Translation from Bulgarian language

REPUBLIC OF BULGARIA

AIR, MARITIME AND RAILWAY ACCIDENTS INVESTIGATION NATIONAL BOARD

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FINAL REPORT

From

Investigation of a serious railway accident - derailment of a freight train № 80561 in the entrance switches of Nova Zagora station on 15.05.2020

2020

PURPOSE OF THE INVESTIGATION AND DEGREE OF RESPONSIBILITY

The Investigation of serious accidents, accidents and incidents is carried out by an independent investigation authority Air, Maritime and Railway Accidents Investigation National Board (AMRAINB) at the Minister Council of the Republic of Bulgaria and it aims to identify the circumstances and the reasons that led to their implementation with a view to improve safety and prevent from others **without seeking personal responsibility and guilty.**

The investigation is carried out in accordance with the requirements of Directive 2004/49 / EC of the European Parliament and of the Council upon safety of the Community's railways transpositioned in the Law for Railways (LR), Ordinance № 59 from December 5, 2006 about the management of safety in railway transport, Ordinance № H-32 from September 19, 2007 about the coordination of the actions and the exchange of information during investigations of railway accidents and incidents and the Agreement for interaction during investigations of accidents and incidents in the air, waterway and railway transport between the Prosecutor's Office of the Republic of Bulgaria, Ministry of Interior and MTITC from April 17, 2018.

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ABBREVIATIONS USED IN THE REPORT

AB – automatic blockage;
BAS – Bulgarian Academy of Sciences;
BIM – Bulgarian Institute in Meteorology;
MAD – Main Air Duct (of the train brake system);
NRIC – National Railway Infrastructure Company;
DFT – Direct Freight Train;
RTA – railway transport act;
RRC - route-relay centralization;
AMRAINB - Air, maritime and railway accidents investigation national board ;
OG – Operational Group;
DPO – District Prosecutor Office;
SE – Safety equipment;
SP – Safety procedure;
RR - relay room;
RW – Railway
ARB - auxiliary recovery button;
RSCS - rolling stock control system;
EPM - electric point machine;
SARB - switch auxiliary reversing button;
ST – Signaling and Telecommunication division
RF – Railway and Facilities division
SMS – Safety management system;
TTSOM – Train Traffic and Station Operation Management;
ШСБЛ – шлосер стрелки, бариери, лубрикатори;
CMN – Master Node (главен възел);
CPDC – Data Concentrator ;
DED – Derailment Detector;
HBD – Hot Box Detector ;
HWD – Hot Wheel Detector ;
SMS – Short message service ;
WS – Wheel Scan;
DHT – Duty Head of Traffic;
LMTC – Laboratory for material analysis & testing and calibration of measuring facilities

1. Summary.

1.1. Brief description of the event.

DFT № 80561 had left on 14.05.2020 from Zlatitsa station at 18:13 hrs. The train has had 25 full wagons, gross weight 2148 tons with locomotive № 88030 at the head and auxiliary pushing locomotive № 88025. The train has been carrying copper pyrite in the direction Zlatitsa - Sofia - Plovdiv - Port of Burgas (Fig. 1). A second auxiliary locomotive № 88016 has been attached to the train at Sofia station and left at 20:43 hrs. At Vakarel station, the pushing auxiliary locomotive № 88025 had been disconnected from the train and left at 21:52 hrs. At Todor Kableshkov station

Fig. 1. Train route map

- - initial station for train movement
- - station where an auxiliary locomotive is attached/disconnected
- - station where the locomotive crew of the train locomotive changes
- - final station for scheduled train traffic
- - station where the accident takes place
- - route part passed by the train
- - route part not passed by the train

motormen change on locomotive № 88030 and the train leaves at 00:23 hrs. The head auxiliary locomotive № 88016 is disconnected at Plovdiv station and the train leaves with one locomotive № 88030 at 00:36 hrs.

At Khan Asparuh station, after a meeting with FT № 8636, it leaves at 03:02 hrs for Nova Zagora station. The duty head of traffic (DHT) at Nova Zagora station has prepared the route for the train to pass on the fourth main track without stopping. The train enters the entrance arrows of the station at a speed of 67.7 km/h. The locomotive with the first five wagons passes through the entrance arrows № 8, № 16 and through arrow № 20, and 10 wagons - from the 6th to the 15th wagon derail. From the subsequent derailment, the train stops at the station. DHT at Nova Zagora station notifies the interested services and persons.

As a result of the derailment of the train, damages are caused to the railway infrastructure - railway, railway switches, safety equipment and equipment of the catenary. Damages to 10 derailed wagons have occurred. The movement of the trains is interrupted through Nova Zagora station from 03:20 to 08:10 hrs on 15.05.2020..

1.2. Immediate and main cause of the accident.

DFT № 80561 enters Nova Zagora station and passes through the first entrance switches. The locomotive and the first five wagons pass through switch № 20. When the sixth wagon, № 33 52 0806 001-2 passes between the first and second bogies there happens a spontaneous turning of switch № 20 in a mechanical way from the position leading to the straight fourth track to the position leading to the divertive second track at the station. The first bogie continues its movement on the fourth track, and the second bogie of the wagon is directed on the shoulder rails and the left wheels of the second bogie derail, and subsequently the right wheels too. The reason for the derailment is

an incorrectly regulated and maintained spring rocker arm mounted on an arrow № 20, which at the time of derailment has been in an equilibrium (intermediate) position, allowing wild vibration and displacement of the tongues (Fig. 2 and Fig. 3).

Fig. 2. Switch №20 spring rocker arm, set in unregulated (equilibrium) position

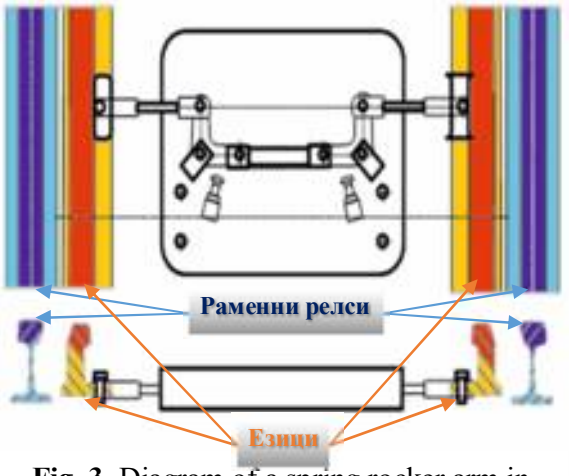


Fig. 3. Diagram of a spring rocker arm in equilibrium position

1.3. Summary of main recommendations.

The safety recommendations are addressed to the Railway Administration Executive Agency (EARA), the railway carrier DB Cargo Bulgaria EOOD and NRIC.

1. Recommendation 1 proposes to conduct an extraordinary briefing of the personnel related to the safety of the transport in "DB Cargo Bulgaria" EOOD and NRIC, to be acquainted with the content of the final report.

2. Recommendation 2 proposes to NRIC to re-equip the platform scales in the operating points of wagons freighting for precise and accurate measurement of the loaded wagons both on axles and on wheels.

3. Recommendation 3 proposes NRIC together with Voestalpine Railway Systems Bulgaria OOD to amend and supplement the "Manual for installation, operation and maintenance of a spring rocker arm with two arms", to write down the parametric data for repair and maintenance in compliance with the norms for railway switches safe operation.

4. Recommendation 4 proposes NRIC to allocate to the "Railroad and Railway Equipment" and "Signaling and Telecommunications" Units responsible for the maintenance of UIC 60 switches equipped with a 550-B turn out switch device , Spherolock locking system and spring rocker ram with two arms, the manipulations for the repair and maintenance of the electrical and mechanical part to be performed jointly according to their competencies.

5. Recommendation 5 proposes, in order to improve the safety of the railway infrastructure, that NRIC should entrust the maintenance of certain stations equipped with UIC 60 switches to Voestalpine Railway Systems Bulgaria OOD, which should be responsible for their maintenance and technical condition in compliance with the norms for safe operation.

