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**FINAL REPORT**

**from**

**Investigation of railway accident – derailment of locomotive № 46041 of direct freight train № 30682 while entering in Kostenets station on 15.07.2020**



**2020**

## **OBJECTIVE OF THE REPORT AND EXTENT OF RESPONSIBILITY**

The National Air, Maritime and Railway Accidents Investigation Board (NAMRAIB), which is an independent body performs the investigation of serious accidents, accidents and incidents. The National Board is within the Council of Ministers (CM) of the Republic of Bulgaria and aims to find the causes that led to their occurrence in order to improve the safety and to avoid such in future, without **searching personal fault and responsibility.**

The investigation is performed in accordance with the requirements of Directive (EU) 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety. The Report structure follows the requirements of Regulation (EU) 2020/572 of 24 April 2020 on the reporting structure to be followed for railway accident and incident investigation reports, and in accordance with the Railway Transport Act (RTA), Ordinance No 59 dated 5.12.2006 on the rail transport safety management, and Ordinance No H-32 dated 19.09.2007 on the coordination of the activities and information exchange during the railway accidents and incidents investigation, as well as per Agreement dated 17.04.2018 on the interaction during investigation of accidents and incidents in the air, maritime and railway transport between the Prosecutor's Office of the Republic of Bulgaria, Ministry of Interior, and the Ministry of Transport, Information Technology and Communications.

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## **ABBREVIATIONS, USED IN THE REPORT**

DFT – Direct freight train

BDZ-Cargo Ltd. – „BDZ-Cargo“ Ltd.

SE NRIC – State Enterprise “National Railway Infrastructure Company“(railway infrastructure manager)

RRI MH-70 – Route Relay Interlocking type MH-70

NAMRAIB – National Air, Maritime, and Railway Accidents Investigation Board (Independent National Investigation Body)

TOSARRT – Train Operation and Shunting Activity Rules in the Rail Transport

TF– Task Force

ALSN – Automatic Locomotive Signalling

RAEA – Railway Administration Executive Agency

ECM – Entity in Charge of Maintenance

LPP – Locomotive Park Prescription

## 1. Summary

### 1.1. Brief Description of the Event.

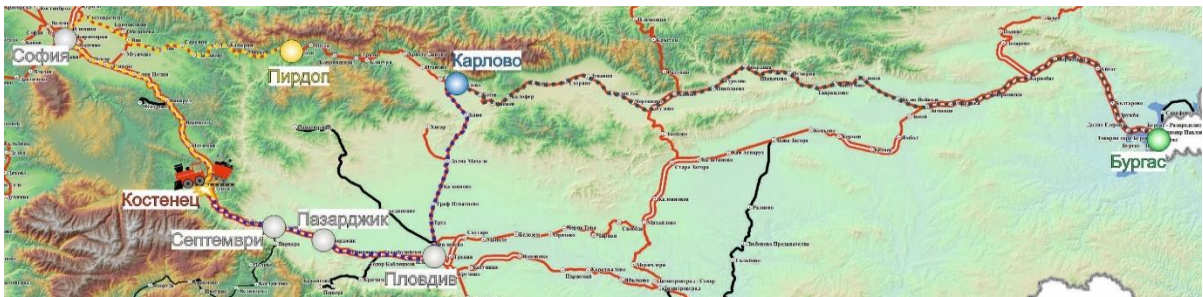
On 15.07.2020 at 05:02 a.m. from Karlovo station departed DFT No 30682 of the railway undertaking „BDZ-Cargo“ Ltd. in a composition of 42 wagons empty tanks, 168 axles, 833 tonnage, pulled by electrical locomotive No 46041. The transport of DFT No 30682 is performed along the route Bourgas – Zimnitsa – Karlovo – Plovdiv – Sofia – Iliyantsi – Pirdop.

The train departed from Septemvri station at 09:12 a.m., passed without stopping through Belovo station at 09:24 a.m. The traffic manager on duty at Kostenets station after receiving the train departure prepared the route with RRI-MH-70 for accepting the DFT No 30682 on third siding track.









The DFT No 30682 entered in Kostenets station within regularly opened entrance signal for third siding track. The train passed in deviation through switch No 15 (right) and then in curve (left) towards third track with running speed 25 km/h. The locomotive crew felt strong vibrations and jolts in the locomotive cabin, and undertook train stopping. After the stopping of the train and performed inspection of the locomotive was found that, the same derailed with first and second wheelset to the right in the running direction.

### 1.2. Location and time of the event occurrence.

The accident happened during the entrance of DFT No 30682 on third acceptance-departure siding track at Kostenets station in the curve after switch No 15 at 09:50 a.m. (fig. 1.1).



#### Legend:

-  - original station for the movement of the train;
-  - station, where the locomotive crew of the train locomotive performed its work shift (shifted);
-  - final destination for the train movement as per the schedule;
-  - station, where the train stopped;
-  - station, where the accident occurred;
-  - station, where the accident occurred;
-  - route, which the train passed with the previous locomotive crew;
-  - route, which the train passed with the new (shifted) locomotive crew;

**Fig. 1.1. Traffic route of DFT 30682**

### 1.3. Factors, defining the event.

Determining factor for the occurrence of the accident is the unsatisfactory technical condition of the left curve of third acceptance-departure siding track immediately after switch No 15 (right) in Kostenets station.

Contributing factor for the occurrence of the accident is the unsatisfactory technical condition of the inter-bogie coupler of train locomotive No 46041 – DFT No 30682.

#### 1.4. Immediate causes and consequences of the event.

Immediate cause for the accident occurrence (derailment of the first two wheel-sets of locomotive No 46041 in the curve after switch No 15 of third acceptance-departure track in Kostenets station). The immediate cause is in combination with discrepancies of the inter-bogie coupler of the locomotive and additionally occurred lateral transverse horizontal force from the external leading right wheel of the first wheel-set in direction of the movement (sixth for the locomotive), caused by inadmissible differences of the track alignment in the left curve with radius  $R=188$  m (fig. 1.2).

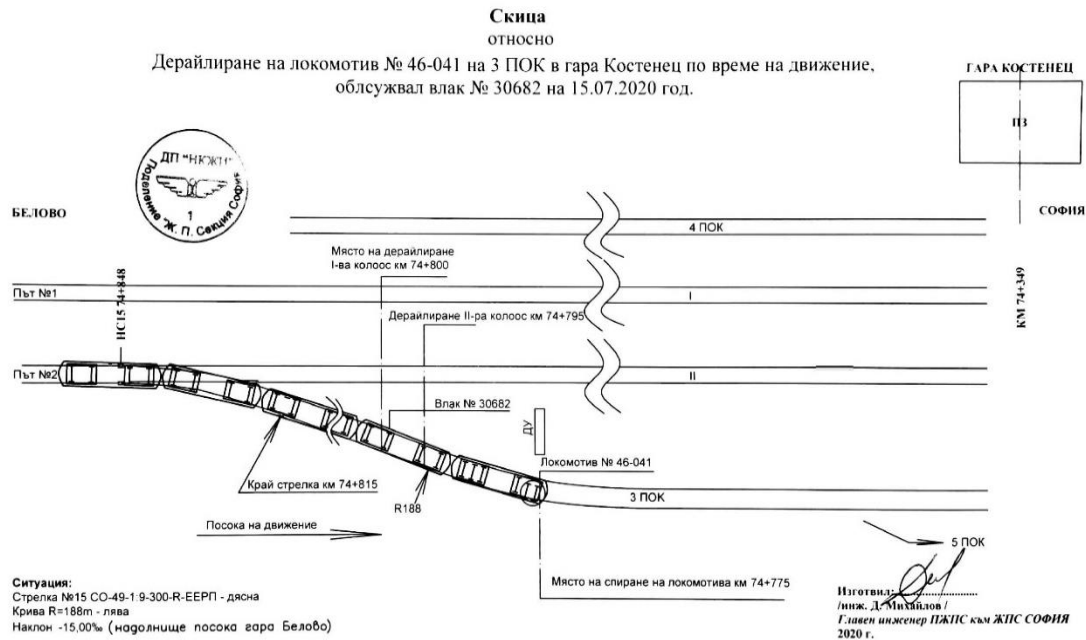


Fig. 1.2.

#### 1.5. Safety recommendations and addressees to which are directed.

- By recommendation 1 it is suggested BDZ-Cargo Ltd. to follow the requirements of the technical documentation for repair and maintenance of inter-bogie coupler when performing planned inspections and repairs of locomotives series 46000;
- By recommendation 2 it is suggested BDZ-Cargo Ltd. when performing planned repairs of locomotives series 46000 to implement the following technological operations:
  - Disassembly and measurement of the force-deformation characteristics of all rubber-metal packets with subsequent arrangement (determination of their optimal location);
  - Regulation (balancing) of the spring system of the locomotives, in order to equalize the vertical load in their wheels and reach the so-called. "State of best regulation".
- By recommendation, 3 it is suggested BDZ Cargo Ltd. to build and implement an electronic stand/system for setting the parameters and testing the inter-bogie coupler of the locomotives series 46000 registering properly the measured parameters and issuance of an electronic protocol for the settings condition.
- By recommendation 4 it is suggested SE NRIC to adjust third track in Kostenets station in accordance with the requirements of item 3.3.6 and item 3.3.12.7 stipulated in Instruction on the layout and maintenance of the rail track superstructure and rail switches (for counter-curves without cant without transition curves and without intermediate line).

## **2. Investigation**

### *1. Decision for starting the investigation.*

The decision to initiate an investigation of the accident took into account the seriousness and its impact on the safety. The investigation aims to prevent this type of accident, which in slightly different circumstances could lead to serious accidents.

### *2. Motives for the decision to initiate the investigation.*

The Decision for starting the investigation is based on art. 20, comma 2, (a), art. 115к, paragraph 1, item 3 of RTA, art. 76, par. 1, item 3 of Ordinance No 59 dated 5.12.2006 and by Order No RD-08-17/07.10.2020 of the NAMRAIB was assigned a Commission for investigation of the railway accident.

### *3. Scope and restrictions of the investigation.*

The scope of the investigation will consider and analyse the violations of the regulations implemented by the entities (NRIC and BDZ-Cargo Ltd.) in the repair and maintenance of the track and in carrying out scheduled repairs of locomotives series 46000.

Given the realized minimal damages, the investigation will be limited to the circumstances that led to the technical causes for the derailment of locomotive No 46041 in Kostenets station.

### *4. Competences of the persons, involved in the investigation.*

The composition of the commission includes external independent experts - habilitated persons from the higher scientific circles and experts with free profession with qualification and professional orientation in fields of activity – track and structures, and rail rolling stock.

### *5. Communication and consultations with the persons and entities, involved in the event.*

During the investigation, the task force, which includes representatives of both entities, was consulted. The task force had collected all the books and samples, as well as telegrams and downloaded records from the recording device of locomotive No 46041. They were handed over to the Chair of the Investigation Commission. Interviews were conducted with the persons, directly involved in the accident. The entities were requested and then provided information on the track maintenance at Kostenets station and on the repair and maintenance of the locomotive as well. Interviews were conducted with the heads of the entities, and with their safety authorities.

### *6. Degree of cooperation from the participating entities*

During the investigation, the participating entities (BDZ-Cargo Ltd. and SE NRIC), and the persons involved in the accident fully cooperated with the Investigation Commission.

