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

No.: ŽS - 04/17
33 No.: 340-00-9180/2017-18
Date: 22.06.2018.

FINAL REPORT ON ACCIDENT INVESTIGATION

Type of accident:	Derailment of shunting composition
Train No.:	Shunting composition
Place:	Belgrade, open track between junction K1 and station Rakovica
Date:	17 September 2017
Time:	08:45

This report presents the results of investigation of accident, derailment of pushed shunting composition, which occurred 17 September 2017 at 08:45 on the main arterial route E70/E85: (Belgrade) - Rakovica - Jajinci - Mala Krsna- Velika Plana, between the junction "K1" and station Rakovica.

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 број 340-9180/2017-1 of 21 September 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, Center for Investigation of Accidents in Transport drafted and published the 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
ŽS	.....	Serbian Railways
RS	.....	Republic of Serbia
a.d.	.....	Joint Stock Company
OJ	.....	Organizational Unit
SS	.....	Signalling Safety
APB	.....	Automatic track block
TT	.....	Telephone-Telegraph
TSI	.....	Technical specifications of Interoperability
JP	.....	Public Enterprise
EPS	.....	Electrical Power Industry of Serbia
TENT	.....	Thermo Power Plant „Nikola Tesla“
JUS	.....	Yugoslav standard

C O N T E N T :

1. Summary

1.1. Short description of the accident

On 17 September 2017 at 08:45 at *km* 1+935 of the main arterial route E70/E85: (Belgrade) - Rakovica - Jajinci - Mala Krsna - Velika Plana, between junction "K1" and station Rakovica, from pushed shunting composition there has been derailment of the first wagon next to locomotive (wagon type Arbel, series Faboo No.43 72 6531 273-0) with one axle. Derailment occurred so that the left wheel of derailed axle, viewed in the direction of train's movement, derailed on the outside of the track, and the right wheel fell into a track. After derailment, shunting composition transferred more 5.25 m after which it stopped.

1.2. The causes of the accident determined by the investigation

On the basis of the data analyzed, it can be concluded that the combination of twist of track above stipulated limit, unfavorable parameters of design of wagon type Arbel series Fabo which are essential to the safety of movement of vehicles on deformed track and suppression of composition of empty wagons with low speed generated the conditions that occur at the climbing of the wheel on the rail and derailing.

"Technical specification, major repair of wagons series Fabo type Arbel" provided by the TENT, does not provide sufficiently detailed check of the traction-buffing device between permanently coupled parts of wagon which leads to the situation that due to jamming of drawbar, compression forces in many cases transferr over it instead of via buffers, which adversely affects the security and increases the possibility of derailing the wagon.

The train driver of locomotive 661-116 was not provided with the safety special conditions that included the prohibition of pushing of shunting composition. In addition, the operational tasks to deliver shunting composition by pushing to the station Rakovica was given to the train driver, which is already a serious flaw in the security procedure.

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_15/18 Railway Directorate to check the licenses for the usage of wagon type Arbel, series Faboo, in sense of control of fulfillment of conditions for issuing safety certificates for transport and to bring in license special conditions for use to the public railway infrastructure these cars can be transported only as a special consignment with the prohibition of repression and, if necessary, other security restrictions, in accordance with the Article 21. of Law on Railway System Interoperability (*"Official Gazzette RS "No. 41/2018*).

SR_16/18 When issuing license for the use of new vehicles which are made by already issued license for the type, Railway Directorate to act strictly in accordance with Article 22. of Law on Railway System Interoperability (*"Official Gazzette RS" No. 41/2018*), to avoid the new vehicles getting licenses for use even when they are not in accordance with valid technical legislation (delivery and issuing of licenses for wagon series Faboo 2007/2008).

SR_17/18 Railway Directorate to to conduct a review of the safety certificate for infrastructure management "IŽS"a.d. for not taking measures to urgently eliminate defects such as type "C" as established by measurements with track examination coach according to the Instruction 339 and to take measures within its jurisdiction in accordance with Article 15. of Law on Safety in Railway Transport *("Official Gazzette RS "No. 41/2018).*

SR_18/18 Railway Directorate to review the Rulebook on technical conditions and maintenance of the superstructure of railway lines ("*Official Gazette RS" No.39/16, and 74/16*) and to include in it the limit of the geometric parameters of railway condition, including twist, on the basis of standards SRPS EN 13848-5 and SRPS EN 13848-6 and to define, complied with these limits, the obligation of measuring the condition of track with track examination coach and action based on measurement results.

Ministry of Construction, Transport and Infrastructure:

SR_19/18 Ministry of Construction, Transport and Infrastructure, Sector for Inspection, Group for Railway Inspection to carry out extraordinary check of railway infrastructure on the main arterial route E70/E85: (Belgrade) - Rakovica - Jajinci - Mala Krsna - Velika Plana between junctions "K1" and station Rakovica and, if necessary, take measures within their jurisdiction.

„IŽS" a.d:

SR_20/18 „IŽS"a.d. to conduct examination of the reasons why the measures have not been taken for urgent elimination of defects type "C" that were determined during the measurement with track examination coach under the Instruction on unique criteria for control of the condition of railways on the network JŽ, Instruction 339 *("Official Gazette ZJŽ" No.2/2001 and 4/2004)* and to develop coordination between sectors that determined the defect and sectors that should eliminate this defect, and under review of management in order to follow and analyze these cases. According to the evaluation of safety risks which due to this occurred, to take efficient measures for elimination of the safety flaws, and in accordance with the Article 5 of Law on safety in Railway Transport *("Official Gazzette RS" No.41/2018)* and its Safety Management Manual.

JP „EPS“ branch TENT:

SR_21/18 JP „EPS“ branch TENT that in future purchases of new vehicles for their fleets require the vendor delivering vehicles compliant with the current technical regulations, in order to avoid the risk of obtaining the decision to deny a license for the vehicle type.

SR_22/18 JP „EPS“ branch TENT to review and supplement the maintenance instructions for the traction-buffing devices between two parts of wagon Arbel series Fabo, by analogy with the checking of head traction-buffing devices along with regulation of control of resilient elements of drawbar and small buffers on the press and the addition of appropriate measuring and control lists, and in order to avoid that these traction-buffing devices are too pre-stressed or with a gap when they are in a state with no external load.

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 17 September 2017 at 08:45 in the territory of Belgrade, on the main arterial route E70/E85: (Belgrade) - Rakovica - Jajinci - Mala Krsna - Velika Plana between Junction “K1“ and station Rakovica, in Belgrade settlement Kneževac, on the section that is located on the embankment.

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

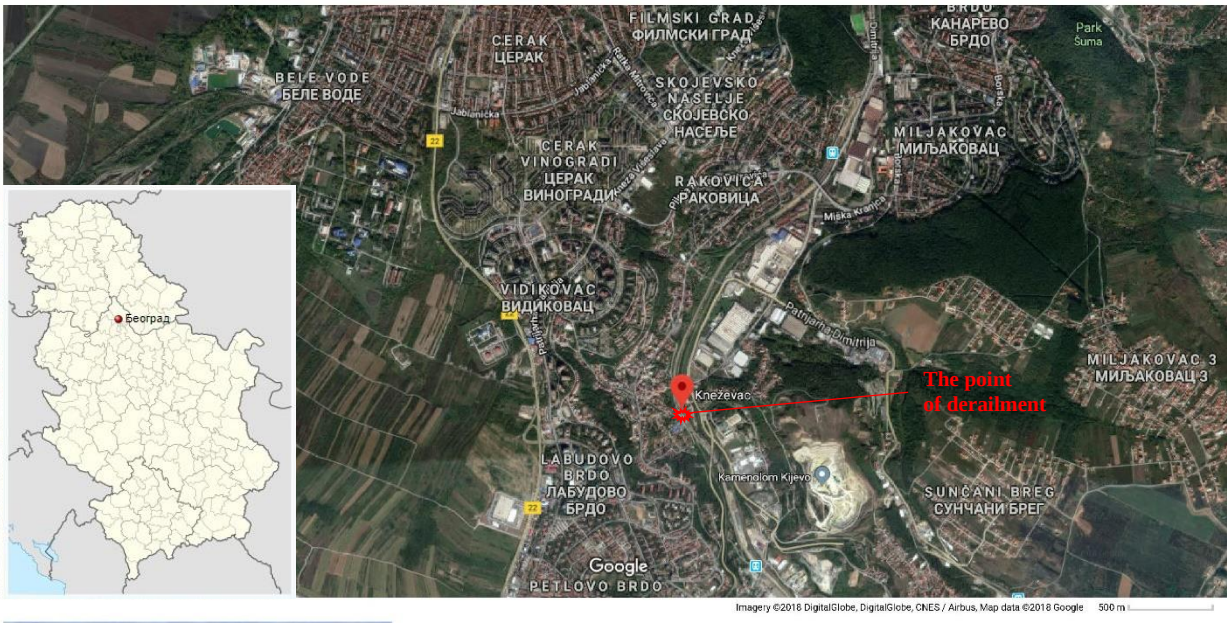


Fig 2.1.1.1: The area of the accident site (source: *Google maps*)

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

On the main arterial route *E70/E85*: (Belgrade) - Rakovica - Jajinci - Mala Krsna - Velika Plana between Junction “K1“ and station Rakovica, immediately after launch of shunting composition in the direction of the junction "K1" to the station Rakovica, on the open line, close to the spatial signal Qu 92 (which is located at 2 + 080 km), at km + 1 935 there has been a derailment of shunting composition.