6. Recommendation 6 proposes NRIC to update the Instruction for work with the rolling stock control system in the section Sofia - Plovdiv, in the part minimum speed for measuring and registering the parameters of passing rolling stock, in order to accurately and completely data registering.

2. Direct facts.

2.1. Date and time of the event.

DFT № 80561 departs on 14.05.2020 from Zlatitsa station at 18:13 hrs. The train consists of 25 full wagons, 100 axles, 2148 tons, train locomotive № 88030, and auxiliary pushing locomotive № 88025. The train carries copper pyrite along the route Zlatitsa - Sofia - Plovdiv - Port of Burgas. The train is served by locomotives of the railway carrier "DB Cargo Bulgaria" EOOD. After the arrival of the train at Sofia station at 20:31 hrs, a second auxiliary locomotive № 88016 is coupled to the head of the train and it leaves at 20:43 hrs. It arrives at Vakarel station at 21:44 hrs, the pushing auxiliary locomotive № 88025 is uncoupled from the train and leaves at 21:52 hrs. The train arrives at 00:04 hrs at Todor Kableshkov station, where the brigade of locomotive № 88030 is shifted it departs at 00:23 hrs. It arrives at Plovdiv station at 00:30 hrs, the auxiliary locomotive № 88016 is uncoupled and the train leaves with locomotive № 88030 at 00:36 hrs. The train arrives at Khan Asparuh station, at 02:55 hrs for a meeting with fast train № 8636, departing from Nova Zagora station. After the train leaves Khan Asparuh station at 03:02 hrs, DHT at Nova Zagora station, through MRC H-68, orders a route on the fourth main track without stopping the train. The train passes through entrance switches № 8, № 16 and № 20, which are parts of the route on the fourth main track, at a speed of 67.7 km/h, as the permitted speed is 75 km/h. After the passing of the locomotive and the first five wagons through arrow № 20 at 03:18:25 hrs, ten wagons derail from the train (from the 6th to the 15th) in the 2nd track direction. Under the sixth wagon between the two bogies, a spontaneous mechanical turn out of switch № 20 happens. The train breaks at three places: between the fourth and fifth, fifth and sixth and sixth and seventh car. The locomotive brigade finds in the inspection, that ten wagons of the train has derailed, as 3 of them has laid with

Fig. 4. Scheme of the derailed train

the load scattered between the 1st and 4th tracks, and the locomotive with the first five wagons stops on the 4th track in front of the station (Fig. 4).

2.2. Event's location.

Nova Zagora Station is a junction station located at km 139 $^{+038}$ on the 8th main railway line, adjacent in the section Plovdiv - Stara Zagora - Karnobat - Bourgas and on the 83rd diverting railway line in the section Nova Zagora - Simeonovgrad (Fig. 5).

At the Nova Zagora station, in the area of turnout № 20, a sixth car with a second bogie derails, followed by nine more cars from DFT № 80561.

Fig. 5. Railway section of the 8th and 83rd railway lines

2.3. Notification procedure and event's classification.

Notification of accidents and incidents occurs 24 hours a day by the personnel on-duty in accordance with the "Safety Procedure SP" 2.03." of NRIC.

On 15.05.2020 at 03:58 hrs an SMS is received to the Vice-President of AMRAINB who has the competence to investigate

railway accidents.

The notification of an accident is confirmed at 04:35 hrs by a mobile phone call from NRIC.

Clarifying the consequences of the event in situ, the Vice-President of AMRAINB having the competence to investigate railway accidents on the grounds of Art. 20 (1) (a) of Directive (EU) 2016/798 and of Art. 68, para. 1, item 1 and para. 2 of Ordinance № 59, classifies the event as a serious railway accident.

2.4. Consequences of the Event:

- no injured personnel and other persons;
- damages to 50 m of 1st track railway ;
- damages to 65 m of 2nd track railway ;
- damages to 75 m of 3rd track railway ;
- damages to 40 m of 4th track railway ;
- damages to arrows №№ 20, 26 and 28;
- damages to the insurance equipment;
- damages to the catenary;
- damages to the derailed ten wagons of the train;
- no damages to the environment;

2.5. Decision to initiate an investigation.

The decision to initiate the investigation is taken before the entry into force of Implementing Regulation (EU) 2020/572 of the Commission of 24 April 2020 on the reporting structure and the report follows the form and content set out in Annex V to Directive 2004/49 / EC of the European Parliament and of the Council.

An investigation commission is appointed in AMRAINB pursuant to Art. 20, paragraph 1 of Directive 2016/798, Art. 115k, para. 1, item 1 of the Railway Transport Act (RTA) and Art. 76, para. 1, item 1 of Ordinance № 59 of 5.December 2006. The chairman of the commission is the vice-president of AMRAINB having the competence to investigate railway accidents. The commission includes external experts with the relevant professional qualification. Other consultants and experts are involved in the Investigation commission.

2.6. Course of the investigation

On 15.05.2020, after verbal notification of the AMRAINB's Vice-President, an initial inspection of the scene of accident is performed at Nova Zagora station. The damages of the railway infrastructure and the rolling stock are outlined. Photographic material is prepared and collected. The inspections are carried out jointly with representatives of the District Prosecutor's Office - Sliven. The investigation of the accident continues in compliance with the Agreement between the Prosecutor's Office of the Republic of Bulgaria, the Ministry of Interior and the Ministry of Transport, Information Technology and Communications. The commission conducts an interview at Nova Zagora station with the staff of the railway companies involved in the accident.

On 16.05.2020 the Commission for Investigation and the representatives of DPO - Sliven carry out inspections for comparability between the indication of MRC in the DHT office, the equipment in RR and EPM at arrow № 20 at Nova Zagora station.

After the inspection of the MRC control panel and the equipment in the RR, an inspection of EPM is started, which has been sealed by DPO - Sliven. When opening the cover, it is found that the device is at its (plus) position and the arrow tongues are in their (minus) position. The position of the switch machine, the tongues and the equipment in RR confirm the information on the MRC desk. The control section for switch № 20 is found at position "occupied" because of damage due to the derailment. Restoration of the cut switch № 20 is commenced. Restoration of the cut switch № 20 is commenced. ARB is unsealed after written permission and an attempt is made to reverse the switch by the individual switch button. The switch does not reverse. A re-attempt to reverse the switch is made using a sealable SARB and the individual switch's button. EPM is electrically activated, and the tongues do not move. There is a correspondence between the position of the tongues, the position of the EPM auto-switches and the deviation control (minus) for the switch appears on the MRC desk. Again, the switch is reversed from the (minus) position to the straight (plus) position, and a control (plus) indication appears on the MRC desk. Several more control reverses of the switch are made by measuring the clearance at the tip of the tongues, using standard templates. The electrical controls of the switch comply with regulatory requirements.

After opening the cover of the spring rocker arm, mounted on switch № 20, it is visually established that it is unregulated and unmaintained. The spring rocker arm has not crossed the neutral line and has remained in an intermediate equilibrium position (Fig. 2 and Fig. 3). The measured distance between the free right tongue and the right shoulder rail in the area of the spring rocker arm is 40 mm, at a rate of 65 ± 3 mm.

The data from the registering device of locomotive № 88030 on the train movement are taken and deciphered in situ by a specialist of DB Cargo Bulgaria EOOD. It is established that the train derails at a speed of 67.7 km/h as the maximal scheduled speed is 75 km/h.

An inspection of locomotive № 88030 and of the non-derailed first five wagons is performed. A detailed inspection is carried out of the sixth wagon of the train, which has derailed with the two bogies, obliquely to the axis of the railway between the fourth and third tracks. A blow is found from the buffer of the seventh wagon, which visibly has torn the front wall of the sixth wagon. Torn left hand spring bolt of the first bogie, first wheel of the sixth wagon towards the direction of travel. The bolt is in place and the integrity of the spring block is not compromised. The head of the Operational group hands over to the chairman of the Investigation commission as a piece of material evidence the torn spring bolt holding the leaf spring of the first bogie of wagon 52 33 52 0806 001-2, the sixth in the train composition.