### *7. Methods and techniques of investigation and analysis.*

After the received information on the accident occurrence and the taken decision for investigation, the Investigation Commission conducted the first two interviews with staff from both railway entities, involved in the accident. It performed primary inspections of the derailed locomotive No 46041 and the permanent way of the 3-rd. track in the area of derailment at Kostenets station. There was required download of the records from the recording device of the locomotive. The Commission was acquainted with keeping of the operational station documentation and with the acceptance plan for train No 30682 in Kostenets station. It required all the documents for the Kostenets station repair and maintenance for a one-year period from the date of the event. The Commission required all the documentation for the repair and maintenance of locomotive No 46041. After lifting the locomotive from the rails of the 3-rd track in Kostenets station, under the Investigation Commission instruction the locomotive departed on its own (self-propelled) to the nearest locomotive depot Plovdiv. A Statement of findings for the technical condition of locomotive No 46041 was prepared in the presence of the Commission, and of the Task Force. The inter-bogie coupler (daixel/tender) was removed from the draft gear of the locomotive. The inspection found technical failures in the coupler. It was ordered the locomotive to depart from Plovdiv to the Bourgas main locomotive depot of housing. In the presence of the

Investigation Commission, the following inspections and measurements were performed in Bourgas locomotive depot:

- Overall inspection of the locomotive draft gear;
- Dimensional maps for the controlled dimensions of the locomotive wheelsets;
- Cards for measuring the static load of the wheels and adjusting the spring system of the locomotive;
- Force-deformation diagrams for testing the metal-rubber packets of the axle box stage of the spring suspension of the locomotive;
- Map for measuring the control distances from the suspension and leading of the locomotive bogies.

There were performed analysis of the data downloaded from the recording device of locomotive No 46041 on the speed of DFT No 30682 dated 15.07.2020 from Karlovo station to Kostenets station.

The permanent way of the 3rd track at Kostenets station was inspected several times. A Statement of findings for the technical condition of the track was drawn up. There were found deviations from the norms for repair and maintenance of the track. The Commission found that in accordance with the approved Plan for acceptance of trains in Kostenets station DFT No 30682 should have been accepted on the 2nd main track, and not on the 3-rd siding acceptance-departure track with stopping at the station

The Commission found serious technical problems within the entrance of the train in Kostenets station on the 3rd track from Belovo station on permanent way No 2, towed with locomotives of series 46000, which have a greater inter-bogie distance. Switch No 15 is an entrance switch leading to the 3rd siding track from the straight line track. The switch is right with a radius  $R = 300$  m and is followed by a left curve with a radius  $R=188$  m. Between the two curves (right and left) there is no straight or transition curve (which is a violation of the norms for the track superstructure), as this makes difficult the entering for the stated locomotives series despite the permissible kinematic gauge clearance. Theoretically and practically with the design of the 3rd track at the station, the derailment of locomotives series 46000 was set.

The Commission received all the collected materials and the report of the Task Force as per the requirements of art. 73 para. 3 and para. 4 of Ordinance No 59. The Commission reviewed and analysed in detail the collected documentation.

*8. Difficulties faced during the investigation.*

During the investigation, the Commission did not encounter any difficulties or obstacles from the entities side in clarifying the circumstances and causes for the accident.

*9. Interaction with the judicial authorities.*

Not applicable.

*10. Other important information for the investigation context.*

There is no such.



### 3. Description of the event

#### a). Information on the event and the context.

##### 1. Description of the event type.

On 15.07.2020 at 01:36 a.m. in Karlovo station arrived DFT No 30682 from Bourgas station. The train departed at 05:02 a.m. to Plovdiv station with 42 empty wagons, 168 axles, 833 tonnages, pulled by electrical locomotive No 46041. The transport of DFT No 30682 is performed by the railway undertaking "BDZ-Cargo" Ltd., operated on direction Bourgas – Zimnitsa – Karlovo – Plovdiv – Sofia – Iliyantsi – Pirdop (Fig. 1.1).

The train arrived at Septemvri station at 08:42 a.m., and departed at 09:12 a.m. It passed by Belovo station at 09:24 a.m. without stopping. The traffic manager on duty in Kostenets station, after received train departure, prepared the route with RRI-MH-70 for acceptance of DFT No30682 on third siding track. The train had to wait at the station for an auxiliary locomotive to be attached.

DFT No 30682 entered in Kostenets station during the regularly opened entrance signal and ordered route for third acceptance-departure track.

After the train entering in the station, the locomotive passed through switch No 15 (right) with radius  $R=300$  m and then in curve (left) with radius  $R=188$  m, leading to the 3-rd track. During the entering in the curve, the locomotive crew felt strong vibrations in the locomotive cabin, and took immediately actions for the train stopping with the automatic train brake. The train speed was 25 km/h, within 40 km/h admissible speed. During the train movement on the route from the origin station to Kostenets station the locomotive operation was accident-free (normal).

##### 2. Date, punctual time and location of the event.

The event occurred on 15.07.2020 at 09:50 a.m., after switch No 15 (right) in counter-curve left on 3-rd track in Kostenets station.

##### 3. Description of the event location.

Kostenets station is located at kilometre 74+349, between the stations Belovo and Ihtiman. There are five tracks in the station; four of the tracks are acceptance-departure tracks. The station is located along the first main railway line in direction Kalotina-West – Sofia – Plovdiv – Svilengrad – Republic of Turkey. The first main railway line is a conventional line with traffic speed up to 160 km/h (Fig. 3.1).



Фиг. 3.1.

*3a. Meteorological and geographical condition at the time of the event.*

- in the daylight hours – 09:50 a.m.;
- weather– clear weather condition for accepting the signals;

*3b. Performance of construction activities on the site or in vicinity.*

In the period of the accident occurrence were not performed any construction activities in Kostenets station area, nor on the track neither on the structures.

*4. Fatalities, injuries and material damages.*

- *Employees of the railway infrastructure manager or railway undertaking.*

None.

- *Other persons officially connected with the location of the event.*

None.

- *Passengers.*

None.

- *External persons.*

None.

- *Cargo, luggage or other property.*

None.

- *Environment.*

None.

- *Rolling stock and railway infrastructure.*

Slight damage was caused to the running gear of locomotive No 46041.

No data on damage were presented.

Minor damages were caused on the permanent way of the 3rd track in Kostenets station.

No data on damages were provided.

*5. Description of other consequences, including the event impact on the usual activity of the participants.*

None.

*6. Identity of the participants and their functions, as well as of the involved entities.*

*Railway infrastructure:*

- Traffic manager on duty in Kostenets station – SE NRIC employee;
- SE „National Railway Infrastructure Company“ has;
  - Safety Authorization No № BG 21/2018/0001 valid from 01.07.2018 until 30.06.2023.

*Railway Undertaking:*

- Engine driver, locomotive of locomotive No 46041 – employee of “BDZ-Cargo” Ltd.;
- Assistant engine-driver, locomotive of locomotive No 46041 employee of “BDZ-Cargo” Ltd.;
- “BDZ-Cargo“ Ltd. has:
  - License for performing railway services No 203/31.12.2018;
  - Safety Certificate part A BG 11 2017 0008, valid until 30.12.2022;
  - Safety Certificate part B BG 12 2017 0008, valid until 30.12.2022;

*7. Description and identifiers of the train and its composition, including the rolling stock and its registration numbers.*

- Freight train No 30682, direct;
- Electrical locomotive No 46041 – registered in the Vehicles Register;
- Tank wagons – series Zas, 42 units registered in the Vehicles Register;

*8. Description of the respective parts of the railway infrastructure.*

*Description of the signalling and interlocking:*

- Kostenets station is equipped with RRI MH-70;

- The semaphores' indications are on the speed signalling;
- The interstation (open lines) Ihtiman – Kostenets and Kostenets – Belovo are equipped with automatic block system (ABS) with passage signals;

8a. Type of the track, rail switch etc. maint.

- Third acceptance-departure track in Kostenets station is with total length 618 meters, with cant from km 74+080 to 74+815 – 0 ‰, and then follows downhill inclination 15 ‰ in direction to Belovo station, equipped with exit signals on the speed signalling, included in the safety installation of the station, with overhead contact line/catenary (fig. 3.2).

8b. Train protection systems.

The Sofia-Plovdiv section is equipped with Automatic locomotive signalling (ALS). Since 04.12.2019 along Sofia – Plovdiv section has been put into operation a modern subsystem Control, Command and Signalling, Train detection, and Train protection as follows:

- Part Train detection along the railway section from the warning signals at Septemvri station,

### СХЕМА НА ГАРА КОСТЕНЕЦ

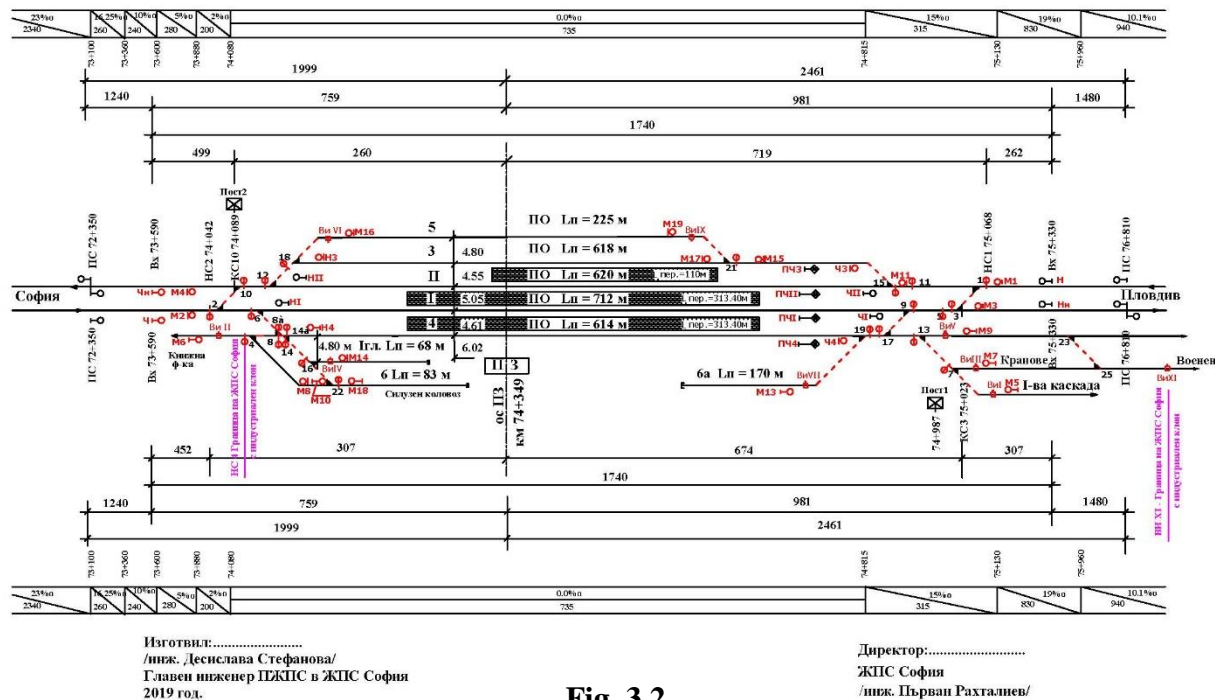


Fig. 3.2.