Shunting composition consisted of locomotive 661-116 and 10 wagons type Arbel series Faboo. Wagons from shunting composition were part of the train No. 53786, in which on 16 September 2017 at 13:05 at km 1+938 derailment occurred of one wagon Arbel type series Fabo (the first car to driving locomotive 461-125). Wagons type Arbel, series Faboo that were part of shunting composition are owned by JP "EPS", a branch TENT Obrenovac. A locomotive 661-116 is owned by "Srbija Kargo" a.d.

After the derailment of the train No. 53786 occurred on 16 September 2017., in order to ensure a car from self rolling before declutching of driving locomotive 461-125 to approach the derailed wagon, at the end of the train was delivered, coupled and included in the main brake pipe of locomotive 661-116. This was done because the wagons type Arbel series Faboo, that were included in the train No. 53786, does not have a stop brake.

After raising on the track and draw from the site derailed wagon in the accident from 16 September 2017. on the aforementioned section remained 10 wagons type Arbel series Faboo with locomotive 661-116.

The respective wagons should be dispatched from the open track to the station Rakovica. For this purpose, from locomotive 661-116 and listed wagons formed pushed shunting composition that is at the site, from the open track, launched in the direction of the station Rakovica on 17 September 2017 at 08:44.

After crossed about 40 m, there occurred a derailment of the first wagon to the locomotive 661-116. Traces of derailment of the first wagon of type Arbel, series Faboo No. 43 72 6531 273-0 to the locomotive have been observed at km 1+935. The shunting composition moved for more 5.25 m, and then it stopped.

The wagon type Arbel, series Faboo, consisting of two two-axle parts, forming an indivisible unit. In the respective accident, on the wagon No. 43 72 6531 273-0 derailment of the second axis, as viewed from the locomotive, occurred, so that the left wheel of the derailed axis, viewed in the direction of movement of shunting composition, derailed at the outside of the track, and the right wheel fell into track.

Derailed wheels are found by the track on the left side of the tracks from which they were derailed, viewed in the direction of movement of the shunting composition, at a distance of 7 cm from the rail from which they derailed.

All eleven wagons type Arbel, series Faboo that were part of the train No. 53786 were empty and were returning to Obrenovac after regular repair in the workshop “Inter Mehanika” d.o.o. Smederevo.

Since there were no killed or injured, there were not engaged emergency medical services and the police.

Because of this accident, there was an interruption of traffic between the stations Rakovica, junction "K1" and Jajinci station. The interruption lasted until 18 September 2017. at 05:30 for trains with diesel traction, and until 11:05 for trains with electric traction.

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 at 09:00 by telephone by the Assistant Director of Operations "IZS"a.d. Based on the received first information and due to the fact that the day before there was a derailment of wagon type Arbel series Faboo, the Main investigator decided to come out to the site. On the basis of the facts established at the site, 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. 340-9180/2017-1 of 21 September 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

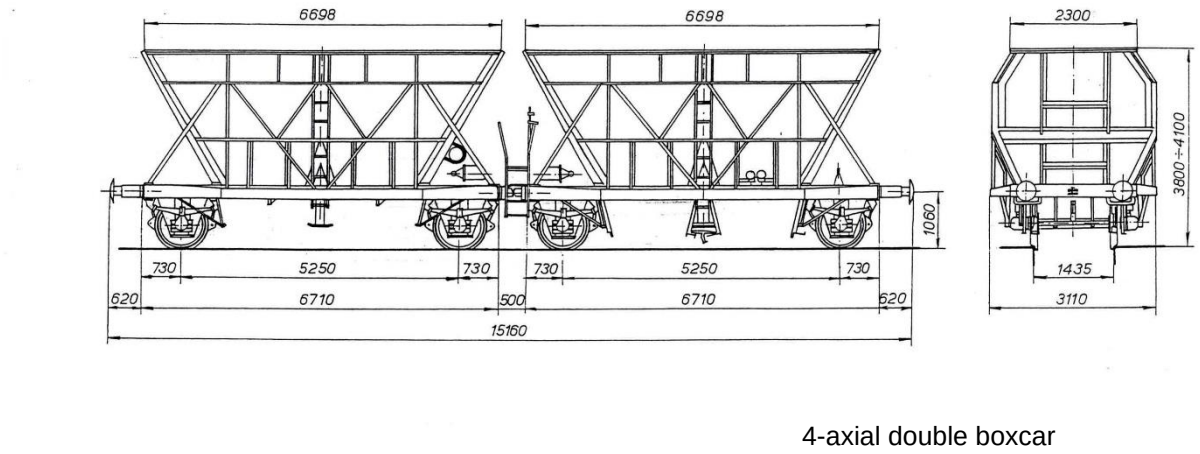
2.2.1. Involved railway staff, contractors, other persons and witnesses

Train driver and assistant train driver were involved in the accident of locomotive 661-116 which was part of derailed shunting composition, employed by the rail undertaking "Kargo Srbija" a.d., Section for traction Belgrade, OJ for traction Belgrade.

The staff of the infrastructure manager "IŽS" a.d. 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 pushed shunting composition was involved. The shunting composition consisted of ten wagons type Arbel, series Faboo and locomotive 661-116.



4-axial double boxcar

Fig. 2.2.2.1: The view of the wagon type *Arbel*, se

The wagon type Arbel, series Faboo are designed for traffic on the lines of normal gauge (1435 mm) and serving for the transport of ore. The wagon is composed of two two-axles parts which form an indivisible unit. Unloading is done by automatic opening doors by affecting on fixed device on the wagon at the place of unloading. The quality and size of material for making wagons comply with the requirements of JUS. Interchangeable parts are corresponding to UIC regulations. The wagon is capable of subsequent reception of the automatic coupling.

Techinical data (some characteristics):

Overall length via buffer	15160 *mm*
The length of the underframe (one part)	6710 *mm*
The distance between axis of one part	5250 *mm*
Number of the axes	4
Maximum speed	80 *km/h*
The wagon mass (according to sign on the wagon)	22,35 *t*

Fig. 2.2.2.2: Table of wagon series *Faboo* No. 43 72 6531 273-0

2.2.3. Infrastructure and safety signaling system

Arterial route *E70/E85*: (Belgrade) - Rakovica - Jajinci – Mala Krsna – Velika Plana, between stations Rakovica and Jajinci is a one-track route. It was built in 1988. On the section the rails type S49 and concrete sleepers type *JŽ-70* have been installed.

Maximum speed, according to the timetable booklet 9.2. (which was valid at the time of respective accident), on the section between stations Rakovica and junction ”K1“ is 80 km/h, and on the section between Jajinci station and junction ”K1“ is 60 km/h.

According to the timetable booklet , on this section, there is a one speed limit and it is, from km 1+700 to km 2+350 with 30 km/h (reason: bad terrain, the substructure of the track). In addition, on the section between the stations Rakovica and Jajinci, from km 3+620 to km 3+710 (area of junction ”K1“) a restricted-speed running with 30 km/h was introduced (reason: the poor condition of parts of switches No. 2K1 and 3K1).

The section between Rakovica and Jajinci is equipped with APB devices, in which train traffic is regulated in block departments.

For the purpose of regulating the traffic, on the section between Rakovica and Jajinci, the main signals have been built (spatial, protective, entry) showing a two-way aspects of signal.

Due to the condition of SS devices formed as a result of frequent thefts of railway property (parts of SS devices) by third parties, APB devices are not in operation, and traffic on the aforementioned section is regulated in the station distance.

2.2.4. Communication tools

On the section between the stations Rakovica and Jajinci, communication between personnel in charge of traffic regulation is performed by phone via local TT connection. The line of communication includes all official locations on the track. Communication on this line is recorded on the register device located in the ETP Section Topčider, so this type of communication is considered as evidence-based communication.

Telephones by the main signals are connected to a local TT line which enables communication between train staff and staff that regulates the traffic. This line is not included in register device (phone calls are not recorded).

2.2.5. Works at or near the accident site

On the section *E70/E85*: (Belgrade) - Rakovica - Jajinci - Mala Krsna - Velika Plana, in the zone of occurrence of the respective accident, which is located on the embankment, as well as near the accident site, the works have not been performed.

The works are performed on the reconstruction by main repair of the part of the main arterial route *E70/E85*: (Belgrade) - Mladenovac - Lapovo - Niš - Preševo - state border - (Tabanovce), between the junction “G” and station Rakovica and stations Rakovica and Resnik. The site of works is partly located in the foot of embankment on which the respective accident occurred.

The works were carried out and the organization of traffic during the works was carried out according to the Instruction on the organization and regulation of traffic during the conduction of works on reconstruction by main repair of the section Junction “G” - Rakovica - Resnik on the route Belgrade - Niš - Preševo - State border - (Tabanovci) No. 1/2017-1623 of 29 March 2017.