On 18.05.2020 on the wagon scale at Nova Zagora station sixth wagon № 33 52 0806 001-2 is measured with a gross weight of 85800 kg. The following checks are carried out on the wagon scales at the station:

- On 25.07.2018. From ESIT RWPWI periodic inspection, accuracy class: iii ± 50 kg;

- On 19.06. 2019. Complex inspection by TTSOM Plovdiv Division , for which an audit act has been drawn up;

- On 27.04.2020. from the chief of Nova Zagora station - the scales are in good condition.

On 21.05.2020 in Stara Zagora Locomotive depot the Investigation Commission performs a visual inspection from the overpass for the distribution of the load in the basket of the sixth car № 33 52 0806 001-2 of the train composition. It is found that as a result of the derailment and the blows suffered by the wagon, the load is shifted to the right and longitudinally in the basket to the first bogie of the wagon. The static load distributed to the wheels of the wagon on an electronic scale is also measured. The result of the total gross weight is: 84300 kg.

On 22.05.2020 NRIC changes the left tongue and left shoulder rail of switch № 20 at Nova Zagora station (Fig. 6).

On 26.05.2020 on switch № 20 at Nova Zagora station in the presence of representatives of DPO - Sliven, the Investigation commission and NRIC the rocker arm is mounted to the replaced left tongue and adjustment of its spring is completed.

On 02.06.2020 the railway enterprise ST - Plovdiv is visited, where the integrity of the

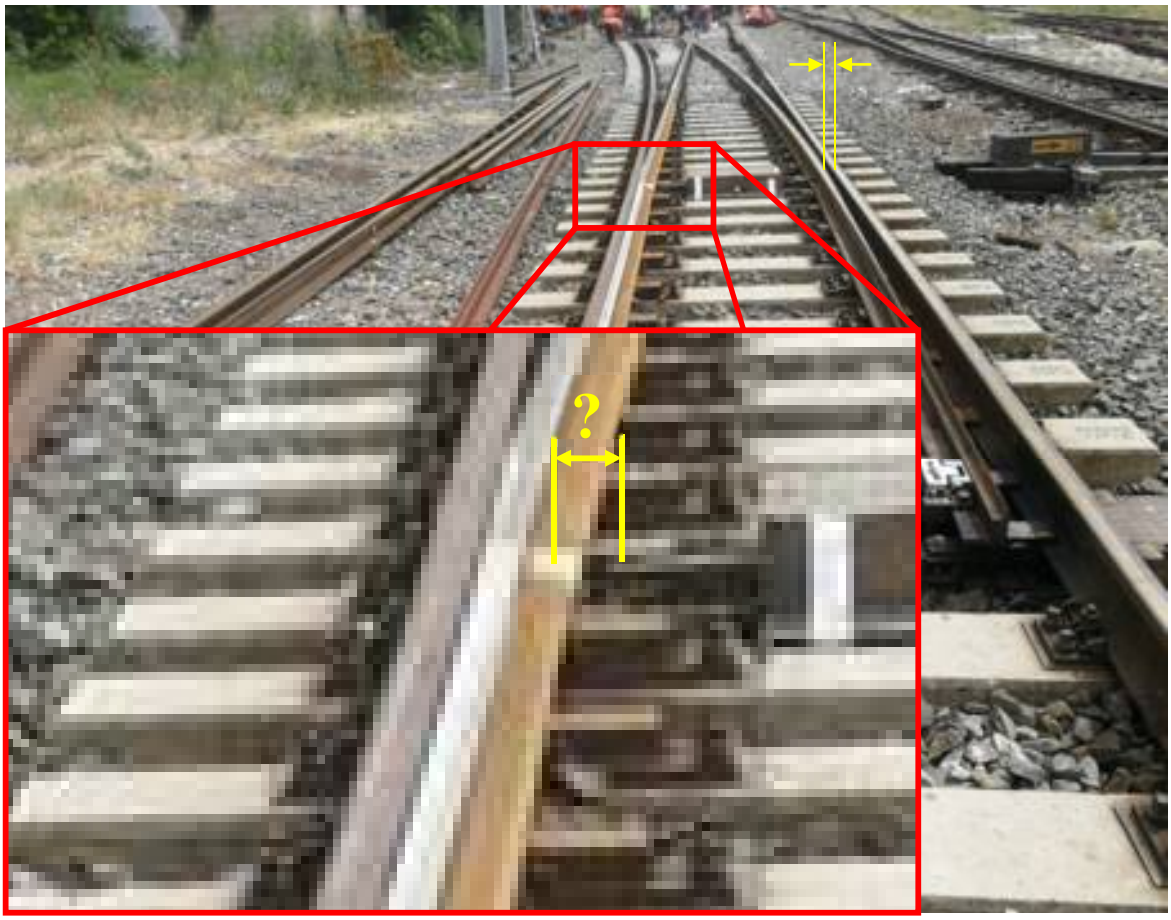


Fig. 6

dismantled PM of switch № 20 at Nova Zagora station is checked and the scheme for the electric reverse of the switch is required.

On 11.06.2020, in TTSOM Plovdiv Division the Investigation commission accepts the collected materials from the Operational group.

On 15.07.2020 a joint inspection is carried out with representatives of BAS and DPO - Sliven of the mechanical part of the dismantled tongue of switch № 20 and examination of the tongue for traces of DFT № 80561 rolling stock's wheels on the tongue.

On 22.07.2020, **after additional adjustments of the spring rocker arm and its normalization**, some experiments are performed with dynamic stabilizer DGS 62-2, for the main and diversion track with maximum load 100 kN and frequency 33 Hz (Fig. 7) to switch № 20 at Nova Zagora station. Three test measurements are performed in both directions, and no changes in

the technical condition of the switch are found. No switch cuts are caused in these tests. The tests are performed along the tongue of the switch.

Fig. 7

A test is carried out by locomotive № 88027, passing against the tongues on the straight element of the arrow for the fourth main track at a speed of 67 km/h. No changes in the technical condition of the switch are found. During the tests, it is found that no cutting of the switch is caused. The same locomotive is led twice along the tongues of the diverting element of the second track at a speed of 40 km/h and at a speed of 3-5 km/h, both times the switch being previously diverted to the fourth track. In both cases, the switch is cut (Fig. 8). Afterward, the spring rocker arm is dismantled from both tongues and the switch is diverted several times to the straight and diverting track. During the tests, it is found that the distance between the shoulder rails and the adjacent tongues is 60 mm at a remote position of the tongues, and 30 cm after the ideal axis the measured distance between the tongue and the shoulder rail is 53 mm.

Fig. 8

On 17.08.2020, the Investigation Commission holds a meeting with representatives of Voestalpine Railway Systems Bulgaria OOD, at which issues related to the installation, repair and maintenance of Spherolock locking system and spring rocker arm with two arms for switches type UIC 60 are discussed. The company is a manufacturer and main supplier of the cited equipment, which it has installed on switch № 20 at Nova Zagora station in 2014. The company provides written information on installation and maintenance of the locking system Spherolock and spring rocker arm with two arms for switches type UIC 60.

In the course of the investigation, the report submitted by the Operational group and the materials and documents collected for it, as well as the additionally requested materials have been analyzed.

Two technical expertise were requested and received from DPO - Sliven, prepared in an independent laboratory at the Institute of Metallurgy, Equipment and Technology with a center of hydro and aerodynamics "Acad. A. Balevski ”at the Bulgarian Academy of Sciences.

In the course of the investigation, the Commission holds several meetings to clarify the circumstances and causes of the accident.

The Chairman of the Commission adopts the written opinions of the external experts participating in the Investigation commission in fulfillment of the tasks assigned to them in the ongoing investigation, holds consultations with the involved experts.