### KOSTENETS STATION LAYOUT

- Belovo side to the entrance signals of Plovdiv station, Todor Kableshkov side;
- Part Train protection along the railway section from the warning signals at Septemvri station, part Belovo until after the entrance signals at Plovdiv station, Todor Kableshkov side;
- Part Radio connection along the rail section from Sofia Central Railway Station to Plovdiv railway station, including the building of SE NRIC Head office;
- Kostenets station is equipped only as it refers „radio connection“ with GSM-R;
- Locomotive No 46041 is equipped with vigilance device active type, registering speedometer type „Hasler“ RT9, and non-registering speedometer type „Hasler“ A16 .

9. Other information referring the event.

None.

***b). Factual description of the occurred.***

*1. Immediate sequence of events that led to the accident, including:*

*1a. Actions that the involved in the event persons undertook.*

Under instruction of the train dispatcher, the traffic manager on duty in Kostenets station agreed to accept DTF No 30682. After the train passes through Belovo station at 09:23 a.m. without stopping, the traffic manager on duty in Kostenets station ordered entrance route for third acceptance-departure siding track and opened entrance signal for the train acceptance.

DFT No 30682 departed from Septemvri station at 09:12 a.m., passed through Belovo station at 09:23 a.m., and at 9:50 a.m. entered in Kostenets station on third acceptance-departure siding track within regularly opened entrance signal. At 09:52 a.m., the engine driver called the traffic manager on duty in Kostenets station on his telephone and told him that locomotive No46041 derailed in the curve after switch No 15 with the first two wheel-sets in movement direction (fifth and sixth of the locomotive).

*1b. Rolling stock and technical facilities functioning.*

The rolling stock has been regular with proper function until the moment of the accident. The technical facilities in Kostenets station are regular with proper functions.

*1c. Operational system functioning.*

The operational system is regular with proper functions.

*2. Sequence of events from the beginning of the accident to the end of the rescue services actions:*

- At 09:50 a.m. derailed locomotive No 46041 of DFT 30682 while entering on 3-rd track in Kostenets station;
- The train operation along Kostenets – Belovo interstation was interrupted from 09:50 a.m. to 12:17 p.m.;
- There was no immediate necessity of the rescue services actions;

*2a. Undertaken measures for protecting and guarding the event location.*

Not applicable.

*2b. Actions of the emergency rescue services.*

Under an order of SE NRIC from Sofia station to Kostenets station on 15.07.2020 departed specialized rehabilitation vehicle UNIMOG for lifting the locomotive.

At 12:32 p.m. from Belovo station departed locomotive No 46037, which was attached to the train's tail of DFT No 30682, and the same was turned back in Belovo station.

At 13:25 p.m. locomotive No 46041 was placed on the rails.

At 14:25 p.m. DFT No 30682 with train locomotive No 46037 and auxiliary locomotive No 43551 departed from Belovo station on the route to Iliyantsi station.

At 17:55 p.m. locomotive No 46041 departed from Kostenets station to Plovdiv locomotive depot.

**4. Analysis of the event when is necessary as it refers the individual facts.**

**a). Roles and responsibilities.**

*1. Participation and responsibilities of the entities, involved in the event.*

*Railway undertaking.*

**Analysis of the operation of DFT No 30682 from Karlovo station to Kostenets station.**

Within the analysis of the speedometer, tape was established that the tape was shifted/changed against the zero positions of the pens and their registrations do not exactly match with the tape markers that is why on certain places were placed additional markers for clarifying the instantaneous speed values and the other parameters.

DFT No 30682 was accepted from the locomotive crew in Karlovo station. It departed in Plovdiv direction at 05:03 a.m. Along Karlovo-Plovdiv section it kept the admissible movement speed. It arrived in Philipovo station at 06:13 a.m. and stopped over there for 2 minutes. It departed at 06:15 a.m., and arrived in Plovdiv station at 06:25 a.m. It remained there 9 minutes from 06:25 a.m. to 06:34 a.m., and then it performed shunting activities to 25 km/h in order to re-park on the other side of the train composition and to reverse the movement direction.

DFT No 30682 departed from Plovdiv station in Sofia direction at 07:08 a.m. Within its movement, it kept the admissible speed and arrived in Pazardzhik station at 07:52 a.m., where it remained until 08:20 a.m. for 22 minutes. Before departure from Pazardzhik station the engine driver performed test D of the automatic train brake of the train composition in accordance with article 301, item 5 of the TOSARRT – Train Operation and Shunting Activity Rules in the Rail Transport.

DFT No 30682 departed from Pazardzhik at 08:22 a.m. as it kept the admissible movement speed. It arrived in Septemvri station at 08:51 a.m., and stopped over in the station until 09:23 a.m. for 24 minutes. Before departure the engine driver performed test D of the automatic train brake of the train composition in accordance with article 301, item 5 of the TOSARRT – Train Operation and Shunting Activity Rules in the Rail Transport.

The train departed from Septemvri station at 09:23 a.m., and kept the admissible speed along the section. At 09:46 a.m. passed by the warning signal at Kostenets station with speed 42 km/h in traction mode (fig. 4.1). At 09:48 a.m. the train passed by the entrance signal at Kostenets station with speed 35 km/h with clear trend to



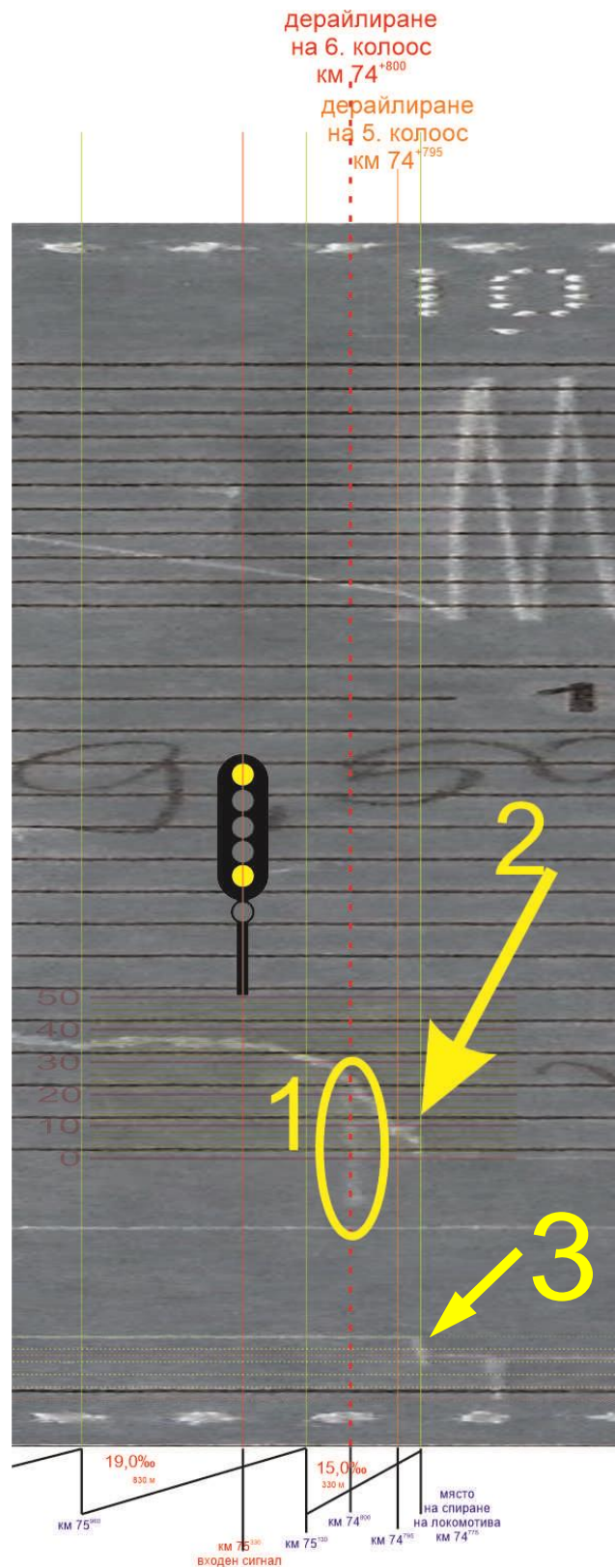
**Fig. 4.1.**



reduce the speed. After passing 200 meters (from the entrance signal at km 75<sup>+330</sup> to km 75<sup>+130</sup>) the speed reached 31 km/h and from that moment the reduction rate increased – the locomotive turned off the traction mode and started to move by inertia. The train moved in that mode to km 74<sup>+800</sup> for 330 meters and at the same place with speed 25 km/h was registered long vertical line by the pen, which registers the movement speed (fig. 4.2, pos. 1). The registered was a result from the derailment of the locomotive sixth wheel-set, which was first in movement direction. It shall be noted that the Tacho converter of locomotives series 46000 is located on sixth wheel-set, i.e. in the case was the first derailed wheel-set. The conclusion is that the locomotive derailed at km 74<sup>+800</sup> within 25 km/h speed with the first in movement direction (sixth for the locomotive) wheel-set. Only five meters after the derailment of the first wheel-set, derailed the second in movement direction wheel-set (fifth for the locomotive) at km 74<sup>+795</sup> (fig. 4.2, pos. 2). The registered of the passed distance between the derailment of the sixth and fifth wheel-set is not is not proportional to the passed distance, because in that moment the sixth wheel-set was not in contact with the rail track and did not report it correctly. At the moment of derailment of the second wheel-set, the engine driver activated the automatic train brake as he performed complete official retention, decreasing the pressure in the main air conduct to 3,5 bars, as a result the speed was decreased to zero, and the locomotive stopped over at km 74<sup>+775</sup> (fig. 4.2, pos. 3), calculated as per the location of the front locomotive buffers, which means that the track actually passed by the locomotive from the moment of derailment of the second wheel-set until its final stopping was 2,5 meters shorter, i.e. its first wheel-set location was at km 74<sup>+772,5</sup>.

*Railway infrastructure.*

During the train acceptance on third acceptance-departure siding track in Kostenets station at approximately 09:50 a.m., the locomotive derailed with the first two wheel-sets in the left curve area after right switch No 15, S 49, deviation 1:9, radius R=300 m, as the locomotive took a position, within which the front buffers were against the remote indicator, and the leading first wheel-set stopped at 2 m before the indicator. The traces that the first and second derailed wheel-sets left were the following:



**Fig. 4.2.**

- The right leading wheel of the first wheel-set went on the crown of the right leading rail in the curve at a distance of 15,77 m from the end of switch No 15 and slid from the external part of the rail.
- After 0,85 m followed also sliding from the left wheel of the internal side of the left rail.
- At 21,40 m after the end of switch No 15, followed rising of the right wheel of the second wheel-set that left a trace with 0,15 m length on the crown of the right rail and slid to the right from its external side.
- Then followed sliding of the left wheel of the same wheel-set from the internal part of the left rail in the curve.

The train movement speed within the derailment is 25 km/h. The curve was with radius R=188 m, without transitional curves in the interim straight-line from the switch side without cant and without transitional curves and interim straight-line. The beginning and the end of the curve were not marked with an indication sign on the spot.

