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Number: 375-16/2010/14

Ref. No: 0012317

Date: 9 June 2011

**FINAL REPORT ON THE INVESTIGATION OF A RAILWAY
ACCIDENT – COLLISION OF LOCOMOTIVE TRAIN NO. 96366
WITH PASSENGER VEHICLE**



TABLE OF CONTENTS

1	SUMMARY	2
1.1.	Copies of the accident report with recommendations to	4
2	IMMEDIATE FACTS OF THE OCCURRENCE.....	5
2.1	Date, exact time and location of the occurrence.....	5
2.2	Description of the events and the accident site	5
2.3	The body that established the investigation.....	7
2.4	The decision to establish an investigation, the composition of the team of investigators and the conduct of the investigation.....	7
2.5	The background to the occurrence.....	7
2.5.1	<i>Staff involved</i>	<i>8</i>
2.5.2	<i>The trains and their composition, including the registration numbers of the items of rolling stock involved</i>	<i>8</i>
2.5.3	<i>Description of the infrastructure and signalling system (track types, switches, interlocking, signals, train protection)</i>	<i>8</i>
2.5.4	<i>Means of communication.....</i>	<i>9</i>
2.5.5	<i>Building works at the scene of the accident or in the vicinity</i>	<i>10</i>
2.5.6	<i>Trigger of the railway emergency plan and its chain of events.....</i>	<i>10</i>
2.5.7	<i>Trigger of the emergency plan of the public rescue services, police and medical services and its chain of events</i>	<i>11</i>
2.6	Fatalities, injuries and material damage	11
2.7	External circumstances	11
3	RECORD OF INVESTIGATIONS AND INQUIRIES	12
3.1	Summary of testimonies	13
3.2	The safety management system.....	15
3.3	Rules and regulations	16
3.4	Operation of rolling stock, technical facilities and technical installations.....	16
3.5	Documentation on the operating system	17
3.6	Man-machine-organisation interface.....	17
3.7	Previous occurrences of a similar character	17
4	ANALYSIS AND CONCLUSIONS.....	18
4.1	Final account of the event chain.....	19
4.2	Discussion.....	19
4.3	Conclusions	20
4.4	Additional observations.....	21
4.5	Measures that have been taken	21
4.6	Recommendations	21
5	BIBLIOGRAPHY	22

1 SUMMARY

On 27 January 2010 at 20:45, locomotive train no. 96366 passed at danger the US-C entry signal at Maribor Studenci station, and then at the Ljubljanska ulica level crossing at km 0+819 collided with a road passenger vehicle crossing the railway line.

The railway line between Maribor and Prevalje international border has a single track. The railway line runs in the shape of a triangle between Maribor, Maribor Tezno and Maribor Studenci stations. The lines from the directions of Maribor and Maribor Tezno run parallel from km 0+600 towards Maribor Studenci station. The extended station tracks are parallel when they cross Ljubljanska ulica (Ljubljanska Street) at km 0+819.

Locomotive train no. 96366 was travelling from Pragersko to Maribor Studenci. The train switched from the main Zidani Most–Šentilj international border railway line onto the regional Maribor–Prevalje line at the Ptujška cesta junction, and then travelled in the direction of Maribor Studenci.

The Ptujška cesta junction is located between Maribor Tezno and Maribor stations at km 592+142, and for the branch line from the direction of Maribor Tezno–Prevalje international border this is the start or km 0+000 on the line from the Ptujška cesta junction to Prevalje international border.

Locomotive train no. 96366 was travelling from Maribor Tezno station towards Maribor Studenci station.

The Ljubljanska ulica level crossing is equipped with mechanical double-leaf barriers and illuminated road signs. The barriers are lowered by two levers installed in the level crossing guard box. The box is located on the left-hand side of the line next to the right-hand pavement in Ljubljanska ulica viewed from the direction of Ulica Moše Pijada (Moše Pijada Street) towards Ulica Pariške komune (Pariške komune Street).

The Ljubljanska ulica level crossing at km 0+819 was not protected at the time of the accident; the barriers were not closed.

The driver of the passenger vehicle drove along the correct right-hand lane in Ljubljanska ulica from the direction of Ulica Moše Pijada towards Ulica Pariške komune. She entered the level crossing on the right-hand side of the locomotive train viewed from its travelling direction.

After the collision, the locomotive pushed the passenger vehicle forward for 49 m before the vehicle came to a halt in the area

between the two tracks, while the locomotive came to a halt next to the road vehicle after another 10.8 m.

The driver of the passenger vehicle sustained minor injuries and was taken by ambulance to Maribor University Medical Centre.