2.7. Conducting of rescue and emergency-recovery actions:

Under the order of NRIC, specialized rehabilitation means are directed from Karnobat, Stara Zagora and Plovdiv stations to Nova Zagora station.

From Plovdiv and Karnobat stations, recovery trains are also directed to Nova Zagora station for lifting the derailed full wagons.

The chairman of the Investigation commission and the bodies of DPO - Sliven, after the inspection, allowed the withdrawal of non-derailed wagons from the train in order to create an organization for lifting the derailed ten wagons and rebuilding the railway infrastructure.

An organization is established at Nova Zagora station between NRIC and the railway company DB Cargo Bulgaria EOOD for transshipment of the cargo from the derailed 9 car wagons and its transportation to the port of Burgas. The sixth car, after the inspections and measurements, is reloaded on cars at Stara Zagora station. Parallel work is organized to lift the derailed wagons, which lasts three days.

The railway infrastructure reconstruction begins after the release of the station tracks from the derailed wagons.

Renewed railway as follows:

- 1st track - 50 m;
- 2nd track - 65 m;
- 3rd track - 75 m;
- 4th track - 40 m.
- Replaced left tongue and left shoulder rail at switch № 20.
- Renewed railway for switches and PM № 26 and № 28.
- Restored exit mast traffic light for the 4th track at Nova Zagora station, Khan Asparuh direction, and other security equipment systems.

At 15:45 hrs on 05.06.2020, the movement of the trains along the 3rd and 4th track of Nova Zagora station is restored at a speed of up to 40 km/h.

3. General data established during the investigation process.

3.1. Participating officers.

NRIC personnel:

- Duty head of traffic at Nova Zagora station;
- switchman/crossing guard at posts № 1 and № 2 at Nova Zagora station;

DB Cargo Bulgaria EOOD personnel:

- locomotive motorman, I-st person on electric locomotive № 88030;
- locomotive motorman, II-nd person on electric locomotive № 88030;

3.2. Data on rolling stock.

- At the request of the railway carrier DB Cargo Bulgaria EOOD for freight transport, NRIC has developed a year-round timetable for the movement of a pair of DFT (№ 80561/№ 30562), transporting goods in open wagons along the route Zlatitsa - Sofia - Plovdiv - Stara Zagora - Zimnitsa - Karnobat - Burgas and vice versa.

- DFT № 80561 at the time of the accident is composed of a traction electric locomotive № 88030, 25 full wagons with a gross weight of 2148 tons, moving in the direction from Zlatitsa station to Burgas station.

3.3. Data on the carrier.

At the time of the accident DB Cargo Bulgaria EOOD owns:

- License for the performance of railway transport services № 206 / 14.10.2019, valid through 31.12.2020;
- Unified safety certificate EN 11 2016 0002, valid from 30.05.2016 to 26.05.2020.;

3.4. Train type, number and category.

- Freight train № 80561, direct, in daily motion;

3.5. Train tractive rolling stock type and number, servicing DFT № 80561.

- Electric locomotive № 88030 – registered in Vehicles' register;
- Electric locomotive № 86016 – registered in Vehicles' register;
- Electric locomotive № 88025 – registered in Vehicles' register;

3.6. Train non-tractive rolling stock type and series

- wagons with movable roof - Tamns series, 24 pcs. filled with copper pyrite - registered in Vehicles' register;
- open wagons - Eaos series, 1 pc. full of copper pyrite - registered in Vehicles' register;;

3.7. Railway infrastructure description at Nova Zagora station.

Railway and switches:

- 4th main track, straight, without rail joints, rails type UIC 60, sleepers type ST-6, fastening SKL, profile in downward direction 0,59 ‰ in the direction of the train's movement, switch № 20 with radius R = 300 m, diverting apparatus Thales W 550-B, Spherolock and Spring Rocker arm;

3.8. Signalization, station safety installations and between-station block system.

- Nova Zagora station is equipped with RRC H-68;
- the indications of the traffic lights are synchronized with the speed signalization;
- the Khan Asparuh - Nova Zagora - Konyovo sections are equipped with an AB without duct capacitor signals and with axis counters;

3.9. Contact network

- Full-compensation elastic chain;

3.10. *Train protection*

- electric locomotive № 88030 is equipped with a regular and sealed alertness device;
- electric locomotive № 88030 is equipped with a "Hasler" type locomotive movement recorder..

3.11. Communication system.

- Nova Zagora station is equipped with automatic telephone connection, station telephone connection to the two switch posts - Post 1 and Post 2, interstation telephone connection with the three adjacent stations Khan Asparuh, Konyovo and Radnevo, dispatch connection with train dispatcher and power dispatcher, the station is provided with an official mobile phone, it is equipped with a train-dispatching radio connection between DHT and locomotive motormen, an official mobile phone is provided at the station;
- The locomotive crew of locomotive № 88030 is provided with an official mobile phone;

3.12. Construction or repair work carried out near or at the scene of the accident.

- repair works are not carried out in the section Khan Asparuh - Nova Zagora until the accident the :
- the rehabilitation of the railway infrastructure in the section Stara Zagora - Zimnitsa is carried out in the period 2013 ÷ 2015. In this regard, the fourth main track, a continuation of the current road through Nova Zagora station, has been renewed with UIC 60 rails.

4. Deaths, injuries and material damages.

4.1. No deaths:

4.2. No injured personnel:

4.3. Material damages to the roling stock.

- no damages to locomotive № 88030;
- the inflicted material damages to the derailed ten wagons amount to BGN 425,534.04.

4.4. Damage and costs to NRIC for railway infrastructure and passenger transhipment.

- costs for the railway infrastructure reconstruction BGN 866,456.96;
    - Burgas railway section expenses - BGN 654,248.76;
    - Vratsa railway section expenses- BGN 776.01;
    - Plovdiv railway section expenses - BGN 43,049.17;
    - costs for restoration of signaling and telecommunications - BGN 131,840.50;

- costs for restoration of the catenary - BGN 29,535.02;
- expenses for recovery means - BGN 7,007.50;

- costs for changes of TMS in the period 15.05. ÷ 18.05.2020 - BGN 11,197.70;
- costs of BDZ Passenger Transport EOOD for transhipment of passengers - BGN 970.08;

Total damages and expenses from the accident - BGN 1,304,158.78.

5. External circumstances - weather and geographic conditions.

Weather meteorological data affecting visibility:
- in the dark part of the day - 03:20 hrs;
- weather - clear for signal perception;

6. Data for railway infrastructure and railway carrier staff related to the accident.

6.1. Position, place of work, sex and age.

Personnel of NRIC at Nova Zagora station:
- ,,head of traffic" – employee at TTSOM Plovdiv Division, work experience 12 years, woman of 35;
- ,,switchman/postman" – employee at TTSOM Plovdiv Division, work experience 27 years, woman of 42 ;
- ,, switchman/postman " – employee at TTSOM Plovdiv Division, work experience 26 years, man of 38 ;

Personnel of DB Cargo Bulgaria EOOD:
- "locomotive motorman", I-st person on electric locomotive № 88030 – work experience 27 years, man of 50 ;
- "locomotive motorman", II-nd person on electric locomotive № 88030 – work experience 17 years, man of 38 ;

6.2. Position certificate and certificate data.

Personnel of NRIC:
- Certificate № 1950/26.07.2012 for occupying position head of traffic at TTSOM - Plovdiv Division;
- Certificate № 1989/02.12.2008 for occupying position switchman / crossing guard at TTSOM - Plovdiv Division;
- Certificate № 1996/26.05.2008 for occupying position switchman / crossing guard at TTSOM - Plovdiv Division;

Personnel of DB Cargo Bulgaria EOOD:
- motorman I-st person, Certificate № 193/01.08.2016 for occupying position locomotive motorman;
- motorman II-nd person, Certificate № 63/01.08.2016 for occupying position locomotive motorman;