#### **Assessment of the rail track condition.**

In order to perform an assessment, it is necessary to review in details the main parameters that characterize its condition. These are the rail gauge, transverse level, deviations of both rail threads in plan (on axle), vertical and horizontal bedding of the rails, condition of the sleepers grid and of the fastenings, ballast prism fouling, corrugation fatigues on the rails surfaces, slippage and other not so important factors.

- **Rail gauge (fig. 4.3, 4.4):**

- The transverse dimensions of the rail gauge in combination with the wheel-sets of the rolling stock play an important role for the safety operation of the rolling stock. In the case the accident occurred in the left curve without transitional curve (or interim straight line), which was a counter-curve against the deviation of switch No 15.
- There was switch No 15 (right) with radius R=300 m, and immediately after it left curve in the train movement direction with radius R=188 m. As per Table 3.1 of the „Instruction for the track superstructure planning and maintenance“ for curves with radius R=180 m to R<250 m, admissible is amplification +10 mm, as it is given in the circular curve nevertheless the presence or not of transition curves.
- From the protocol of the TF is evident that the point of ascent/rise of the rail gauge was with amplification +10 mm, in the next point (-1), the amplification was e +2 mm, and in the next point increased to +10 mm. In that situation, probably an insertion was induced and pressure exerted by the right wheel flange between the clamping set and the outer side of the external rail. The track respects the requirements against rail gauge.

- **Transverse level of the rail track (fig. 4.3, 4.4):**

- The distance between the first and the second wheel-sets of the bogies of locomotive No 46041 is 2 250 mm.
- Having in mind the hidden falls of the right rail 11mm and of the left rail 10 mm with difference from +1 mm, the cant in point 0 became equal to 3 mm.
- In p.0 = 3 mm; in point 2 = 0 mm, difference = 3 mm

$$K = \frac{L}{H} = \frac{2000}{3},$$

transition 1:666 before the rise, measured based on the locomotive bogie wheel-base (2 250 mm).

- In p.0 = 3 mm; in p. (-2) = 4 mm; difference = 1mm

$$K = \frac{L}{H} = \frac{2000}{1},$$

transition 1:2000 after the raise, measured based on the locomotive bogie wheel-base (2 250 mm).

- In p.0 = 3 mm; in p. 10 = 8 mm, difference = 5 mm.

$$K = \frac{L}{H} = \frac{10000}{5},$$

transition 1:2000 before the raise, measured based on the locomotive bogie wheel-base (10 300 mm).

- In p.0 = 3 mm; in p. (-10) = -4 mm, difference = 7 mm.

$$K = \frac{L}{H} = \frac{10000}{7},$$

transition 1:1438 after the rise, measured based on the locomotive bogie wheel-base (10 300 mm).

It is evident that the rail track respects the technical norms regarding the transverse level – Ordinance No 58 and „Instruction on the rail track superstructure planning and maintenance“.

- **Rail track condition in plan (under axis) (fig. 4.3, 4.4):**

- In the cases, when there are no benchmarks, the rail track position in plan is controlled and assessed via alignment differences, as for curves with radius  $R \leq 300$  m, as in the case, are measured with length of the chord 10 m, and report of the alignments through 5 m.
- The main rule is respected that on each magnitude (size) of a given alignment corresponds the respective curve radius, and it is defined under the formula:

$$f = \frac{a^2}{2R} = \frac{S^2}{8R}$$

where:

$a$  – ½ of the chord length;

$f$  – the measured alignment in a certain curve;

$S$  – the used chord,  $S = 10$  m;

$R$  – curve radius;

- The theoretical alignment of the curve with  $R=188$  m is as follows:

$$f_{theor.} = \frac{S^2}{8R} = \frac{10^2}{8 \times 188} = \frac{100 \times 1000}{1504} = 66,48 \text{ mm}$$

- In curve without transition curve and speed up to 40 km/h the difference between the alignments is the following:

$$\Delta f_{theor.} = 0,5 \frac{a^2}{2R} \pm 5 \text{ mm}$$

where  $a$  is the half of the ten-meters chord.

$$\Delta f_{theor.} = 0,5 \frac{5^2}{2 \cdot 188} = 33 \text{ mm}$$



1. Измерени параметри на 20 м. преди точката на възкачване (дерайлиране).

Таблица №1

Посока на движение	Точки на измерване	Заб. 1 (мм.)	Ниво (мм)	Скрити провадания на база ..... м (мм)		Междурелсие (мм)	Флеш хорда 20м/10 м (мм)	Износване на релсите		
				Лява р.	Дясна р.			вертикално	странично	
				Н	Нл					Нд
1	2	3	4	5	6	7	8	9	10	
Посока на движение на дерайлиралото возило ↓	20		6				3			
	19		12	сърце			4			
	18		7				4			
	17		10				9			
	16		10				14			
	15		10	край стр			15	-10		
	14		10				13			
	13		10				11			
	12		10				10			
	11		8				9			
	10		8				9	34	0	0
	9		6				8		0	0
8		1				9		0	1	
	7		1				9		0	6
	6		0				9		0	6
	5		0				8	74	0	6
	4		0	5	9		8		0	8
	3		0				10		0	4
	2		0				10		0	4
	1		0				11		0	4
т. на възкачване	0		2	10	11	10	76	0	3	

2. Измерени параметри на 20 м. след точката на възкачване (дерайлиране) или до мястото, до което железния път е разрушен.

Таблица №2

Посока на движение	Точки на измерване	Заб. 1 (мм.)	Ниво (мм)	Скрити провадания на база ..... м (мм)		Междурелсие (мм)	Флеш хорда 20м/10 м (мм)	Износване на релсите		
				Лява р.	Дясна р.			вертикално	странично	
				Н	Нл					Нд
1	2	3	4	5	6	7	8	9	10	
Посока на движение на дерайлиралото возило ← срещу сзипите / по сзипите	-1		0				2		0	2
	-2		4				10			
	-3		6				13			
	-4		6				14			
	-5		6				14	28		
	-6		5				11			
	-7		5				9			
	-8		3				5			
	-9		0				3			
	-10		-4				1	10		
	-11		-5				0			
	-12		-4				0			
	-13		-3				-2			
	-14		-2				-2			
	-15		-2				-3			
	-16		-1				-4			
	-17		1				-6			
	-18		3				-6			
	-19		3				-4			
	-20		3				-3			

Fig. 4.3.

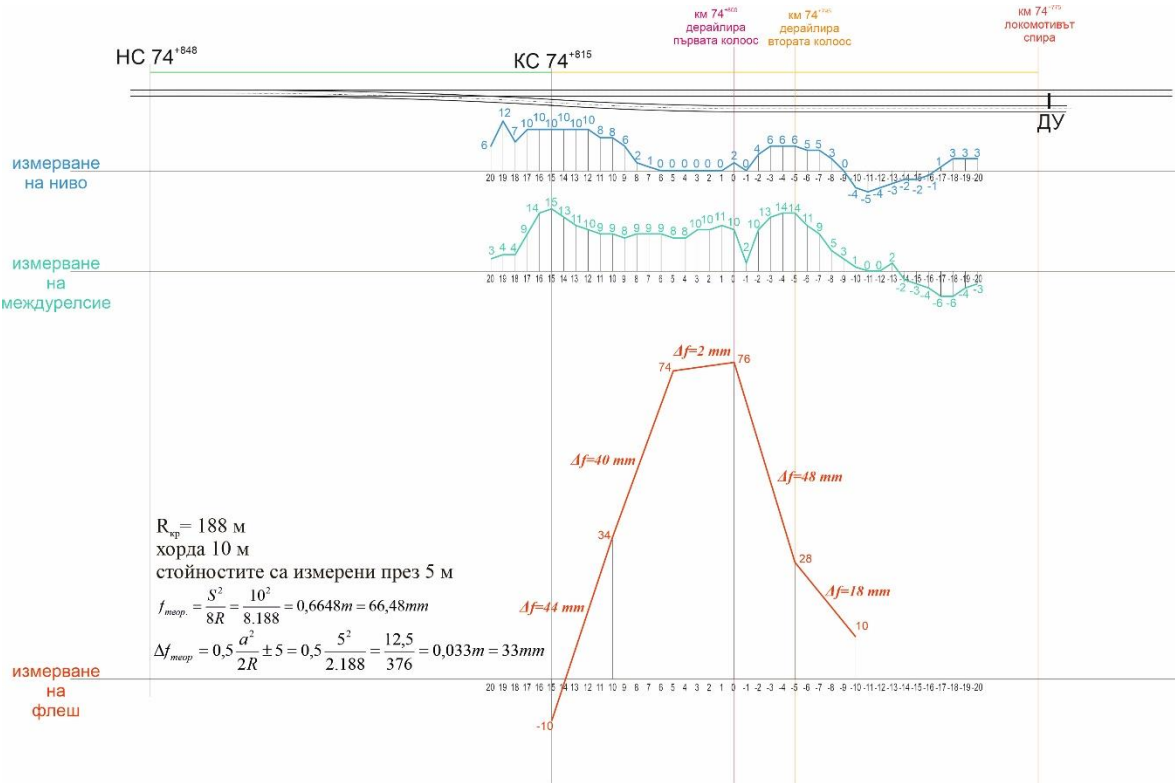


Fig. 4.4.



Fig. 4.5.



- Evident from the written values for the alignment in the circular curve, the alignment differences are from 34 mm, after 5 m to 74 mm in the rise point 76 mm, and after 5 m – 28 mm and after another 5m fell to 10 mm (Fig. 4.4).
- The greatest difference is in the neighboring rise points = 76 mm and p. (-5) = 28 mm, or difference of 48 mm and from p. 10 with value 34 mm to p. 5 with value 74 mm evident difference of 40 mm as the admissible is 33 mm (Fig. 4.4).
- **The requirements for the admissible thresholds alignment (under axis) values were breached.** The requirements are stipulated in Table 4.11 of the „Instruction on the rail track superstructure planning and maintenance“, as for speed to 60 km/h it is 24 mm (Fig. 4.5).
- **Lateral and vertical wear/fatigue of the external guide rail in the curve.**
  - From the Statement of findings on the rail track condition is evident there was no vertical wear of the rails, and the horizontal reached the maximum value of 8 mm having in mind that the admissible is from 13,5 mm for rails type S49.
- **Sleepers grid condition**
  - The sleepers grid condition is good; there is no missing or loose fastening.
  - The ballast prism is in good condition, without fouling.
- **Corrugation fatigue and slippage on the rail crown and around the place of derailment.**
  - There is no corrugation fatigue and slippage on the rail crown and around the place of derailment.

During the inspection of the place of rising the wheel-set on the rail and before it was visually found that from the internal working lateral surface of the right guide rail crown in the curve there were traces of filings. That was caused by the interaction between the first leading wheel-set of the locomotive and the right rail and it was an indicator for interrupted normal interaction within the insertion of the locomotive in the curve (fig. 4.6).



**Fig. 4.6.**

3. Entities in charge of the technical maintenance.

During the investigation process, the Commission required and analysed the documents on the performed inspections and repairs of locomotive No 46041, and was acquainted with the actual technical condition of its draft gear, and in particular with the spring suspension, wheelsets and the inter-bogie coupler.

