



REPUBLIC OF SERBIA
CENTER FOR INVESTIGATION OF ACCIDENTS IN TRANSPORT
SECTOR FOR INVESTIGATION OF ACCIDENTS IN RAILWAY TRAFFIC
AND INTERNATIONAL COOPERATION
Nemanjina 11, 11000 Belgrade

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Date: 14.08.2018.

FINAL REPORT ON ACCIDENT INVESTIGATION

Type of accident:	Derailment of train
Train No.:	56990
Place:	Despotovac, open track between stations Svilajnac and Despotovac
Date:	11 November 2017
Time:	15:25



This report presents the results of investigation of accident, derailment of the train No.56990, which occurred 3 November 2017 at 15:25 on the local track Markovac - Resavica, between the stations Svilajnac and Despotovac.

Director of the Center for Investigation of Accidents in Transport of the Republic of Serbia established the Working Group for the investigation of this accident by the Decision 33 No. 340-00-10982/2017-1 of 9 November 2017.

In accordance with the Article 33 of the Law on Investigation of Air, Rail and Water Traffic Accidents ("*Official Gazette of the RS*" No.66/15) and the Article 23 of the Directive 2004/49/EC of the European Parliament and of the Council of EU (Directive on Railway Safety), Center for Investigation of Accidents in Transport drafted and published this Final Report.

In this report, all sizes and measurements are expressed in accordance with the International System of Units (*SI*).

The meaning of abbreviations used in the text is explained in the Glossary.



CINS has been established in accordance with the Law on Investigation of Air, Rail and Water Traffic Accidents (*“Official Gazette of the RS” No. 66/15*). The founder is the Republic of Serbia and the holder of founding rights is the Government of the Republic of Serbia.

Department for investigations of railway traffic accidents and international cooperation carries out tasks within the competence of the Centre for investigation of accidents in traffic in relation to rail traffic with the aim of possible improvement of safety on the railways by issuing safety recommendations. The investigation procedure in the field of railway traffic is conducted on the basis of the provisions of the Law on Investigation of Air, Rail and Water Traffic Accidents (*“Official Gazette of the RS” No. 66/15*).

CINS conducts investigations after serious accidents on the railway system with a view to possible improvement of railway safety and the prevention of new accidents caused by the same or similar causes. Serious accident in railway traffic means any train collision or derailment of trains, resulting in the death of at least one person or serious injuries to five or more persons or extensive damage to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety.

In addition to serious accidents, CINS may also investigate other accidents and incidents that could lead to a serious accident, including the technical failure of structural subsystems or interoperability constituents.

CINS has the discretion to decide whether to open an investigation of other accidents and incidents.

CINS is independent in its work and performs independent accident investigations. The aim of an investigation is to identify the causes and the possibility of improving safety on the railways and to prevent accidents by issuing safety recommendations.

Professional activities related to safety investigations are independent of judicial inquiry or any other parallel investigations which objective is to determine responsibility or the degree of guilt.



Glossary:

CINS	.....	Center for Investigation of Accidents in Transport
IŽS	.....	Serbian Railways Infrastructure
ZJŽ	.....	Community of Yugoslav Railways
JŽ	.....	Yugoslav Railways
RS	.....	Republic of Serbia
a.d.	Joint Stock Company
OJ	Organizational Unit
OC	Organizational Entity



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1. Summary

1.1. Short description of the accident

On 03 November 2017 at 15:25 at *km* 33+150 of the local track Markovac - Resavica, between the station Svilajnac and Despotovac, there have been a derailment and decoupling of the train No. 56990. From the train composition, viewed from the driving locomotive, derailed twenty first wagon of series Eas No. 80 72 5952 334-6 with both bogies (four axles). Derailed wagon was loaded with brown coal (Senja - Resavian fine coal). After the derailment, the last derailed wagon stopped at *km* 33+085. Decoupling occurred between the sixth wagon No.80725952245-4 and seventh wagon No.80725958891-9 on the sixth wagon of series Eas No.80725952245-4 the coupling device was torn).

1.2. The causes of the accident determined by the investigation

Direct cause of the accident is the unsatisfactory state of the railway on the section where the accident occurred. The direct cause is the missing and loose fastening system and rotting and cracked series of sleepers, combined with the twist of the track in the zone of derailment of 23 mm, which is over the allowed maximum of exploitation, that is 18 mm.

The main cause of the accident is that the maintenance of the railway on the observed section is below technically acceptable minimum.

Instruction on common criteria for control of the condition of railways on the network JŽ, Instruction 339 (*“Official Gazette ZJŽ” No.2/ 2001 and 4/2004*), was introduced in the case of "unsatisfactory" condition of track (errors in the geometry of the track above the limits of exploitation "C") as an alternative measure of "speed reduction", which in previous editions of the Instructions (from 1989) did not exist. A passage from the previous issue of Instruction 339 of 1989 was deleted, which stipulated that before reaching the limits exploitation to take certain measures to prevent their overdraft. Applicable Rulebook on technical conditions and maintenance of the superstructure of the track No. 340-201-2/2016 (*“Official Gazette RS” No.39/26 and 74/16*) as well as the Instruction 339, does not define explicitly and clearly the exploitation boundaries for the condition of the sleepers and fastening systems in which, due to security risks, certain corrective measures must be taken or to close the track for traffic.

1.3. Main recommendations and information on subjects to which the report is submitted

Aiming to achieve the possible improvement of railway safety and to prevent occurrence of new accidents, CINS issued the following safety recommendations:

To the Railway Directorate:

SR_23/18 Railway Directorate that as soon as possible defines in the current Rulebook on the technical requirements and maintenance of the superstructure of railway



tracks ("Official Gazette" No. 39/2016 and 74/2016) limits conditions and elements of the upper substructure which requires the immediate removal of or closure of railway for traffic by eliminating unauthorized condition.

(Note: An identical recommendation has already been given in the Report ŽS- 02/17, 33 No. 340-8059/2017-16 from 05 January 2018.)

„IŽS“ a.d.:

SR_24/18 „IŽS“ a.d. to make amendments to the Instruction on common criteria for control of the condition of railway track on the network JŽ, Instruction 339 (*“Official Gazette ZJŽ” No.2/ 2001 and 4/2004*), which with the decision of the "IŽS" a.d. No.4/2015-51-17 from 29 December 2015 is still applicable in "IŽS" a.d., in accordance with the provisions of Instruction 339 of 1989 which are listed in paragraph 3.3.4. For future track examination coaches parameters in accordance with standards: EN 13848-1, EN 13848-2, EN 13848-6 are recommended.

(Note: An identical recommendation has already been given in the report ŽS - 02/17, 33 No.: 340-8059/2017-16 from 05 January 2018.)

SR_25/18 „IŽS“ a.d. that, given the extremely poor condition of the track, makes an assessment of risk of train traffic on the local railway track Markovac - Resavica and take measures to reduce risks to an acceptable level. Based on this, to make a technical assessment of the minimum required resources (materials, machinery, labor) for track maintenance.

Ministry of construction, traffic and infrastructure:

SR_26/18 Ministry of construction, traffic and infrastructure, Section for Inspection, Group for Railway Inspection, to carry out an extraordinary check of the condition of railway infrastructure on the local railway track Markovac - Resavica and to take measures within its jurisdiction.

2. Direct facts about the accident

2.1. Basic accident data

2.1.1. Date,time and place of the accident

The accident occurred on 03 November 2017 at 15:25 in the territory of municipality Despotovac, near the settlement Vitance, on the local railway track Markovac - Resavica between the station Svilajnac and Despotovac, on the open section near the point of level crossing with the local road Despotovac - Vitance - Balajnac. The area where the accident occurred is not populated.

The review of the accident site is given in Fig 2.1.1.1.

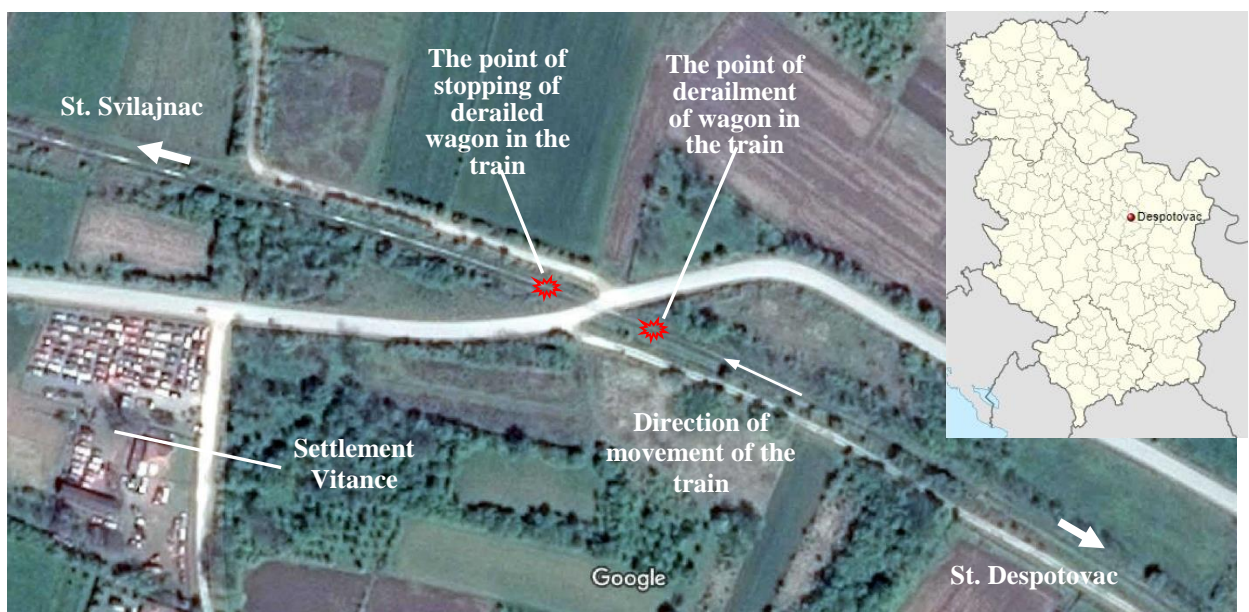


Fig. 2.1.1.1: The area of the accident (source: Google maps)

2.1.2. Description of the accident and the accident site and work of rescue and emergency services

At the local railway line Markovac - Resavica, between the stations Svilajnac and Despotovac, driving in the direction from the station Despotovac to the station Svilajnac, on the open track, near the level crossing (located at *km* 33+102), at *km* 33+150 there have been the derailment and decoupling of the train No.56990.

From the composition of the train, as viewed from the driving locomotive, the last wagon derailed (twenty first wagon of series *Eas* No. 80 72 5952 334-6) with both of the bogies (four axles).