The direct cause of the accident was a malfunction in a brake on the locomotive train, which resulted in inadequate braking performance, and the locomotive driver of the train involved in the accident not being able to control his speed between the PS-C pre-entry signal and the US-C entry signal at Maribor Studenci station, and to stop in a safe and timely manner in front of the US-C entry signal at Maribor Studenci station, which was displaying signal 1: "Stop".

The indirect cause of the accident was the irregular marking of the US-C entry signal, indicating the distance of the railway line between the PS-C pre-entry signal and the US-C entry signal at Maribor Studenci station, which measures 668 m, while the complete prescribed distance is 700 m with a permitted reduction of 5%. The PS-C pre-signal is not marked with signal 25 as prescribed: "Pre-signal marking", located at a distance that is up to 5% shorter than the braking distance, which is misleading for locomotive drivers.



Figure 1: The red arrow shows the direction of the train, the blue arrow shows the direction of the passenger vehicle, and the black cross the point of collision

Recommendations:

1. In the case of regular or extraordinary maintenance of traction vehicles, especially the maintenance of their vital components (i.e.

braking systems, tread profiles and safety devices), traceability must be provided on the basis of detailed internal regulations for individual types of vehicles.

2. Maribor Traction Section (*Sekcija za vleko Maribor*) must amend the EV-41 record of track information with section 30-34, the curve between Tezno and Maribor Studenci, a regional railway line without an AS device at the US-C entry signal.

3. The PS-C pre-signal at Maribor Studenci station must be marked with signal 25 as prescribed: "Pre-signal marking", located at a distance that is up to 5% shorter than the braking distance.

4. Instructions, including a detailed description of the device and how to operate it, should be drawn up for devices (chain spindles) used by guards at level crossings protected with half-barriers or barriers, for the lowering or raising of these barriers manually.

1.1. Copies of the accident report with recommendations to:

Slovenske železnice, d.o.o.
Kolodvorska 11
1506 Ljubljana

Republic of Slovenia
Ministry of Transport
Minister, Dr Patrick Vlačič
Langusova 4
1000 Ljubljana

Public Agency of the Republic of Slovenia for Railway Transport
Kopitarjeva 5
2000 Maribor

Ministry of the Interior
Maribor Police Directorate
Maribor Traffic Police Station
Ptujska cesta 117
2000 Maribor

ERA – European Railway Agency
160 Boulevard Harpignies
BP 20392
F-59307 VALENCIENNES Cedex

2 IMMEDIATE FACTS OF THE OCCURRENCE

When the level crossing is not protected or the barriers are not horizontally lowered across the road, road users are protected against trains by the US-A and US-C entry signals and the IS-K1 and IS-K2 exit signals at Maribor Studenci station; all these signals must display signal 1: "Stop".

The NPr-0.9 level crossing in Ljubljanska ulica is constructed according to the standards in force and crosses two parallel single-track lines at Maribor Studenci station: one at km 0+819 between the Ptujška cesta junction and Maribor Studenci station, and the other at km 0+893 between Maribor and Prevalje international border stations. At this level crossing, road users must yield to trains and are protected against trains with a safety device: half-barriers for the two road directions, which are lowered or raised manually by order of the traffic control at Maribor Studenci station. The device was in perfect working order at the time of the accident. The level crossing was not protected at the time of the accident. The half-barriers were not lowered horizontally across the road when locomotive train no. 96366 passed over the level crossing.

2.1 Date, exact time and location of the occurrence

The incident – locomotive train no. 96366 passing the US-C entry signal at danger and subsequently hitting the left-hand side of the passenger vehicle, a Peugeot 307, at a level crossing protected with a mechanical device with four half-barriers and located at km 0+819 of the Ptujška cesta junction–Maribor Studenci railway line and at km 0+893 of the Maribor–Prevalje international border railway line – occurred on 27 January 2010 at 20:45.

2.2 Description of the events and the accident site

On 27 January 2010 at 20:45, locomotive train no. 96366 travelling from Pragersko to Maribor Studenci passed at danger the US-C entry signal at Maribor Studenci station on the Ptujška cesta junction–Maribor Studenci railway line, and then at the NPr-Ljubljanska ulica level crossing at km 0+819 hit the passenger vehicle crossing the railway line.

Two single-track lines run into Maribor Studenci station: the railway line from Maribor to Prevalje international border and the Ptujška cesta junction–Maribor Studenci section in the shape of a curve. The Ptujška cesta junction branches off the double-track Zidani Most–Maribor railway line between Maribor Tezno and Maribor stations at km 592+142, and is located at km 0+000 or at the start of

the branch line running from Maribor Tezno to Prevalje international border. The lines from the directions of Maribor and the Ptujška cesta junction towards Maribor Studenci station run parallel from km 0+600 to the US-A entry signal at km 000+835 and the US-C entry signal at km 000+764. The parallel lines cross Ljubljanska ulica; the Ptujška cesta junction–Maribor Studenci line at km 0+819, and the Maribor–Prevalje international border line at km 0+893.