These works did not affect the organization and safety of traffic on the main arterial route E70/E85: (Belgrade) - Rakovica - Jajinci - Mala Krsna - Velika Plana.

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

All the intersted parties were infomed 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. The representative of the wagon owner (TENT) was not included in the work of the Committee. Upon completion of the investigation, the Investigation Report U-429/17 was drafted.

Given the fact that at pushed shunting composition, the first wagon to the locomotive derailed, the first nine wagons with the use of emergency locomotive was drawn into the station Rakovica on 17 September 2017 at 12:26. On-site remained derailed wagon and locomotive 661-116.

Emergency train arrived at the station Rakovica at 16:39. After dispatchers order it was dispatched at 16:58 to km 1+920 (up to derailed wagon). With the purpose of raising of the derailed wagon at 21:17 the voltage in the catenary was turned off on the section between the stations Rakovica, junction "K1" and station Beli Potok. After raising the derailed wagon, the voltage is switched on at 22:07. Emergency train with derailed wagon arrived at the station Rakovica at 22:32.

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 wagon is damaged (wagon type *Arbel*, series *Faboo* No. 43 72 6531 273-0).

The structure of the material damage is given as follows:

Damage on *Faboo* wagon No. 43 72 6531 273-0	32660,66	rsd
Total costs of raising the derailed wagon (with the engagement of traction vehicles of „Srbija Kargo"a.d.):	313534,40	rsd
Costs of the work of catenary team on the check of contact line and securing the place of work	11880,00	rsd
Costs of work of motor track vehicle series 916-180:	38796,00	rsd
Total direct material damage:	**396871,06**	**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 15 September 2017, which is 1 EUR (Euro) = *119,0326* RSD (Dinars), the total material damage caused in the respective accident amounts to 3334,14 Euro (EUR).

The material damage in this report is stated based on documents submitted by invoices, estimates, i.e. documents that that confirm the stated damage amounts, delivered by "Srbija Kargo" a.d. and JP "EPS" banch TENT.

2.3.4. External conditions - weather conditions and geographic characteristics

The site of serious accident is located in the area of Belgrade, in the settlment Knjaževac, on the section which is located on the embankment.

The geographic coordinates of the place of accident are: 44º 43' 56,95" *N* and 20º 25' 51,56" *E*.

At the time of the accident, the weather was changeably cloudy with occasional intensive rainfall, followed by the wind of stronger intensity. The air temperature was 19°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:

- On-site investigation performed by CINS Investigation team,
- Aditional review of the derailed wagon that CINS Investigation team performed with the presence of JP "EPS" branch TENT in Obrenovac,
- Materials delivered from infrastructure manager "IŽS"a.d.,
- Materials delivered from undertaking "Srbija Kargo"a.d. and
- Materials delivered from JP "EPS" branch TENT in Obrenovac.

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. In the work of joint investigation committee the representative of the wagon owner JP "EPS" branch TENT in Obrenovac has not been included.

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

3.1. Summary of testimonies

Statements from hearings of train driver and train driver assistant of locomotive 661-116 from "Srbija Kargo"a.d. were obtained.

From "IŽS"a.d. Reports on irregularities during opearation were obtained from train dispatchers (*S-23*) of stations Rakovica and Jajinci 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: “from dispatcher of the station Jajinci I was given a little travel certificate (S-56) and general order (S-51) with a kilometer position of the train where I need to come with a locomotive. When approaching the end of the train, we coupled locomotive for gross, letting out the air, we kept the train braked with a pressure of one bar and from the dispatcher we waited for further instructions. At 8:30 train dispatcher of station Rakovica called me on the phone and told to push the train into station Rakovica on the seventh track. I released brakes on the train and started pushing the gross and after twenty meters I saw that the first wagon to locomotive has fall out and I braked the train. After falling out, I informed the train dispatcher and mechanical dispatcher”.

The train driver assistant stated: “with locomotive 661-116 I came with the train driver to km 2+050 to ensure a car from self-rolling, after the accident that occurred on 16 September 2017 at 13:05. On 17 September 2017 in the period from 06:30 to 08:40, the train driver have repeatedly spoken with the train dispatcher from station Rakovica via telephone line, related to pushing the wagons into the station. As soon as the composition started moving, I noticed that the first wagon to the locomotive rocked and we immediately stopped the locomotive. We took a tour and found that the first wagon to the locomotive derailed with one axle. We immediately informed train dispatcher at the station Rakovica and traction dispatcher about the accident occurred.“

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 investigaton, they drafted a Report on investigation U-429/17. In the work of the joint committee the representatives of the owner of the derailed wagon were not included.

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 accident, where the train driver and the train driver assistant 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.

3.2.3. Procedures for internal audits and controls and their results

JP "EPS", branch TENT, as infrastructure manager does not have established Safety Management System.

"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 additonal maintenance includes regular supervision, controls, checks, repairs.

Requests, standard and activities for maintenace 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 superstructure 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.41/2018*)

Artcle 10, Paragraph 1:

Infrastructure Manager is required to provide a safe and continuous organization, regulation and management of railway traffic, uninterrupted access and use of railway infrastructure and access to facilities that are given for management and services that he provides in these facilities to all interested applicants for infrastructure capacity allocation, under equal, non-discriminatory and transparent conditions, as well as permanent, continuous and quality maintenance and protection of the railway infrastructure.

3.3.2. Law on Railway System Interoperability (*"Official Gazzette RS" No. 41/2018*)

Article 21, extract:

...

License for use must contain specific terms of use or other restrictions.

...

After issuing the license for use of structure subsystems, Directorate checks:

1) infrastructure, in terms of issuance and control of the fulfillment of conditions for issuing safety certifactes for infrastructure management,
2) vehicles, in terms of issuance and control of the fulfillment of conditions for issuing safety certificates for transport.

Article 22, excerpt:

...

For existing vehicles that have received license for use before the entry into force of this Law, shall be deemed to have license for use, but to them is also applicable Article 30 of this Law.

In the case of changes in the relevant provisions of the TSI-s and national railway technical regulations based on which type of vehicle is authorized, Directorate will decide whether already issued license for the type remains valid or it is needed to issue a new one.

The subject of verification in case of issuance of new licenses for the type of vehicle applies only to parts of the regulations that have been changed. Issuance of new regulations for the type does not affect on the licenses for use of vehicles that are issued on the basis of previously authorized types of vehicles.

3.3.3. Law on Safety in Railway Transport (*"Official Gazzette RS" No. 41/2018*)

Article 5, (extract):

Ministry responsible for traffic (hereinafter: the Ministry), Directorate, Center for investigation of accidents in transport (hereinafter: Center), infrastructure manager (hereinafter: manager) and the railway undertaking, each in accordance with the activites performed, provides:

1) that safety of railway traffic is maintained in the railway system, and, where appropriate, to be continuously improving, wherein priority is given to prevention of accidents

....

Article 10:

Law on Safety in Railway Transport for oversight of the safety performance after issuing safety certificates for transport or safety certificates for managing railway infrastructure Directorate applies for the purpose of monitoring of the implementation of safety management system of the railway undertaking and control after the issuance of safety certificates for transport or safety certificates for management of railway infrastructure, as well as control over the implementation of Law on Safety in Railway Transport in Article 11 of this Law by the rail undertaking and the person responsible for maintenance.

Article 14, paragraph 1:

Manager and Railway undertaking shall establish a safety management system, which aims to achieve Law on Safety in Railway Transport for the railway system as a whole. Safety management system must comply with the notified national safety regulations and safety requirements set out in TSI and relevant provisions of Law should be applied.

Article 15:

Directorate conducts review over Safety Management Systems of infrastructure manager and railway undertaking, after issuance of safety certificates for railway infrastructure management and safety certficates for transport.

With review of Paragraph 1 of this Article whether infrastructure manager and railway undertaking are applying the Safety Management System is checked, and, when necessary, conduction of certain measures is ordered.

The decision ordering the implementation of appropriate measures referred to in Paragraph 2 of this Article is final in an administrative procedure and against it may be initiated dispute at the Administrative Court.

Review on the site, in terms of Paragraph 1 of this Article, is performed by authorized personnel of the Directorate, at least once a year.

3.3.4. Law on Railway (*"Official Gazette RS" No. 45/2013 and 91/2015*) repealed on 08 June2018

Important notice: at the time of the respective accident, the law was applicable.

Artcle 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 means for rail traffic, as well as the organization and regulation of safe and smooth rail transport.

3.3.5. Law on Railway Safety and Interoperability *("Official Gazette RS" No. 104/2013, 66/2015 - other laws and 92/2015*) repealed on 08 June2018

Important notice: at the time of the respective accident, the law was applicable.

Article 42, Paragraph 1:

Infrastructure manager and railway undertaking shall establish safety management system, which aims to achieve ZBC for the railway system as a whole. Safety management system must comply with the notified national safety regulations and safety requirements established in the TSI and relevant provisions of the common safety methods should be applied.