Derailed wagon was found in the area of track on its wheels. There was no tilting or overturning of the wagon and there was no movement or dissipation of the load.

Decoupling occurred between the sixth wagon of series *Eas* No.80 72 5952 245-4 and seventh wagon of the series *Eas* No. 80 72 595 8891-9. On the sixth wagon of series *Eas*



No. 80725952245-4 the coupling device was torn. All wagons of Eas series that were part of the train No.56990 were loaded with brown coal (Senja-resavian fine coal).

For the rehabilitation of the consequences of the accident there was no need to involve the police, rescue and other emergency services because in this accident there were no killed nor injured persons, there has been no spillage of cargo and in the train were no substances hazardous to human health and harmful for the environment. Remediation of the consequences caused in this accident was carried out by engaging professional services and resources "IŽS" a.d. and "Serbia Kargo" a.d.

Due to this accident, there was an interruption of rail traffic between the stations Svilajnac and Despotovac. With the closure lasting until 11 April 2017. at 17:00 when the railway opened for traffic of trains for restricted speed running with 10 km/h from km 33+100 to km33+400.

2.1.3. Decision to launch the investigation, composition of the investigation team and conducting of the investigation

The first notice of an accident has been received by chief investigator for rail traffic on 3 November 2017 at 15:54 by telephone by the Assistant Director of Operations "IŽS" a.d. Based on the received first information and due to the facts that the investigation team determined by additional on site investigation, CINS has launched an investigation of the accident concerned pursuant to the Law on the investigation of accidents in air, railway and water transport (*"Official Gazette" No. 66/15*).

Composition of the Working Group for research of respective accident is determined by the Decision 33 No. 340-00-10982/2017-1 of 9 November 2017. The Director of CINS, according to the Articles 6 and 32 of the Law on investigation of accidents in air, rail and water transport (*"Official Gazette" No. 66/15*).

2.2. Accident background

2.2.1. Involved railway staff, contractors, other persons and witnesses

Train driver and assistant train driver of locomotive 661-158 were involved in the accident, employed by the rail undertaking "Kargo Srbija" a.d., Section for traction Belgrade, OJ for traction Belgrade and conductor which was accompanied by the train No.56990, employed by the rail undertaking "Kargo Srbija" a.d., Section for transport of goods Lapovo, Station Lapovo.

At the time of occurrence of the respective accident, in the locomotive 661-158 there was, among the abovementioned persons, a shunter, employed at infrastructure manager "IŽS" a.d.

Other staff was not involved in the respective accident, as well as contractors, other persons and witnesses.

2.2.2. Trains involved in the accident and their composition

In the respective accident the train No. 6990 was involved. The train composition consisted of driving locomotive of series 661-158, property of "Srbija Kargo" a.d. and 21 wagons of series Eas loaded with brown coal.



Fig. 2.2.2.1: The view of the wagon series Eas No.80 72 5952 334-6

Wagon of series Eas is standard four-axle wagon with high sides intended for the traffic on the tracks of standard gauge (1435 mm). They fully comply with the provisions for standardized open wagon Type 1 in the UIC 571-2. They are used for transport of goods in bulk of all granular quality and in pieces, and especially for those goods which does not need to be protected from weather conditions during transport. Loading is carried out from above or through the side door and the front side, and unloading through the side door and front sides or above. Load can be protected with blankets binded in loops, with which the most wagons are provided.

Technical data (some characteristics):

Overall length via buffer	14040 mm
Distance between staff bogies	9000 mm
Payload area	35,2 m ²
Payload volume	72 m ³
The wagon mass	22 t
Axle load	20 t
Load mass	58 t
The number of axles	4
Bogies (type)	Y25Cst
Maximum speed	100 km/h

2.2.3. Infrastructure and safety signaling system

Local railway track: Markovac - Resavica is onetrack, unelectrified It was built and put into traffic according to the following: 1951. section between station Markovac and station Despotovac and 1967. section from station Despotovac to station Resavica. Overall length of open track with main passing track is 53.250 km.

The maximum slope of the track is 16.3‰ and is located between the stations Dvorište and Resavica.

The railway was built from second-hand materials. Rails of various types have been built, from standard 49a and 45 to non-standard 35a, Xa and 8a with the convenient non-standard track accessories. In non-standard rail appears connection of rails to sleepers using the rolling pin.



Wooden sleepers are installed at a distance of 0.75 m. Distance of sleepers corresponds to the axle load of 16 t only if standard type rail is installed, which on this line is not the case.

On the section between station Markovac to km 19+600, ballast is made of broken stone, while the rest of the railway ballast is made of slag.

The track is designed for speeds:

- from km 0+000 to km 19+600, $V=55$ km/h,
- from km 19+600 to km 35+300, $V=40$ km/h,
- from km 35+300 to km 53+750, $V=55$ km/h.

On this track, the maximum permissible loads are: on the part of the section between stations Markovac and Svilajnac 18 t/axle and 6.4 t/m (180 kN/axle, and 64 kN/m; category B2) and on the section between stations Svilajnac and Resavica: 16 t/axle and 5 t/m (160 kN/axle, and 50 kN/m; category A).

Maximum speed, according to the Booklet of the timetable 9.5 (which was valid at the time of occurrence of the respective accident), on the section between stations Resava and Despotovac is 20 km/h.

Traffic on the abovementioned section is regulated in station distance, seeking permission for train traffic, notifying of the departure of the train and checking out (verbally, via phonograms).

2.2.4. Communication tools

Communication between personnel in charge of traffic regulation on the section between stations Svilajnac and Despotovac is performed by phone via fixed telephone line provided by telephony operator. Communication on this line is not recorded on the register device so the communication is performed with the presence of witness. This type of communication is considered as evidence-based communication.

2.2.5. Works at or near the accident site

There were no works performed near the accident site.

2.2.6. Activation of the emergency plan for railways and the sequence of events

All the interested parties were informed on this accident according to regulation. Infrastructure Manager "IŽS" a.d informed CINS, i.e., the Main investigator for railway traffic. The Railway Infrastructure Manager "IŽS" a.d and railway undertaking "Srbija Voz" a.d, established a joint investigation committee that conducted an investigation of the accident in accordance with applicable regulations. Upon completion of the investigation, the Investigation Report U-525/17 was drafted.

Lifting of derailed wagon and its removal from the accident site was carried out by engaging breakdown train (urgent) in the ownership of "IŽS" a.d., Section TKP Kraljevo.

In order to ensure the conditions for work on lifting derailed wagon and the repair of damage to the track, taking into account the damage to the wagon caused by a train decoupling, removing the part of the train (twenty wagon of series Eas) that did not derail was carried out according to



the following: the first part of a train of six wagons was dispatched to the station Svilajnac at 18:15, and the second part of fourteen wagon at 22:30. On the site remained only twenty-first, derailed wagon.

Breakdown train (urgent) from the station Svilajnac was dispatched as pushed shunting composition and on the site has arrived on 04.11.2017. at 07:15. After completing of lifting of the derailed wagon, breakdown train (urgent) returned to the station Svilajnac at 14:28.

Works on rehabilitation of tracks were made on 4 November 2017. in the period from 07:00 to 17:00, after which the railway was opened for traffic.

2.2.7. Activation of the emergency plans of public rescue services, police and medical services and sequence of events

In this accident there was no need for activation of the emergency plan of public rescue services, police and medical services.

2.3. Dead, injured and material damage

2.3.1. Passengers, third parties and railway staff, including contractors

In this accident there were no injured or dead persons.

2.3.2. Goods, luggage and other assets

In this accident there were no damages on goods and other assets.

2.3.3. Railway cars, infrastructure and environment

In the respective accident the railway vehicle and infrastructure is damaged. On the third parties' property there was no material damage.

Apart from the derailed wagon and wagon at the point of decoupling, the damages were stated and on the wagon next to the derailed in the form of damage to the traction-buffering devices.

The structure of the material damage is given as follows:

Damage on the railway vehicles (wagons in train composition):	70 320,00 RSD
Total costs of lifting the derailed wagon (with the engagement of traction vehicles of „Srbija Kargo“a.d.):	749 607,96 RSD
Damage to the track and railway facilities:	478 296,00 RSD
Total direct material damage:	1 298 223,96 RSD

The damage is stated in the official currency of the Republic of Serbia (Dinar - RSD).



According to the official middle exchange rate of the National Bank of Serbia on 03 November 2017, which is 1 EUR (Euro) = 118,8253 RSD (Dinars), the total material damage caused in the respective accident amounts 10 925,48 Euro (EUR).

The material damage in this report is stated based on invoices, evaluations i.e. documents with which the aforementioned amounts of damage are confirmed, delivered by IŽS a.d. and Serbia Kargo a.d.

2.3.4.External conditions - weather conditions and geographic characteristics

The site of serious accident is located in the area of municipality Despotovac, in the unpopulated settlement Vitance. The landscape in the vicinity of the occurrence of the respective accident is mainly lowland.

The geographic coordinates of the place of accident are: 44° 5' 59,7" N and 21° 24' 16,2" E.

At the time of the accident, the weather was cloudy, with occasional rain. The air temperature was ca 8°C.

3. Minutes on the investigation and interviews

Information, facts and evidence related to the occurrence of the respective accident were collected and determined based on the following:

- Additional on site investigation and review of the derailed wagon which was performed by investigation team of CINS along with the representative of “IŽS“ a.d.
- Materials delivered from infrastructure manager “IŽS”a.d. and
- Materials delivered from undertaking “Srbija Kargo”a.d.

For the respective accident, investigation on site and investigation was carried out by the joint investigation committee of infrastructure manager “IŽS”a.d. and undertaking “Srbija Kargo”a.d.

Police and judicial investigation bodies have not performed the on site investigation.

3.1. Summary of testimonies

From “Srbija Kargo”a.d. statements from hearings of train driver and train driver assistant of locomotive 661-158, and statement from hearing of conductor that accompanied the train No.56990 and during the occurrence of respective accident was in the locomotive, were obtained.

From “IŽS”a.d. the statement of hearing of shunter who accompanied the train No.56990 and at the time of occurrence of the respective accident was in locomotive, was obtained. Also, Reports on irregularities during operation (S-23) were obtained from train dispatchers of stations Despotovac and Svilajnac, which were on duty during the occurrence of the respective accident (staff that regulates the traffic on the section). Given the fact that it was not involved in the accident, the staff that regulates the traffic on the section was not interviewed and the statements from staff hearings were not obtained.



