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FINAL REPORT

from

**Technical investigation of railway accident – derailment of freight train No 50501 in
Voluyak – Hrabarsko interstation on 03.09.2016**



February 2017

FINAL REPORT
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Technical investigation of railway accident – derailment of six loaded wagons from the composition of freight train No 50501 in Voluyak – Hrabarsko interstation at km 14⁺⁰⁵⁵ on 03.09.2016

Objective of the report and extent of responsibility

As per Directive 2004/49/EC of the European Parliament and the Council on safety of the rail transport in the Community, Rail Transport Act (RTA) of the Republic of Bulgaria and Ordinance No 59 dated 5.12.2006 on the safety management in the rail transport, the investigation of railway events aims: to find the causes that led to their occurrence in order to eliminate and avoid such in future, **without searching personal fault and responsibility.**

The investigation was performed in accordance with art. 115 k of RTA, art. 76 of Ordinance No 59 dated 5.12.2006, and by Order No RD-08-426/17.09.2016 of the Ministry of Transport, Information Technology, and Communications was assigned a Commission for investigation of the railway accident.

The Commission for investigation performed several inspections to the accident site, and conducted meetings with the persons directly involved in the accident. In order to achieve the fast clarification and to find the circumstances and causes that led to the accident occurrence, external experts were also involved in the Commission of technical investigation. In the course of the investigation there were analyzed the report and collected materials to it submitted by the Task Force, and the additionally requested materials.

The Chairman of the Investigation Commission accepted the presented statements of the appointed external experts for the accident in implementation of the tasks that were assigned to them.

1. Established facts and circumstances in the investigation process.

Under a request of “BDZ – Cargo” Ltd. on 03.09.2016 was assigned a freight train No 10690 in composition of 18 loaded wagons (coals), 72 axles and gross mass 1348 tons, serviced by electrical locomotives No 46033.7. With traffic route Plovdiv-marshalling – Plovdiv – Sofia - Voluyak. In Iskar station, the train arrived at 05:00 a.m. and after a change of the locomotive crews at 05:20 a.m. departed, in Voluyak station, destination station for the train, it arrived on the third track at 05:42 a.m. with 47 min. ahead the schedule.

In Voluyak station the train stopped over for 6 min. due to a change of the train number, and change of the front part of the authorization for brake mass (form VP-11) and performance of shortened test „D“ of the automatic train brake by a mechanic technician wagon inspector. The train departed from Voluyak station under No 50501 with destination Voluyak – Exchange – Batanovtsi – Dupnitsa.

For ensuring the running of train No 50501 the traffic manager on duty first person in Voluyak station exchanged telephone messages with the traffic manager on duty in Hrabarsko station, and then ordered the route and opened an allowing indication at the exit signal. The traffic manager on duty second person in Voluyak station sent the train, which departed at 05:48 a.m.

After the train departure from Voluyak station, it developed speed to 58 km/h and passed approximately 8 km, then the speed decreased to 12 km/h without having a registered activation of the train brake. Then followed gradual increase of the speed to 32 km/h, by which the train passed another 7,5 km, and then the pressure of the main air conduit dropped sharply to 0 bar and the train stopped at km 24⁺²⁷⁶ at 06:11 a.m. (evident from the encoding of the speedometer tape).

During the train running in Voluyak – Hrabarsko interstation at km 14⁺⁰⁵⁵ derailed wagon No 31 52 665 1221-1 twelfth in order in the composition, with the first wheelset to the right in movement direction and continued its running as subsequently derailed also the second wheelset of the first bogie of the wagon to the right. In this condition (with the derailed first bogie) the train continued its running without that to be noticed or felt by the locomotive crew. During the train entering in curve of the track with radius R-500 m from km 23⁺¹⁶⁴ to km 24⁺⁸³⁰, after the

twelfth wagon derailed another five wagons from the train from 13th to 17th including and the same time the train torn between fifth and sixth, and between eleventh and twelfth wagons.

The location of the locomotive and the wagons after the train derailment was the following:

The first part, which includes the train electrical locomotive No 46033.7 and the attached to it five wagons with No No 31526650219-6, 31526650394-7, 31526650932-4, 31526651452-2 и 31526651571-9 did not derail and stopped at km 24⁺²⁷⁶ after the train tearing.