6.3. Qualification certificate and certificate data.

Personnel of NRIC:
- Certificate № 14381/27.04.2012 acquired qualification Head of traffic, teaching structure PTC at NRIC;
- Certificate № 8889/26.05.2008 acquired qualification: switchman / crossing guard, teaching structure PTC at NRIC;
- Certificate № 8895/26.05.2008 acquired qualification: switchman / crossing guard, teaching structure PTC at NRIC;

Personnel of DB Cargo Bulgaria EOOD:
- motorman I-st person, Diplom № 000184/25.08.1992 acquired qualification, railway technics - electric locomotives, teaching structure HMTS ,,Todor Kableshkov"- Sofia;
- motorman II-nd person, Diplom № 000520/14.08.1993 acquired qualification railway technics - electric locomotives, teaching structure HMTS „Todor Kableshkov"- Sofia;

6.4. Document for professional qualification.

Personnel of NRIC:

- Head of Traffic – Certificate for professional training № 3235/27.04.2012 acquired qualification „ Head of Traffic with the right to issue tickets“, teaching structure PTC at NRIC;
- Switchman/crossing guard – Certificate for professional training № 53-5/15.07.2020 (dublicate) acquired qualification „ Switchman/crossing guard“, teaching structure PTC at NRIC - Sofia;
- Switchman/crossing guard – Certificate for professional training № 1780/23.05.2008 acquired qualification„ Switchman/crossing guard“, teaching structure PTC at NRIC - Sofia;

Personnel of DB Cargo Bulgaria EOOD:

- locomotive motorman, I-st person, Diplom № 000184/25.08.1992 acquired qualification, Electric Locomotive motorman, teaching structure HMTS „Todor Kableshkov“- Sofia;
- Certificate for locomotive driving BG 71 2017 0629 – EA RA;
- locomotive motorman, II-nd person, Diplom № 000520/14.08.1993 acquired qualification Electric Locomotive motorman, teaching structure HMTS „Todor Kableshkov“-Sofia;
- Certificate for locomotive driving BG 71 2017 1339 – EA RA;

DB Cargo Bulgaria EOOD has not presented certificates for professional qualification for the respective locomotive series of the motormen who has operated electric locomotive № 88030, issued by a teaching organization, licensed for the respective professions, in accordance with the requirements of Art. 9, para. 1, item 1, art. 9, para. 6 of PETA.

6.5. Certificate for passing an examination as per Ordinance № 56 from 2003.

Personnel of NRIC:

- Head of Traffic at Nova Zagora station – № XI-22-15/14.05.2018;
- Switchman/crossing guard Nova Zagora station –№ XI-22-32/12.06.2018;
- Switchman/crossing guard Nova Zagora station –№ XI-22-38/20.06.2018;

Personnel of DB Cargo Bulgaria EOOD:

- locomotive motorman, I-st person –№ XI-29-28/29.07.2019;
- locomotive motorman, II-nd person –№ XI-29-14/15.04.2019;

6.6. Data on the staff familiar with the railway infrastructure.

Personnel of DB Cargo Bulgaria EOOD:

- locomotive motorman, I-st person – № BG 7120170629 от 24.02.2017 no limits for 1435 mm railways;
- locomotive motorman, II-nd person – № BG 7120171339 от 18.10.2017 no limits for 1435 mm railways;

6.7. Duration of staff rest in relation to the accident.

In accordance with the requirements of the Labor Code and Ordinance № 50 of 28.12.2001 for the working hours of the management and executive staff engaged in providing the transport of passengers and goods in the railway transport, the necessary rest is provided before the shift.

Personnel of NRIC

- „ Head of Traffic“ Nova Zagora station, has rested from 19:00 hrs on 13.05.2020, to 19:00 hrs on 14.05.2020 – 24 hours;
- „ Switchman at post ” – Nova Zagora station, has rested from 19:00 hrs on 13.05.2020, to 19:00 hrs on 14.05.2020 – 24 hours;
- „ Switchman at post ” – Nova Zagora station, has rested from 19:00 hrs on 13.05.2020, to 19:00 hrs on 14.05.2020 – 24 hours;

Personnel of DB Cargo Bulgaria EOOD:

- “locomotive motorman”, I-st person on electric locomotive № 88030, has rested from 01: 30 hrs on 12.05.2020 to 23 : 00 hrs on 14.05.2020– 45,5 hours;
- “locomotive motorman”, II-nd person on electric locomotive № 88030 has rested from 01:30 hrs on 13.05.2020 to 23 : 00 hrs on 14.05.2020 – 21,5 hours;

6.8. Shift (travel) briefing.

Personnel of NRIC:

- Personnel at Nova Zagora station is briefed for duty on 14 / 15.05.2020, and they sign in the instruction book stating that they were cheerful, rested and haven't used an alcohol and other narcotics.

Personnel of DB Cargo Bulgaria EOOD:

- the locomotive brigade of locomotive № 88030 is instructed by the transport group supervisor at Plovdiv station at 23:20 hrs, and with their signature, in a declaration, they have declared that they were cheerful, rested and have not used alcohol and other intoxicants;

7. Data on the investigations. Summary of testimony.

The Investigation Commission interviewed the staff of the railway company DB Cargo Bulgaria EOOD and NRIC involved in the accident and demanded their written statements.

The Investigation Commission has no testimony.

8. Safety Management System (SMS) of National Railway Infrastructure Company and "DB Cargo Bulgaria" EOOD.

8.1. Observing the procedures set out in SMS of NRIC.

The Investigation commission got acquainted with the procedures prescribed in the SMS of NRIC and found that the shift staff of TTSOM Division - Plovdiv at Nova Zagora station, has acted in accordance with the emergency situation. The DHT at Nova Zagora station promptly has notified the train dispatcher on duty, the station manager and the interested services in accordance with the established notification procedure.

During the rehabilitation and modernization of the railway infrastructure, the S49 rails have been replaced with UIC 60 rails, as well as a corresponding traverse grate. New equipment has been installed in the safety equipment - EPM type 550-B, locking system Spherolock and auxiliary turning device - spring rocker arm with two arms. From the required and submitted documents it was established that the staff maintaining the Spherolock equipment and the auxiliary turning device - spring rocker arm, are not trained and are not issued the necessary documents to work with them. At the time of the accident the following documents are presented: Description of EPM type 550-B 380 V, 220 mm, 5 kN, four-wire, made by Balkantel; Manual for installation and maintenance of locking system Spherolock for profiles 49E1 / 54E2 / 60E1, and Instruction for installation, operation and maintenance of a spring rocker arm with two arms, prepared by VAE Sofia. In the cited documents at the time of the accident, there are no parametric and adjusting data for adjustment, operation and maintenance of spring rocker arm with two arms.

No risk assessment materials for UIC 60 switches, equipped with an electro-hydraulic switch turning device with a Spherolock locking device and a two-arm spring rocker arm auxiliary device, put into operation in 2019, were presented at the NRIC SMS.

In connection with the requirements of Art. 13, para. 1, item 4 and para. 2, item 4 of "Safety Procedure SP 2.03." In force from 02.03.2020 part of the SMS of NRIC, the Vice-President of AMRAINB has not been notified of the accident according to the procedure prescribed in the document.

8.2. Compliance with the procedures in SMS of DB Cargo Bulgaria EOOD.

The Investigation commission requested the SMS procedures of the railway carrier DB Cargo Bulgaria EOOD and after getting acquainted with them, found the following:

The Risk Assessment № OD 22-05-01/01 by the method of relative categorization of hazards by calculating the risk index shows that the statistically defined hazards, such as broken spring leaves and spring bolts, is the largest - 273 pieces. According to the prepared risk assessment, the danger is defined as "Very probable", but since it has not led to the accident, the severity of the event is defined as "Probable".

The Investigation Commission considers that the identified failure of the spring suspension poses a significant risk to the safety of rail transport and should not be underestimated. This damage should be considered as a potential precondition for an accident. In the present case, taking into account the technical expertise prepared by BAS and the analysis of the fracture of the spring bolt holding the spring block together with the earring to the first bogie, it can be argued that the rupture has occurred due to the derailment of the full wagon with both bogies. The axles and the spring

suspension of the two bogies have borne off the forces of the resistances in the movement of the wagon obliquely along the ballast prism for 140.58 meters between the 4th and 3rd track (Fig. 4).