3.1.1. Railway staff

The train driver stated: “during the reception of locomotive I checked the gear of the type of brake and I determined that it was in the position G. The speed that I was driving at was between 18 and 20 km/h. Since on this section the track is at fall, the train was moving under inertia. I felt the twitch of the train and I started fast braking immediately. From the point when I started fast braking to the train stopping the train has passed, according to my judgement, from 8 to 10 m. After stopping the train, I returned the handle of indirect automatic brake valve in the driving position, but then I noticed that I have losses in the main brake pipe, which is why I have come down from the locomotive and went along with the conductor and shunter towards the end of the train in order to determine what is the cause of breathlessness in the main brake pipe. Then we saw that decoupling occurred, between six and seven wagon. When we came to the end of the train, we noticed that there occurred a derailment of last (twenty first) wagon in the train. During the train moving there were no twitches; the train was well coupled. The last time I braked the train was at about 1000 m before the occurrence of the accident, so we complied with the time interval that all wagons brake, and then I put the automatic brake valve of indirect brake in the position of train drive and the train disengaged and it went under inertia until I felt the twitch. From the use of automatic brake valve until the decoupling, and the derailment of the train passed about 5 minutes. On resulting accident, I informed the station (Despotovac) via mobile phone, and told them to inform the operations. Then I informed the supervisor of traction in Lapovo and traveling supervisor“.

Assistant train driver stated: “During the moving of the train from the station and during the braking and unbraking of the train there was no twitch. The train was well coupled. The speed at which the train was traveling was somewhere about, as I recall, between 15 and 20 km/h. Given the fact that the train driver was driving the train, I was on the other side watching the way of driving so I could inform him of signals, level crossings etc. During the train ride that is, the train movement under inertia, the twitch was felt and the train driver immediately started the process of speed braking and stopped the train. After stopping the train, train driver returned the handle of indirect driver's automatic brake valve in driving position and then we noticed that there was the loss of air in the main brake pipe. The train driver together with the conductor and shunter headed to the end of the train because we suspected that there is either a decoupling or derailment of the train. As I recall, the train driver braked with indirect driver's automatic brake valve few minutes earlier (before the accident) after which he unbraked and the train after unbraking was moving under inertia until the occurrence of the accident. After the occurrence of the accident, the train driver via mobile phone called the last station, then a supervisor in Lapovo for traction of trains, as well as a traveling supervisor.”

The conductor stated: “On 03 November 2017 I accompanied a train No.56990. The train was assembled and dispatched from Resavica station at 14:10 and in the composition of the train was 21 Eas loaded with coal for the station Svilajnac. Due to the use locomotive 661 train was operating with the $V_{max} = 20\text{km/h}$ throughout the transportation path and during the drive I did not notice anything suspicious. At 15:15 the train has to pass through the station Despotovac. After passing through the station Despotovac, specifically at km 33+115 a brief twitch was felt and the train driver immediately braked. After stopping the train, I went out to inspect the train with train driver and shunter. On examination we found a train decoupled between sixth and seventh wagon and derailment of the last wagon in the train. On resulting accident I informed the dispatcher at the station Lapovo.”

Shunter stated: “On 03 November 2017 I was part of the train crew of the train No.56990 in the position of accompany shunter. Because the composition of a train did not have official wagon,



I was in the driving locomotive 661-158 with a conductor, assistant train driver and train driver. During the movement of the train, we did not notice any disturbance or irregularity that could threaten the safety of traffic of the train. At the moment of derailment, we did not feel any vibration or twitch of locomotive 661-158. The locomotive remained without air in main brake pipe, and the train stopped. At first I thought that there occurred the decoupling-detaching of the half-coupling on some of the wagons in the train. With a conductor and train driver I walked to the end of the train to find the point of rupture of brake pipe. On site we have seen that there occurred decoupling at the middle of the train and derailment of the final wagon of the train. The conductor and the train driver immediately informed the supervisors about the occurrence of decoupling and derailment“.

3.1.2. Other witnesses

There were no witnesses of this accident.

3.2. Safety Management System

3.2.1. Organisational frame and manner of issuing and executing orders

According to the Safety Management System, "IŽS"a.d. informed all interested parties on the accident.

Railway infrastructure manager "IŽS"a.d. and the railway undertaking "Srbija Kargo"a.d., according to the Law on Railway safety and interoperability ("*Official Gazette RS No.104/13, 66/15-other law and 92/15*"), established a joint investigating committee that carried out an investigation of the respective accident. After the completion of investigation, they drafted a Report on investigation U-525/17.

3.2.2. Requirements that must be fulfilled by railway staff and the way they are applied

"Srbija Kargo"a.d. insured through its Safety Management System (SMS) management of competencies, i.e. the processes, that all the employees participating directly in railway traffic are trained and competent, as well as the planning of the work load.

Regarding the respective accident, where the train driver, the train driver assistant and conductor employed in "Srbija Kargo"a.d. were involved, all the activities related to the professional training, competencies and the planning of working time were carried out in accordance with applicable regulations.

"IŽS"a.d. through its Rulebook of Safety Management System (SMS) provides competencies management, i.e. processes that all employees who are directly involved in the performance of rail transport are trained and competent, as well as planning of the workload.

Regarding the respective accident, involving a shunter, employed at "IŽS"a.d., all activities related to professional training, competencies and planning of workload are conducted in accordance with applicable regulations.



3.2.3. Procedures for internal audits and controls and their results

“IŽS“a.d. as an infrastructure manager has established Safety Management Manual. It includes organization and all the procedures and activities done by “IŽS“a.d. for the safe railway traffic.

Risk Management related to maintenance of railway infrastructure (subsystems infrastructure, energy, control, management and signalling-railway part) and railway vehicles that “IŽS“a.d. uses for maintenance is based on application of defined activities of regular and additional maintenance and their tracking and control. Regular and additional maintenance includes regular supervision, controls, checks, repairs.

Requests, standard and activities for maintenance of “IŽS“a.d. were based on regulation, general and individual documents, instructions of manufacturers and standards.

Regarding the respective accident, regular and additional maintenance of the track was not done according to valid regulations.

3.3. Relevant international and national regulations

3.3.1. Law on Railway (“Official Gazette RS“ No. 45/2013 and 91/2015) repealed on 08 June 2018

Notice: at the time of the occurrence of the respective accident, this law was binding.

Article 14, Paragraph 1:

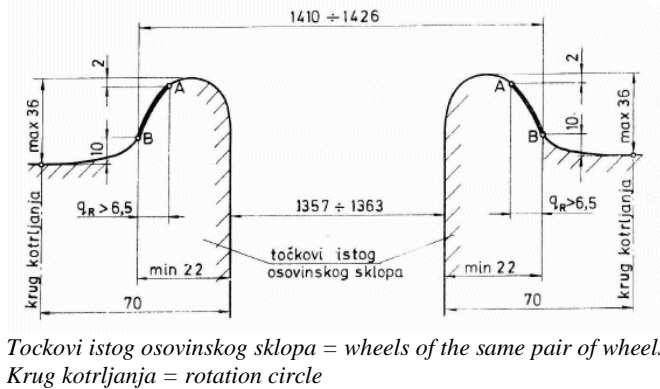
Infrastructure Manager is required to provide a permanent, continuous and quality maintenance and protection of the railway infrastructure, uninterrupted use of railway infrastructure facilities and other devices for rail traffic, as well as the organization and regulation of safe and smooth rail transport.

3.3.2. 250 Instructions for operation and maintenance of bogies type Y 25 and Y 27 type adopted by the Yugoslav railways (“Official Gazette ZJŽ“ No.2/87)

Notice: With the Decision “IZS”a.d. No.4/2015-51-17 from 29 December 2015 on the Adoption of Regulations Issued by the ZJŽ as their internal acts in accordance with Article 152 of the Law on Railway safety and interoperability, and the Decision on Adoption of regulations within the safety management system of railway traffic “Serbia Kargo”a.d. No.4/2015-29-13 from 01 December 2015., the Guide has been taken over and is still in the implementation of the “IZS”a.d. and “Serbia Kargo”a.d.

Part II of Instruction, Point 1.1.1. Wheel set (excerpt):

The distance between wheels on the same pair of wheels and wheel flange dimension must correspond to the measures according to the Figure below:



- the width of the wheel rims must be between 133 mm (in wagons BR 130 mm until 31.12.1982) and 140 mm, including the jutting points;

- the wheels must not show traces of movement on the axle;

3.3.3. Instructions for maintenance of wagons “Srbija Kargo” a.d. No.4/2017-361-139 from 14 July 2017

Article 7 (excerpt):

Exceptionally, in the wagons which are intended for domestic traffic small repairs can be made-repair of minor importance, which extends the useful life of freight cars (post-investment), with a term of repair of 3 (three) years. ...

3.3.4. Instruction on unique criteria for control of the condition of tracks on the network JŽ, Instruction 339 (“Official Gazette ZJŽ” No.2/2001 and 4/2004)

Notice: With the Decision “IZS” a.d. No.4/2015-51-17 from 29 December 2015 on the Adoption of the regulations issued by ZJŽ as their internal acts in accordance with Article 152 of the Law on Railway safety and interoperability, the Guide has been taken over and is still in the implementation of the “IZS” a.d.

Paragraph 2 of the sub-paragraph 6 (extract):

“... The minutes should contain the following basic elements: what is examined and what with it will be examined, recording date and station of recorded railway line or section, **floppy with graphical and analytical presentation of the technical condition of measured railway or the section ...**”

.....
Important notice: Emphasized part of the text was amended in 2004, replaced by the following text from a copy of Instruction 339 of 2001:

“The minutes should contain the following basic elements: what is examined and what with it will be examined, recording date and station of recorded railway line or section, **registered places that directly endanger the safety of railway traffic ...**”

Paragraph 7 of the current edition of Instruction 339 is missing from Article 7 the text under the 5 from the edition of Instruction from 1989 (which is not applicable).

Article 7 under 5. Instruction 339 from 1989:



“Registered errors which directly threaten traffic safety, must be removed the same day after the passage of track examination coach. If this is not possible, take appropriate security measures should be taken.”

.....

Paragraph 9, sub-paragraph 3 (extract) the applicable instructions 339 from 2001/2004:

- “B - mistakes which should plan works for their elimination”
- “C - errors that are beyond the limits of exploitation **and requiring immediate elimination or reduction of speed**”

.....

Important notice: Emphasized part of the text is in the Instruction 339 of 1989 read:

“and must be removed immediately because they endanger road safety.”

.....

Paragraph 9. (extract) of the applicable Instruction 339 from 2001/2004:

“Condition of the track is evaluated by the total length of errors in the groups “B”and “C” in a length of one kilometer”.