Locomotive train no. 96366 was travelling from Pragersko to Maribor Studenci. The train switched from the main Zidani Most–Šentilj international border railway line onto the regional Maribor–Prevalje line at the Ptujška cesta junction, and then travelled along the branch line towards Maribor Studenci station.

Locomotive train no. 96366 was travelling from Maribor Tezno station towards Maribor Studenci station.

The Ljubljanska ulica level crossing is equipped with mechanical double-leaf barriers and illuminated road signs. The barriers are lowered by two levers installed in the level crossing guard box. The box is located on the left-hand side of the line next to the right-hand pavement in Ljubljanska ulica viewed from the direction of Ulica Moše Pijada towards Ulica Pariške komune.

The Ljubljanska ulica level crossing at km 0+819 of the Ptujška cesta junction–Maribor Studenci railway line was not protected at the time of the accident; the barriers were not closed.

The driver of the passenger vehicle drove along the correct right-hand lane in Ljubljanska ulica from the direction of Ulica Moše Pijada towards Ulica Pariške komune. Because of the noise barrier on both sides of the railway line in the direction of the approaching locomotive train that stretches all the way from the road underpass at km 000+523 to the level crossing, the driver of the passenger vehicle was not able to see the oncoming locomotive train. The passenger vehicle entered the level crossing on the right-hand side of the locomotive train viewed from its travelling direction on the left-hand track running from the direction of Maribor towards Maribor Studenci.

After the collision, the locomotive pushed the passenger vehicle forward for 49 m before the vehicle came to a halt in the area between the two tracks on the right-hand side of the locomotive. The locomotive then came to a halt after 10.8 m.

The driver of the passenger vehicle sustained minor injuries and was taken by ambulance to Maribor University Medical Centre.



Figure 2: Rail and road vehicles involved in the accident immediately after the occurrence

2.3 The body that established the investigation

The investigation procedure was launched by the Railway Accident and Incident Investigation Division, Ministry of Transport of the Republic of Slovenia, and Slovenske železnice, d.o.o.

Pursuant to the Minor Offences Act, an investigation was performed by Maribor Traffic Police Station.

Their investigation procedures were conducted separately.

2.4 The decision to establish an investigation, the composition of the team of investigators and the conduct of the investigation

The Railway Accident and Incident Investigation Division, Ministry of Transport of the Republic of Slovenia, launched an investigation to determine all direct and indirect causes, with the purpose of collecting information important for improving safety at high risk locations.

The Chief Investigator of Railway Accidents and Incidents at the Ministry of Transport of the Republic of Slovenia conducted the investigation and brought it to a close himself.

Slovenske železnice, d.o.o., conducted its investigation through an investigation commission.

2.5 The background to the occurrence

The occurrence involved the 61-year-old driver of the passenger vehicle and the 31-year-old driver of locomotive train no. 96366.

There is a speed limit of 50 km/h in force for road users in Ljubljanska ulica.

The maximum permitted speed for rail vehicles on this section is 80 km/h.

Road users have no view of the railway line in the direction of Maribor due to a high noise barrier erected on both sides of the railway line. A view is not required since the level crossing is protected with half-barriers covering the entire width of the road.

The passenger vehicle was registered and insured with the Grawe insurance company, insurance policy no. 1228400.

The local road surface on both sides of the level crossing is made of coarse asphalt concrete. The driving surface was slightly damp at the time of the accident, which diminished the tyre grip of passenger vehicles.

Road traffic is heavy at this level crossing, especially during peak hours. There is an average of 35 trains in both directions per day on workdays.

2.5.1 Staff involved

The locomotive driver was a 31-year-old man employed by Slovenske železnice, d.o.o., Traction Business Unit (*Poslovna enota Vleka*), Maribor Traction Section (*Sekcija za vleko Maribor*).

He had a valid certificate for a locomotive driver of diesel traction vehicles issued on 18 April 2006.

The driver of the passenger vehicle was a 61-year-old female citizen of the Republic of Slovenia.

2.5.2 The trains and their composition, including the registration numbers of the items of rolling stock involved

Locomotive train no. 96366 was composed of diesel traction vehicle no. 94 72 2 643-032-5. Locomotive no. 94 72 2 643 032-5 weighs 67.2 tons, has 4 axles and is 14.74 m in length.

2.5.3 Description of the infrastructure and signalling system (track types, switches, interlocking, signals, train protection)

On the Maribor–Prevalje international border section between Maribor and Maribor Studenci station, and the Maribor Tezno–Maribor Studenci section via the Ptujška cesta junction, trains travel according to the principle of one at a time on the sections between stations. Between Maribor and Maribor Studenci station and between Maribor Tezno and Maribor Studenci station, permission must be arranged and obtained from the neighbouring station for every train from either direction. Notification and pre-notification must be sent for every train.