9. Rules and norms:

9.1. *The established damages,* recorded in the Book for the condition of the facilities for safety equipment - Fig. VII-51 "of Nova Zagora station are as follows:

On April 10, 2020, at 04:30 hrs, after passing without stopping DFT № 80561 consisting of 25 wagons and gross mass 2091 tons with locomotive № 86025 through switch № 20 with the route prepared for the 4th main track, the DHT finds that after the train passing a cut position appears on the dashboard at switch № 20. After exchanging telephone messages with the train dispatcher, the DHT restores switch № 20 through ARB. The duty electrician responsible for the safety equipment on the same date at 11:03 hrs measures the switch and puts a permanent seal to the ARB;

On 13 May 2020 at 05:11 hrs, after passing without stopping DFT № 80561, consisting of 26 wagons and gross weight of 2158 tons, with locomotive № 88030 through switch № 20 with the route prepared for the 4th main track, the DHT finds that after the train passing a cut position appears on the dashboard at switch № 20. After exchanging telephone messages with the train dispatcher, the DHT restores switch № 20 through ARB. The duty electrician responsible for the safety equipment on the same date at 13:05 hrs measures the switch and puts a permanent seal to the ARB;

The information about the two cases of cut switch № 20, registered on the dashboard, is not provided to the responsible services in NRIC for analysis and control.

9.2. In connection with the requirements of Art. 380, (1), (2), (3) of the Regulations for Technical Operation of Railway Infrastructure (PTORI), the personnel responsible for the maintenance and operation of locking system type Spherolock and spring rocker arm with two arms have not been trained.

NRIC did not submit to the Investigation commission minutes of training exams and documents entitling staff to work with the said facilities.

Pursuant to the prepared schedule for the movement of a pair of DFT № 80561/30562 Zlatitsa - Burgas - Zlatitsa, the railway carrier DB Cargo Bulgaria EOOD operates with three trains, the number of wagons is similar.

10. Functional condition of rolling stock and technical facilities of the railway infrastructure.

10.1. Functional condition of the railway infrastructure after the accident.

Railway and points:

- partially damaged railway from 1st to 4th track at Nova Zagora station;
- damaged switches №№ 20, 26 and 28 at Nova Zagora station;

Safety equipment, communications, radio and power supply:

- damaged equipment and systems of the signalisation and the safety equipment;
- damaged catenary equipment.

10.2. Functional condition of rolling stock after the accident.

- technical condition of the locomotive - fitted to operate;
- technical condition of derailed 10 wagons from the train - damages on the running gear (bogies and axles) and on the basket of 3 wagons;
- technical condition of the other 15 wagons of the train - fitted to operate;
- data downloaded from the locomotive recorder № 88030.

Established parameters and distances.

- locomotive's final stop place - km 139 $^{+250}$, which corresponds to conditional km 4936,425 of the mileage of the locomotive's registration device. The mileage of the recording device increases in the direction of the increase of the railway mileage.
- axis reception building at Khan Asparuh station - km 124 $^{+355}$, corresponds to km 4921,530 of the recording device;
- beginning of switch № 20 - km 138 $^{+789}$,
- place of derailment - 6.40 m after the tip of the tongues of switch № 20 - km 138 $^{+795}$, corresponds to km 4935,970 of the recording device.

- distance from the leading cabin of the locomotive to the second bogie of the sixth car (first derailed from the train) - 110 m.

Speed analysis presented by DB Cargo Bulgaria EOOD.

At 03:03:10 hrs the locomotive passes through Khan Asparuh station abeam the reception building at a speed of 42 km/h in traction mode. The locomotive accelerates to 75 km/h. At 03:13:02 hrs, at a speed of 75 km/h, the train brake is applied, the pressure of the main air duct drops and the locomotive stops at 03:13:32 hrs at conditional km 4933,968, corresponding to railway km 136 $^{+}$ ^{523}. From the moment of brake applying to the stopping, the locomotive travels 350 m.

Traction is applied at 03:14:44 hrs and at 03:15:11hrs, after a stay of 1:40 minutes, the locomotive starts and accelerates smoothly to 67.7 km/h, with traction reaching 77.2%. At 03:18:25 hrs, at a speed of 67.7 km/h, the thrust drops sharply and goes into rheostatic braking mode (motorman's reaction), the pressure of the main air duct begins to fall at 03:18:26 hrs, and the automatic train brake is applied at 03:18:27 hrs. Within two seconds the pressure in the main air duct drops to 3 bar, the registering device does not read values below 3 bar (because at values below 3.4 bar the braking force is maximum). The locomotive stops at 03:18:53 hrs or 28 seconds after the motorman's reaction.

Derailment occurs at km 138 $^{+ 797}$. At that time the locomotive is located at km 138 $^{+ 907}$, which corresponds to a conditional km. 4936,082 of the mileage of the registering device. The registering device registers a record at km 4936,085 - 3 meters after the moment of the derailment, which is a negligible difference. We assume that the derailment occurs at km 4936,085 of the conditional mileage of the registering device. The speed at this moment is 67.7 km/h, and the exact time of the registering device is 03:18:22 hrs. The motorman's reaction comes three seconds after the derailment.

From the moment of derailment to the reaction of the motorman the locomotive travels 54 m.

From the moment of derailment to the final stop the locomotive travels 340 m.

From the reaction of the motorman to the final stop, the locomotive travels 286 m.

The Investigation commission finds that the speed analysis presented by DB Cargo Bulgaria EOOD **does not correspond to the actual train movement**.

11. Operating system documentation - inspections, checks, repairs, maintenance.

11.1. Measures taken by staff to regulate train movements.

Due to the rapid recovery of the trains' movement on the 5th and 6th tracks through Nova Zagora station, no operational changes have been made in the trains' movement schedule in the section Stara Zagora - Yambol.

During the interruption of the trains' movement in the interval 03:20 ÷ 08:10 hrs the passengers traveling along this route are transhipped by buses by the railway carrier "BDZ-Passenger Transport" EOOD.

11.2. Exchange of Vocal Orders and Written Messages.

- on 15.05.2020 at 03:20 hrs in case of transit of train № 80561 (DB Cargo Bulgaria EOOD) on the Nova Zagora station's fourth track with regularly open input and output signals, DHT reports to the train dispatcher for the derailment of the train at the throat towards Khan Asparuh station. It is subsequently established that 10 wagons of the train are derailed;
- at 04:52 hrs, under order № 110 of the train dispatcher the movement of the trains is suspended in the Khan Asparuh - Nova Zagora section and in Nova Zagora station, except for the movement of recovery means;
- at 08:10 hrs the movement of trains is restored in the Khan Asparuh - Nova Zagora section and in Nova Zagora station on the fifth receiving-departure track at a speed of up to 25 km/h ;
- at 08:55 hrs the method for ensuring the movement of trains in the Khan Asparuh - Nova Zagora section is changed;
- at 14:11 hrs the voltage at Nova Zagora station on the second, third and fourth tracks is switched off;
- at 15:00 hrs the director of the railway section of Burgas allows traffic on the fifth, sixth and seventh tracks at a speed of up to 25 km/ h;
- on 21.05.2020 at 13:36 hrs the traffic along the fourth main track is restored at a speed of up to 25 km/h, without performing train traffic;

- on 01.06.2020 at 11:50 hrs the director of the railway section of Burgas allows traffic on the fourth main track at a speed of up to 40 km/h;
- on 03.06.2020 the contact network on the first, second, third and fourth tracks at Nova Zagora station is restored.