The condition of a one km of the track is:

- “Satisfactory, up to 250 m of errors in a group of B, and up to 25 m of errors in the group C, or 250/25 (B/C)”
- “Unsatisfactory, more than 250 m of errors in a group of B and over 25 m of errors in the group C, or 250/25(B/C)”.

.....

Important Notice: In addition in Instruction 339 with amendments from 2001, the last paragraph is deleted from Paragraph 9, which in issue of the Instruction 339 from 1989 in Article 9 of the last paragraph (extract) read:

“Immediately after measuring drive the works for all miles where errors occur of greater length than 200/20 are undertaken, while it must be determined by the Minutes how it came to this situation. After determining the reason of errors and their location, developing a plan is immediately done for improvement of the situation of the observed mile “

.....

3.3.5. Rulebook on technical conditions and maintenance of the superstructure of railways No.: 340-201-2/2016 (“Official Gazzete RS“ No.39/16 and 74/16)

Article 81, paragraph 1 and 2:

“The technical condition of all kinds of rail accessories and accessories as a whole must be such as to ensure a firm connection between the rails, rails with a sleeper and prevent loosening of fittings and connections. Damaged, worn out or missing elements of rail accessories should be replaced or supplemented, tighten the loose fittings, and if necessary lubricate some of the elements.”



3.3.6. Law on Railway (“Official Gazette RS“ No.41/2018)

Article 10, Paragraph 1:

Infrastructure Manager is required to ensure safe and smooth organization, regulation and management of rail traffic, uninterrupted access to and use of public railway infrastructure and access to service facilities that are entrusted for the management and the services it provides in these facilities to all interested applicants for the allocation of infrastructure capacity, under equitable, non-discriminatory and transparent conditions, as well as permanent, continuous and quality maintenance and protection of the railway infrastructure.

3.4. Functioning of railway vehicles and technical installations

3.4.1. Control, command and signalling

On the section of the local railway line Markovac - Resavica between stations Svilajnac and Despotovac traffic is regulated in the station distance. At the specified in addition to the entry signal of the station Svilajnac and Despotovac, there are no other major signals. Entry signals of stations Svilajnac and Despotovac are descriptional. They are not working and not in function. In stations Svilajnac and Despotovac electro - mechanical snap block devices are installed, which are used for locking of the input and output switches (entry and exit) with input signals. By using the above apparatus key dependence of switches with the entry signals is realized. In stations Svilajnac and Despotovac mentioned apparatus are working and functional.

3.4.2. Infrastructure

The site of the respective accident is located on a gradient of 5.1‰ (a downgrade of 5.1‰, viewed in the direction of movement of the train) and the left curve viewed in the direction of movement of the train (i.e. right-hand curvature when viewed in the direction of increasing mileage), of the radius $R=1000$ m and the length of $l=471,26$ m.

On the railroad rails of various types are built, standard 49a and 45 and non-standard 35a, Xa and 8a with the respective non-standard arrangements of rail accessories. In non-standard rails appears rail-sleeper link using the rolling pin. Rails are related with classical ensembles, and over the past years due to the rupture of rails a large number of short tracks is installed, length of 6 m. On the open line and the main passage tracks 70353 pieces of wooden sleepers is installed, of which 31803 is marked as obsolete and useless, thus 46% of the total number of sleepers. At many places three or more obsolete sleepers in a row were observed, which directly affects the stability and geometry of the track. The sleepers are embedded at a distance of 0.75 m. On the section between Markovac and to km 19+600 the ballast is formed of broken stone, with a large percentage of pollution, while the rest of the ballast is made of slag, which with time turned into the ground.

In stations Svilajnac, Resava, Despotovac, Dvoriste and Resavica 50 switches have been installed, and of the facilities on the lower structure of track has 9 bridges, 134 failures, 9 underpasses, an overpass, 6 tunnels, 29 support walls, 1 lining wall and 44 crossings.

With regard to the condition of the track, the Section responsible for the maintenance of this track for many years was addressing with the requirements to the Department of construction works for the procurement of necessary materials to incorporate in the aforementioned track and thereby preserve the safety and regularity of traffic.



Local railway line Markovac - Resavica until 25 December 2017 was maintained by railway section Despotovac, Section for track maintenance Paracin, which consisted of the following executives directly involved in the railway maintenance:

- Chief of the section, 1 executive,
- Assistant Chief of the section, 1 executive,
- Track foreman, 1 executive,
- Linemen, 4 executives,
- Level crossings keeper, 3 executives,
- Locksmith - mechanic, 1 executive,
- Light railway equipment operator, 5 executives,

Which constitutes 16 executives in total.

From 25 December 2017 the maintenance of local railway line Markovac - Resavica is performed by railway section Lozovik, Section for track maintenance Pozarevac, with the following executives:

- Assistant Chief of section, 1 executive,
- Lineman, 2 executives,
- Railway workers, 1 executive,

In total 4 executives.

From 25 December 2017 the level crossings keepers, 3 executives, are arranged in Section of traffic affairs Belgrade.

Due to the age and type of rail grid, as well as ballast material (slag) this track can not be maintained by machine (machine regulation of track), but exclusively by manual labor. For these jobs either in the previous nor the current systematization there is not a sufficient number of executives. Currently, the maintenance of this line, is reduced to the removal and repair of ruptured rails and removing irregularities on the switches.

According to data of the railway inspections carried out in the period before the occurrence of the respective accident, carried out by track maintenance manager "IZS"a.d., Section for track maintenance Paracin, the state of facts given below is established.

The wear out of the rails in the exterior and interior arches is within the limits of exploitation values.

The geometry of the track is very bad and is manifested with disturbed grade line in the longitudinal and transversal direction. The twist is above the threshold, which endangers the road safety.

Due to the poor state of the elements of the super and sub structure of the track, the maximum speed on the section between the stations Resava and Despotovac in the period from 11 December 2016 until 12 September 2017 was $V_{max}=20$ km/h, and from December 2017, on the entire track from the station Markovac to the station Resavica was $V_{max}=20$ km/h.

After examining the book of inventory of rotted sleepers on the section Despotovac for 2017 it was established that on 10 May 2017 from km 33+100 to km 33+200 from 136 embedded sleepers 76 or 58.88% are rotten.

On-site investigation carried out after the occurrence of the respective accident, by the joint investigative committee "IZS"a.d. and "Srbija Kargo"a.d., the condition given in the text below is established.



On the railway line, at km 33+150 in the track first traces of derailment of the train are detected in the form of metal chips or damaged standing studs on the rail accessories by the left rail track (as viewed in the direction of movement of the train), wherein the first trace of falling the left wheel into the track is detected. At this spot on the right rail of the track and right next to the right rail of the track, any traces have not been noticed.

At km 33+126 (rail joint in front of a level crossing located at km 33+102, seen in the direction of movement of the train), on the right rail of the line (as seen in the direction of movement of the train) traces of climbing of wheel flange onto the rail, the movement of wheel flange on the head rail, and the fall of the wheel flange next to the rail track on the outer side of the track were noticed (traces in the form of scratches formed on the rail head and damages to the outside of the track and the stone cubes on the level crossing).

Between km 33+126 and km 33+085, in the track, next to two railway tracks traces of movement derailed wagons in the form of damages to rail accessories, sleepers and ballast were noticed.

During the investigation by the joint investigative committee "IŽS" a.d. and "Serbia Kargo" a.d, measuring gauge in the zone where the first signs of derailment were observed was carried out on site. The measurement is performed on every third sleeper 15 m before the derailment, viewed in the direction of movement of the train, measurer for the track of brand *Robel*, the property of "IŽS" a.d. The measured values are shown in Table 3.4.2.1.

Table 3.4.2.1: The gauge measured directly before the occurrence of the derailment

The point of measuring	width (mm)	camber (mm)	notice
-6	0		<i>km 33+165</i>
-5	+8		
-4	+18		
-3	+27		
-2	+39		
-1	+48		
0	+50		<i>km 33+150</i>
1	+50		
2	+50		

In Table 3.4.2.1, the sleepers are labeled, so as to for "0" sleeper the sleeper that is located at km 33+150 is taken, at which the first traces of derailment are observed (falling of the left wheel into the track). Sleepers marked with prefix "-" are the sleepers that are found before the point of derailment, and those bearing the prefix "+" are behind the derailment point, as seen in the direction of movement of the train. The distance between adjacent sleepers is 0.75 m.

As the plan of the Department for construction work "IZS" a.d., for the local railway Markovac - Resavica does not provide the control of track geometry with track examination coach 80L EM in 2017, track geometry was checked with manual gauges.

The determined values are recorded in the book of measurement of the track (ZOP 6) and are shown in Table 3.4.2.2.



Table 3.4.2.2: Width of the track and camber, measured 10 March 2017

Measurment point	width (mm)	cross level (mm)	note	Measurment point	width (mm)	cross level (mm)	note
-6	4	-4	km 33+000	3	2	-10	
-5	-6	-20		4	13	-20	
-4	-5	-5		5	13	-20	
-3	-5	5		6	-2	-10	
-2	0	0		7	2	-15	km 33+150
-1	+6	3		8	0	-5	
0	+4	-20		9	7	-10	
1	+32	-34		10	11	-20	
2	-12	-10	Level corssing km 33+102	11	2	-15	

At the local railway line Markovac - Resavica, on 20 May 2016. the measurement of parametres of the track was carried with track examination coach, the type of EM 80L. Data on executed measurements are provided in the form of graphical and analytical part of the report. After the measurement the operational plan for error removal beyond all tolerance has been made and delivered to the section of the track Despotovac (track section in charge of the maintenance of this line) with a performance period up to 30 June 2016. The railway section during the period June - September 2016, in accordance with their capabilities, executed works to fix the errors mentioned in the operational plan, which is regularly reporting to the authorities.

Overview of the railroad by the lineman was carried out regularly, which from "IZS" a.d. submitted documentation regularly. In the book of lineman (ZOP-2) there are not recorded any irregularities that could endanger the safety of the traffic.

3.4.3. Communication tools

At the time of occurrence of the respective accident, the communication tools were working and in function. There were no interferences or faults recorded.

3.4.4. Railway vehicles

At the time of the occurrence of the respective accident, train No.56990 was moving in the direction from the station Despotovac to station Svilajnac (from end to beginning of the line, in the direction of decreasing mileage). During the drive of the train at the wagon series Eas No.80 72 5952 334-6 (the last wagon of the train) there occurred derailment of all axles and at the sixth wagon of series Eas No.80 72 5952 245-4 it came to the tearing of the coupling device.

The first trace of derailment occurred at km 33+150 on the inside of the left rail, viewed in the direction of movement of the train.

