést végez.

Ilyenkor a vezetőállásjelző megismétli a közelített főjelzőre vonatkozó előrejelzést, azaz a közelített főjelzőnél alkalmazható megengedett max. sebességre utaló színkép (és felirat) jelenik meg. A mozdonyvezető ennek megfelelően köteles a vonat sebességét szabályozni.

[…]

4.1.4. Ha sárga fény világít a vezetőállásjelzőn, akkor a következő főjelzőn ,,Megállj" jelzés van. 15 km/h sebesség felett sűrített az éberségi felhívás.

4.1.5. Ha vörös fény világít a vezetőállásjelzőn, akkor a mozdony „Megállj" jelzést adó főjelző mellet haladt el, és a jelző utáni vágány foglalt (foglaltnak tekintendő). A berendezés éberségi része ebben az esetben nem működik. 15 km/h-nál nagyobb sebesség esetén a berendezés éberségi felhívás nélkül leold.

4.1.6. Ha fehér fény világít a vezetőállásjelzőn, akkor a mozdony:

- vonatbefolyásolásra ki nem épített pályaszakaszon közlekedik vagy

- az EÉVB berendezés meghibásodott, vagy

- vonatbefolyásolásra ki nem épített pályaszakaszról vonatbefolyásolásra kiépített, de foglalt pályaszakaszra érkezett.

Az éberségi rész a 3. pontban leírtaknak megfelelően működik.

4.2. Közlekedés „Megállj!" jelzésnél:

4.2.1. Kizárólag térközjelző szerepet betöltő, végig fehér árbocú jelző esetén: A jelzőt a Forgalmi Utasításban szabályozott esetekben és módon szabad meghaladni, majd a vezetőállásjelzőn kapott előjelzés szerint kell a vonat sebességét szabályozni.

Ha vezetőállásjelzőn a vörös fény jelenik meg, az azt jelenti, hogy a térköz foglalt. Továbbhaladni a foglalt térközre vonatkozó szabályok szerint szabad még abban az esetben is, ha a térköz látszólag szabad, mert a főjelző és a vezetőállásjelző vörös fényét más üzemveszélyes helyzet (pl. síntörés) is előidézheti.

A vezetőállásjelző vörös fénye esetén a berendezés legfeljebb 15 km/h sebességű közlekedést enged meg, e sebesség felett éberségi felhívás nélkül leold. Az ilyen jelző után bármely okból leoldott berendezést megállás után a pedál kezelésével kell visszaállítani, és menetet vörös vezetőállásjelzővel kell folytatni. A visszaállítást tilos a 4.2.2. pontban említett részegységek kezelésével vagy bármely más olyan módon végezni, amely a berendezés tápfeszültségét megszakítja, mert ez a vezetőállásjelző vörös fényét fehérre változtatja.

4.2.2. Bejárati jelző esetén:

A jelzőt a Forgalmi Utasításban szabályozott esetekben és módon szabad meghaladni, amely után a vezetőállásjelző fénye vörösre változik. Az állomásban a kijelölt helyen meg kell állni és a vörös fényt az 1.2.6. és 1.2.8. pontban szereplő vagy a berendezés tápfeszültségét megszakító valamely kapcsoló ki-, majd bekapcsolásával törölni kell, azaz fehérre kell változtatni.*

Menesztés után a kihaladás sebességére a Forgalmi Utasítás rendelkezései a mérvadók. Ha behaladás közben a vezetőállásjelzőn a vörös fényt a kijárati jelzőre vonatkozó színű előjelzési fény váltja fel, akkor a fenti törlést értelemszerűen nem kell elvégezni, de a vonat sebessége csak akkor növelhető, ha az utolsó kocsi is elhagyta a bejárati váltókörzetet. […]

*KBSZ megjegyzése: ezek a saját/csatolt átkapcsoló illetve a berendezés biztosítója

2. APPENDIX

Az EVM-120 berendezés (EÉVB) funkcionális ellenőrzési jegyzőkönyvei:

- 2008. január 23-án, és
- 2008. október 8-án (a balesetet követően)