3.3.6. Instruction on unique criteria for control of the condition of tracks on the network JŽ, Instruction 339 (*"Official Gazzette ZJŽ" No.2/ 2001 and 4/2004*)

Warning: Decision "IZS" ad No. 4/2015-51-17 from 29 December 2015. on take over of the regulations issued by ZJŽ as their internal acts in accordance with Article 152 of Law on railway safety and interoperability, the Instruction has been downloaded and is still in use by "IŽS" a.d.

Paragraph 9, subparagraph 3. of the applicable Instruction 339 from 2001/2004, extract:

...

All errors on the track of the individual elements of the geometric condition of tracks are divided into three groups:

- A - values per parameter to which it is not necessary to plan and carry out works
- B - mistakes because of which one should plan work for their elimination
- C - errors that are beyond the limits of exploitation and which require urgent elimination or reduction of targets speed

...

3.3.7. Rulebook on maintenance of railway vehicles No. 340-382-7/2015 from 04 December 2015 (*"Official Gazzette RS" No. 101/2015*)

Article 4, extract:

...

Parts of railway vehicles important for safe railway traffic, within the meaning herein, include:

1) the braking devices and their parts (brakes);
2) the axle set;
3) traction and buffing equipment;

....

3.4. Functioning of railway vehicles and technical installations

3.4.1. Control, command and signalling

On the section between stations Rakovica and Jajinci the devices for control, management and siganlization are not in operation. The traffic on the aforementioned section is done in station distance

3.4.2. Infrastructure

According to the data from surveys of track conducted in the period before the occurrence of the respective accident, carried out by the industry for track maintenance "IŽS" a.d., Section for track maintenance Beograd, the state of facts given below was established.

The site of the resepective accident is located on a gradient of 5.8‰ (a downgrade of 5.8‰, viewed in the direction of movement of shunting composition) and the right curve viewed in the direction of movement of shunting composition (i.e. left-hand curvature when viewed in the direction of increasing mileage), the radius R=504 m and the length of 532 m. The accident (derailment), viewed in the direction of movement of shunting composition, has been on the part of the transition curve, 7 m ahead of the start of the circular curve.

Due to the poor condition of the elements of the substructure, on the section at the km 1+700 to km 2+350, the introduction of a speed limit of 30 km/h was set.

Rail grid is on crashed stone ballast bed of limestone origin.

From "IŽS" a.d. information was obtained that in the period from 01 September 2016 until the occurrence of the respective accident, in this part of the railway there were not important works, besides review of track with track examintion coach and visually.

On the part of the railway line between the stations Rakovica and Jajinci, on 23 May 2017 the measurement of parameters of track was carried out by track examination coach, type EM 80L. Data on executed measurements are provided in the form of graphical and analytical part of the report. Not submitted: analysis of measuring drive, proof of delivery of errors of type "C" to the supervising relevant section and evidence that the competent railway section in time of "emergency" conducted elimination of the identified errors of type "C", especially errors of twist and stability.

After examining the submitted graphic part of the report, it can be seen that the section from km 1+700 to km 2+300 recorded more errors type "C" and on the twist of track and cross level. Part of graphical review of reports of measuring drive is shown in Figure 3.4.2.1.

Monthly visual inspection of the railway by the head of railway sections, was carried out according to the priority of work. For carried out checks (the exercise date, found condition, record) data have not been submitted except the conclusion that in the period from 09 January 2016 until 16 September 2017. the larger deficiencies were not detected for a given train speed.

Due to an insufficient number of guards of the track, the track review, which should be done daily, was carried out according to the existing situation, depending on the current number of guards and priorities of the respective tracks. In the book of guards of the track (ZOP-2) irregularities that could endanger the safety of the traffic were not recorded.

Other data on the performed regular and extraordinary inspections of the section were not submitted.

On-site investigation carried out after the formation of the respective accident, the condition was determined in the following text.

Shunting composition stopped so that the end shunting composition (end of locomotive 661-116) was found at km 1+955, while the derailed axle was found at km 1+930.

During the investigation on-site, measurement of the track gauge and cross level was performed in the area where the first signs of derailment were noticed. The measurement was carried out after the resulting derailment, and before a mechanical regulation of track which is performed after clearing the site of an accident in order to repair the damages.

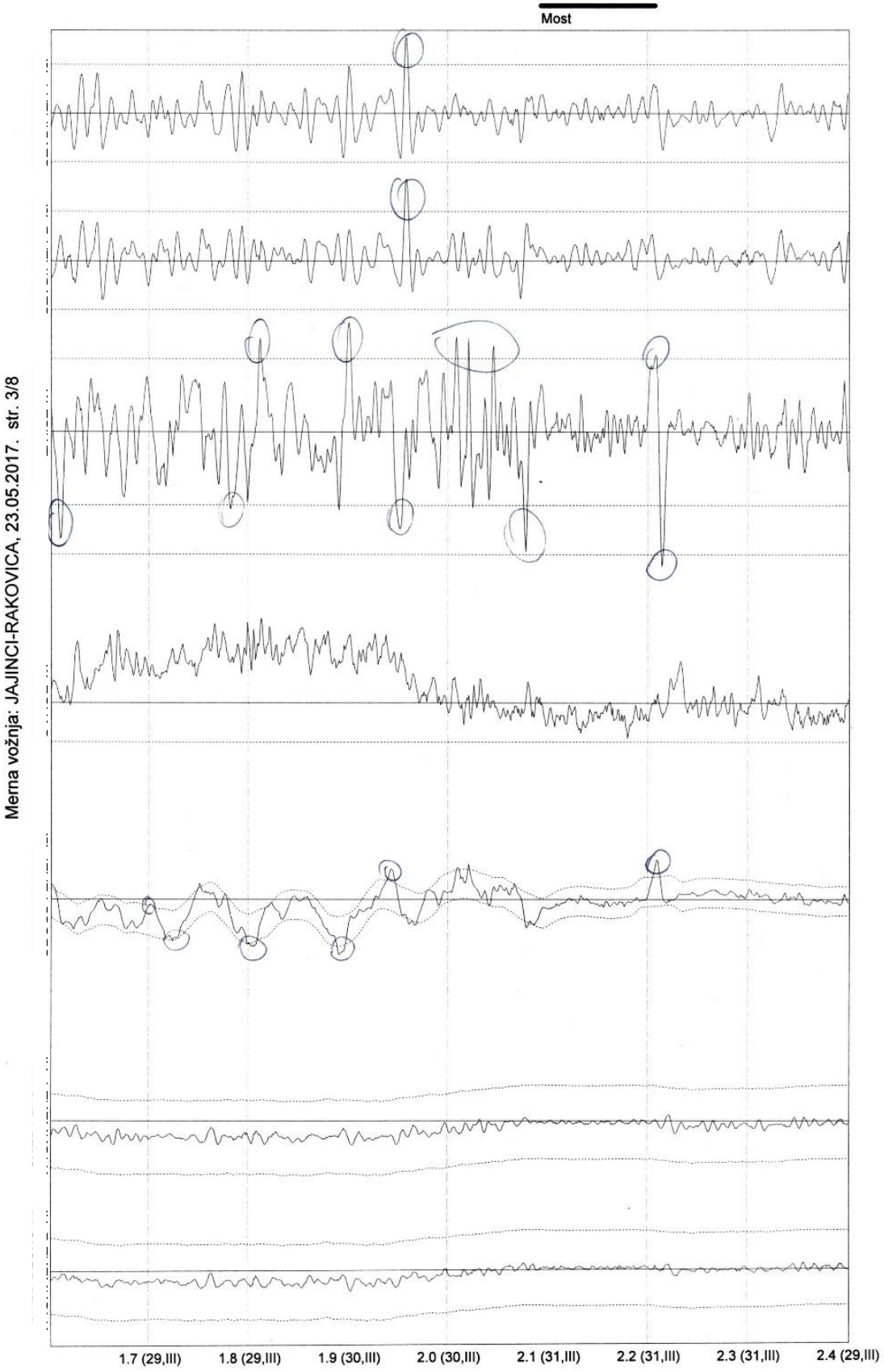


Fig. 3.4.2.1: Part of graphic report of the track examination coach

Record of the measuring of track is delivered from the Section for track maintenance Belgrade, "IŽS" a.d. The measured values of the gauge and cross level are given in Table 3.4.2.1

Table 3.4.2.1: Gauge of track and cross level of rails

km position	gauge (mm)	cross level (mm)	warning
km 1+938	+12	26	
km 1+943	+10	21	
km 1+948	+10	21	
km 1+953	+10	20	
km 1+958	+9	19	
km 1+963	+9	18	
km 1+968	+8	17	
km 1+973	+7	16	
km 1+978	+7	15	
km 1+983	+7	14	
km 1+988	+6	10	

By the chief investigator for rail traffic of CINS and representatives of the construction affairs "IŽS"a.d, on-site measurement of track gauge and cross level of the rails in the derailment area.is performed. Measurements were made by Gauge measure device of brand Robel, property of "IŽS"a.d. As prime sleeper is designated sleeper at km 1+938 (where trail of derailment was spotted from 16 September 2017). The measurement was carried out on the sleeper from 1 to 12 in the direction toward decreasing mileage at km 1+935 where the observed track of derailment for accident of 17 September 2017, i.e. in the direction of movement of shunting composition. View of track gauge and cross level of rails is given in Table 3.4.2.2.