On 16.07.2020 in Plovdiv locomotive depot were performed measurements of the controlled dimensions of the wheel-sets of locomotive No 46041. All the controlled dimensions

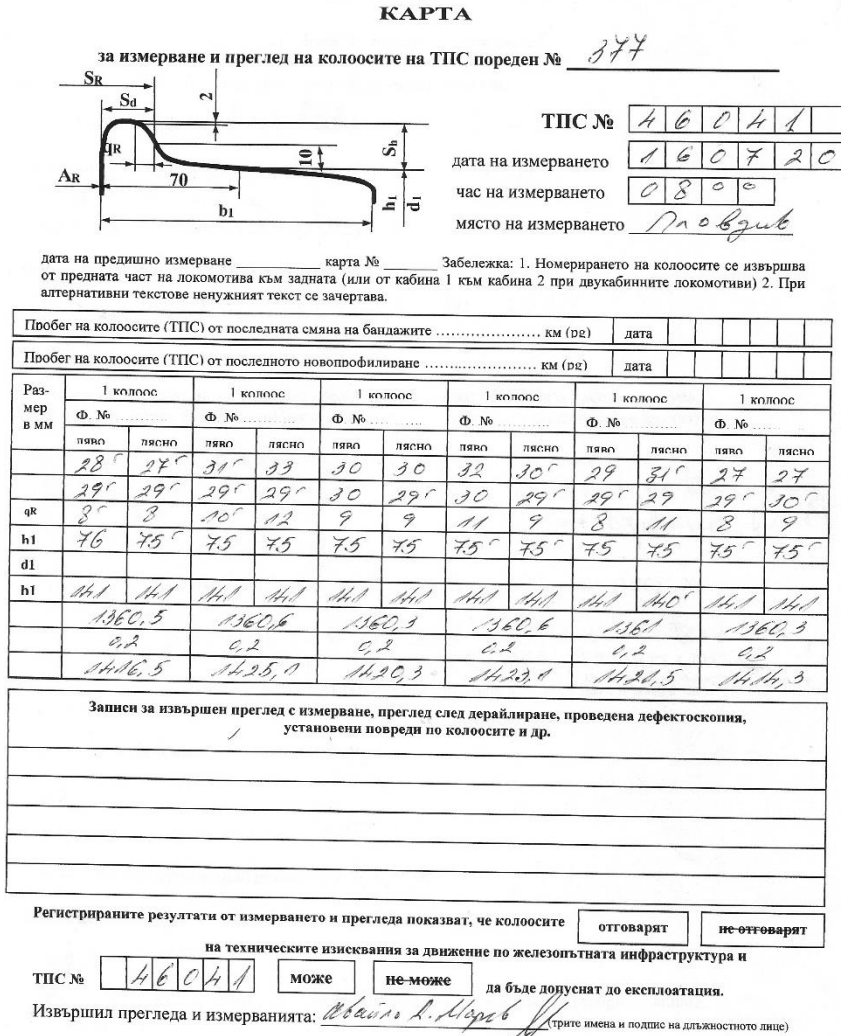


Fig. 4.7.

are regular and respect the requirements of the normative documents (Fig. 4.7).

On 16.07.2020 in Plovdiv locomotive depot were performed three control measurements of the static load of the locomotive wheels under axles (fig. 4.8, 4.9 and 4.10), as the obtained results do not respect the technical norms.

*3-го измерение*

*до измерения*



Fig. 4.8.

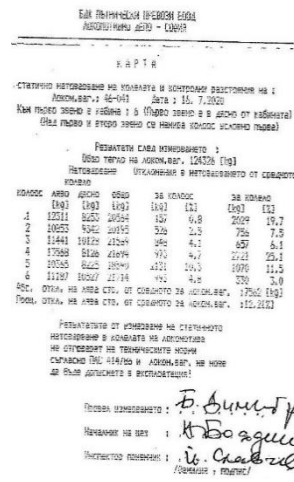


Fig. 4.9.

*3-го измерение*

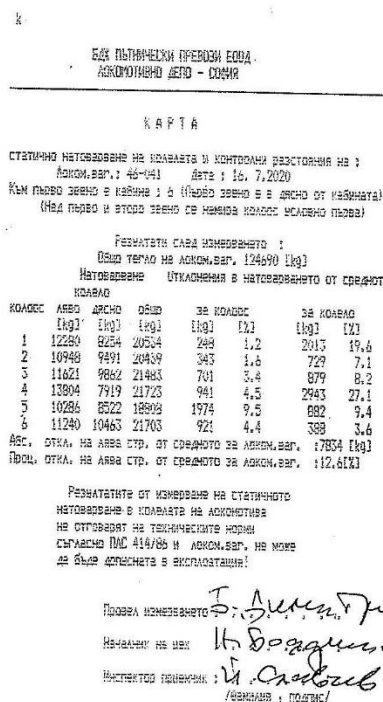


Fig. 4.10.

On 23.07.2020 again in Plovdiv locomotive depot were performed two control measurements of the static load of locomotive No 46041 under axles and again the results do not respect the technical norms (fig. 4.11 and 4.12).

46041 - 1-во измерване  
23.07.2020

46041 - 2-ро измерване  
23.07.2020 г.



Fig. 4.11.

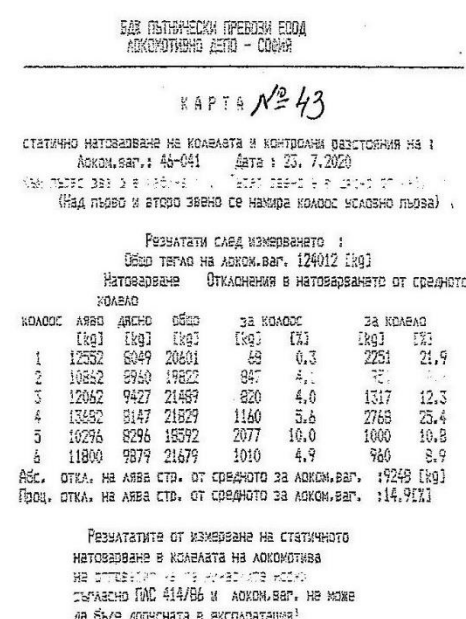


Fig. 4.12.

The reasons for that are because of the fact that the measurements of the static load were performed on a stand for measurement of the static load of four-axle locomotives. In that case were necessary the measurement of six-axle locomotive to be performed separately per each wheel-set, which was related to the locomotive shifting for each measurement. That led to displacement of the locomotive draft-gear – position of the wheel-sets on the rail track, reallocation of the locomotive weight on the separate elements of the spring suspension that gave impact to the static load of the locomotive separate wheels.

When the measurement is performed for each wheel-set separately, it is necessary to a given length of the locomotive before the couple of sensors and after it the presence of track levelling with precision  $\pm 1$  mm. That is impossible to be obtained on the stand for wheel-sets measurement in Plovdiv locomotive depot.

These reflections are also confirmed by the results, achieved during the measurement of the static load of the locomotive on the stand in Bourgas locomotive depot, which was constructed

for measurement of six-axle locomotives, and there the measurement was performed much more precisely, and without the need of locomotive shifting for the measurement of the static load on the separate wheel-sets.

In the period 04÷07.08.2020, members of the Investigation commission for the accident performed controlled measurements on the spot in Bourgas locomotive depot.

Data on the measured static load in the wheels of locomotive No 46041 dated 04.08.2020 (after the accident) are displayed on a Map for measurement of the static load in the wheels and adjustment of the spring system on fig.4.13.

From the obtained results was found that:

- In the load of the 4<sup>th</sup> wheel-set of the locomotive there were deviations to the left/right wheel from 5,5 % (the admissible difference is 5 %). All the rest 5 axles on that indicator are within the admissible field;
- In the load of the 5th wheel-set of the locomotive there were deviations to the left/right wheel from 5,63 % (the admissible difference is 2 %). All the rest 5 axles on that indicator are within the admissible field;

These deviations are minimal and insignificant; they were found after the accident and cannot be considered as a cause for its occurrence.

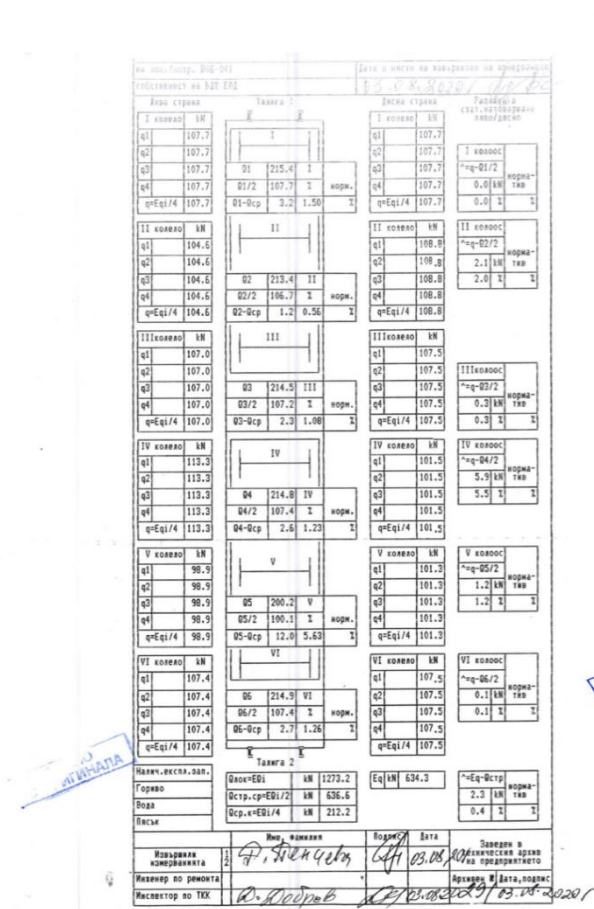


Fig. 4.13.

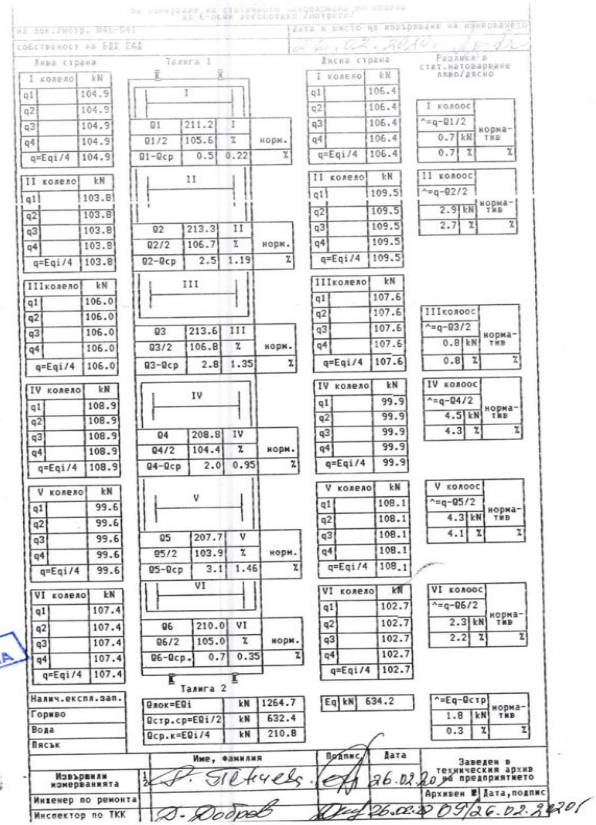


Fig. 4.14.



In the locomotive passport are conserved Maps for measurement of the static load of the wheels and adjustment of the spring system. Data on the measured static load in the wheels of locomotive No 46041-dated 26.02.2020 (**last measurement before the accident**) are displayed on the Map on fig.4.14.