The Ljubljanska ulica level crossing is located on side “A” of Maribor Studenci station at km 000+893 of the Maribor–Prevalje international border railway line and at km 000+819 of the Ptujška

cesta junction–Maribor Studenci section. It is protected with mechanical double-leaf barriers and illuminated road signs. The barriers are lowered by two levers installed in the box of the level crossing guard. Barriers are lowered and raised by the guard of this level crossing from his Box VII on the right-hand side of the railway line in front of the level crossing.

Occupancy of the sections between Maribor and Maribor Studenci station and between the Ptujška cesta junction and Maribor Studenci station is established on the basis of track circuits. Whether the two sections are free or occupied is optically indicated on the control panel of the electrical relay safety device at Maribor station.

Whether the section between Maribor Tezno station and the Ptujška cesta junction is free, is established by devices for inter-station dependency using axle counters. Control of occupancy is exercised by Maribor Tezno and Maribor stations.

Along this section (Maribor Tezno–Ptujška cesta junction) trains travel in both directions. The regular track for trains from Maribor Tezno towards the Ptujška cesta junction is the left-hand track (line 101) and the right-hand track is in this case the neighbouring track. The regular track for trains from the Ptujška cesta junction towards Maribor Tezno station is the right-hand track (line 102) and the left-hand track is in this case the neighbouring track.

The PS-C pre-signal at Maribor Studenci station is not properly marked with signal 25 as prescribed: “Pre-signal marking” – a white inverted triangle at the top with black rims indicates a distance up to 5% shorter than the prescribed braking distance of 700 m.

2.5.4 Means of communication

The traffic controller of Maribor Studenci station is connected via a telecommunications desk of the traffic telecommunications system (PTS-TK) to the following circuits:

- ŽAT 25555 (railway automatic telephony) with the possibility of accessing the Telekom public phone network;
- dispatcher circuit for Maribor–Prevalje (269);
- Maribor–Prevalje circuit (263) for direct connection between station traffic controllers along this section;
- guards' circuit for Maribor Studenci–Ruše, Maribor Studenci–Maribor, Maribor Studenci–Maribor Tezno;
- direct circuit for traffic controller–switchman of Maribor Traction Section (*Sekcija za vleko Maribor*);
- direct circuit for traffic controller–switchman I and switchman III;
- direct circuit for traffic controller–switchman I;

- direct circuit for traffic controller–switchman III.

In addition to the aforementioned, a switching telephone with the following circuits is installed on the wall of the traffic controller's office:

- guards' circuit, Maribor Studenci–Maribor Tezno;
- guards' circuit, Maribor Studenci–Maribor;
- guards' circuit, Maribor Studenci–Ruše;
- Maribor–Prevalje circuit (263) for direct connection between station traffic controllers along this section;
- switchmen's circuit with connections to the traffic controller and the two signal boxes;
- circuit with connections to the traffic controller and switchman of Maribor Traction Section (*Sekcija za vleko Maribor*).

Signal box I is connected via a telephone desk to the following circuits:

- ŽAT 25 557 (railway automatic telephony);
- direct circuit switchman I–switchman of Maribor Traction Section (*Sekcija za vleko Maribor*);
- direct circuit switchman I–guard of the level crossing (Box VII);
- direct circuit switchman I–switchman III; and
- direct circuit switchman I–traffic controller of Maribor Studenci station.

The box at the Ljubljanska ulica level crossing (Box VII) is connected via an induction telephone with switches to the following circuits:

- guards' circuit for Maribor–Maribor Studenci;
- guards' circuit for Maribor Tezno–Maribor Studenci;
- direct circuit for level crossing guard–switchman I.

Diesel locomotive 643-032 (no. 94 72 2 643 032-5) of locomotive train no. 96366 has a built-in radio transceiver with an optional local connection for movement operations.

2.5.5 Building works at the scene of the accident or in the vicinity

At the time of the accident, no building works on road or railway infrastructure were in progress along the section of the railway line where the accident occurred.

2.5.6 Trigger of the railway emergency plan and its chain of events

The level crossing guard at Box VII notified the traffic controller of Maribor Studenci station that train no. 96366 passed the main signal at danger and collided with a passenger vehicle.

The driver of locomotive train no. 96366 notified his superiors of the accident and gave first aid to the injured driver of the passenger vehicle at the scene of the accident.

2.5.7 Trigger of the emergency plan of the public rescue services, police and medical services and its chain of events

Following the notifications by the driver of locomotive train no. 96366 and the guard of the level crossing at Box VII, the traffic controller of Maribor Studenci station informed the notification centre.