Табела 3.4.2.2: Gauge of track and cross level of rails

km position	gauge (mm)	cross level (mm)	warning
1. sleeper	+14	+21	
2. sleeper	+16	+22	
3. sleeper	+17	+20	
4. sleeper	+17	+21	
***5.* sleeper**	**+16**	**+19**	***km* 1+935, point of derailment**
6. sleeper	+16	+18	
7. sleeper	+15	+18	
8. sleeper	+16	+19	
9. sleeper	+16	+20	
10. sleeper	+15	+19	
11. sleeper	+14	+19	
12. sleeper	+13	+21	

Measuring of wearing out of rails is not executed on the spot. From "IŽS"a.d. evidence for wearing out of rails for the year 2016 was submitted. The measurement was carried out in September 2016. Measured values of wearing out of rail in the derailment zone are given in Table 3.4.2.2.

Table 3.4.2.2: Wear out of the rails in the derailment zone (*mm*)

km position		Internal rail (left rail)		Extrnal rail (right rail)	
		I	II	I	II
km 1+500	ппк	1	1	3	12
km 1+657	пк	0	1	2	12
	ск	1	1	1	12
km 1+928	кк	3	0	1	12
km 2+058	кпк	2	2	1	12

ппк Beginning of the switch curve
кпк End of the switch curve
пк Beginning of the curve
ск Middle of the curve
кк End of the curve

3.4.3. Means of communication

At the time of the respective accident, the means of communication were safe and operational. No malfunctions or failures of communication devices were documented

3.4.4. Railway vehicles

At the time of occurrence of the respective accident, the pushed shunting composition was moving in the direction from the junction K1 to the station Rakovica (from the beginning towards the end of the railway line, in the direction of decreasing mileage).

During the drive of shunting composition, at wagon No. 43 72 6531 273-0 (first next to locomotive 661-116) the second axes has derailed, viewed from the locmotive, in a manner that the left wheel in the direction of movement has lifted on the outside rail of the curve and behind that he fell on the outside part of track. Just after moving the shunting composition, the derailment occurred after passed 40 m approximately.

The wagon derailed was found so that the derailed axle was at km 1+929.75 and is caught in a manner that the left wheel, viewed in the direction of movement of shunting composition, fell on the outside of the track, a right wheel fell into a rut. The other three axles of respective wagon were caught on the tracks. The wheels of derailed axle were found at a distance of 7 cm from the rails. On the derailed car are observed damages on the wheels of slipped axles (lanes caused by movement on track equipment and broken stone).

Shunting composition was not decoupled. Derailed wagon type Arbel series Faboo No. 43 72 6531 273-0 are caught up as the first next to locomotive in the area of track on its wheels. There was no tilting or overturning of the car.

Appearance of the derailed wagon is shown in Figure 3.4.4.1. and 3.4.4.2.

Fig. 3.4.4.1: The view of the derailed wagon

Fig. 3.4.4.2: The view of the derailed wagon

On locomotive 661-116 speed meters of the manufacturer Hasler are installed: registering speed meter of the type RT9, serial No. 0005 and indicating speed meter type A16, serial No.H07.222. These speed meters were tested on 28 February 2017, with expiration date on 28 February 2018.

From registering speed meter of the driving locomotive 661-116, registering lane was removed on 17 September 2017 at 13:16. By analyzing the data (Report from speed meter lane No.3-485 from 29.09.2017), it was determined that last moving of the locomotive was registered at 08:22 and slight movement up to 7 km/h. All the times are based on the speed meter clock.

From stopping to removing the registering lane, the moving of locomotive 661-116 has not been registered.

Given the data from the speed meter lane of locomotive 661-116, it was stated that there was no violation of the speeding limit on this section (30 *km/h*).

3.5. Traffic operation and management

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

Starting the shunting composition from the open track to station Rakovica was done according to the order of the train dispatcher of station Rakovica.

3.5.2. Exchange of voice messages in relation to the accident

Immediately prior to the occurrence of the accident, communication between train driver of locomotive 661-116 and staff which regulates the traffic (train dispatcher of station Rakovica) for the purpose of issuing orders for the starting movement of shunting composition from the open track and pushing it into the station Rakovica was achieved.

The communication between train drivers and staff which regulates traffic was achieved after the occurrence of the accident concerning the purpose of notification, in such a manner that a driver of locomotive 661-116 informed the train dispatcher of station Rakovica and dispatcher of traction of the resulting accident.

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

Traffic was closed on the section from 13:05 on 16 September 2017 due to derailment of one wagon type Arbel series Faboo from the train composition No. 53786.

Given the fact that all ten wagons type Arbel series Faboo that were in shunting composition do not have the parking brake, that shunting composition after the respective accident stopped on the part of the railway where the gradient is 5.85‰ and 9‰ (a downgrade of 5.85‰ and 9‰, viewed in the direction of movement of shunting composition), with a tendency of increase of downgrade to 15‰, and that there has not been a derailment, shunting composition is secured against self-rolling with locomotive 661-116.

As the train was not carrying goods hazardous to the peoples lives, no specific measures were undertaken for securig 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 661-116 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 driver and the driver assistant of the locomotive 661-116 were qualified and bodily and mentally fit to perform their work. For the driver of locomotive 661-116 a certificate was issued by the Railway Directorate to confirm that his application was submitted and conditions were fulfiled that are required to issue the licence for the operation of a traction vehicle.

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

The section of the main arterial route *E 70/ E 85*: Belgrade - Rakovica - Jajinci - Mala Krsna - Velika Plana between the station Rakovica and Junction “K1“ is designed for speeds up to 60 *km/h*.

According to the designed condition, there are APB devices that regulate the traffic in block departments.

Due to the poor condition of the field (track substructure), on the section from km 1+700 to km 2+350 there has been introduced the speed limit of 30 km/h.

Given the frequent theft of parts of railroad equipment for traffic regulation by the third parties, the APB devices on this section are not in operation, so that, in accordance with the relevant road traffic regulations, traffic regulation takes place in the station distance.

Managing the locomotive is performed by the driver nad driver assistant. At the locomotive 661-116 all the shortcomings identified in the systems and control devices are eliminated, so any complaints or defects are not 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 17 September 2017, on the "IŽS"a.d. rail network, there have been 11 accidents in total (derailments) in which wagons type Arbel, series Faboo participated. The review of the accidents occurred is given in Table 3.7.1.

In all the aformeentioned accidents there were no dead nor injured.

Warning: 28 February 2011 by Telegram No.770 "ŽS"a.d. it is ordered that this type of wagons is transported as a special consignment and the pushing of this type of wagon is prohibited. The aforementioned telegram was not delivered to CINS.

Table 3.7.1: Review of accidents occurred in the period from 01 January 2008 to 17 September 2017

No.	date	time	Short description	cause
1	04.07.2008.	17:20	At *km* 34+340 during the entrance of the train No. 52184 on 3. track of station Ralja, in front of the crossover no.2, one Arbel wagon derailed	**Set of different cirumstances**
2	27.07.2008.	13:58	At *km* 2+200 between stations Smederevo and Radinac, derailment of the train No. 57704 with one Arbel wagon	**Set of different cirumstances**
3	15.04.2009.	23:03	During the work of maneuvre at station Ćuprija there was a derailment of one Arbel wagons with two axles	**The solid beam - connection between the first and the second half of the wagon Arbel F054 which has fallen out of their normal position and that when supression (pushing) of the wheel does not carry out its function - the proper conduct**
4	02.07.2011.	00:40	During the work of maneuvre at station Niš, on the crossover No. 89 and 87 a/b one Arbel wagon with two axles	**Maneuvring by pushing which is forbidden with the telegram No. 770 from 28.02.2011. because of the technical construction of wagon type *Arbel.***
5	29.05.2013.	02:25	At *km* 34+404 in the area of the station Ralja between switch 2 and 3 at the train No. 62188 дошло је до исклизнућа једних *Arbel* кола	**Set of different cirumstances**
6	08.07.2014.	17:42	In the area of station Ralja between switches 1 and 2 at train No. 52186 two Arbel wagons derailed	**Set of different cirumstances**
7	11.07.2014.	09:25	At *km* 37+690 between stations Grošnica and Drgaobraća, at the train No. 53801 four Arbel wagons derailed	**Set of different cirumstances**
8	09.05.2016.	23:02	At *km* 2+170 between stations Smederevo and Radinac, at train No. two Arbel wagons with one axle each derailed	**Set of different cirumstances**
9	14.04.2017.	13:50	In the area of station Lapovo during the work of maneuvre at the switch No. 376 one Arbel car with two axles derailed.	**Technical defect on the wagon - nut on the solid ties**
10	16.07.2017.	23:33	At *km* 59+300 between stations Gruža and Guberevac at train No. 6801 two Arbel wagons derailed with four axles, and other with two axles	**Set of different cirumstances: track, constructive characteristics of wagon and unstable drive of the train**
11	16.09.2017.	13:05	At *km* 1+938 between stations Rakovica and junction „K1“, at train No. 53786 one Arbel wagon with one axle derailed	**Set of different cirumstances: rigid coupling of wagon, twist of track, side wear of rail in curve**

Based on data provided by JP “EPS” branch TENT Obrenovac, for the period from 01 January 2008 to 17 September 2017, on the network of industrial railway there have been 10 accidents (derialments), in which wagon type Arbel series Faboo participate. A review of the accidents is given in Table 3.7.2.