From the displayed on the figure results was found that **all the differences in the load of the wheels** (left/right wheels of one axle, on wheelsets against the average load of wheelset and amount of loads of all left against the amount of loads of all right wheels) **are within the admissible normative thresholds.**

In order to establish the technical condition of the spring suspension of the derailed wheelsets of locomotive No 46041, were dismantled and tested on a stand the stiffness of three-layer metal-rubber packs of the wheel-sets.

The main parameters of the metal-rubber pack No 10-18-1731-33 are displayed to the right from the force-deformation diagram fig.4.15 with the registered and calculated results from the measurement:

- $P_{nom} = 50000 \text{ N}$  – nominal force of the pack load;
- $f_{nom} = 37,64 \text{ mm}$  – deformation of the pack corresponding to the nominal load force;
- $K_{nom} = 1556 \text{ kN/m}$  – nominal stiffness of the pack, defined on the base of the the tangent to the branch load at the coordinate point ( $P_{nom}, f_{nom}$ );
- $S(49) = 1606 \text{ N.m}$  – quantity of absorbed/consumed energy for a complete cycle of loading – unloading of the pack.

The main parameters of the metal-rubber pack No 10-18-1737-33 are displayed to the right from the force-deformation diagram on fig.4.16 with the registered and calculated results from the measurement:

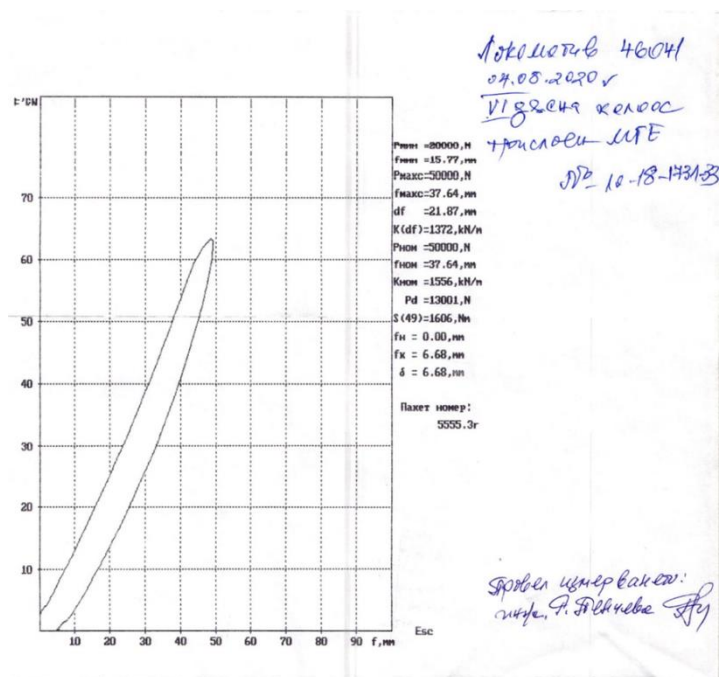


Fig. 4.15.

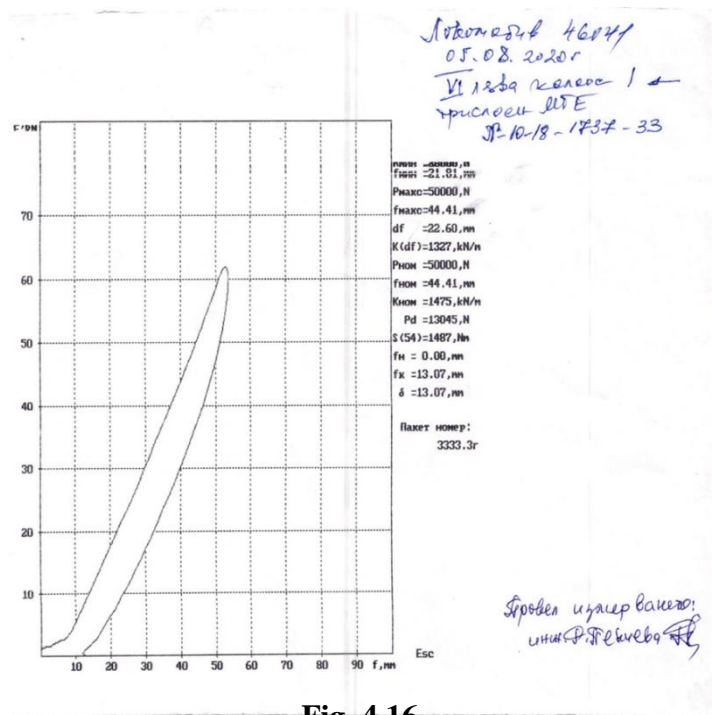


Fig. 4.16.



- $P_{nom} = 50000 \text{ N}$  – nominal load force of the pack;
- $f_{nom} = 44,41 \text{ mm}$  – deformation of the pack corresponding to the nominal load force;
- $K_{nom} = 1475 \text{ kN/m}$  – nominal stiffness of the pack, defined on the base of the tangent to the branch load at the coordinate point ( $P_{nom}, f_{nom}$ );
- $S(54) = 1487 \text{ N.m}$  – quantity of absorbed/consumed energy for a complete cycle of loading – unloading of the pack.

The main parameters of the metal-rubber pack No 10-18-1733-33 are displayed to the right from the force-deformation diagram on fig. 4.17 with the registered and calculated results from the measurement:

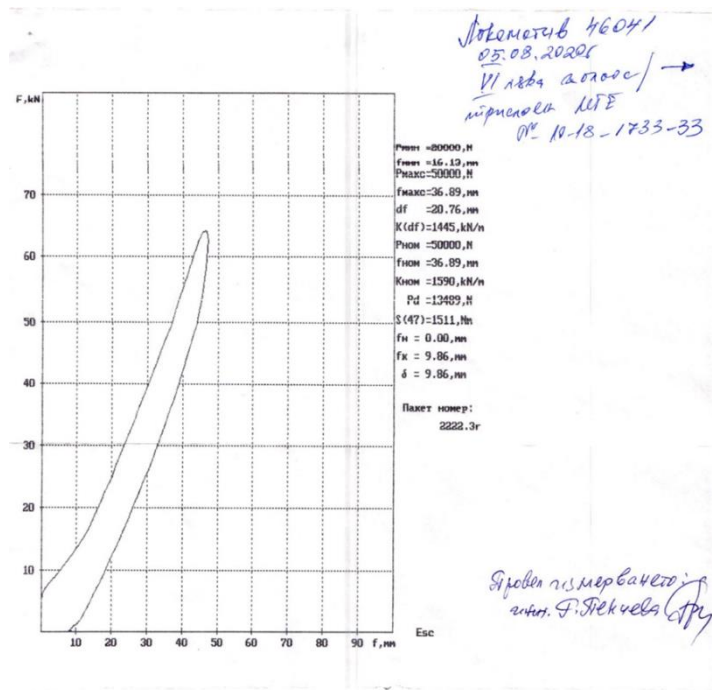


Fig. 4.17.

- $P_{nom} = 50000 \text{ N}$  – nominal force of the pack loading;
- $f_{nom} = 36,89 \text{ mm}$  – deformation of the pack corresponding to the nominal loading force;
- $K_{nom} = 1590 \text{ kN/m}$  – nominal stiffness of the pack, defined on the base of the tangent to the branch load at the coordinate point ( $P_{nom}, f_{nom}$ );
- $S(47) = 1511 \text{ N.m}$  – quantity of absorbed/consumed energy for a complete cycle of loading – unloading of the pack.

The results are displayed graphically on figures 4.15, 4.16 and 4.17. The parameters of the metal-rubber packs show that they are regular and are not a cause for the accident.

There are presented Maps for measuring of control distances from the suspension and guidance of the bogies of electric locomotive No 46041:

- Before the event:
  - From 26.02.2020;
  - From 09.12.2019;
  - From 18.09.2019.
- After the event:
  - 05.08.2020 (fig. 4.18 and 4.19).

As per the data in them, all the controlled distances are within admissible thresholds and respect the requirements.

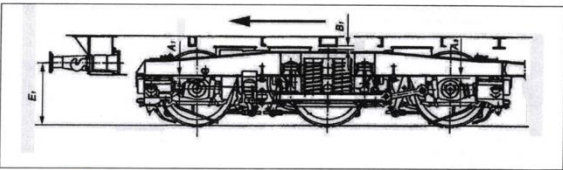
*Ил. Димитров*  
(Ремонтна предприятие, ремонтна база)

**Карта**

за измерване на контролни разстояния от окачването  
и воденето на талигите на електрически локомотиви серия 46

На локомотив № <b>46041</b>	Дата и място на извършване на измерването
собственост на „БДЖ – Товарни превози“ ЕООД	<b>05.08.2020 г. лок. деп. Бг</b>

1. Вертикално разстояние между корпуса на колосните букси и рамата на талигата* (разстояние А)					
Талига I / II Колос №	Съгласно технич. изисквания (mm)	Измерени размери в mm		Съответствие с изискванията	Забележки
		лява страна	дясна страна		
I/1 (A1)	35 <sup>+10</sup> <sub>-3</sub>	40	38	да   не	
I/2 (A2)	32 <sup>+10</sup> <sub>-3</sub>	40	36	да   не	
I/3 (A3)	35 <sup>+10</sup> <sub>-3</sub>	43	35	да   не	
II/4 (A4)	35 <sup>+10</sup> <sub>-3</sub>	43	41	да   не	
II/5 (A5)	32 <sup>+10</sup> <sub>-3</sub>	40	37	да   не	
II/6 (A6)	35 <sup>+10</sup> <sub>-3</sub>	39	41	да   не	



2. Вертикално разстояние между главната рама на локомотива и рамите на талигите (в средата на талигата)* (разстояние В)				3. Хоризонтално разстояние между средните отбивачи на главната рама на локомотива и рамите на талигите* (разстояние С)			
Талига I / II	Съгласно технич. изисквания (mm)	Измерени размери в mm		Талига I / II Место №	Съгласно технич. изисквания (mm)	Измерени размери в mm	
		лява страна	дясна страна			лява страна	дясна страна
I (B1)	58±5	58	60	I (C1)	25±3	26	25
II (B2)		59	57	II (C2)		24	24

Ил. 007-7.46/2018

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**Fig. 4.18.**

На локомотив № <b>46041</b>	Дата и място на извършване на измерването
собственост на „БДЖ – Товарни превози“ ЕООД	<b>05.08.2020 г. лок. деп. Бг</b>

4. Вертикално разстояние „върху“ главните подвески на вторичното окачване (от двете страни на средата на талигите)* (разстояние D)						
Талига I	Съгласно технич. изисквания (mm)	Измерени размери в mm		Съответствие с изискванията	Талига II	Съгласно технич. изисквания (mm)
		предна страна	задна страна			
I (D1)	450±0,5	450	450	да   не	I (D3)	450±0,5
II (D2)		450	450	да   не	II (D4)	

5. Височина на буферите над главна релса* (разстояние Е)						
Място	Съгласно технич. изисквания (mm)	Измерени размери в mm		Разлика в mm	Прегнислени размери** в mm	
		лява страна	дясна страна		лява страна	дясна страна
Отпред	965±1065	1056	1058	2		
Отзад	разлика макс. 15	1056	1059	3		

\* Измеренията се извършват на прав хоризонтален колос с дължина най-малко равна на дължината на измервания локомотив или вагон с макс. отклонения по височина ±1 mm и по хоризонталта ±2 mm и цирочната на железния път 1435±2 mm или на уреда на теглово уравновесяване.