The second part of the train includes six wagons with No No 31526650629-6, 31526651759-0, 31526651797-0, 31526651631-1, 31526651276-5 and 31526650098-4 also there were not derailed and stopped at 24⁺¹⁰⁰ m after the first part.

The next six wagons derailed and part of them laid aside of the track as their location was the following:

The twelfth wagon No 31526651221-1 derailed with the two bogies, however it remained on the ballast prism at km 23⁺⁷⁵⁵.

The thirteenth wagon No 31526650048-9 derailed and laid to the right with spilled cargo at km 23⁺⁷³⁰.

The fourteenth wagon No 31526651693-1 derailed and laid to the right with spilled cargo at km 23⁺⁷¹⁷.

The fifteenth wagon No 31526650732-8 derailed and laid to the right with spilled cargo at km 23⁺⁷⁰⁴.

The sixteenth wagon No 31526650122-2 derailed and inclined to the right at km 23⁺⁶⁹¹.

The seventeenth wagon No 31526650820-1 derailed with the two bogies and remained on the ballast prism at km 23⁺⁶⁷⁸.

The last eighteenth wagon No 31526651741-8 did not derail and stopped at km 23⁺⁶⁶⁵.

After the received information from the train dispatcher on freight train No 50501, at 06:26 a.m. he issued an order for the traffic interruption of all trains that run in Voluyak-Hrabarsko interstation except for assisting rehabilitation vehicles.

From Voluyak station at 06:45 a.m. to the accident site was sent a diesel locomotive No 07065, which when reached km 14⁺⁰⁵⁵ stopped its running due to completely destroyed track by the derailed wagon of the train.

For performance of emergency-rehabilitation activities to the accident site from Sofia station at 07:07 departed a specialized truck UNIMOG and after it at 08:00 a.m. departed two rehabilitation cranes of NRIC.

For ensuring an access to the derailed wagons for work of the rehabilitation cranes was undertook traction of the two group non derailed wagons in Hrabarsko station.

The first group was dragged at 09:42 a.m. on third track in the station, then at 09:45 a.m. locomotive No 46033.7 returned back and dragged the second group of wagons in the station at 10:18 a.m.

The next group derailed wagons from 12th to 17th including, the lifting and the traction from the interstation was performed gradually within the period 03.09÷08.09.2016.

The rehabilitation cranes arrived in Hrabarsko station on 03.09.2016 at 12:14 p.m. and were sent to the accident site at 12:37 p.m.

The first derailed wagon No 31526651221-1 (twelfth of the composition) was placed on the rails and dragged in Hrabarsko station on the same day at 16:37 p.m.

On 04.09.2016 at 10:41 a.m. from Hrabarsko station departed a motor traction engine No № 35-02 with group of workers of Railway Section Sofia for performance of repair activities on the railway infrastructure for ensuring a possibility for work of the rehabilitation train with the derailed wagons.

On 05.09.2016 at 11:19 p.m. from Hrabarsko station was sent rehabilitation crane for lifting the next two wagons with No 31526650048-9 and No 31526651693-1, as the first was dragged at 16:02 p.m., and the second at 18:40 p.m.

On 06.09.2016 at 08:43 a.m. the rehabilitation crane was sent to the accident site for lifting the next wagon No 31526650732-8, which was dragged in the station at 13:17 p.m.

On 07.09.2016 at 09:30 a.m. from Hrabarsko station was sent a motor traction engine (motor tractor) No 35-02 with group of workers from Sofia Railway Section for performance of repair activities on the railway infrastructure for possible reaching by the rehabilitation crane to the last two derailed wagons.

On 08.09.2016 at 09:15 a.m. the rehabilitation crane was sent to the accident site for lifting of the last two derailed wagons No 31526650122-2 and No 31526650820-1. After their placing on the rails to them was attached also the last wagon No 31526651741-8, which did not derail and together were dragged in Hrabarsko station at 11:53 a.m.

The Voluyak – Hrabarsko interstation remained closed to traffic for the regional trains due to performance of repair-rehabilitation activities on the railway infrastructure.

After performed emergency repair of the track (from km 14⁺⁰³⁸ to km 26⁺⁸⁶⁴) the traffic of the regional trains in Voluyak – Hrabarsko interstation was recovered at 19:00 p.m. on 11.11.2016 as the traffic speed was limited to 25 km/h.

As a result from the occurred derailment there was no injured personal, however there were caused material damages to the railway rolling stock, to the railway infrastructure, to the transported cargo (coals), as well as to the environment in the region of the accident.