The officer on duty at the regional notification centre dispatched staff from Maribor Traffic Police Station to the scene of the accident. The passenger vehicle that had come to a halt between the two station tracks of the railway line after the collision was removed by a towing service.

2.6 Fatalities, injuries and material damage

The driver of the passenger vehicle, a 61-year old female citizen of the Republic of Slovenia, sustained minor injuries in the accident and was taken to Maribor University Medical Centre.

Only the right-hand step of diesel locomotive 643-032 was damaged in the accident. According to a non-expert assessment, damage amounts to EUR 200.

The passenger vehicle was extensively damaged in the accident. According to a non-expert assessment, material damage to the road vehicle amounts to EUR 3,000.

2.7 External circumstances

Weather conditions at the time of the accident: clear, -12°C, visibility – night, high humidity – exceeding 90%, up to 5 cm of snow.

The asphalt concrete surface of the local road was sprinkled with salt and, owing to high humidity, the tyre grip was poor.

3 RECORD OF INVESTIGATIONS AND INQUIRIES

On 29 January 2010, the Chief Investigator of Railway Accidents and Incidents of the Ministry of Transport participated as a member of the Commission in the testing of the braking system elements of diesel locomotive 643-032, which was involved in the accident.

On 2 February 2010, an Incident Registration Form No. 01/2010 dated 28 January 2010 was received from Slovenske železnice, d.o.o., Maribor Traffic Management Section (*Sekcija za vodenje prometa Maribor*), Maribor Tezno Supervisory Station (*Nadzorna postaja Maribor Tezno*).

On 4 February 2010, the Chief Investigator of Railway Accidents and Incidents of the Ministry of Transport inspected the scene of the accident.

On 17 February 2010, the following investigation material, no. 1.0.4./26-7/10 dated 15 February 2010, was received from Slovenske železnice, d.o.o., Internal Control Service (*Služba za notranji nadzor*):

- copy of the traffic log book of Maribor Studenci station (P-4);
- original tachometer reading of locomotive 643-032;
- Incident Report of the traffic controller of Maribor Studenci station (P-7);
- copy of the record of working hours of the locomotive driver of train no. 96366 of 27 January 2010 and the day before the accident (EV-31);
- copies of EV-1 and EV-50/3 of the locomotive driver involved in the accident of 27 January 2010;
- copy of EV-41 for 2010;
- copy of EV-6 of locomotive 643-032;
- accompanying documents for train no. 96366 (P-13) of 27 January 2010;
- copy of the timetable for train no. 58358 of 27 January 2010;
- copy of the Commission's protocol of the technical status of D-loc 643-032 of 2 February 2010 with enclosures;
- copy of the protocol of inspection and testing of pressure gauges of 5 February 2010;
- copies of three protocols of interviews with the staff involved in the accident and witnesses;
- review of periodical examinations passed by the locomotive driver of the train involved in the accident;
- medical report of the locomotive driver of the train involved in the accident dated 8 October 2009;
- Incident Report no. 095/10 of 28 January 2010 (EV-49).

On 24 February 2010, a summary report on the traffic accident, no. 2240-436/2010/3, was received from Maribor Traffic Police Station.

On 26 February 2010, the Commission's report on the investigation of incident no. 01/2010 was received from Slovenske železnice, d.o.o., Maribor Traffic Management Section (*Sekcija za vodenje prometa Maribor*).

On 22 April 2010, the Chief Investigator of Railway Accidents and Incidents of the Ministry of Transport again inspected the scene of the accident and the safety device at the level crossing.

On 3 June 2010, the Chief Investigator of Railway Accidents and Incidents of the Ministry of Transport, as a member of the commission, participated in the analysis of the travelling records of train no. 96366 that was involved in the accident.

3.1 Summary of testimonies

The driver of locomotive train no. 96366 did not specify anything of significant relevance in the Daily Report on Incidents No. 095/10 of 28 January 2010 that would explain the direct and any potential indirect causes of the accident. He only noted that the train hit a passenger vehicle at the Ljubljanska ulica level crossing.

In the protocol of the interview with a worker who is a party to proceedings/witness, the following statement of the driver of locomotive train no. 96366 involved in the accident is noted:

"The pre-signal of Maribor Studenci station displayed the signal: "Expect stop." On approaching the entry signal displaying the signal: "Stop", I applied the direct brake of the locomotive in time. There was no effect, so I immediately applied the indirect brake. I simultaneously started to sound the signal for caution, since this brake also did not seem to produce any effect. My left foot was constantly pressed against the siren button while I was turning the wheel of the hand brake with my right hand as far as it went. Then the front right-hand side of the locomotive hit the passenger vehicle. The vehicle was wedged under the locomotive and I pushed it forward along the line until it came to a halt.