\*\* Измеренията са направени при пълно натоварване.

6. Резултати от последното теглово уравновесяване на локомотива			
дата	<b>06.08.2020 г. предпр.</b>	<b>Ил. Димитров</b>	съотв. с изискванията <input checked="" type="checkbox"/> да <input type="checkbox"/> не

7. Допълнителни бележки						
Изм. / Изпълн. №	1.	<b>Ил. Димитров</b>	подпис	дата	<b>05.08.2020</b>	Заведен в техническия архив на предприятието
Изм. / Изпълн. №	2.	<b>Ил. Димитров</b>	подпис	дата	<b>05.08.2020</b>	Заведен в техническия архив на предприятието

Ил. 007-7.46/2018

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**Fig. 4.19.**

**4. Manufacturers or providers of rolling stock and railway products.**

Not applicable.

**5. National Safety Authority.**

Railway Administration Executive Agency is the National Safety Authority for railway transport in the Republic of Bulgaria.

**6. Notified bodies or Risk assessment bodies.**

Not applicable.

**6. Certifying bodies of the entities in charge of maintenance.**

The Railway Administration Executive Agency as the National Safety Authority for railway transport performs certification of the entities in charge of the vehicles maintenance (ECM) in accordance with Directive 2004/49/EC and Regulation (EU) 445/2011, as per Ordinance No 59 on the railway transport safety management and on the maintenance functions in accordance with Directive 2004/49/EC and Regulation (EU) 445/2011.

From June 16, 2020 the RAEA performs certification of the ECM as per the Commission Implementing Regulation (EU) 2019/779 of 16 May 2019 laying down detailed provisions on a system of certification of entities in charge of maintenance of vehicles pursuant to Directive (EU) 2016/798 of the European Parliament and of the Council and repealing Commission Regulation (EU) No 445/2011.

**7. Persons or entities involved in the event, documented or not in the respective safety management systems or indicated in register.**

Not applicable.

***b). Rolling stock and technical facilities.***

*1. Factors, deriving from the design of the rolling stock, railway infrastructure or technical facilities.*

*Rolling stock.*

Locomotive No 46041 was constructed in 1987. It is a six-axle bogie locomotive with an individual start of the wheel-sets. It is known from the theory of the locomotive dynamics that six-axle locomotives are generally more difficult to fit when passing into curves with small radius and cause greater stresses in the rail track and in their own running gear, that is why their flanges are worn faster. In order to compensate the wear of the flanges of the leading wheel-sets of the two bogies when passing into curves with small radius, the locomotive is fitted with an elastic inter-bogie coupler, the purpose of which is to reduce the total wear of the flanges of the locomotive wheel-sets. Under certain circumstances, due to the irregular and incorrect maintenance of the coupler, it is possible to change its power characteristic so that the interaction between the wheels and the rails reaches values that cause derailment of the locomotive.

*Railway infrastructure.*

In Kostenets station, the tracks were designed many years before the Bulgarian EU membership, which means that the tracks are maintained in technical condition as per the national rules, but they are not in conformity with the European norms and standards for interoperability and construction.

*2. Factors deriving from the installation and placing into service of the rolling stock, railway infrastructure and technical facilities.*

Not applicable.

*3. Factors deriving from manufacturers or another provider of railway products.*

Not applicable.

*4. Factors, deriving from the technical maintenance and/or modification of the rolling stock or the technical facilities.*

*Technical condition and maintenance of the rolling stock.*

In the period 1999-2001, numerous accidents with locomotives of the same series were observed under similar and even identical circumstances. Among the other causes (statically unbalanced locomotives due to unequal force and deformation characteristics of the spring suspension) the behaviour of the inter-bogie elastic coupler of these locomotives was among the causes for such events. For this reason, analysis and testing of this node were performed with the necessary design/constructive changes. After the taken measures, accidents of a similar nature almost completely disappeared by the time the event under investigation occurred.



On 23.07.2020, the Investigation Commission performed a detailed inspection of locomotive No 46041 in Plovdiv locomotive depot; the inter-bogie elastic coupler of the locomotive was dismantled.

The inter-bogie elastic coupler is a device, which is installed mainly on six-axle locomotives in order to reduce the total wear of the flanges in curves. It improves significantly the behaviour of the two bogies during operation of the locomotive in curves, by equalizing the angle of attack of their front wheels and improving the rotation of the two bogies when entering and exiting a curve. It is necessary to be noted, however that the inter-bogie coupler may also significantly worsen the behaviour of the bogies when moving the locomotive in curves, if it is not constructed correctly or does not maintain its technical characteristics in operation. Similar cases with this type of locomotives under almost identical conditions were observed more than 20 years ago. The measures taken at that time consisted of changing the design of the inter-bogie coupler in order to change some of its parameters: increasing the stroke of the spring, which reduces its pre-tension; removal of the restrictive sleeve between the guides, which increases the elastic pace of the spring apparatus.



**Fig. 4.20.**

During the inspection, the Commission found that the technical condition of the coupler is unsatisfactory, mainly because of its irregular maintenance (fig. 4.20). There was found that only the coupler spring was greased (fig. 4.21, pos. 1), which did not need such a treatment, and the friction surfaces of the individual bushings/bosses, ensuring the action of the coupler (stretching and shrinking) by their relative displacement to each other were not greased (fig. 4.22, fig. 4.23, pos. 1), nevertheless the presence of cavities and holes provided for the passage of the grease (fig. 4.23, pos. 2), as well as holes for greases, which were also missing (fig.



**Fig. 4.21.**

4.24). It confirms that from the condition of the individual bushings and shafts (fig. 4.22

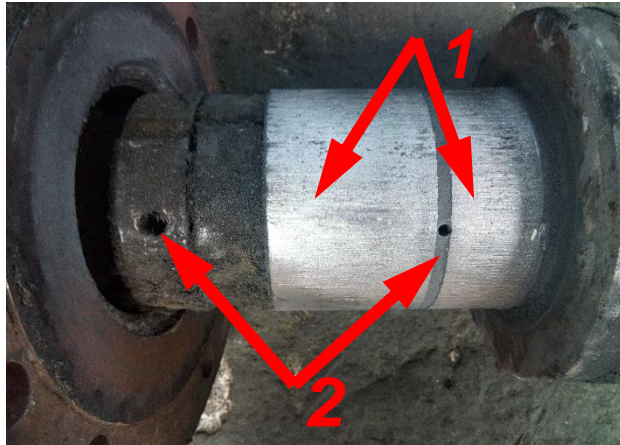


**Fig. 4.22.**

4.24). It confirms that from the condition of the individual bushings and shafts (fig. 4.22

and 4.23), which had torn surfaces, as well as the presence of chips on the individual elements and in the cavities around them.

All the listed findings lead to the conclusion that the neglected condition of the inter-bogie coupler, and the resulting friction between its parts has several times increased the resistance forces when turning the bogies, which has turned the elastic inter-bogie coupler into a rigid coupler,



**Fig. 4.23.**



**Fig. 4.24.**

deteriorating the force interaction between the locomotive and the rail track as it moves in the counter curve.

*Technical condition and maintenance of the railway infrastructure.*

Evident from the records on the monthly inspections of the rail track, no qualitative inspections were performed on the technical condition of the curve after switch No 15 on the 3rd track, no measurements of the alignment in the curve were performed according to the requirements of the Instruction for current maintenance of the rail track and switches.

*5. Factors due to the entity in charge of the technical maintenance, workshops for technical maintenance and other technical maintenance service providers.*

*Rolling stock.*

As per the requirements of the Prescription for technical inspections of electrical locomotives series 46000 (PLS 121-2/86) the inter-bogie coupler shall be inspected, its hinges shall be greased and the condition and strengthening of the safety ropes shall be checked (p. 2.9).

No detailed and in-depth inspections of the inter-bogie coupler were regulated, as well as during which scheduled inspections and repairs these activities to be performed.

There were not planned any inspections on the condition and operation of the inter-bogie coupler and of the values of its force and deformation characteristics.

*Railway infrastructure.*

According to the data from the Statement of Findings of the Task Force on the condition of the rail track, it is not in norms. It is evident that the measured alignment differences in and around the derailment point further complicated the entry of the locomotive bogies, increased the steering force and the angle of attack of the driving wheel, which led to the derailment of the first and then the second in direction of the train movement wheel-sets (fig. 4.5).

*6. Other factors or consequences considered as involved within the inspection objectives.*

There was not organized operational traffic management for DFT No 30682 in order Plan II-24 for the train acceptance in Kostenets station on II-nd main track to be respected.

**c). Human factor.**

*1. Individual human characteristics:*

*a). Training and development, including skills and experience.*

*Railway undertaking:*

- Engine driver – protocol No 10-568-337/22.11.2010 for obtaining professional qualification „Engine driver of electrical locomotive series 46000“, issued by Professional Training Center (PTC) of Bulgarian State Railways (BDZ EAD).
- Assistant engine driver – certificate for professional qualification „Engineer-operator in the transport – engine driver for electrical locomotives „series C-99, No 000705, reg. No 98/24.07.1999, issued by Transport College at HMTU „Todor Kableshkov“.

Railway Infrastructure:

- Traffic manager – Diploma No 17186/14.07.1978

*b). Medical and personal circumstances, which influence the event, including the presence of physical and psychological stress.*

Railway undertaking:

- Engine driver:
  - Medical exam card dated 17.02.2020, issued by Multi-profile Transport Hospital Plovdiv. Conclusion: suitable for engine driver.
  - Physiological exam No 1176/16.10.2017, issued by Laboratory for physiological expertise at Plovdiv Multi-profile Transport Hospital for engine driver – conclusion: accepted for a 3-year period.
- Assistant engine driver:
  - Medical exam card dated 31.10.2019, issued by Multi-profile Transport Hospital Plovdiv. Conclusion: suitable for engine driver.
  - Physiological exam No 1161/15.10.2018, issued by Laboratory for physiological expertise at Plovdiv Multi-profile Transport Hospital for assistant engine driver – conclusion: accepted for a 3-year period.

Railway infrastructure:

- Traffic manager:
  - Single health dossier No 3952 for periodic preventive examinations for traffic manager at SE NRIC, issued by National Multi-profile Transport Hospital Sofia, conclusion – suitable.
  - Physiological exam No 307/05.03.2019, issued by Laboratory for physiological expertise at National Multi-profile Transport Hospital Sofia – accepted for traffic manager at SE NRIC for a 2-year period.

*c). Fatigue.*

Railway undertaking:

- Engine driver:
  - Break/rest: from 05:00 a.m. on 06.07.2020 to 04:30 a.m. on 15.07.2020 (215 hours and 30 minutes).
- Assistant engine driver:
  - Break/rest: from 03:35 a.m. on 13.07.2020 to 04:30 a.m. on 15.07.2020 (48 hours and 55 minutes).

Railway infrastructure:

- Traffic manager:
  - Rest: from 07:00 a.m. on 13.07.2020 to 07:00 a.m. on 15.07.2020 (48 hours and 00 minutes).