Derailed wagon was found as the last part of the train, in the area of track, on its wheels. There was no tilting or overturning the wagon. Derailed wagon was not decoupled from the penultimate wagon. Decoupling occurred between the fifth and sixth wagon, as viewed from the driving locomotive.

Appearance of the derailed wagon is shown in Figure 3.4.4.1. and 3.4.4.2., and the appearance of the damages on the sixth wagon due to decoupling is shown in Fig. 3.4.4.3.



Fig. 3.4.4.1: The view of derailed wagon



Fig. 3.4.4.2: The view of derailed wagon



Fig. 3.4.4.3: The view of the broken coupling device on the sixth wagon

On locomotive 661-158 speeding devices of manufacturer Hasler are embedded including: registering speeding device of RT9i type, serial number L08.095 and speed-indicating meter A16-type device, the serial number 5871. Both devices are tested, for the validity of certificates until 28 December 2017.

Analysis of the data registered on the registering tape that was removed from the speeding device on the locomotive 661-158 (Data from the registering tape No.32-17 from 13 November 2017 and No.36/17 from 20 December 2017) it was determined that the train No.56990 since the departure from the station Resavica to occurrence of the respective accident had a total of three stoppings.

During the drive on the mentioned section, the train speed was between 10 and 20 km/h. The last 500 m immediately before stopping due to derailment and decoupling, the train was moving



at the speed up to 20 km/h, then the speed sharply decreased and the speed printer is lowered to zero position and the position of the train is fully stopped at 15:26, further movements of the train were not registered until 18:53. The times are given according to the speeding device clock.

Based on the data from registering tape of the locomotive 661-158, it was stated that it did not exceed the speed limit on this section of railway line (20 km/h).

3.5. Traffic operation and management

3.5.1. Actions taken by the staff that manages traffic regulation, control and signaling

Traffic of train No.56990 from Despotovac to Svilajnac took place in the station distance. Before the dispatch of train No.56990, for it it was asked and obtained permission in accordance with applicable regulations, and in that sense there were no irregularities.

Train staff, via accompanying documents, received orders and notifications on the train traffic on this section.

3.5.2. Exchange of voice messages in relation to the accident

Immediately prior to and during the occurrence of the respective accident, communication between train driver and staff which regulates the traffic was not achieved.

The communication between train driver and staff which regulates traffic was achieved after the occurrence of the respective accident concerning the purpose of notification, in such a manner that a driver of train No.56990 informed, via mobile phone operator, the train dispatcher of station Despotovac and supervisor of Section of traction of trains Lapovo and traveling supervisor of traction.

3.5.3. Measures taken to protect and secure the place of accident

After the occurrence of the respective accident, traffic on local railway line Markovac - Resavica was closed on the section, between the stations Svilajnac and Despotovac.

Given the fact that the train No.56990 stopped on the section that was, viewed from the direction of movement of the train, was at gradient of 5.1 ‰, that it came to derailment of the last wagon from the train composition, that it came to decoupling of the train (shredding of the main brake pipe), and that locomotive of series 661-158 was found on the head of the train, no special measures of securing the train from self rolling were undertaken.

As the train was not carrying goods hazardous to the environment and peoples lives, no specific measures were undertaken for securing the accident site.

Other measures to secure the accident site have not been undertaken.



3.6. Interface between man, machine and organisation

3.6.1. Working hours of the staff involved

For the railway staff, information was submitted based on which it is clear that the train driver and the train driver assistant of the locomotive 661-158 and the conductor and shunter had the legally stipulated rest before going to work and that they did not spend more time at work than the maximum working hours defined by law.

3.6.2. Health-related and personal circumstances that have effects on the accident, including the presence of physical or mental stress

For the railway staff, information was submitted based on which it is clear that the conductor, train driver and the driver assistant and shunter of the train No.56990 were qualified and bodily and mentally fit to perform their work. From “Srbija Kargo” a.d. the request for the issuing of the license for managing the traction vehicle was done (delivered on 14 November 2016), and for the train driver assistant Confirmation of receipt of the application the requirements for a license to operate a towing vehicle, issued by the Directorate of Railways I-01-1 No. 340-1469-2 / 2016 from 21.12.2016.

3.6.3. Design of the equipment that has influence on the interface between user and machine

Section of the local railway Markovac-Resavica, between the stations Svilajnac and Despotovac is designed for speeds up to 40 km/h and maximum load of 16 t/axle and 5 t/m (160 kN/axle, and 50 kN/m)

Due to the poor condition of the track, designed speed of 40 km/h is reduced to 20 km/h.

According to the designed condition, traffic on the abovementioned track is regulated in station distance.

Management of locomotive is done by train driver and train driver assistant via commands from the driver's cab, designed during the production of locomotive. At the locomotive 661-158 all the failures identified in the systems and control devices are eliminated, so any complaints or defects are not registered.

At designed technical-exploitation characteristics of the wagons series Eas and maintenance of the wagon any complaints or defects have not been registered.

3.7. Previous accidents of similar nature

Based on the data provided by “IŽS” a.d. for the period between 01 January 2008 and 3 November 2017, on the local track Markovac - Resavica, there have been in total ten accidents derailments. The review of the accidents occurred is given in Table 3.7.1.



Table 3.7.1: The review of accidents occurred in the period between 01.01. 2008 and 03.11.2017.

No.	date	time	Short description	Cause
1	18.10.2014.	19:40	Derailment of train No. 56990 at km 33+810 with two wagons.	Large percent of rotten sleepers.
2	26.10.2014.	05:40	Upon entering the station Svilajnac, between the switches No.1 and 4, derailment of train No.66991 with the first wagon.	More rotten sleepers on the track link between switches 1 and 4 and the diameter of the wheel on the derailed wagon is outside the permitted tolerance.
3	19.07.2015.	13:32	At km 23+500, derailed train No.53974 With six wagons.	High temperature of the rail, deterioration of the ballast made of slag which turned to dust, non-standard track accessories, increase of the percentage of rotten sleepers, which caused the deformation of the track under the train.
4	18.12.2015.	14:54	At km 21+700 derailed train No 56999 with three wagons.	Poor condition of the track, deterioration of the ballast made of slag that turned to dust so it cannot provide the necessary stability of the track, as well as the high percentage of rotten sleepers.
5	21.01.2016.	00:25	At km 12+630 from the train No.56991 derailed loc:666-001 with 1 bogie.	Uncleaned ice in the grooves on the level crossing.
6	06.03.2016.	01:25	At km 19+800 derailed train No.56990 with five wagons loaded with stone.	Greater percentage of rotten sleepers, and the ballast made of slag that turned to sand-dusty material due to exploitation and is saturated with water due to which it does not have the necessary capacity and fastens the process of rotting of sleepers.
7	02.03.2017.	14:15	At km 20+200, from the train No.56990 derailed five wagons. In this accident four workers were heavily injured (head of the station Resavica, shunter, wagon examiner and conductor).	Greater percentage of rotten sleepers, and the ballast made of slag that turned to sand-dusty material due to exploitation and is saturated with water due to which it does not have the necessary cross section and capacity
8	28.09.2017.	01:58	At km 45+000 derailed train No.66990 with five wagons.	Ballastway that is made of slag and that during the long period of exploitation has turned into sand-dusty material so that it does not have the needed cross-section and intended capacity.
9	12.10.2017.	02:10	At km 45+800 derailment of train No. 56990 with two wagons	Ballastway that is made of slag and that during the long period of exploitation has turned into sand-dusty material so that it does not have the needed cross-section and intended capacity.
10	25.10.2017.	14:59	AT km 33+950 derailment of train No. 72951 (loc.:661-158 with one axle).	Deterioration of non-standard accessories for type of rails 35a, at the point of derailment slack of supplies and transport of loc. series 661

In all the accidents there were no dead persons. In the accident occurred on 02 March 2017, at derailment of train No.56990, four workers were heavily injured (head of station Resavica, shunter, wagon examiner and conductor).

4. Analysis and conclusions

4.1. Final review of the course of events and adoption of conclusions about the occurrence based on facts determined during the investigation and interviews

According to the documentation submitted by the "IZS" a.d., the train No.56990 composed of a locomotive 661-158 of weight of 112 t and of twenty one wagons of the series Eas loaded with coal, the total gross mass of 1286 t, was dispatched on 03 November 2017 at 14:10 from the station Resavica to the station Svilajnac at the local railway line Markovac - Resavica. By checkweighing after the accident it has been established that all wagons on the train were properly loaded with cargo for axle load of 160 kN.

In the locomotive there were train driver, train driver assistant, conductor and shunter. After passing through the station Despotovac the train was moving at speed up to 20 km/h. According to the staff's statement, just before the accident, the train was moving by inertia given the fact that the railroad at that point is in slight decline. The record of registering tape does not indicate that immediately prior to the accident braking was performed, which is in line with the statement of the staff of the towing vehicle.

At 15:25, the train staff felt a brief twitch and train driver started fast braking and the train stopped at km 33+085 (final wagon). After regaining driver's automatic brake valve in the driving position, the train driver noticed the loss of air from the main brake pipe.

Train driver, conductor and shunter came down from locomotive and with the review along the train found that between six and seven wagon came to decoupling. By reviewing until the end of the train they found out that the last wagon in the train composition derailed from the track with all the axles.

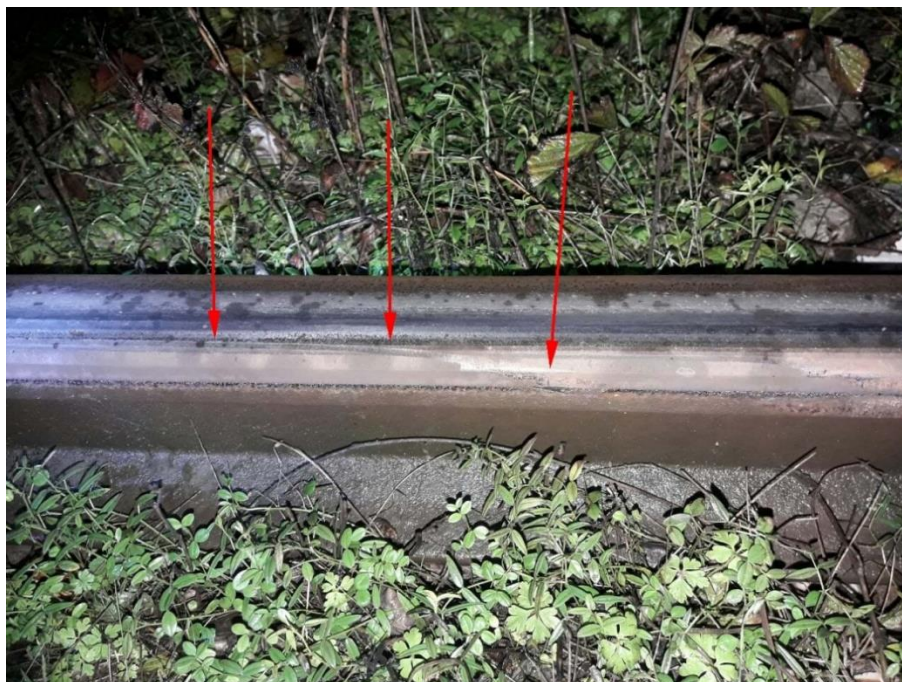


Fig 4.1.1: The first trace of falling of the wheel on the left rail, as seen from the direction of the train movement (source: „IZS“ a.d.)