12. Health and Safety work conditions.

- With reference to the requirements of Art. 20, para. 2 of Ordinance № 54 / June 02, 2003 the officials of NRIC and the railway carrier, related to the accident, have valid certificates for psychological fitness.
- With reference to the requirements of Art. 28, para. 1 of Ordinance № 54 / June 02, 2003 for medical examinations of the personnel related to the accident, at NRIC and the railway carrier, no violations are found.
- With reference to the requirements of Art. 28, para. 2 of Ordinance № 54/2003, the manager of the railway carrier DB Cargo Bulgaria EOOD, has instructed by an order the officials (Head of Transport Group) at the stations Pirdop, Ruse, Burgas and Svilengrad to conduct shift (travel) briefings to the motormen on their transport activity, as well as alcohol testing. The inspections are registered in the issued journey form of the locomotive brigade.

13. Accidents of similar nature previously registered.

- On 23.12.2014 DFT № 30561, serviced by the railway carrier DB Schenker EOOD with 25 wagons, 1112 tons, auxiliary head locomotive № 92-34 and train locomotive № 92-27 at 07:04 hrs on its departure for Straldzha station from the fourth track at Zimnitsa station both locomotives derail with all axles on switches № 15/11 and № 9. Cause - transverse brittle fracture of the left tongue of switch № 11, has occurred in the transition zone from switch to rail profile of the tongue, due to the created external stress concentrator and internal microcrack.
- The staff involved in the accident on the part of the railway enterprise and the railway infrastructure have no registered accidents of a similar nature.

14. Analysis and conclusions of the Investigation commission.

14.1. Final description of the chain of events by determining the conclusions of the accident based on the facts.

The Investigation Commission at AMRAINB, on the basis of the collected documents and materials, analyzes the possible circumstances, facts and evidence that could lead to the establishment of the causes of the railway accident. It has carried out detailed and in-depth inspections of the railway and facilities, of the safety equipment and of the rolling stock. Experiments have been performed to prove the behavior of switch № 20 in normal operating mode (after installing the new tongue and the corresponding switch settings) at maximum rail loads with dynamic stabilizer DGS 62-2 and with a locomotive of the same series (88-000). The materials and documents provided by the OG are analyzed. The technical expertise provided by BAS and the opinions of the experts involved in the investigation are analyzed. The actions of the personnel involved before and during the accident are taken into account, as well as the testimony presented, for which the commission finds the following:

- On DFT № 80561, served by a locomotive № 88030, a route is prepared for passing without stopping through Nova Zagora station on the fourth main track.
- The train passes through the first entrance switches and through switch № 20 at a speed of 67.7 km/h where the maximal permissible speed is 75 km/h.
- The locomotive and the first five cars pass unimpeded through the switch.
- When the sixth wagon passes through switch № 20, the first bogie continues its movement along the route and after a spontaneous reversal of the switch, the axles of the second bogie of the wagon go on both shoulder rails and derail in the area of switch 1530 mm track gauge.
- After the reversal of the switch under the sixth car, the train is directed in a deviation to the second track from the seventh car. This leads to the derailment of the first bogie of the sixth car and to the rupture of the train in three places.

- The locomotive and the first five cars stop in front of the station. The sixth wagon moves between the third and fourth tracks obliquely along the ballast prism, as it pulls and causes the derailment of 9 more wagons - from the 7th to the 15th.

14.2. Analysis of the facts in respect of the causes of the accident.

14.2.1. Analysis of the recordings from the locomotive recorder № 88030.

The analysis of the movement of DFT № 80561 is performed on the basis of the data

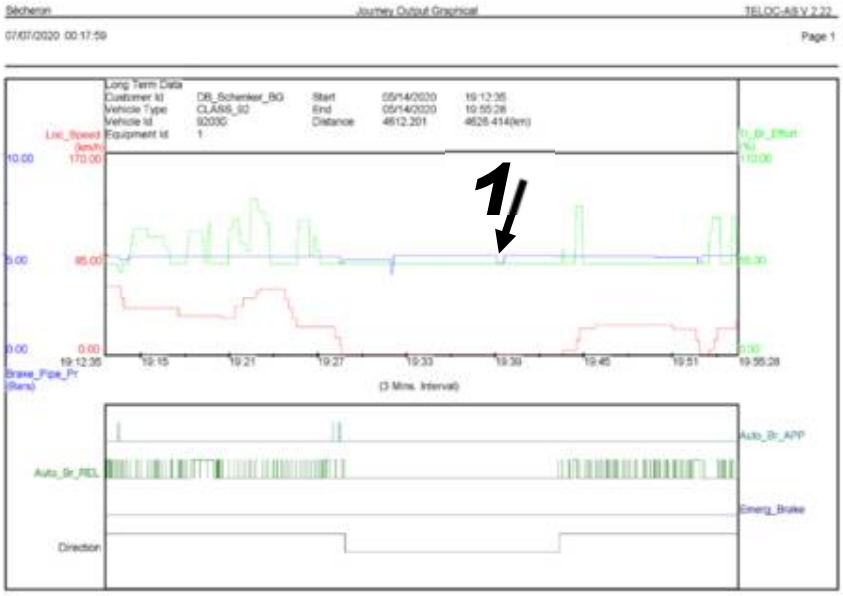


Fig. 11. Stay at Sofia station

downloaded from the records of the registering device of locomotive № 88030 from the moment of departure of the train from Zlatitsa station to the moment of establishment of locomotive № 88030 on the fourth track in Nova Zagora station, km 139 $^{+250}$.

It is correct to note that the clock of locomotive № 88030 lags behind the actual astronomical time by one hour. The analysis is made in accordance with the reading of the locomotive clock, and the distance traveled is calculated on the basis of the locomotive odometer.

According to the schedule DFT № 80561 has had to travel along the route Stolnik - Musachevo - Kazichene (Fig. 9). In fact, it crosses the route Stolnik - Yana - Kremikovtsi - Svetovrachene - Iliyantsi - Sofia-north - Sofia - Poduyane-passenger - Iskar - Kazichene.

DFT № 80561 departs from Zlatitsa station at 17:13:12 hrs (conditional time) (Fig. 10) consisting of:

- Locomotive № 88030 at the head;
- 25 freight 4-axle full wagons, of which:
    - o 24 pieces of Tamns series;
    - o 1 piece of Eaos series;
- Locomotive № 88025 is an auxiliary one (pushing).

At 19:28:39 hrs (conditional time) the train arrives at Sofia station. During its travel in the section from Zlatitsa station to Sofia station the section speeds for the train movement are observed.

An auxiliary head locomotive № 86016 is coupled to the train at Sofia station. After coupling the auxiliary locomotive, test D of the automatic train brake is performed according to the regulations. The train leaves Sofia station at 19:43:31hrs (conditional time) after a stay of 14 minutes and 52 seconds (Fig. 11).

The train arrives at Vakarel station at 20:46:25 hrs (conditional time). At Vakarel station, the pushing auxiliary locomotive № 88025 is uncoupled from the train and the train continued its movement with two locomotives № 88030 train and № 86016 auxiliaries (at the head). No test D of the train is performed at Vakarel station (Fig. 12, item 1). The train leaves Vakarel station at 20:50:57 hrs (conditional time) after a stay of 4 minutes and 32 seconds. In the section Sofia - September the train moves, observing the section speeds.

Arrives at Septemvri station at 22:07:50 hrs (conditional time) after traveling 68,107 km for 1:16:53 hrs. Departs from the station at 22:20:52 hrs (conditional time) after a stay of 13 minutes and 2 seconds, accelerates for 3 minutes and 51 seconds and travels 2,892 km, reaching a speed of 86.00 km/h (Fig. 13). At this speed, it travels 4,133 km in 2 minutes and 53 seconds. At this point, the locomotive motorman of leading locomotive № 86016 applies the automatic train brake and reduces the pressure in the main air duct to 4.35 bar, whereby the speed begins to decrease at 22:28:34 hrs (conditional time) after passing 726 meters in braking mode stops at km 110 $^{+543}$ (calculated by the mileage of the locomotive № 88030 - conditional km 4740,461 - Fig. 13, item 1).