*d). Motivation and attitudes.*

Not applicable.

## **2. Work related factor**

*a). Tasks planning.*

The cargo/freight traffic planning is performed under a Plan for train composition and carried out as per the Train Operation Schedule of “BDZ-Cargo”Ltd.



*b). Constructive particularities of the facilities that influence the connection human-machine.*

Not applicable.

*c). Communication means.*

Not applicable.

*d). Practices and processes.*

Not applicable.

*e). Operation rules, local instructions, staff requirements, prescriptions for technical maintenance and applicable standards.*

Application of the national normative acts!

*f). Working time of the involved personnel.*

As per the requirements of the normative acts. Working regime on shifts in 12 hours working shift.

*g). Risk treatment practices.*

SE NRIC applies safety procedure SP 2.09 „Methods of evaluation, assessment and management of the risk „version 05 effective from 01.03.2019, which is part of the SMS.

BDZ-Cargo Ltd. Applies a procedure „Methods of analysis and assessment of the risk within BDZ-Cargo Ltd” effective from 2013 as part of the SMS.

*h). Context, machinery, equipment and indications for shaping the working practices*

Not applicable.

### **3. Organizational factors and tasks**

*a). Planning of the working force and the working load.*

As per the requirements of the normative documents and best practices.

*b). Communications, information and teamwork.*

Not applicable.

*c). Recruitment, staffing requirements, resources.*

Not applicable.

*d). Implementation management and supervision.*

Not applicable.

*e). Compensation (remuneration).*

Not applicable.

*f). Leadership, powers related issues.*

Not applicable.

*g). Organizational structure.*

Not applicable.

*h). Legal issues (including the respective European and national rules and provisions).*

Not applicable.

*i). Regulatory framework conditions and safety management system application.*

Railway undertaking.

- Directive (EU) 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety;

- Commission Delegated Regulation (EU) 2018/762 of 8 March 2018 establishing common safety methods on safety management system requirements pursuant to Directive (EU) 2016/798

of the European Parliament and of the Council and repealing Commission Regulations (EU) No 1158/2010 and (EU) No 1169/2010.

- COMMISSION IMPLEMENTING REGULATION (EU) 2019/779 of 16 May 2019 laying down detailed provisions on a system of certification of entities in charge of maintenance of vehicles pursuant to Directive (EU) 2016/798 of the European Parliament and of the Council and repealing Commission Regulation (EU) No 445/2011

- COMMISSION IMPLEMENTING REGULATION (EU) No 402/2013 of 30 April 2013 on the common safety method for risk evaluation and assessment and repealing Regulation (EC) No 352/2009;

- Railway Transport Act;

- ORDINANCE No 59 dated 5.12.2006 on the railway transport safety management.

Railway infrastructure.

- Directive (EU) 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety (;

- Commission Delegated Regulation (EU) 2018/762 of 8 March 2018 establishing common safety methods on safety management system requirements pursuant to Directive (EU) 2016/798 of the European Parliament and of the Council and repealing Commission Regulations (EU) No 1158/2010 and (EU) No 1169/2010.

- COMMISSION IMPLEMENTING REGULATION (EU) 2019/779 of 16 May 2019 laying down detailed provisions on a system of certification of entities in charge of maintenance of vehicles pursuant to Directive (EU) 2016/798 of the European Parliament and of the Council and repealing Commission Regulation (EU) No 445/2011;

- Commission Implementing Regulation (EU) No 402/2013 of 30 April 2013 on the common safety method for risk evaluation and assessment and repealing Regulation (EC) No 352/2009;

- Railway Transport Act;

- Ordinance No 59 of 5.12.2006 on the railway transport safety management.

#### *4. Environmental factors.*

*a). Labour conditions (noise, illumination, vibrations).*

Not applicable.

*b). Meteorological and geographic conditions.*

The event occurred in the daylight hours, sunny and bright weather, with good visibility for the signals acceptance in Kostenets station on the third track.

*c). Construction works, performed on the spot or in very proximity.*

At Kostenets station in the area of the event have not been performed any construction works.

#### **4. Any other significant factor for the investigation objectives.**

There is no such.

#### ***d). Feedback and control mechanisms, including risk and safety management, as well as monitoring processes***

##### *1. Regulatory framework conditions.*

- Commission Delegated Regulation (EU) 2018/761 of 16 February 2018 establishing common safety methods for supervision by national safety authorities after the issue of a single safety certificate or a safety authorisation pursuant to Directive (EU) 2016/798 of the European Parliament and of the Council and repealing Commission Regulation (EU) No 1077/2012

- ORDINANCE No 59 of 5.12.2006 on the railway transport safety management.

*2. Processes, methods and results from the activities on the risk assessment and monitoring that the involved entities performed:*



*Railway undertakings.*

“BDZ-Cargo” Ltd. applies a procedure „Methods of risk analysis and assessment within BDZ-Cargo Ltd.“ effective from 2013 as a part of SMS.

*Railway infrastructure.*

SE NRIC applies a safety procedure SP 2.09 „Methods of risk evaluation and assessment „version 05 effective from 01.03.2019, which is a part of SMS.

*2a. Entities in charge of the technical maintenance.*

SE NRIC and “BDZ-Cargo” Ltd. are certified ECM.

SE NRIC applies a safety procedure SP 2.09 „Methods of risk evaluation and assessment“ version 05 effective from 01.03.2019, which is a part of SMS.

“BDZ-Cargo” Ltd. applies a procedure „Methods of risk analysis and assessment within BDZ-Cargo Ltd.“ effective from 2013 as a part of SMS

*2b. Manufacturers and all other participants.*

Not applicable.

*Reports on independent risk assessment.*

There have not been performed an assessment by independent Assessment Body (AsBo) on changes/modifications performed in operational conditions and factors that refer to the occurred accident.

*3. Safety Management System of the involved:*

*Railway Undertakings.*

The last annual planned supervision of the SMS of “BDZ-Cargo” Ltd. was performed in the period from 13.01.2020 to 31.01.2020.

*Railway Infrastructure.*

The last annual planned supervision of the SMS of SE NRIC was performed in the period from 19.10.2020 to 30.10.2020.

*4. Safety Management System of the entities in charge of the technical maintenance.*

Not applicable – the entities are certified ECM and in 2020 have had performed planned audits.

*5. Results from the supervision, performed by the National Safety Authority.*

The results from the performed audits and inspections referring the functionality of the Safety Management System of SE NRIC and “BDZ-Cargo” Ltd. as per the requirements of Regulation (EU) 2018/761, Regulation (EU) No 1169/2010, Ordinance No 56 and Ordinance No 59 on respect of the specific requirements of the European legislation and national rules for design, maintenance and operation of the managed railway infrastructure demonstrate that the entities maintain SMS and are able to respect the requirements, envisaged in the respective normative documents;

*6. Permits, certificates and assessment reports, provided by the National Safety Authority or other Conformity Assessment Bodies.*

*6a. Safety certificates of the involved railway infrastructure managers.*

- Safety Authorization No BG 21/2018/0001 valid from 01.07.2018 to 30.06.2023.

*6b. Safety certificates of the involved railway undertakings.*

- Safety Certificate part A BG 11 2017 0008, valid to 30.12.2022;

- Safety Certificate part B BG 12 2017 0008, valid to 30.12.2022;

*6c. Authorizations for placing in service of permanently fixed equipment and permits for placing on the market of vehicles.*

Not applicable.

*6d. Entities in charge of the technical maintenance.*

“BDZ-Cargo” Ltd. has an ECM Certificate for railway vehicles BGRA/2017/0003 valid to 30.12.2022;

SE NRIC is in charge of the repair, maintenance and operation of the national railway infrastructure.

*7. Other system factors.*

There are no.

*e). Previous similar cases.*

Similar cases within similar or identical circumstances were witnessed 20 years ago, which were inspected and analysed.

## **5. Conclusions**

*a). Summary of the analysis for the event causes.*

*Railway undertaking:*

The neglected condition of the inter-bogie coupler, and the resulted increased friction between its parts several times increased the resistance forces when turning the bogies, which has turned the elastic inter-bogie coupler into a rigid coupler, deteriorating the force interaction between the locomotive and the rail track as it moved in the curve.

*Railway infrastructure:*

The parameters for the threshold admissible values under alignment (axle), indicated in Table 4.11 of the „Instruction on the rail track superstructure planning and maintenance were violated as for speed to 60 km/h is 24 mm (fig. 4.5).

Having in mind Plan II-24 for the train acceptance in Kostenets station, DFT No 30682 was not accepted under plan on II-nd main track, but on 3-rd acceptance-departure track under decision of the traffic manager on duty, who did not know about the violated parameters of the track. The assistance locomotive of DFT No 30682 should have been attached to the train in Belovo station, as Kostenets station under the plan was not-stopping station for the train.

*b). Undertaken measures after the event occurrence.*

*Railway undertaking:*

To locomotive No 46041 was performed change of the inter-bogie coupler and detailed inspection with measurements of the draft gear.

*Railway infrastructure:*

After the accident on the 3<sup>rd</sup> track in Kostenets station was performed a partial repair of the rail track in the area of derailment.

*c). Additional findings.*

There are no.

## **6. Safety recommendations**

In order to prevent other accidents of similar nature, with reference to the requirements of art. 94, par. 1 of Ordinance No 59 dated 5.12.2006. The Investigation Commission suggests to the Railway Administration Executive Agency to order to „BDZ-Cargo“ Ltd. and SE NRIC to implement the following safety recommendations.

- By recommendation 1 is suggested “BDZ-Cargo” Ltd. to improve the technical service of the inter-bogie coupler of locomotive series 46000, respecting the technical documentation requirements for repair and maintenance;
- By recommendation 2 is suggested “BDZ-Cargo” Ltd. to performer the following technical operations during the planned repairs of locomotive series 46.000:
  - Dismantling and measurement of the force-deformation characteristics to all the rubber-metal packs with subsequent setting (defining their optimal placement);

○ Adjustment (balancing) the spring system of the locomotives, in order to level/equalize the vertical load on the wheels and reach „best adjustment condition“.

• By recommendation 3 is suggested „BDZ-Cargo” Ltd. to construct and implement an electronic stand/device for adjustment of the parameters and testing inter-bogie coupler of locomotive series 46000 with objective registration of the measured parameters and issuance of electronic protocol for the condition and adjustments.

• By recommendation 4 is suggested SE NRIC to arrange third track in Kostenets station as per the requirements of item 3.3.12.7 and item 3.36 for counter curves without cant without transitional curves, and without interim straight line of the Instruction for rail track and rail switches planning and maintenance.

With reference to the requirements of art. 94, paragraph 2 of Ordinance No 59 of 5.12.2006. The NAMRAIB Investigation Commission suggests to RAEA and interested parties a final report. The Report's Addressees shall inform in written the member of the NAMRAIB Administrative Board (President of the Commission) on the undertaken measures under the presented recommendations.

**The NAMRAIB Commission suggests a final report with recommendations dated 22.12.2020.**

**President:**

**Dr. Eng. Boycho Skrobanski**

*Deputy President of the NAMRAIB AB*

*I, the undersigned Giulietta Marinova Marinova-Popova, certify that this is a true and accurate translation done by me from Bulgarian into English of the attached document.*

*The translation consists of 35 pages*

*Translator: Giulietta Marinova-Popova*