Based on the data obtained by reviewing the track by the investigative committee "IZS" a.d. and "Srbija Kargo" a.d., the first trace of derailment was observed on the inner side of the left rail in the direction of the train movement (Figure 4.1.1.). Beyond that, the next 24 m there are traces of hitting of the wheel on the fixing accessories on the inside part of the left rail.

After 24 m at the left wheel strokes transversely displaced hovering composition of the left rail (Figure 4.1.2.). On the composition the inner longitudinal tie was broken. With photos it can be observed rusty intersection of fractures of the ties on the basis of which it can be concluded that it was broken before the accident, which is why the compound was dislocated laterally.



Fig. 4.1.2: The trace of hitting and lifting the wheel on the moved composition of the left rail and broken tie
(source: „IZS“ a.d.)



Fig. 4.1.3: The trace of falling out of the wheel on the external part of the right rail
(source: „IZS“ a.d.)

In the same intersection on the right rail, climbing of right wheel on the rail and the trace of derailed right wheel on the outer part of the right rail. (Figure 4.1.3.).

From this composition, traces of derailed wheels are visible to the point of stopping. In Figure 4.1.4. uprooted coupling device of sixth wagon in the composition of the train is shown, on the point of decoupling that is made as a result longitudinal twitches after the derailment of the last wagon in the train.



Fig. 4.1.4: Torn coupling device of sixth wagon (source: „IZS“ a.d.)

4.2. Analyses of facts determined during the investigation

4.2.1. The review of the derailed wagon

Based on the documentation ("Record of the final inspection of the derailed wagon in relation with derailed wagon No.80 72 334-6 5952"), derailed wagon after derailment, on 20 November 2017 were checked at a workshop in Velika Plana. The surveying of typical measures of axle assemblies relevant to this investigation were performed (see section 3.3.2). From the submitted data it can be established:

- that the characteristic dimensions of the profile of all wheels are of the allowable limits,
- that the internal spacing of the wheels (dimension L), and the distance of ranges of wheels, measured 10 mm under the circle rolling (dimension C) on all axles are in acceptable limits.

On that basis, the state of geometry of axle assemblies did not contribute to the occurrence of the accident.

4.2.2. Review of maintenance documentation of derailed wagon

Review of the documents submitted by the owner of the wagon series Eas-z No.80 72 5952 334-6 "Serbia Kargo"a.d., determined the following:

- entity for vehicle maintenance is "Kargo Serbia"a.d.,
- regular repair of wagon (small repair) was made on 06 March 2017 in the workshop in Kikinda,
- instruction owner of the car (see paragraph 3.3.3.) stipulates that the wagon intended for domestic traffic, it is possible to perform small repairs, with a deadline of repair of three (3) years. The wagon-labeled with "NO" and at the time of the accident were within the prescribed limits of maintenance,
- on the car it is registered that on 06 March 2017 in the workshop of 474 (Kikinda) an overview of brakes of rank RK 1 was made.

Based on the above, the wagon is maintained in accordance with applicable regulations.

4.2.3. Reports on condition of track

At the local railway line Markovac - Resavica standard rails 49E1 and S45 are embedded, as well as non-standard 35a (Figure 4.2.3.1.), Xa and 8a with the corresponding non-standard arrangements of connecting and fastening accessories (mounting of rails with rail nails - Fig.4.2.3.2. and 4.2.3.3.). The rails are interconnected by classic rail joints that are supported (Fig. 4.2.3.4.) and floating (4.2.3.5.)

On the open section and main driving tracks 70353 pieces of wooden sleepers have been built in, out of which 31803 pieces due to the large rottenness are unusable (bad connection rail-sleeper, figure 4.2.3.6.), which constitutes 46% of total built-sleepers. At many places there are three or more rotten sleepers in a row ("nests" of rotten sleepers - Figure 4.2.3.7.), which directly affects the stability and geometry of the track. On the section from the station Markovac (km 0+500) to km 19+000 ballastway was formed from highly polluted broken stone (over 15% - Figure 4.2.3.8.), while the rest of the railway ballast is made of slag, which turned into the ground.



Fig 4.2.3.1: Non-standard rail 35a



Fig 4.2.3.2: Nails fastening



Fig. 4.2.3.3: Nails fastening



Fig. 4.2.3.4: Supported rail joint



Fig. 4.2.3.5: Floating rail joint



Fig. 4.2.3.6: Connection sleeper-rail



Fig. 4.2.3.7: Nest of rotten sleepers



Fig. 4.2.3.8: Ballastway

On the line with limited speed of 20 km/h locomotives of series 661 with the axle load of 183 kN and a load of 59.5 kN/m are used, which further influences the rapid collapse of the railway line.

From 11 December 2016 until 9 December 2017 (Timetable Booklet 9.5 for 2016/17) due to the poor condition of the substructure of the track the speed limits have been introduced: between the station Markovac and Resava from km 19+600 to km 27+034 with $V_{max}=20$ km/h, and station Dvoriste to station Resavica from km 47+400 to km 48+800 with $V_{max}=20$ km/h.



In the letter of head of the Section for track maintenance Paracin No.20/2018-3259 of 26 January 2018 that was sent to the Department for construction works, for local railway Markovac-Resavica states:

“... reviews of Section for construction works "IZS" a.d., were carried out on bridges, tunnels, slopes and level crossings. Control of the superstructure is not performed”.

“... measurement and control of the condition of the superstructure of the track were performed by expert service of Section for track maintenance Paracin and railway section Despotovac ...”

Table 4.2.3.1: Review of the control of the track on the traction vehicle and tour

Date	Condition found	Deadline of elimination	Eliminated, day and page of the work book	Remark
Review of the track on the traction vehicle				
2014, 2015. и 2016.	No objections			Section Despotovac
05.07.2017.	Regulate the dents from km 33+000 to km 34+000	Immediately	05.07.2017, 8	Section Despotovac
03.05.2017.	Replace deficient rails at km 33+650	10.05.2017.	05.05.2017, 9	Section Despotovac
20.04.2017. 30.05.2017.	Regulate the stability of the composition according to direction and nivel and reduce dilatation at km 33+600	17.05.2017. 22.06.2017.	05.07.2017, 8	Section for rail maintenance Paracin
23.08.2017.	Regulate the stability of the composition acc to direction and nivel 33+200	22.09.2017.		Section for rail maintenance Paracin
22.09.2017.	Regulate the stability of the composition acc to direction and nivel 33+200	20.10.2017.		Section for rail maintenance Paracin
23.10.2017.	Regulate the stability of the composition acc to direction and nivel 33+200	20.11.2017.		Section for rail maintenance Paracin
27.11.2017.	Regulate the stability of the composition acc to direction and nivel 33+200	20.12.2017.		Section for rail maintenance Paracin
28.12.2017.	Regulate the stability of the composition acc to direction and nivel 33+200	22.01.2018.		Section for rail maintenance Paracin
Visual review of the track				
20.10.2015.	Regulate the dents from km 32+950 to km 33+100	27.10.2015.	23.10.2015, 8	Section Despotovac

The minutes of the established facts of the Center for Internal Control ("IZS" a.d.) No.8-2.2/2017-2/1 of 21 February 2017 on the control of the technical condition of railway safety, switches and facilities in the territory of Section for Infrastructure of the Lapovo node (OC for track maintenance Paracin) for the local railway line Markovac - Resavica from km 0+500 to km 53+750 it is stated:

“On sections the ballast made of broken stone is very grassy and muddy. “

...

“rottenness of wooden sleepers on the railway section is up to 66.9% by hectometer”



Letter No.14-3/2017-174 of 17 March 2017, the Section for infrastructure of node Lapovo (OC for track maintenance Paracin) reported the Center for Internal Control on the measures taken after the Report on inspection of the Center for Internal Control ("IZS" ad) No.8-2.2/2017-2/1 of 21 February 2017 for the local railway line Markovac - Resavica from km 0+500 to km 53+750, where it is stated:

“Operational plan of machine maintenance of tracks for period III-VIII of 2017 on the territory of OC for track maintenance Paracin, railway sections that need to implement ballast sifting for rail grid are given. In this regard, the request was sent to the Department for construction work No.38/17-III-77 from 21 January 2017 for the procurement and delivery of broken stone. “

...

“Commencement of the works of machine sifting of tracks can not be defined until it is realized: procurement of broken stone, fuel procurement plan, parts for machines and service delivery repair of machinery and equipment.”

...

“a request to the Department of construction works was sent, for the procurement and delivery of beech sleepers of track No.14-3/2017-231 of 17 March 2017 requisitioned quantities were not supplied.

Track Markovac - Resavica (65199 m track) until 25 December 2017 was maintained by the section Despotovac of Section for track maintenance Paracin with 16 executives (one chief of section, 1 chief of section assistant, 1 railroad supervisor, 4 linemen, 3 level crossing keepers, a locksmith - mechanic and 5 operators of light railway equipment).

The new organization and systematization of "IZS"a.d. from 25 December 2017 respective railway track is maintained by section Lozovik of Section for track maintenance Požarevac with 4 executives in total (1 assistant chief of section, 2 linemen and 1 track operator) and Section for traffic operations with 3 level crossings keepers.

Railway section Despotovac maintained a railroad with hand tools (packing of sleepers, forks, shovels and barbell), and light railway equipment (saw with telescopic shaft, a chainsaw and wrappers of track accessories).

On the basis of the facts railway track Markovac - Resavica is under technically acceptable norms defined in current regulations. Competent track section does not have the proper management and proper equipment. Number of employees on the section of the December 2017 decreased. The procurement of material is not implemented, according to the requirements of the relevant sections. Since the construction of the railway track in 1951, i.e. 1967, the overhaul of track was not performed.

4.2.4. Record of track examination coach

In the letter of head of the Section for track maintenance Paracin No.20/2018-3259 from 26 January 2018 to the Department of construction works “IZS”a.d., for the local railway track Markovac - Resavica stated:

“Recording data from track examination coach have been delivered to you on 20 May 2016. Track examination coach have not been trafficking in 2015 due to the defect, and in 2017 were not according to plan of review.”