2. Officials, involved in the case.

2.1 Locomotive crew:

2.1.1. “Locomotive driver” of electrical locomotive No 46033.7 employee at Dupnitsa Locomotive Depot, “BDZ –Cargo” Ltd. – 5 years and 3 months of working experience;

2.1.2. “Assistant locomotive driver” of electrical locomotive No 46033.7 employee at Dupnitsa Locomotive Depot, “BDZ –Cargo” Ltd. – 15 years of working experience;

2.2. Station employees:

2.2.1. “Traffic manager” – II-nd person in Voluyak station – employee at Train operation and station activity management division – Sofia (TOSAM-Sofia), NRIC–9 months working experience at the position;

2.2.2. “Traffic manager” – I-st person in Voluyak station – employee at Train operation and station activity management division – Sofia (TOSAM-Sofia), NRIC–8 years and 2 months working experience at the position;

2.2.3. “Traffic manager” in Hrabarsko station – employee at Train operation and station activity management division – Sofia (TOSAM-Sofia), NRIC–9 months working experience at the position;

2.2.4. “Switchman/level-crossing guard” – Voluyak station – employee at TOSAM-Sofia, NRIC–5 years and 9 months of working experience;

3. Physical condition of the officials, involved in the accident.

To the officials, involved in the accident was ensured the necessary duration of rest before starting work as required by the Labor Code and Ordinance No 50 dated 28.12.2001 on the Working time of the management and executive personnel, involved in the provision of passenger and freight rail transport.

To the same was performed a pre-travel (pre-shift) instruction and they were declared to be alerted, rested and that did not drink any alcohol and other drugs.

The officials involved in the accident possessed valid certificates of psychological examination.

4. Documents, certifying work qualification and exercise of work position.

The officials from SE NRIC involved in the accident possess the necessary qualification and documents for their working position.

The locomotive crew of locomotive No46033.7 of BDZ- Cargo Ltd. possessed the necessary qualification documents and qualification for driving the respective locomotive series.

5. Activities of the officials before and during the accident.

The SE NRIC officials, acted immediately prior and during the accident in accordance with the established regulations and internal rules, which regulate the rail transport safety.

The „BDZ- Cargo” Ltd. officials, acted immediately prior and during the accident in accordance with the established regulations and internal rules, which regulate the rail transport safety.

6. Circumstances, preceding the accident in terms of track, signalling equipment, catenary, rolling stock etc.

6.1. Meteorological weather data, which had impact on the visibility of the signals:

- in the daylight hours,
- air temperature: $14 \div 15$ °C,
- without wind,
- clear weather without clouds.

6.2 Track:

- regular under documents.

6.3. Station and interstation signalling equipment before the accident:

- the interstation is equipped with Semi-automatic block system (SABS), regular does not refer the occurred accident.
- the two neighboring stations were equipped with Route-relay interlocking (RRI), regular and do not refer to the occurred railway accident.

6.4. Catenary:

- regular with no reference to the occurred railway accident.

6.5. Train composition station:

- Plovdiv marshalling.

6.6. Communication technique and telecommunications interfaces:

- Technically regular.

6.7. Profile, geometry and track layout:

- in the Voluyak – Hrabarsko interstation from km 14^{+055} to km 23^{+755} the track is a straight section with an uphill inclination 6 ‰, after km 23^{+755} the track passes in a right curve with an uphill inclination 10,7 ‰.

6.8. Rolling stock:

Electrical locomotive No 46033.7, serviced FT No 50501 was with regular draft gear, brake systems, illumination and sound signals as per the technical norms and requirements, which is evident from the records in the respective log-books, copies of which are presented with report of the Task Force.

Wagons:

- Series Fals₄, 18 pcs. loaded with coals – 72 axles.

7. Fulfilment of the working procedures and technologies within the system of the SE NRIC before and during the accident.

The working procedures and technologies before and during the accident at the Train Operation and Station Activity Management Division – Sofia, part of the SE NRIC structure, were complied. The above stated was evidenced by the report of the Task Force and its annexes, additionally requested materials and conducted interviews with the persons, involved in the accident by the investigation Commission.

8. Fulfilment of the procedures and technologies for rolling stock service within the railway undertaking system before and during the accident.

Freight train No 10690 was composed in Plovdiv marshalling yard, provided with the necessary brake mass and the necessary train documents.