I personally took over the locomotive at Pragersko station from a locomotive driver who had previously conducted a movement operation with it. There was nothing special in the running of train no. 96366 from Pragersko towards Maribor Studenci station until the failure of the brake."

In the protocol of the interview with a worker who is a party to proceedings/witness, the following statement of the locomotive driver who at Pragersko station handed over the diesel locomotive to the driver of locomotive train no. 96366, which was involved in the accident, is noted:

“At Ptuj station during the movement operation at around 09:30, I noticed a malfunction, i.e. the brake on the second bogie was occasionally ineffective. This was evident from the pressure gauge of the brake cylinders. The white indicator of the pressure gauge on control panel 2 was occasionally stuck. When I again released and applied the direct brake, the malfunction did not occur again.

I noticed the malfunction for the second time during the movement at Pragersko station but fixed it with the same procedure as in the first case. In both cases the braking performance of the locomotive was not significantly diminished.

I informed the supervisor of diesel traction of the malfunction in the braking system. I did not take the locomotive out of service, since this was not a failure of the brake but only a fault in the indication.

I did not notice anything irregular on the ammeter; I did not have any problems with switching off traction.”

In the protocol of the interview with a worker who is a party to proceedings/witness, the following statement of the level crossing guard, who at the time of the accident was responsible for the protection of the level crossing with manually operated barriers, is noted:

“There was nothing special, train 4006 travelled as scheduled along the Maribor–Maribor Studenci railway line. While train 4006 was travelling towards Maribor Studenci station, the traffic controller of Maribor Tezno station sent a pre-notification for train no. 96366 to the traffic controller of Maribor Studenci station who simultaneously informed me of train no. 96366, because I was on the phone at the time, so I confirmed receipt of notification by exchanging control numbers. While I was entering the information in the notebook I heard signals sounded by train no. 96366. I went to the door to check what was happening and I saw that the train had not stopped at the entry signal and that it was proceeding towards the level crossing. With my hand I signalled to the train to stop, but the train did not stop, so I quickly jumped to the barrier levers with the intention of lowering the barriers, but in the meantime the train had already proceeded over the level crossing where it hit the passenger vehicle. At that moment I received a call from the switchman at signal box I, who ordered me to protect the traffic at the level crossing, and I replied that the engine had just passed at danger the entry signal and the open barriers.”

In the Incident Report (P-7), the traffic controller of Maribor Studenci station noted:

“Maribor Tezno station offered me train no. 96366 scheduled to depart from the station at 20:41. I indicated the route of train no. 96366 after train no. 4006 was dispatched at 20:42, then at 21:46 I

received a call from the level crossing guard that the train passed at danger the US-C entry signal and the level crossing at km 0+819 (Ljubljanska ulica) where it hit a passenger vehicle, MB J7 94R, pushing it forward for about 25 m. The driver of the passenger vehicle was not injured. I was informed at 21:15 that both tracks were occupied and blocked – unscheduled closure of both tracks – lines.”

3.2 The safety management system

At the Ljubljanska cesta level crossing at Maribor Studenci station, road users crossing the railway line are protected against rail vehicles with a mechanical device for the protection of the level crossing. The device is operated from a work station located in the box on the left-hand side of the railway line next to the level crossing. The guard of the level crossing receives via a telephone connection an order to protect the level crossing from the switchman at signal box I, who in turn receives via a telephone connection an order to set up and protect the route from the traffic controller of Maribor Studenci station. In line with the Rules on Road Signs and Equipment on Public Roads, for road users the level crossing is marked with the following road signs: no. I-39 “Warning of level crossing ahead – crossing of a road with a railway line with barriers or half-barriers” which marks the distance to the level crossing protected with barriers or half-barriers; and no. I-36 “Crossing of a road with a railway line with barriers or half-barriers”, which marks the proximity of the level crossing of a road with a railway line protected with barriers or half-barriers.

The road signs are clear and visible from a sufficient distance. Nothing blocks the view of these road signs.

At the time of the accident, the device was in perfect working order, but the level crossing guard did not lower the half-barriers because he had not received an order from the switchman at signal box I to protect the level crossing. At the level crossing, road users were protected with the US-C entry signal of Maribor Studenci station displaying signal 1: “Stop”.

Ljubljanska ulica crosses the railway line at this level crossing at an angle of 90 degrees.

For road users approaching the level crossing in the direction of the University Medical Centre, the view of the railway line in the direction of Maribor station is obstructed by the level crossing guard box and the concrete noise barrier.