Табела 3.7.2: Преглед несрећа насталих у периоду од 01.01.2008. до 17.09.2017.

No.	date	Time	Short description	cause
1	04.03.2008.	12:00	At km 21 + 980 railway Brugle-Vreoci, the freight train No. 9 / 27c there was a fracture of the sleeve on the wagon No. F245 and derailing them	**Break of sleeve on wagon *F245***
2	01.06.2009.	11:20	When turning the steering received the audit, there was a derailment of wagons F341 with one axle on the track 17d triangle station Obrenovac	**Tecnical characteristics of track, small radius of 96 m**
3	15.10.2010.	13:45	Upon entering the train number 6II the station Tamnava RBK, there was a derailment of wagons F309 with four axles and roll-over of the last cell of wagon on menjalica crossover number 14	**Damages on the the mandrel belt leaf spring in the No. 3 of wagon No. F309**
4	20.01.2012.	05:30	When pushing the empty sets on the fourth track of Obrenovac station, on the switch No.1 there was a derailment of three wagons No. F003 with two shafts, four shafts with F211 and F031 single shaft	**Defect on wagon *F211***
5	25.02.2012.	08:05	When pushing the on first railway station Obrenovac (addition of sets), in front of the No. 1 crossover there was a derailment of wagon No. F242 with single axle	**No causes determined**
6	13.08.2013.	12:10	While pushing the seven empty wagons into the railway station 13d Obrenovac, on the switch No. 7d there was a derailment of wagon No. F337 with two axles	**Technical defect on the wagon *F337***
7	08.11.2013.	09:45	At km 6 + 550 of railway Stubline - Vorbis, while driving a loaded of code V5 / T9 / 261 sleeve was ruptured on wagon No. F190 and derailing of them with two axles	**Break of sleeve on wagon *F190***
8	21.06.2014.	09:28	During dispatch of empty train from the station V4 Vorbis, between the switches 6 and 8, there has been a derailment of the wagon F226 with two axles and F044 wagon with one axle	**No causes determined**
9	18.10.2014.	11:16	When pushing the seven empty wagons at the railway station 12d Obrenovac, on the switch No. 7d there was a derailment of wagon No. F354 with four axles.	**Technical defect on the wagon *F354***
10	07.04.2015.	05:52	At km 0 + 881 of railway Stubline - Vorbis, while driving a loaded train of code V53 there was a derailment of wagons F102 single axle	**Fall off the nipple in the number 8 from the wagon F102**

JP “EPS” branch TENT Obrenovac also submitted a document “Information on regular and additional repairs, regular checks and failures on the derailed wagon before the occurrence of the extraordinary event”. The document for the wagon type Arbel, Faboo series, No. 43 72 6531 273-0 states that the on 02 June 2017 the replacement of the axle in No.3/4 was performed due to the derailment. This derailmet regarding the accidents occurred in the period from 01 January 2008 to 17 September 2017 was not recorded, indicating that the list of accidents occurred in the period from 01 January 2008 to 17 September 2017. was not complete and up to date.

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

An on-site investigation team CINS found that the derailment was created at the beginning of the right curve in the direction of movement, by climbing of the leading wheel (in the direction of the movement it is the left front wheel) of the second part of wagon type Arbel series Faboo No. 43 72 6531 273-0 during a slight push of shunting composition.

Type of derailment at low speeds in the twisted track and derailment type under the influence of compressive forces in the "S" curves are processed in European technical regulations and standards: TSI WAG 2013, item 4.2.3.5.2, EN 14363:2005, EN 16235:2013, EN 15839:2012, UIC 530-2:2011.

Here the requirements of these regulations with the purpose to clarify the cause of derailment are analyzed, since in 1983, at a time when, according to documents submitted by the owner of the wagon type Arbel series Faboo No. 43 72 6531 273-0 got initial license for use, these regulations were not valid.

There are a number of tracks and parameters of vehicles that in certain combination can bring to the certain type of derailment:

- greater twist of the track,
- greater cross level,
- a small radius of curvature,
- large torsional constant of wagon body,
- large torsional constant of complete vehicles (which includes the stiffness of the spring),
- structures of a running device (in particular, longitudinal guiding axle - impact on the force of keeping the curve),
- low speed,
- unfavorable characteristics and geometry of the traction- buffering device,
- etc.

In the case of wagon of series Faboo additional factor is the fact that it is a permanently connected two-axle part unit, with its particular traction-buffing devices between the two-axle parts which form an indivisible unit.

4.1.1. Analysis of the condition of track

Based on the records of measuring circuits from 25 March 2017 for the section of the main arterial route between stations Rakovica and Jajinci, provided by "IŽS"a.d. can be seen that an accident occurred at the kilometer of tracks having the greatest number of errors of type "C".

The radius of curvature R=504m, and cross level of up to 26mm do not fall in the critical value for the relevant derailment. Of all the information explained in the point 3.4.2 the data of deviation of twist is relevant (deformations), outside the prescribed limit of error of type "C" (Fig.3.4.2.1. and delivered tabular data) from *km* 1+949 to *km* 1+955, because the shunting composition was moving in the direction of decreasing mileage.

Track examination coach measures twist based on the distance of 3.5m, while for the car of series Faboo twisting of the axle distance of 5.25m is applicable. Therefore, the data on twist is very indicative and shows that even on the basis of a length of 5.25 m great value of twist can be expected, but numerical values obtained on the basis of length of 3.5m are not directly applicable. Length where excessive twist exists measured on two different bases is not the same, but also the maximum is relatively moved.

On-site no traces that would help to determine the exact point of the start point of climbing the wheel on the rail were detected. Typically climbing of the wheel on the rail is happening around the legth from the half to one turnoaround of wheel, after which the wheel is rolling on the top of the rails for a while, and at the end falls on its outer side.

Taking into account the distance of the axle, this means that initial twist that leads to starting of climbing of wheel on the rail may be at a distance of about 5 to 15m in front of the place where a trace of falling of wheel on the rails was noted. In addition, on the site it was determined that the trace of wheel of wagon series Faboo, that derailed the previous day is 3m in front of the spotted trace of the wheel that derailed in the respective accident, on the same rail. This is a very clear indication that high twist of track influenced both derailments.

Pursuant to the Law on the Railway (*"Official Gazette RS" No.45/2013 and 91/2015*), (see section 3.3.4), infrastructure manager is required to ensure continuos and proper maintenance of the railway infrastructure. According to the Article 42 of Law on railway safety and interoperability (*"Official Gazette RS" No.104/2013, 66/2015 - other law and 92/2015*), (see section 3.3.5), that is, Article 14. of Law on Safety in Railway Transport (*"Official Gazette RS" No.41/2018*), (see section 3.3.3), infrastructure manager is obliged to establish safety management system. As part of its safety management system, "IŽS"a.d. adopted the Instruction on unique criteria for control of the condition of railways on the network JŽ, Instruction 339 (*"Offical Gazette of ZJŽ" No.2/2001 and 4/2004*) (see section 3.3.6) as their own. According to this instruction errors of type "C", which are beyond the limit of explotation, "urgently require the removal or reduction of speed". Considering that the derailments of the type happen with low speeds, speed reduction would be counterproductive, however, the immediate removal remains the only option.

In a letter submitted to the "IŽS"a.d. No V-429 of 01 December 2017, point 8 states that the data on the measurements of track examination coach delivered without the analysis of measuring driving, without proof of delivery of errors type "C" to section for maintenance track and no evidence that the relevant section in "emergency" time conducted elimination of identified errors of group "C", particularly errors of twist and stability. In the letter there is no data that the competent leadership "IŽS"a.d. performs analyzes why the above procedure is not carried out, nor is there data on possible corrective measures. In the letter there is no data that the competent management of "IŽS"a.d. performed the analyses because the abovemetioned procedure is not carried out, nor there is data on possible corrective measures.

This omission is repeated because it is similarly noted in the report of CINS No. ŽS 02/17, 33 No. 340-8059/2017-16 from 05 January 2018.

In the Rulebook on the technical requirements, and maintenance of the superstructure of railway tracks (*"Official Gazette RS" No.39/16, 74/16*) twist, which for decades have been measured with track examination coach, and which has limited values specified in the Instructions on common criteria for control of the state railways on the network of JŽ, Instruction 339 (*"Offiical Gazette of JŽ" No.2/2001 and 4/2004*) is not mentioned at all, despite the fact that this is one of the most important parameters of derailment and one compromising security. Limits from

Instruction 339 and the whole issue of the limiting condition of track geometry requires complying with the SRPS EN standards, especially EN 13848-5 and EN 13848-6 and must be regulated with by-laws.