The train stopped over in Voluyak station 6 min. for performance of shortened test of the automatic brake and an issuance of a new authorization for brake mass due to change of the train number with another one No 50501.

As per the schedule of train No 50501, it departed from Voluyak station with 33 min. delay.

The train was serviced by a railway undertaking “BDZ Cargo” Ltd. with License No203/16.10.2013 and with Safety Certificates part „A“ BG1120130002 and part „B“ BG1220130002.

The locomotive crew, which serviced the train was provided with business mobile phone.

During the review of the technical documentation of locomotive No 46033.7 were not found and registered breaches of the effective “Regulation for factory and depot repair and maintenance of electrical locomotives”, as well as of the technologies in the organization and operation.

From the provided technical documentation for the wagons was found that the wagons are owned by “BDZ Cargo” Ltd., the middle repair did not expired, and it was performed in wagon-repair factory of the railway undertaking.

To the twentieth under order wagon No 31526651221-1, which derailed first, was performed a repair in Wagon-repair Factory Plovdiv on 03.05.2011.

9. Railway infrastructure and rolling stock status before, during, and after the accident.

9.1. Status before the accident.

9.1.1. Switches – technically regular;

9.1.2. Signalling equipment.

- Semi-automatic block system (SABS) – technically regular;

9.1.3. Catenary – technically regular;

9.1.4. Rolling stock locomotive – before the accident electrical locomotive No 46033.7 was regular and after the occurred accident there were no caused damages on it.

9.1.5. Rolling stock, wagons – before the accident the wagons were regular under documents, during and after the accident there were visibly noticed deviations of the twelfth wagon in technical condition and the arrangement of the cargo.

9.2. Status after the accident.

9.2.1. Fatalities – there were no any;

9.2.2. Seriously injured – there were no any;

9.2.3. Failures and damages caused to the locomotives– there were no any;

9.2.4. Failures and damages caused to the wagons:

Wagon No 31526651571-9 (5-th under order in the composition) – not derailed;

- deformed carrier;

- torn traction rod;

Wagon No 31526650098-4 (11-nth under order in the composition) – not derailed;

- deformed carrier;

- torn clamp with screw car coupler;

Wagon No 31526651221-1 (12th under order in the composition) – derailed;

- bogie BT-6 set (without wheelsets);

- wheelsets – 2 pcs.;

- axle box body – 1 pcs.;

- axle box cover – 2 pcs.;

- axle box bearings – 2 pcs.;

- carrier of traction hook – 2 pcs.;

- traction hook – 1 pcs.;

- overhang for coupling – 2 pcs.;

- safety bent for brake shaft – 2 pcs.;

Wagon No 31526650048-9 (13th under order in the composition) – derailed;

- deformed front beam;
 - traction hook – 1 pcs.;
 - carrier of traction hook – 2 pcs.;
 - shunting step – 2 pcs.;
 - unloading valve – 2 pcs.;
 - set of axle box springs for bogie BT- 6 – 1 pcs.;
 - safety belt for brake shaft – 1 pcs.;
 - overhang for coupling – 2 pcs.;
 - signal stands – 2 pcs.;
- Wagon No 31526651693-1 (14th under order in the composition) – derailed;
- coupling clamp – 1 pcs.;
 - deformed platform for hand brake with railing;
 - unloading valve – 2 pcs.;
 - deformed front beam – 2 pcs.;
 - buffer 105 A – 1 pcs.;
 - Knorr sleeve and Ackermann crane (set) – 2 pcs.;
 - signal stand – 1 pcs.;
 - shunting step – 1 pcs.;
 - Ferry eye – 1 pcs.;
- Wagon No 31526650732-8 (15th under order in the composition) – derailed;
- deformed platform for hand/manual brake with railing;
 - manual brake (set);
 - deformed front beam – 2 pcs.;
 - buffer 105 A – 2 pcs.;
 - unloading valve – 2 pcs.;
 - triangle shaft (set) – 2 pcs.;
 - brake block holder – 1 pcs.;
 - Knorr sleeve and Ackermann crane (set) – 2 pcs.;
 - frame of bogie BT- 6 – 2 pcs.;
 - shunting step – 2 pcs.;
 - internal axle box spring for bogie BT-6 – 2 pcs.;
 - carrier of traction hook – 1 pcs.;
 - punctured body shell of wagon – 0,5 m²;
 - clamp for coupling – 1 pcs.;
 - ferry eye – 1 pcs.;
- Wagon No 31526650122-2 (16th under order in the composition) – derailed;
- deformed front beam – 1 pcs.;
 - unloading valve – 1 pcs.;
 - shunting step – 1 pcs.;
 - buffer 105 A – 1 pcs.;
 - triangle shaft (set) – 1 pcs.;
 - clamp for coupling – 1 pcs.;
 - punctured body shell of wagon – 1 m²;
 - brake block holder – 1 pcs.;
 - Knorr sleeve and Ackermann crane (set) – 2 pcs.;
 - Axle box body – 1 pcs.;
- Wagon No 31526650820-1 (17th under order of the composition) – derailed;
- punctured body shell of wagon – 0,5 m²;
 - Knorr sleeve and Ackermann crane (set) – 1 pcs.;