Figure 2: Road users' visibility or view of the railway line

3.3 Rules and regulations

Safety at protected level crossings of roads with railway lines is governed by Article 51 of the Safety of Railway Transport Act (official consolidated text) (ZVZeIP-UPB1), *Uradni list RS* [Official Gazette of the Republic of Slovenia], No. 36/2010 of 4 May 2010, and Article 50 of the Safety of Road Transport Act, *Uradni list RS*, No. 56/2008 of 6 June 2008.

Crossings of roads and railways at level crossings are regulated in more detail in the Rules on Railway Level Crossings published in *Uradni list RS* [Official Gazette of the Republic of Slovenia], No. 85/2008, on 29 August 2008.

3.4 Operation of rolling stock, technical facilities and technical installations

On 27 January 2010, train no. 96366 involved in the accident was travelling from Pragersko station to Maribor Studenci station. According to EV-6, the locomotive driver of train no. 96366 noted on 27 January 2010 at 20:30, on the basis of a partial braking system test, that the brake was in perfect working order, and verified this with his signature.

The device protecting the Ljubljanska ulica level crossing at Maribor Studenci station was in perfect working order at the time of the accident. Half-barriers were not lowered horizontally across the road because the guard of the level crossing, who manually operates the barriers from Box VII, did not receive an order to protect the level crossing from the switchman at signal box I.

3.5 Documentation on the operating system

The Ljubljanska ulica level crossing at Maribor Studenci station on the Maribor–Prevalje railway line is equipped with a Waldner protection device – half-barriers are raised and lowered from Box VII, in the signal box and on the individual half-barriers, with a chain mechanism connected with metal wires (4 mm in diameter).

There are no instructions for this particular device. The elements of this device and its operation are not described.

3.6 Man-machine-organisation interface

At the Ljubljanska ulica level crossing at Maribor Studenci station, no special safety devices are installed to assist drivers of locomotives and passenger vehicles in reducing their speed and stopping. Locomotive drivers and drivers of road vehicles operate their vehicles by pressing or releasing the accelerator and applying braking devices.

Rail vehicles are fitted with pneumatic braking systems that become effective after 3.5–4 seconds.

The driver of locomotive train no. 96366, who was involved in the railway accident at the Ljubljanska ulica level crossing at Maribor Studenci station on 27 January 2010 at 20:45, had passed all the required qualifying examinations, and was physically and mentally fit for driving, had taken the statutory rest break between the last two working shifts and had not exceeded the prescribed working hours in the shift. He passed the examination for a driver of a series 643 diesel locomotive on 18 April 2006.

The driver of the passenger vehicle who sustained minor injuries in the accident was a holder of a statutory driving licence for category B, in line with the regulations for the operation of the passenger vehicle involved in the accident.

3.7 Previous occurrences of a similar character

A similar accident has not occurred at this level crossing in the past 10 years.

4 ANALYSIS AND CONCLUSIONS

On 29 January 2010, the elements of the braking system of a series 643-032 locomotive that was involved in the accident were tested at Ljubljana Moste central workshop for the maintenance of locomotives. A commission composed of three experts from the central workshop, one from Slovenske železnice, and the Chief Investigator of Railway Accidents and Incidents tested the following elements of the braking system:

- two indirect braking devices, Öerlikon FV4a, nos.: 1338 and 0962;
- Öerlikon LST1 distributor no.: 0326;
- Öerlikon D1 relay valve;
- the valve between the indirect and direct brakes;
- directional switch valve for automatic applying and releasing of brakes.

The examination of the Öerlikon LST1 distributor no. 0326 that underwent an inspection on 12 February 2002 has shown that the ring seal was torn. The distributor was casted because it had been previously disassembled in an investigation by Slovenske železnice on 28 January 2010 at *Proizvodnja Maribor*, therefore it is possible that the seal was torn when the distributor was disassembled or assembled.

On the basis of the analysis of the train's travelling dynamics between Ptujška cesta and the point where it came to a complete halt after the collision, it cannot be claimed that the effect of the brakes was too weak. According to the tachometer reading of the locomotive involved in the accident, the speed of the locomotive train was 40 km/h at the pre-entry signal of Maribor Studenci station at km 0+098 and 28 km/h at the US-C entry signal at km 0+764. We cannot establish where the locomotive driver activated the brakes, because the relevant data is not recorded. The locomotive train covered a distance of 124.8 m from the US-C entry signal to the point where it came to a halt.

In 2010, Slovenske železnice recorded 103 trains that passed at danger the main signal (signal indicating “Stop”), of which 11 endangered the safety of railway transport. There were 32 collisions of trains with road vehicles at level crossings, in which 10 road users sustained fatal injuries. All the other accidents at level crossings in 2010, except this one, were caused by road users.



Figure 3: The ring seal of Öerlikon LST1 distributor no. 0326 was torn.