4.1.2. Analysis of the impact of the vehicle structure

From the submitted license for use No. 340-342-2 / 2013 for wagon type Arbel series Faboo No. 43 72 6531 273-0 shows that this type of wagons is based on approved technical documentation of JŽ No 2846/68 of 29.04.1969. Wagon type Arbel series Faboo No. 43 72 6531 273-0 issued initial license for use in 1983.

Beginning in 1984, announcement UIC 530-2, to which in the appropriate context valid EN standards invite, defined the conditions which new vehicles must meet in terms of safety of movement on the railway. Security of movement in this technical regulation is based on safety criteria from the derailment in the twisted track and derailment safety criteria in the "S" curves under the action of the longitudinal compressive forces, ie. in pushing the vehicle.

When it comes to two-axle wagon to achieve security of the derailment, as a mandatory provision for circuits of up to 14.1 m it is required that:

- axle distance is between 6 and 9m,
- weight wagon is 11.5t or more,
- torsional constant of wagon body must be greater than $0{,}5x10^{10}$ but less than the value of the corresponding diagrams that could safely transmit the required force when repressing,
- guides axle comply with the regulation UIC 517 (now EN 16235),
- radius of curvature of buffer plates is 2750 mm,
- when it comes to permanently coupled wagons, traction-buffing devices between them must comply with the regulation UIC 572 (now EN 15839 and EN 16235)

and other conditions to be verified using the family of graphs for relation between the designed parameters.

Wagon of series Faboo do not meet many of these demands:

- axle distance of 5.25m is less than required,
- mass of one wagon of 22.35/2=11,175t is below the required minimum value,
- traction- buffing devices between permanently coupled parts of wagon do not meet the requirements of EN 16235,
- leaf springs range of 1100mm are much stiffer than the spring range of 1200mm or 1400mm specified in UIC 530-2
- wagons have single short links, as per regulations for new cars is not allowed for decades (negative impact on keeping forces in the curve), and so on.

TSI regulations, referring to the use of the EN standards, which for the wagon which does not satisfy specified conditions, necessitate complex type investigations. For wagon series Faboo is quite certain that because of these deviations of parameters, criteria of such investigations, would not be able to meet.

Based on the above facts of wagon of series Faboo have a higher risk of derailment of wagons built according to UIC regulations changed after 1984. Therefore, in combination with the parametres of the track that do not represents the most unfavorable situation, there is a risk of derailment.

According to the original documentation supply and delivery of wagons series Faboo was carried out and in 2008, ie. over the two decades after 1984, and amendments of relevant technical regulations. New wagons were given license for use based on the type of license for the period before 1984, if at the time of contracting of the delivery they did not comply with the current, in the meantime, altered, technical regulations.

4.1.3. Analysis of the existing traction-buffing devices between wagons

Figure 4.1.3.1. shows a traction-buffing device of wagon of series Faboo and Figure 4.1.3.2. shows the functioning of the traction pole. Between the pole -1 and revolving cup -3, as well as between the thrust poles -1 and the pressure piece -5 there is radial clearance. This should ensure that in urging force is transmitted through the buffer, and drawbar freely slips in the spring, as illustrated in Figure 4.1.3.2. and does not transmit thrust force.

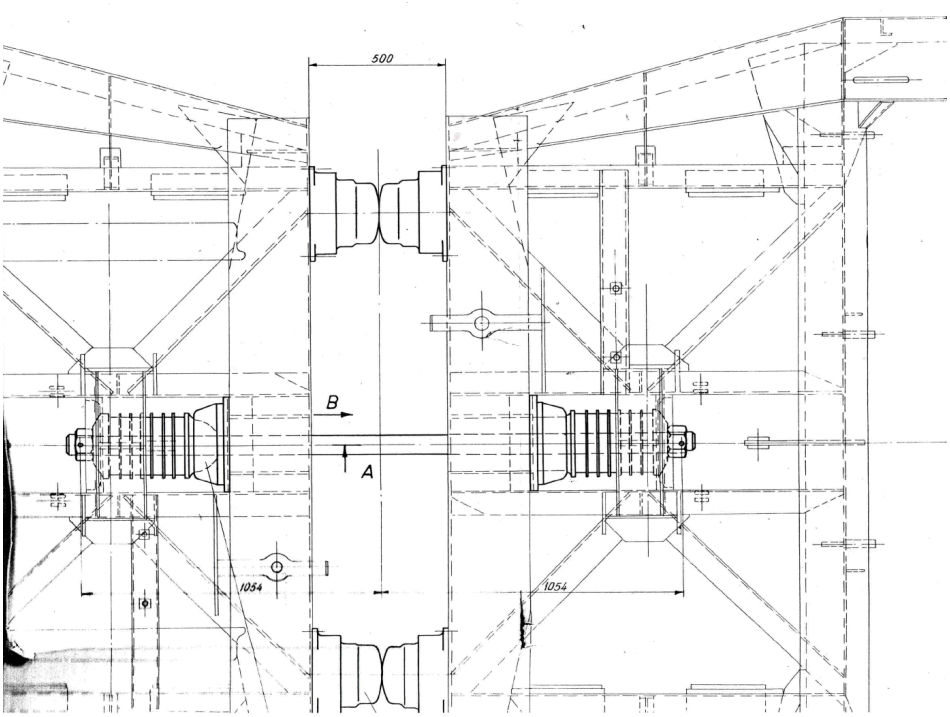


Fig. 4.1.3.1: Traction-reflective devices between wagons

During an investigation after an accident on the shunting composition standing it is determined that on all the buffers between two composite parts of wagon, buffers are apart. Given the fact that shunting composition was stiff, this is not applicable, but it is indicative. At the derailed wagon the situation seen after the derailment is shown in Figure 4.1.3.3.

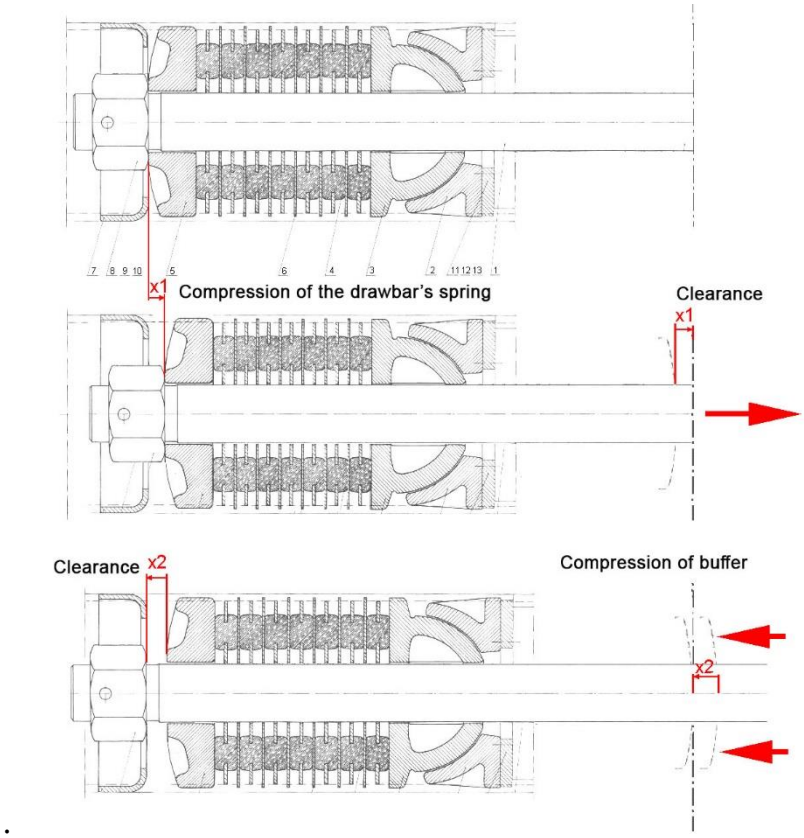


Fig. 4.1.3.2: The manners of operation during the traction and supression

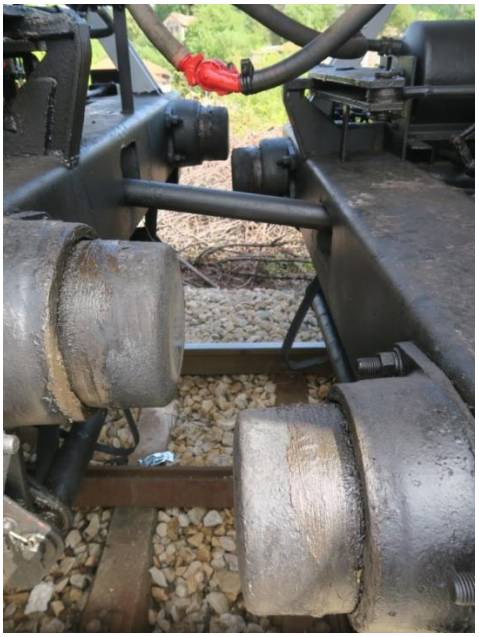


Fig. 4.1.3.3: The position of traction-buffing devices between the parts of the wagon serie Faboo No. 43 72 6531 273-0 after the derailment

During a visit to TENT by the investigation team of CINS, it was noted that it often happens that when standing or when pushing, buffers are not in contact, so that the thrust force is transmitted through the drawbar, which should not be happening. Therefore, the test of a light supression of wagon via the sharp curve within TENT is performed. Figure 4.1.3.4. is a display of sequences from a video clip recorded in repression.