Instruction on common criteria for control of the condition of railways on the network JŽ, Instruction 339 (*"Official Gazette ZJŽ" No.2/2001 and 4/2004*), part III types and number of control of tracks, Paragraph 3 (excerpt):

"Regular testing of geometric condition of railway tracks on the tracks of JZ is performed by the track examination coach that fulfill the technical requirements:

...

- on all other tracks of public transport and industrial railway lines on which traction vehicles of JŽ traffic least once a year (in spring or autumn) ... "

From the submitted record from the measurement of condition of the track with track examination coach on the section between Markovac-Resavica from 20 May 2016 it can be seen:

1) from km 0+000 km 34+810 the errors type "B" appear at a length of 12345 m and errors type "C" at a length of 2001 m, and from km 34+288 to km 48+484 errors type "B" in a length of 3803 m occur and the errors of the type "C" at a length of 283 m, so that from measured 49006 m of the track is in the unsatisfactory condition of the railway on 36970 m, or 75.44%.

2) in the zone of derailment of the train No.56990 (km 33+150) in the summary part of the km 33+000 to km 34+100 appear the errors type "B" at a length of 253 m and the error of type "C" at a length of 57 m.

On the basis of the applicable Instruction on common criteria for control of the condition of railways network JŽ, Instruction 339 (*"Official Gazette ZJŽ" No.2/2001 and 4/2004*), railways in the zone of intersection of the wheel in the track (at km 33+150) in May 2016 was not at a satisfactory condition.

It is unacceptable that the condition of track defined by Instruction 339 as "unsatisfactory" and errors over the exploitation boundaries of endangering traffic safety, are tolerated, ie. eliminated by reducing the allowed speed limit.

In Figure 4.2.4.2. a graphic copy of the record of track examination coach is shown in the critical zone of the track from May 2016, and the figure 4.2.4.3. shows a copy of the numeric record.

"IZS" a.d. has submitted an analysis of records of track examination coach, and a report on the measures taken on the irregularities observed during the measurement with track examination coach, which shows that the observed errors in the derailment zone are partially eliminated (extension, but not twist).

Figure 4.2.4.1 shows the Report on eliminated errors underlined in red lines at dates set aside.

SUZENJE	33.106	33.108	2	-11MM68	106	10MM	4	5	C	R
PROSIRENJE	33.120	33.127	7	42MM38	122	35MM	4	5	T	10.08.2016
VITO. 3.5m	33.124	33.127	3	23MM37	126	18MM	4	5	T	
SUZENJE	33.401	33.404	3	-18MM42	402	10MM	4	5	T	22.06.2016
STABILNOST-L	33.457	33.459	2	22MM92	457	20MM	4	5	T	
VITO. 3.5m	33.621	33.624	3	-29MM50	622	18MM	4	5	T	
NADVISENJE	33.621	33.628	7	-26MM23	623	15MM	4	5	T	

Fig. 4.2.4.1: Report on eliminated errors (source „IZS“ a.d.)

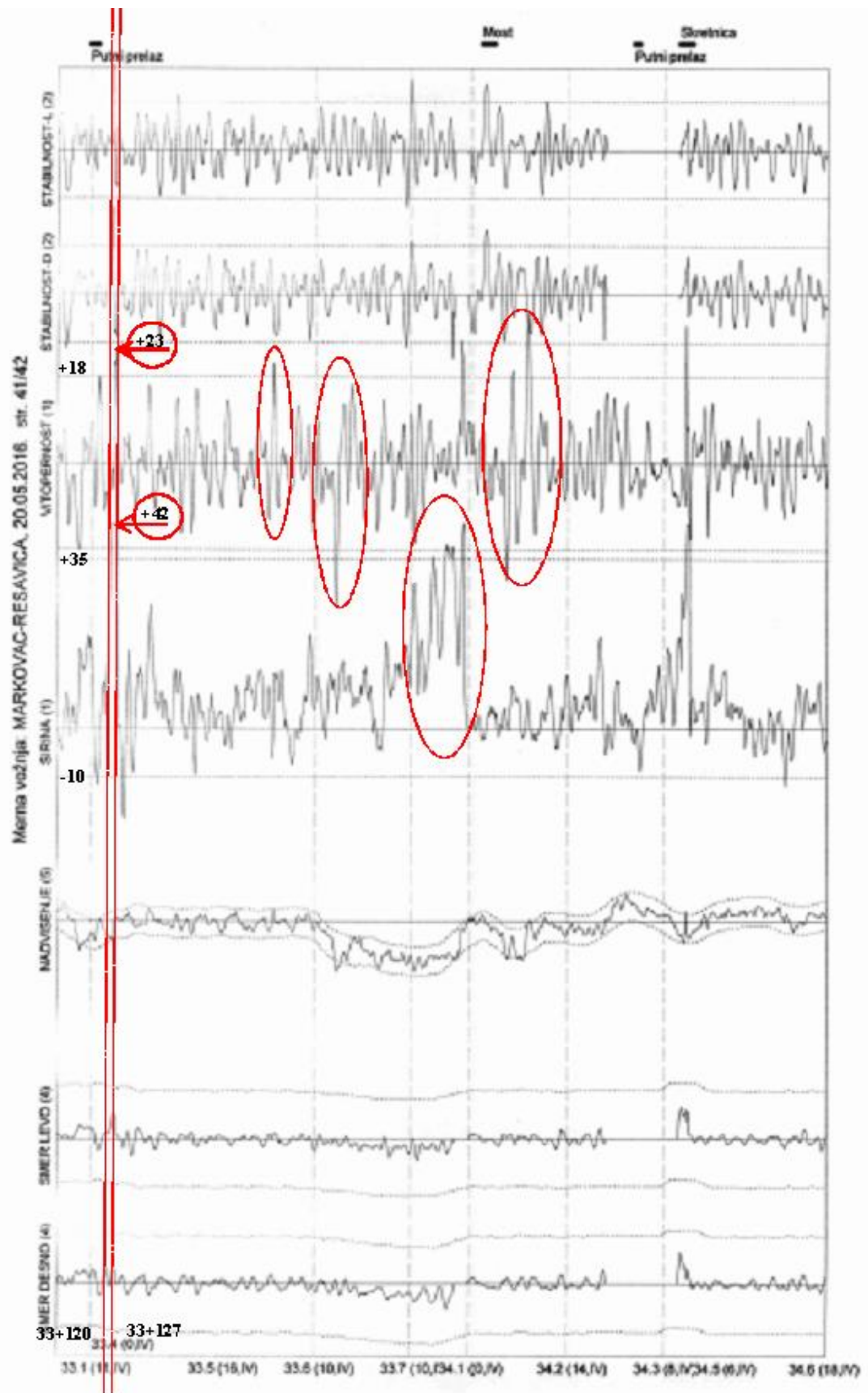


Fig. 4.2.4.2: Graphic record of track examination coach on 20 May 2016



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MARKOVAC-RESAVICA, 20.05.2016.

PARAMETER	START	END	LEN(M)	VALUE	DIST	THRES	L	S
NADVISENJE	33.006	33.008	2	15MM67	6	15MM	4	5 T
KM 33.016	KRIVINA							
KM 33.018	TANGENT							
VITO. 3.5m	33.016	33.019	3	-24MM29	17	18MM	4	5 T
NADVISENJE	33.017	33.022	5	-24MM23	18	15MM	4	5 T
KM 33.029	KRIVINA							
KM 33.042	TANGENT							
NADVISENJE	33.041	33.043	2	16MM08	41	15MM	4	5 T
NADVISENJE	33.071	33.073	2	17MM38	71	15MM	4	5 T
STABILNOST-D	33.072	33.074	2	-22MM04	73	20MM	4	5 T
KM 33.075	KRIVINA							
KM 33.079	TANGENT							
KM 33.083	KRIVINA							
KM 33.089	TANGENT							
NADVISENJE	33.087	33.092	5	-23MM44	88	15MM	4	5 T
KM 33.103	KRIVINA							
SUZENJE	33.106	33.108	2	-11MM68	106	10MM	4	5 C R
Putni prelaz START 33099 END 33108 LEN 9								
KM 33.111	TANGENT							
Derail Center 33.125								
PROSIRENJE	33.120	33.127	7	42MM38	122	35MM	4	5 T
VITO. 3.5m	33.124	33.127	3	23MM37	126	18MM	4	5 T
Derail Rear 33.130								
Vertical Pressure Off 33.131								
KM 33.400 LOCATION CHANGE: OLD LOCATION> KM 33.131								
SUZENJE	33.401	33.404	3	-18MM42	402	10MM	4	5 T
STABILNOST-L	33.457	33.459	2	22MM92	457	20MM	4	5 T
VITO. 3.5m	33.621	33.624	3	-29MM50	622	18MM	4	5 T
NADVISENJE	33.621	33.628	7	-26MM23	623	15MM	4	5 T
KM 33.644	KRIVINA							
KM 33.649	TANGENT							
KM 33.651	KRIVINA							

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MARKOVAC-RESAVICA, 20.05.2016.

PARAMETER	START	END	LEN(M)	VALUE	DIST	THRES	L	S
STABILNOST-D	33.694	33.696	2	-21MM89	695	20MM	4	5 C L
STABILNOST-L	33.699	33.702	3	29MM23	700	20MM	4	5 C L
STABILNOST-D	33.700	33.702	2	22MM46	700	20MM	4	5 C L
KM 33.743	TANGENT							
PROSIRENJE	33.736	33.745	9	38MM20	737	35MM	4	5 T
Derail Rear 33.746								
Vertical Pressure Off 33.748								
VITO. 3.5m	33.753	33.756	3	25MM49	753	18MM	4	5 T
PROSIRENJE	33.753	33.757	4	42MM33	755	35MM	4	5 T
Derail Center 33.759								
KM 34.100 LOCATION CHANGE: OLD LOCATION> KM 33.760								

-----PLANIRANJE RADOVA-----

START	END	TAMP LINE TQI GAUGE BAL					
KM/M	KM/M	SPD	126	186	200	246	161
33.000	34.100	20	59	153	110	184	127

<<<SUMMARY>>> KM 33.000 TO 34.100 = 493M

-----CLASS: 4

-----A-----

-----B-----

-----C-----

PARAMETER	LEN(M)	#DEF	LEN(M)	#DEF	LEN(M)	#DEF
STABILNOST-L	278	71	116	37	5	2
STABILNOST-D	258	64	87	29	6	3
SMER-LEVO	20	4	0	0	0	0
SMER-DESNO	13	4	0	0	0	0
PROSIRENJE	195	24	37	5	20	3
SUZENJE	40	11	17	5	5	2
NADVISENJE	240	41	133	24	23	6
NADV. > 150mm	0	0	0	0	0	0
VITO. 3.5m	93	30	24	8	12	4
TOTAL	452	249	253	108	57	20

Fig. 4.2.4.3: Numerical record of track examination coach 20 May 2016

4.2.5. Condition of sleepers and fastening systems

Falling of wheel in track can take place due to movement of the wheels on the axle (looseness of interference fit) in the direction of reducing the internal distances of wheels, or due to the spacing of rails.