4.1 Final account of the event chain

The direct cause of this accident – locomotive train no. 96366 passed at danger the US-C entry signal at Maribor Studenci station and subsequently collided with a passenger vehicle at the level crossing – was the failure in the air brake of the locomotive train. The failure in the air brake can be deduced from the fact that the locomotive driver, immediately before passing at danger the US-C entry signal at Maribor Studenci station, continuously sounded horn signal 63: “Caution” (one long sound). In this way the locomotive driver wanted to warn all persons potentially at risk that the train would not be able to stop ahead of the level crossing.

Considering the fact that approximately 4 s are needed for the braking system to take effect, the locomotive would cover a distance of 31 m from the US-C entry signal to the point where the braking system would take effect. The distance between the US-C entry signal and the edge of the road at the level crossing is 64 m, which means that the locomotive train had only 33 m to stop. When the locomotive driver activates the braking system at the US-C entry signal, however, this distance may not be sufficient given the fact that low temperatures have an impact on the response of the braking systems of rail vehicles.

4.2 Discussion

Discussions about the cause and the consequences of the accident

were held by various expert groups. The travelling dynamics of the locomotive train immediately prior to the accident between the pre-entry signal and the entry signal at Maribor Studenci station were discussed. Potential causes of the accident were also discussed.

The impact of the torn ring seal of Öerlikon LST1 distributor no. 0326 on braking performance was examined.

The impact of the locomotive driver's knowledge of the conditions along the railway line was discussed.

Any potential impact of the use of a mobile phone by the locomotive driver immediately prior to the accident on his concentration was discussed.

4.3 Conclusions

The investigation results revealed a number of deficiencies which might have had a direct impact on the cause of the train passing the US-C entry signal at danger and its subsequent collision with the passenger vehicle at the Ljubljanska ulica level crossing at km 0+819 on the Ptujška cesta junction–Maribor Studenci section.

Since the section of the railway line from the Ptujška cesta junction to Maribor Studenci is not included in the Record (EV-41) of track information for 2010 of the locomotive drivers of Maribor Traction Section (*Sekcija za vleko Maribor*), we cannot establish whether the locomotive driver of the train involved in the accident had any knowledge of the conditions along this section.

With respect to the previously detected malfunction in the locomotive's braking system – when the previous locomotive driver during the movement operation at Ptuj station on that day at around 09:30 noticed that the brake on the second bogie occasionally did not take effect – despite the fact that he was convinced that the brake was working, the previous locomotive driver should have taken the locomotive out of operation and requested a thorough inspection and repair, in particular owing to the fact that the brakes are the most important devices in terms of safety.

With respect to the impact of the torn ring seal of Öerlikon LST1 distributor no. 0326, in repeated tests the Commission did not establish that the failure had an impact on braking performance. However, a potential impact could not have been completely ruled out, since this failure could result in a deficiency in the braking system causing insufficient braking effect.

The ring seal of Öerlikon LST1 distributor no. 0326 was labelled with category no. 702006-3, which means that the seal originates from 2006 and the distributor underwent an inspection on 12 February 2002. There was no entry in the records that the ring seal of the distributor had ever been replaced.

4.4 Additional observations

Weather data from the nearest measuring post at Edvard Rusjan Airport for Wednesday, 27 January 2010 at 22:00: visibility: 10 km; barometric pressure: 1,022 mbar and falling; dew point temperature: -15 °C; air humidity: 92%.

In view of the very low temperature (-12°C) which at the time of the occurrence was measured by the traffic controller of Maribor Studenci, and high humidity measured at **Edvard Rusjan Airport**, it is likely that the friction coefficient between the tracks and the tread profiles, and between the tread profiles and the brake blocks was significantly reduced, which can have an impact on the braking performance.

4.5 Measures that have been taken

There is no record of any special measures having been taken previously or taken as a result of the accident – the train passed at danger the US-C entry-signal at Maribor Studenci station and collided with the passenger vehicle – at this level crossing.

4.6 Recommendations

1. In the case of regular or extraordinary maintenance of traction vehicles, especially the maintenance of their vital components (i.e. braking systems, tread profiles and safety devices), traceability must be provided on the basis of detailed internal regulations for individual types of vehicles.
2. Maribor Traction Section (*Sekcija za vleko Maribor*) must amend the EV-41 record of track information with section 30-34, the curve between Tezno–Maribor Studenci, a regional railway line without an AS device at the US-C entry signal.
3. The PS-C pre-signal Maribor Studenci must be marked with signal 25 as prescribed: “Pre-signal marking” located at a distance that is up to 5% shorter than the braking distance.
4. Instructions, including a detailed description of the device and how to operate it, should be drawn up for devices (chain spindles) used by guards at level crossings protected with half-barriers or barriers, for the lowering or raising of these barriers manually.

5 BIBLIOGRAPHY

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