EVM-120 funkcionális ellenőrzési jegyzőkönyv

megrendelő: MÁV Szolnok FJ
típus: EVM-120-24V-T-2200
gyári szám: 03029
gyártó: MA Kft 2030 Érd, Alsó u. 10.
mérés ideje: 2008.01.23.
a mérést végezte:

1. Bekapcsolási teszt:	megfelelő	nem megfelelő
2. Ütemérzékelés és zavar időzítés:		
t_0= 7,0 s t_Z= 2,9 s	megfelelő	nem megfelelő
t_S= 8,5 s		
3. Dekódolás, regisztrálás:	megfelelő	nem megfelelő
4. Fékezés 'vörös' jelzés és tolatás esetén:	megfelelő	nem megfelelő
5. Sebességtúllépés és éberség ellenőrzés:	megfelelő	nem megfelelő
6. Fékezés sebességtúllépés nélkül:	megfelelő	nem megfelelő
7. Útmérési idők ellenőrzése:		
t_{200}= 3,9 s t_{1550}= 30 s	megfelelő	nem megfelelő
8. 'Pótkötél' áramkör ellenőrzése:		
t_{TZ}= 20 s t_{V2}= 20 s	megfelelő	nem megfelelő
9. Sebességtúllépés ellenőrzés VCS1-ről:	megfelelő	nem megfelelő
10. 'Pótkötél' áramkör ellenőrzése VCS2-ről:	megfelelő	nem megfelelő
11. Szűrő érzékenység: 90 mV	megfelelő	nem megfelelő
12. Szűrő sávszélesség: 74-76 Hz	megfelelő	nem megfelelő
13. X ütem felismerés túlvezérlés esetén:	megfelelő	nem megfelelő

EVM-120 funkcionális ellenőrzési jegyzőkönyv

megrendelő:
típus: EVM-120 T-2200 24V
gyári szám: 03029
gyártó: MA Kft 2040 Budaörs, Komáromi u.
mérés ideje: 2008. 10.08.
a mérést végezte:

1. Bekapcsolási teszt:	megfelelő	nem megfelelő
2. Ütemérzékelés és zavar időzítés:		
t_0= 6,8 s t_Z= 2,9 s	megfelelő	nem megfelelő
t_S= 8,5 s		

3. Dekódolás, regisztrálás:

K1	Sj	Regisztrálás LED-ek
"4"	"MAX"	mind sötét ✓
"4*"	"120"	"40...120" ✓
"3"	"80"	"40...120"
"2"	"40"	"40...120" ✓
"1"	"O"	"S" ✓
"O" az "1" után "	"●"	"V" ✓
"O" bármely egyéb után	"---"	"F/Zav" ✓

4. Fékezés 'vörös' jelzés és tolatás esetén:	megfelelő	nem megfelelő
5. Sebességtúllépés és éberség ellenőrzés:	megfelelő	nem megfelelő
"MAX" kijelzést követő jelkimaradásra az **Sj:**	megfelelő	nem megfelelő
Kürtjel jelentkezik	megfelelő	nem megfelelő
6. Fékezés sebességtúllépés nélkül:	megfelelő	nem megfelelő
7. Útmérési idők ellenőrzése:		
t_{200}= 3,9 s t_{1550}= 31 s	megfelelő	nem megfelelő
8. 'Pótkötél' áramkör ellenőrzése:		
t_{TZ}= 21 s t_{V2}= 21 s	megfelelő	nem megfelelő
9. Sebességtúllépés ellenőrzés VCS1-ről:	megfelelő	nem megfelelő
10. 'Pótkötél' áramkör ellenőrzése VCS2-ről:	megfelelő	nem megfelelő
11. Szűrő érzékenység: 89 mV	megfelelő	nem megfelelő
12. Szűrő sávszélesség: 73 - 77 Hz	megfelelő	nem megfelelő
13. X ütem felismerés túlvezérlés esetén:	megfelelő	nem megfelelő

Az eredeti adatok lerövé, ellenőrzés után visszazárva
A berendezés hibátlanul üzemel.