The damages to the failure wagons amount to 58 952,10 BGN without VAT.

9.2.5. Caused failures and damages to the railway infrastructure:

9.2.5.1. Track and structures:

- completely destroyed track in Voluyak-Hrabarsko interstation from km 14⁺⁰⁵⁵ to km 23⁺⁷⁵⁵ with total length 9700 m.

The damages for rehabilitation of the railway infrastructure amount to 470 909,84 BGN.

9.2.5.2. Signalling technique and communications, radio-connections and power supply:
- KERV cables – 8 pcs.;

The damages for “Signalling and Telecommunications” amount to 432,00 BGN with VAT;

9.2.5.3. Catenary:

- there were no caused damages.

9.2.5.4. Other failures and damages:

As a result from the accident was spilled the transported cargo (coals) 375 000 kg. by which are caused damages to the user TBL Ltd. amounting to 34 773,23 BGN with VAT.

9.2.6. Traffic interruption:

As a result from the accident in Voluyak-Hrabarsko interstation the traffic in the section was interrupted from 06:26 a.m. on 03.09.2016 to 19:00 p.m. on 11.11.2016.

9.2.6.1. Caused train delay:

Delayed trains:

BDZ-Cargo Ltd.:

- train No 60292 + 11 min. in Hrabarsko station;

- train No 60203 + 44 min. in Pernik station;

Cancelled trains:

BDZ-Passenger Services Ltd. – 55 trains;

BDZ –Cargo Ltd. – 20 trains;

TBD CARGO PLC – 1 train;

Assigned trains:

BDZ-Passenger Services Ltd. – 16 trains;

BDZ –Cargo Ltd. – 154 trains;

TBD CARGO PLC – 81 trains;

BRC AD – 3 trains;

9.2.6.2. Costs for modifying the Train operation schedule:

Total costs from the modification of the TOS amount to – 21 960,35 BGN with VAT.

9.3. Rehabilitation vehicles movement.

9.3.1. Rehabilitation train:

- on 03.09.2016 from Sofia station to the accident site departed two rehabilitation cranes of NRIC.

9.3.2. Other rehabilitation vehicles:

- on 03, 04, 05 and 06.09.2016 from Sofia station to the accident site and vice versa travelled a specialized truck UNIMOG.

The costs for the work of the rehabilitation train and the specialized automobile UNIMOG amount to 12 812,00 BGN without VAT.

9.4. Total damages and costs from the accident amount to: 602 839,52 BGN.

10. Causes for the accident.

After performed number of inspections on the accident site, led interviews to the railway personnel involved in the accident and several measurements of the track, performed several measurements of the static loading of the separate wheels of wagon No31526651221-1, (twelfth under order), the visible fatigues of the metal peripheries and the cracked phenolic resin pad as well as the submitted statements of the external experts the Commission of technical investigation came to the conclusion that the original technical cause that led to the accident occurrence is: **Irregular loading and allocation of the bulk cargo in the twelfth wagon of the train, as a result of which the central bearing of the first bogie during movement, worked aggressively and the inscription of the bogie was hindered, which led to an uphill of the right wheel of the first wheelset of the first bogie over the rail head without leaving a trace.**

11. Analysis of the causes that led to the railway accident occurrence.

From the performed inspections, additionally required materials from the Task Force, and the performed additional measurements of the track and static loading of the separate wheels of the twelfth wagon No 31526651221-1, the Commission of technical investigation found the following:

- the derailment of the twelfth wagon from the composition of FT No 50501 in Voluyak-Hrabarsko interstation occurred at 05:54 a.m. on 03.09.2016 at km 14⁺⁰⁵⁵ (evident from the speedometer tape);
- the derailment of the first bogie of the twelfth coach was realized in a straight line section of the track with an uphill inclination 6‰;
- the train traffic speed at the moment of the derailment was 58 km/h, within allowed of 60 km/h;
- the derailment of the rest five wagons was realized between km 23⁺⁶⁷⁸ and km 23⁺⁷⁵⁵ during the train entrance in right curve;
- as a result from the derailment, the train was torn at two places: between fifth and sixth, and between eleventh and twelfth wagons.