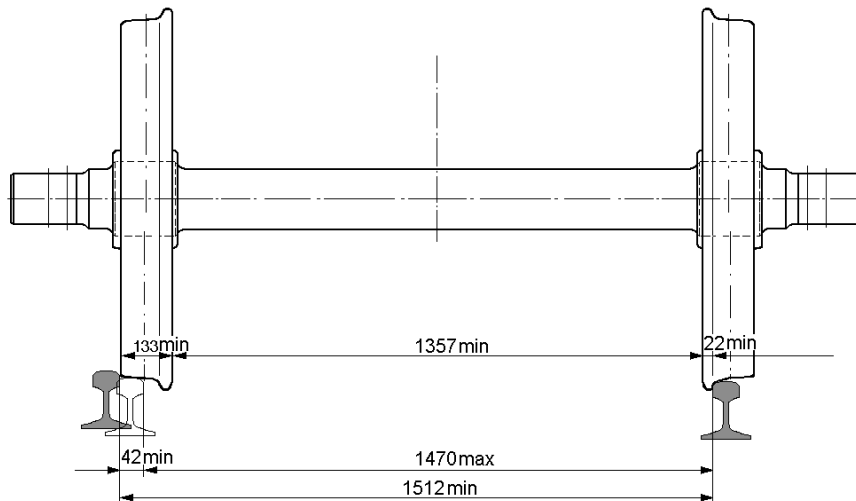


Fig. 4.2.5.1: Conditions for falling of wheel into the track

The figure 4.2.5.1. illustrates needed ratio of track and wheel set to lead to falling of wheel in the track, when the authoritative dimensions are of the permitted limits. It can be seen that it is necessary that the rails due to a loose or missing fastening systems or rottenness of sleepers, are separated by at least 42 mm over the permitted limit of 1435+35 mm. Since from the record of track examination coach it can be seen that in many places enlargement of tracks is greater than exploitation limit of +35 mm, in such places falling of wheel in the track is possible and at low additional spacing of rails.

By checking the condition of the sleepers and fastening materials it is noted that in the wider area around the point of falling of the wheel in track, track is in a state of disrepair due to a loose or missing fastening systems, shifted fastening plates and cracked or rotted sleepers. Bearing in mind that the railway is built in the early fifties of second-hand materials, sleepers are over 70 years old.

Condition of sleepers and fastening materials in the zone of falling of wheel in the track it is illustrated in Fig.: 4.2.5.2, 4.2.5.3, 4.2.5.4 и 4.2.5.5.



Fig. 4.2.5.2: Local rot beneath the support of the rail and longitudinal cracks of sleepers



Fig. 4.2.5.3: Rail- sleeper link with fastening plate and direct fastening with coach screws



Fig. 4.2.5.4: Rail-sleeper link with supporting plate and direct support with track nails



Fig. 4.2.5.5: Rail-floating and supporting joint

The shown state is not in accordance with the requirements of the applicable Rulebook of technical conditions and maintenance of the superstructure of railway track No.340-201-2/2016 (*“Official Gazette RS”* No.39/16 and 74/16), see section 3.3.5.

Also, a large number of improperly repaired rail joints has been noted.

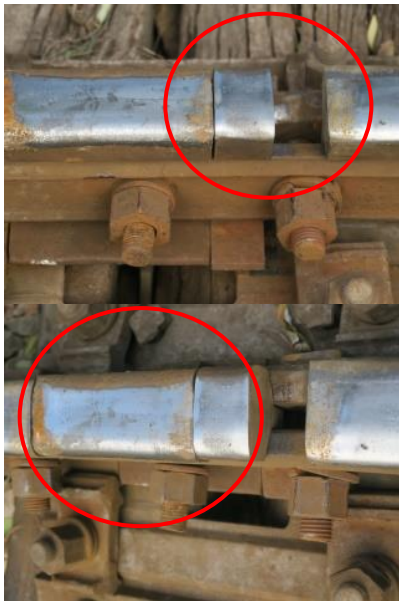


Fig. 4.2.5.1: Repaired rail travel



Fig. 4.2.5.2: Consequence of rail travel

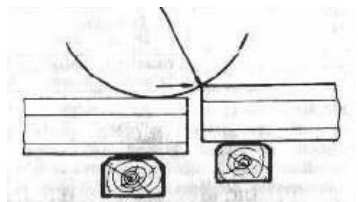


Fig. 4.2.5.3: The impact of the wheel on the rail joint

Due to the operation of the horizontal longitudinal forces especially while braking or starting the train, as well as the temperature changes, when there is reduced friction between the fastening device and the rail and between the rails pins and its substrate, there occurs a longitudinal movement of the track ("travel of rail"). In Figure 4.2.5.1, remediation of rail travel is shown on the railway track Markovac - Resavica, by inserting short rail parts, from 2-3 cm (Figure 4.2.5.1. Above), and up to 10 cm (Figure 4.2.5.1. Below).

This way of remedying of rails travel leads to the increases of the dynamic influences on the track and the impact point of the wheel on the rail in the rail joint, as shown in Figure 4.2.5.3. Connection of rail joints on a large number of places is achieved with a smaller number of connecting bolts. All of this leads to a shift of rails from the supported to the floating rail joint (Fig 4.2.5.2.), which is in contradiction with the Rulebook on technical conditions and maintenance of the superstructure of railways No.340-201-2/2016 (*"Official Gazette RS" no.39/16 and 74/16*), Article 4 and the Article 77.

4.2.6. Inspection review

Given the very poor condition of the railway track Markovac - Resavica, in order to consider all the relevant facts, CINS, on the basis of the Law on investigation of accidents in air, railway and water transport (*"Official Gazette of RS" No.66/15*), with letter 33 No.340-00-10982/2017-12 from 11 June 2018 has turned to the Ministry of Construction, Transport and Infrastructure, the Section for rail inspection, with the requirement to submit the following:

- how many inspections (regular, emergency, control and additional) were carried out at the local railway track Markovac - Resavica in the period from 01 January 2008 to 31 December 2017, and
- that for every completed inspection submits the inspection report and the decision on ordered measures (if any).

CINS has not received response to the letter.

4.3. Conclusions

4.3.1. Direct cause of the accident

The immediate cause of the accident was the unsatisfactory condition of the railway on the section where the accident occurred. The direct cause is the missing and loose fastening systems and rotting and cracked series of sleepers, combined with the track twist in the zone of derailment of 23 mm, which is over the allowed maximum exploitation that is 18 mm.

4.3.2. Basic causes deriving from skills, procedures and maintenance

Maintenance of the track on the observed section is below technically acceptable minimum.

4.3.3. Main causes deriving from legal framework and safety management system

Instruction on common criteria for control of the condition of railways on the network JŽ, Instruction 339 (*"Official Gazette ZJŽ" No.2/2001 and 4/2004*) introduced that in the case of "unsatisfactory" status of the track (errors in the geometry of the track above the limits of exploitation "C") "speed reduction", as an alternative measure, which in previous editions of Instruction 339 (in 1989) did not exist. A passage from the previous issue of Instruction 339 of 1989 was also deleted, which stipulated that prior to reaching the limits of exploitation to take measures to prevent their overdraft. Applicable Rulebook on technical conditions and maintenance of the superstructure of railways No.340-201-2/2016 (*"Official Gazette RS" No.39/16 and 74/16*)



as well as Instruction 339 does not define explicitly and clearly exploitation boundaries for condition of sleepers and fastening systems in which, due to security risks must take immediate corrective measures or close the railway track for transport.

4.3.4. Additional observations on deficiencies and shortcomings established during the investigation, but without relevance for conclusions about the causes

There aren't any observations.

5. Measures taken

After the occurrence of the respective accident, Section for track maintenance Paracin acceded to the determination of the damage and developing a plan of work organization on the repair of the damages on the tracks. Work on the remediation of the railway began on 04 November 2017 at 07:00 and lasted until 17:00, when the railway opened to traffic of trains with a restricted speed running with 10 km/h from km 33+100 to km 33+400. During the execution of works, 14 workers have been engaged who replaced 36 wooden sleepers, 12 m of rails, 216 sleeper screws, 20 base-plates and 4 ties.

6. Safety recommendations

Aiming to achieve the possible improvement of railway safety and to prevent occurrence of new accidents, CINS issued the following safety recommendations:

To the Railway Directorate:

SR_23/18 Railway Directorate that as soon as possible defines in the current Rulebook on the technical requirements and maintenance of the superstructure of railway tracks ("*Official Gazette*" No. 39/2016 and 74/2016) limits conditions and elements of the upper substructure which requires the immediate removal of or closure of railway for traffic by eliminating unauthorized condition.

(**Note:** An identical recommendation has already been given in the Report ŽS- 02/17, 33 No. 340-8059/2017-16 from 05 January 2018.)



„IŽS“ a.d.:

SR_24/18 „IŽS“ a.d. to make amendments to the Instruction on common criteria for control of the condition of railway track on the network JŽ, Instruction 339 (*“Official Gazette ZJŽ” No.2/ 2001 and 4/2004*), which with the decision of the "IŽS" a.d. No.4/2015-51-17 from 29 December 2015 is still applicable in "IŽS" a.d., in accordance with the provisions of Instruction 339 of 1989 which are listed in paragraph 3.3.4. For future track examination coaches parameters in accordance with standards: EN 13848-1, EN 13848-2, EN 13848-6 are recommended.

(**Note:** An identical recommendation has already been given in the report ŽS - 02/17, 33 No.: 340-8059/2017-16 from 05 January 2018.)

SR_25/18 „IŽS“ a.d. that, given the extremely poor condition of the track, makes an assessment of risk of train traffic on the local railway track Markovac - Resavica and take measures to reduce risks to an acceptable level. Based on this, to make a technical assessment of the minimum required resources (materials, machinery, labor) for track maintenance.

Ministry of construction, traffic and infrastructure:

SR_26/18 Ministry of construction, traffic and infrastructure, Section for Inspection, Group for Railway Inspection, to carry out an extraordinary check of the condition of railway infrastructure on the local railway track Markovac - Resavica and to take measures within its jurisdiction.