In the segment long about 30m (passing through the switch, the entry into the curve and move through the curve R=80m), the internal buffers touched only in three short moments, which means that the supressing force is transmitted via a drawbar.

The reason for this phenomenon is not entirely clear. The explanation would be that the radical clearance between the ore -1 nad -5 pressed sleeve are too small. When the ore in the suppression is found in the set position, it is possible that it is leaning diagonally on the sleeve and pressing the force transmitted by friction.

The transfer of thrust through the ore may have an additional negative effect on the lateral forces. Compressive forces may occur in uneven braking of the tracted compositions, when compression can occur forces due to recoil in longitudinal part composition. Transmission of tensile forces over the drawbar, by contrast, has a centering effect, and is moving in the regime of pulling in a safer manner.

Although the listed flaw of the wagon of series Faboo known and telegrams on the prohibition of pushing in the carriage on the public railway infrastructure are issued, in the license for use such a restriction does not exist. In the traffic on the public railway infrastructure suppression is a routine operation widely represented in the formation of the cargo composition, and generally ban of suppression of wagons that are licensed for use without restrictions is unacceptable.

An exception can be made only if the transport to and from the overhaul workshop is treated as a special consignment, as it was done in this case, but then the limit must be stated in the license for use.

Fig. 4.1.3.4: Clearance between buffers in the rehersal of supression

4.1.4. Analysis of operational procedures

The fact that the design of wagons of series Faboo is prone to derailment at suppression was confirmed by the experience of operators and owners, and on 28 February.2011 by telegram No. 770 "Serbian Railways" a.d. it was ordered that this type of wagons are transported as a consignment commission and that the pushing is banned. The documentation submitted by the operator "Serbia Kargo" a.d. is given with the form and S-52, Appendix "A" General order I / 26 of the train No. 53,186. In that attachment specific safety requirements were listed, including prohibition of pushing, as well as the start and stopping of the train can not be abrupt.

When after the first derailment on 16 September 2017 a locomotive was replaced, with list of staff of the traction vehicle EV 1 for train driver of locomotive 661-116 for unknown reasons

Form S 52 was not submitted with the mentioned special security conditions. According to the submitted minutes of the hearing locomotive train driver 661-116, on the 17 September 2017, he received an order over the phone by the dispatcher of station Rakovica to deliver by pushing shunting composition from the point of the first derailment (from 16 September 2017) to the station Rakovica. Immediately after the launch there was a new derailment which is the subject of this investigation. This was a mistake in the procedure which has contributed to the occurrence of derailment.

4.1.5. Review of maintenance documentation

In the enclosed documentation for maintenace the required replacement of the rubber elements of rigid drawbar is calculated, removal of small buffers, a visual inspection and, if necessary, replacement of the rubber elements, and the required distance between the cell and the distance of axes for the cotter holes of rigid drawbars is defined.

Recording of the characteristics of elastic elements of rigid drwabar nor rude bumper characteristcis is not intended,it cannot be seen if there are measurements and control lists with defined tolerances. Since the traction-buffing devices according to the Rulebook on the maintenance of railway vehicles (*"Official Gazette RS" No.101/15*) (Section 3.3.7) are in the order of importance parts important for the safety, it is necessary that both of the equipment between the two parts of the wagon series Faboo , controlled in the same way as the butt traction-reflective devices.

4.2. Conclusions on the causes of the accident

4.2.1. Direct cause of the accident

On the basis of the data analyzed, it can be concluded that the combination of twist of track above stipulated limit, unfavorable parameters of design of wagon type Arbel series Fabo which are essential to the safety of movement of vehicles on deformed track and suppression of composition of empty wagons with low speed generated the conditions that occur at the climbing of the wheel on the rail and derailing.

4.2.2. Basic causes deriving from skills, procedures and mainetnance

"Technical specification, big repair of wagons series Faboo type Arbel" provided by the TENT does not provide sufficiently detailed check of the traction-buffing device between permanently connected parts of wagon which leads to the situation that due to jamming of drawbar, compression forces in many cases transferred over it instead of over buffers which adversely affects the security and increases the possibility of derailing of the wagon.

4.2.3. Causes deriving from legal framework and safety management system

The driver of locomotive 661-116 was not provided with a special safety conditions that included the prohibition of pushing of shunting composition. In addition he was given the operational task to deliver by pushing the shunting composition in the station Rakovica, which is already a serious flaw in the security procedure.

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

There are no deficiencies and shortcomings.

5. Measures taken

After the occurrence of the respective accident, "IŽS"a.d., Section ZOP Belgrade, primarily approached determination of the damage and developing a plan of organization and remediation of damage. It was found that as a result of the accident disturbed geometry of track remained, according to direction and levelization, which was the cause of organization of machine regulated track. Mechanical regulation was made on 18 September 2017. from km 1+500 to km 2+070 when the railway opened for traffic.

In order to reduce the derailment of the wagon, since 2011 in the workshop of TENT - railway transport preventive examination of axle-bearings and visual control of grease is carried out. In order to reduce accidents and accidents caused by scuffing bearings onto axles, since 2006 devices for contactless temperature measurement of a axle-bearings on wagons in motion type "Meros" manufacture "Institut Nikola Tesla" are in operation. The devices are placed on the two unloading stations Obrenovac and Vorbis, as well as the loading station Vreoci. In order to reduce derailment consequences, on the wagons detectors of derailment are installed from 2017.

6. Safety recommendations

For potential safety improvement on the railway and prevention of new accidents, CINS issued the following safety recommendations:

Railway Directorate:

SR_15/18 Railway Directorate to check the licenses for the usage of wagon type Arbel, series Faboo, in sense of control of fulfillment of conditions for issuing safety certificates for transport and to bring in license special conditions for use to the public railway infrastructure these cars can be transported only as a special consignment with the prohibition of repression and, if necessary, other security restrictions, in accordance with the Article 21. of Law on Railway System Interoperability (*"Official Gazzette RS "No. 41/2018*).

SR_16/18 When issuing license for the use of new vehicles which are made by already issued license for the type, Railway Directorate to act strictly in accordance with Article 22. of Law on Railway System Interoperability (*"Official Gazzette RS" No. 41/2018*), to avoid the new vehicles getting licenses for use even when they are not in accordance with valid technical legislation (delivery and issuing of licenses for wagon series Faboo 2007/2008).

SR_17/18 Railway Directorate to to conduct a review of the safety certificate for infrastructure management "IŽS"a.d. for not taking measures to urgently eliminate defects such as

type "C" as established by measurements with track examination coach according to the Instruction 339 and to take measures within its jurisdiction in accordance with Article 15. of Law on Safety in Railway Transport *("Official Gazzette RS "No. 41/2018).*

SR_18/18 Railway Directorate to review the Rulebook on technical conditions and maintenance of the superstructure of railway lines ("*Official Gazette RS" No.39/16, and 74/16*) and to include in it the limit of the geometric parameters of railway condition, including twist, on the basis of standards SRPS EN 13848-5 and SRPS EN 13848-6 and to define, complied with these limits, the obligation of measuring the condition of track with track examination coach and action based on measurement results.

Ministry of Construction, Transport and Infrastructure:

SR_19/18 Ministry of Construction, Transport and Infrastructure, Sector for Inspection, Group for Railway Inspection to carry out extraordinary check of railway infrastructure on the main arterial route E70/E85: (Belgrade) - Rakovica - Jajinci - Mala Krsna - Velika Plana between junctions "K1" and station Rakovica and, if necessary, take measures within their jurisdiction.

„IŽS" a.d:

SR_20/18 „IŽS"a.d. to conduct examination of the reasons why the measures have not been taken for urgent elimination of defects type "C" that were determined during the measurement with track examination coach under the Instruction on unique criteria for control of the condition of railways on the network JŽ, Instruction 339 *("Official Gazette ZJŽ" No.2/2001 and 4/2004)* and to develop coordination between sectors that determined the defect and sectors that should eliminate this defect, and under review of management in order to follow and analyze these cases. According to the evaluation of safety risks which due to this occurred, to take efficient measures for elimination of the safety flaws, and in accordance with the Article 5 of Law on safety in Railway Transport *("Official Gazzette RS" No.41/2018)* and its Safety Management Manual.

JP „EPS" branch TENT:

SR_21/18 JP „EPS" branch TENT that in future purchases of new vehicles for their fleets require the vendor delivering vehicles compliant with the current technical regulations, in order to avoid the risk of obtaining the decision to deny a license for the vehicle type.

SR_22/18 JP „EPS" branch TENT to review and supplement the maintenance instructions for the traction-buffing devices between two parts of wagon Arbel series Fabo, by analogy with the checking of head traction-buffing devices along with regulation of control of resilient elements of drawbar and small buffers on the press and the addition of appropriate measuring and control lists, and in order to avoid that these traction-buffing devices are too pre-stressed or with a gap when they are in a state with no external load.