During the train movement in Voluyak-Hrabarsko interstation immediately after the front-crossing semaphore at km 14⁺⁰⁵⁵ in a straight line section of the track derailed with the first wheelset in the movement direction the 12th wagon No 31526651221-1 of the composition.

From the performed inspection on site on the place of derailment at km 14⁺⁰⁵⁵ was found that the flange of the right wheel did not leave a trace on the working side of the rail head, which proves, that wheel got over the right rail (fig. 1-фиг. 1).



Фиг. 1

The distancing to the right of the derailed wheelset is a cause after 1,10 m to derail the second wheelset of the first bogie in the gauge, leaving clear traces to the right from the rail and traces in the gauge (Fig. 2-Фиг.2).

After the derailment of the first bogie of the 12th wagon, the train continued its movement as through the place of derailment passed smoothly the second bogie of the wagon and the rest six loaded wagons. So the train continued its running with different speeds (evident from the encoding of the speedometer tape) to km 23⁺⁷⁵⁵, where derailed another five wagons and laid in the section from km 23⁺⁶⁷⁸ to km 23⁺⁷⁵⁵ and the train was torn at two places.



Фиг. 2

The last wagon of the train composition did not derail and stopped immediately after the derailed wagons at km 23⁺⁶⁶⁵.

From the inspection at the accident site was found that there were no missing or loosen fastenings as well as damaged sleepers. There was not found the presence of one-sided or twist downgrades of the track.

Based on the performed measurements of the track there were calculated the transitions before and after the place of derailment.

I. Before the place of derailment

The points are with corrected level, as there are taken into account the hidden downgrades of the right and left rail in the train running direction.

a) Based on central bearings = 7,5 m:

level in p. „0“ = -1 mm; level in p. 8 = 9 mm; Difference = 10 mm;

$$K = \frac{L}{H} = \frac{7,5\text{m}}{10\text{mm}} = \frac{7500\text{mm}}{10\text{mm}} = 750; \text{Inclination} = 1:750;$$

б) Based on 1,8 m – wheelsets of first bogie:

level in p. „0“ = -1mm; level in p.2 = 1 mm; Difference = 2 mm;

$$K = \frac{L}{H} = \frac{1,8\text{m}}{2\text{mm}} = \frac{1800\text{mm}}{2\text{mm}} = 900; \text{Inclination} = 1:900;$$

And in both cases is taken more unfavorable base for the calculation of the transitions.

II. After the place of derailment

a) Based on central bearings of bogies = 7,5 m:

level in p. „0“ = -1 mm; level in p. -8 = -5 mm; Difference = 4 mm;

$$K = \frac{L}{H} = \frac{7,5\text{m}}{4\text{mm}} = \frac{7500\text{mm}}{4\text{mm}} = 1875; \text{Inclination} = 1:1875;$$

b) Based on 1,8 m – wheelsets of the first bogie of the wagon:

level in p. „0“ = -1 mm; level in p. -2 = -5 mm; Difference = 4 mm;

$$K = \frac{L}{H} = \frac{1,8\text{m}}{4\text{mm}} = \frac{1800\text{mm}}{4\text{mm}} = 450; \text{Inclination} = 1:450;$$

Due to the nature of the derailment was calculated also the transition between the end axles of the two bogies with distance = 9,30 m. The distance of 9,30 m is an indicator that the wagon during the derailment was located in a zone of the track with parameters in norms.

Level in p. „0“ = -1 mm; level in p. 9 = 14 mm; Difference = 15 mm;

$$K = \frac{L}{H} = \frac{9,3\text{m}}{15\text{mm}} = \frac{9300\text{mm}}{15\text{mm}} = 620; \text{Inclination} = 1:620;$$

From the performed calculations is evident that there were fulfilled the requirements of art. 48, par. 5, item 2 of Ordinance No 58 dated 2.08.2006 on the rules for the technical operation, train traffic and signaling in the rail transport.

From point 10 before the derailment followed a smooth increase of the right rail against the left from 16 mm to 26 mm evident from the finding protocol of the Task Force for measurement of the track level by which are violated the requirements under art. 47, par. 4, point 1, letter „a“. The violation in the case is up to 11 mm from the normative, evident from the following description:

point 10 = 16 mm; / point 11 = 20 mm; / point 12 = 23 mm; / point 13 = 26 mm; / point 14 = 24 mm; / point 15 = 24 mm;

point 16 = 26 mm; / point 17 = 26 mm; / point 18 = 25 mm; / point 19 = 26 mm; / point 20 = 26 mm,

as the biggest difference in this smooth transition is 4 mm between points No 10 and No 11 and the transition (inclination) is the following:

$$K = \frac{L}{H} = \frac{1\text{m}}{4\text{mm}} = \frac{1000\text{mm}}{4\text{mm}} = 250; \text{Inclination} = 1:250;$$

Also between point 10 and point 16, where appears a difference of 10 mm:
point 10 = 16 mm; point 13 = 26 mm; Difference = 10 mm

$$K = \frac{L}{H} = \frac{3\text{m}}{10\text{ mm}} = \frac{3000\text{mm}}{10\text{mm}} = 300; \text{Inclination} = 1:300;$$

It is evident that in both cases are respected the requirements of Annex No 7 to art. 48, par. 6 of Ordinance No 58, where for transitions (inclinations) at a distance of one to four meters the sharpest inclination is 1:150 within calculations in both places from 1:250 and 1:300.

For the overall clarification of the case and the impact of the irregularities from point 10 to point 20 in which scope is located the 13th wagon during the derailment of the 12th wagon we must also calculate the transition between the central bearings of the first bogie of the 13th wagon against the second bogie of the 12th wagon.

The central bearing of the second bogie from the 12th wagon is located in the mid between point No 8 with level 10 mm and point No 9 with level 14 mm, or taken average value = 12 mm.

The central bearing of the first bogie of the 13th wagon is between point 13 with level = 26 mm, and point 14 with level = 24 mm. Here we take more unfavorable value of 26 mm, which is the maximum level in this zone. As the distance is 5,30 m follows:

The level between point 8 and point 9 = 12 mm; level point 14 = 26 mm; Difference = 14 mm

$$K = \frac{L}{H} = \frac{5,3\text{m}}{14\text{mm}} = \frac{5300\text{mm}}{14\text{mm}} = 378; \text{Inclination} = 1:378;$$

The inclination is norm as per Annex No 7 to art. 48, par. 6 of Ordinance No 58, where for distance to 5.5 meters the permitted inclination is 1:195, within reported 1:378.

The conclusion is that the status of the 13th wagon, which is in the zone of the found deviation in the super elevation of the track, the same did not impact to the derailment of 12th wagon.

Within the inspection of the derailed twelfth wagon No 31526651221-1 in Hrabarsko station was found that visibly the wagon was irregularly loaded in its front and back part (the load was not equally allocated). As a result from this was confirmed also from the performed additional measurements of the static loading of the separate wheels, stated by the railway undertaking BDZ-Cargo Ltd.

Within dismantling of the derailed first bogie of wagon No 31526651221-1 was found that the insert of the central bearing was deformed and cracked and did not bear regularly (Fig.



Фиг. 3



Фиг. 4

3-Фиг.3), and the slidings of the bogie were strongly worn with changed color.

The insert itself was smashed, without form and irregularly worn (Fig. 4- Фиг.4).

12. Recommendations and suggestions for events that prevent against other accidents of similar nature.

1. The railway undertaking BDZ-Cargo Ltd. and the consignors of bulk cargo shall construct weighing-measuring facilities for vertical loading of each wheel of the freight wagons in the regions, where loading-unloading activities are performed.

2. In case of technical possibility to be constructed a system for control of the rolling stock in motion „Check Point” of the railway infrastructure at NRIC.

3. The railway undertaking BDZ Cargo Ltd. shall strengthen the control on the proper loading of the wagons before their inclusion to a train composition.

4. The railway undertaking BDZ Cargo Ltd. shall strengthen the control on fulfilment of the obligations of the locomotive crews within train servicing.

Chairman:

Boycho Skrobanski

State investigating inspector at MTITC