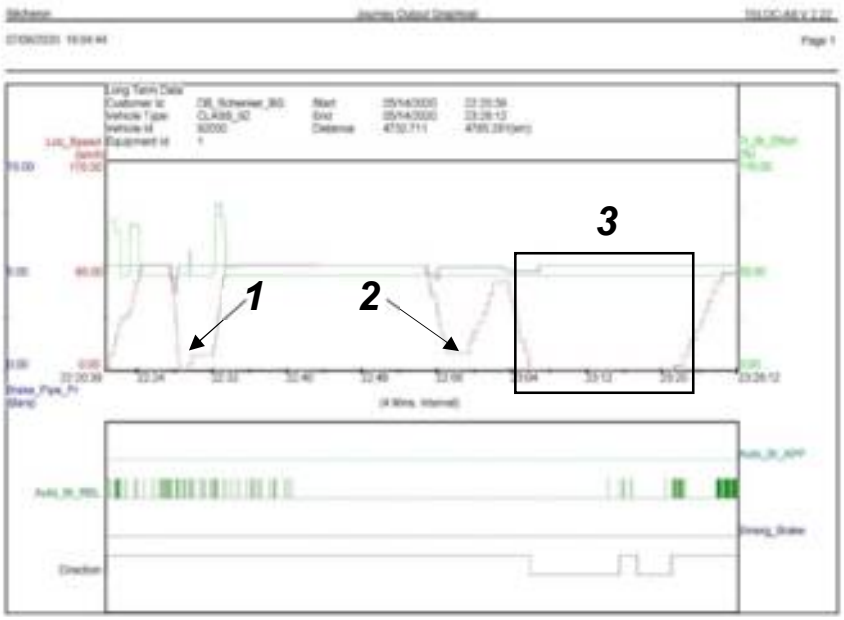


Fig. 13. Deciphering in the section between Septemvri station and Todor Kableshkov station

After a stay of 1 minute and 53 seconds at 22:29:29 hrs (conditional time), it starts again, initially moving at 5.75 km/h for 27 seconds and traveling 45 meters. The speed increases to 12.87 km/h and so moves for 2 minutes and 2 seconds, traveling 443 meters, again increases to 19.93 km/h for 3 seconds for 13 meters, then begins to increase until the maximum speed for the section is 85.84 km/h. From the moment of departure until reaching a speed of 84.2 km/h, the train travels 1567 meters. As calculated by the odometer of the locomotive, the train stops at km 110 $^{+543}$, starts and from km 112 $^{+110}$ it already moves at a speed of 84.2 km/h.

When approaching Todor Kableshkov station at 22:54:59 hrs (conditional time) at conditional km 4742,605 the locomotive motorman of leading locomotive № 86016 applies the automatic train brake and reduces the pressure in the main air duct to 4.64, and then to 4.35 bar, then restores it again to 4.94 bar (fully released brake). The speed starts to decrease and at 22:59:29 hrs (conditional time) at conditional km 4774,896 reaches a value of 14.53 km/h, after which again, without applying traction, it starts to increase (Fig. 13, pos. 2). In this mode of movement, the train passes through the control system of the rolling stock at km 141 $^{+800}$. At 23:05:57 hrs (conditional time) the train settles at Todor Kableshkov station (Fig. 13, item 3). There the locomotive crew of locomotive № 88030 is shifted and no sample D has been registered from the registering device of locomotive №

88030. Train № 80561 departs from Todor Kableshkov station at 23:21:27hrs (conditional time). After traveling 9,063 km for 11 minutes and 43 seconds, the train settles at Plovdiv station at

Fig. 14

23:33:10 hrs (conditional time). At Plovdiv station the auxiliary head locomotive № 86016 is uncoupled from the train and further the train is serviced only by the train locomotive № 88030. Test D of the automatic train brake is performed as seen by the registering device of locomotive № 88030.

The train leaves Plovdiv station at 23:36:35 hrs (conditional time). It travels 64,345 km and at 00:43:00 hrs (conditional time) stops at Chirpan station, stays for 7 minutes and 1 second and at 00:50:01 hrs (conditional time) leaves. It travels for 1 hour and 5 minutes, traveling 67,277 km and at 01:55:46 hrs (conditional time) settles at Khan Asparuh station (Fig. 14, item 1). When running in the section from Septemvri station to Khan Asparuh station, the train observes the permissible speeds for movement in the section.

At Khan Asparuh station, train DFT № 80561 stays 6 minutes and 20 seconds. Departs at 02:02:06 hrs (conditional time) (Fig. 14, item 2). The speed gradually increases and in 02:04:59 hours (conditional time) reaches the maximum speed for this section of 74.96 km/h, with which it travels till 02:14:03 hrs (conditional time) for 9 minutes and 4 seconds, traveling 11,249 km. After leaving Khan Asparuh station and reaching a speed of 74.96 km/h, the locomotive motorman switches off the traction of the locomotive from 02:08:15 hrs (conditional time) to 02:11:24 hrs (conditional time) for 3 minutes and 8 seconds, as the train travels 3,920 km in free-running mode, i.e. by inertia. At 02:11:24 hrs (conditional time) the locomotive motorman puts the controller in the braking position in *rheostatic braking mode,* so that the train travels 3,089 km in 2 minutes and 28 seconds. During this interval, the train speed does not change, despite the braking force applied. At 02:13:52 hrs (conditional time) the locomotive motorman puts the controller in a neutral position, which terminates the *rheostatic braking mode* and the train moves by inertia again. At 02:13:56 hrs (conditional time) the motorman takes a quick stop with the automatic train brake and the pressure drops below 3 bar in 12 seconds. At 02:14:03 hrs (conditional time) the speed starts to decrease and at 02:14:32 hrs (conditional time) at conditional km 4933,968 according to the kilometer reading of the locomotive the train stops, which corresponds to km 137 $^{+634}$ from the railway infrastructure (Fig. 14, item 3).

The train stays for 1 minute and 39 seconds and departs at 02:16:11 hrs (conditional time) (Fig. 15, item 1). The stay is reflected in the journey form of locomotive № 88030.

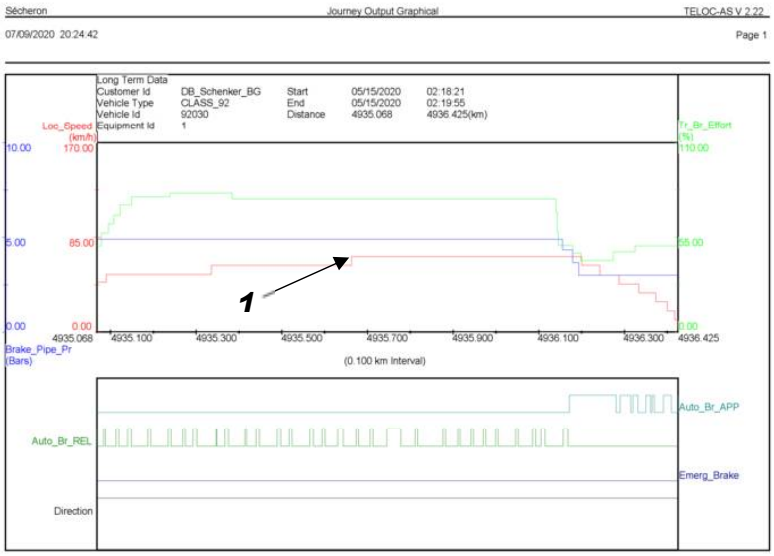
After its departure, the train accelerates and at 02:19:00 hrs (conditional time), after traveling 1.701 km, reaches its maximum speed of 67.69 km/h. At this speed, the train travels for 28 seconds, traveling 526 meters.

At this point, the train derails.

The chronology of the derailment is as follows:

Fig. 15

1. At conditional km 4935,673 at 02:19:00 hrs (conditional time) (752 meters before the final stop) the maximum speed for the between-stations section is reached - 67.69 km/h. The location corresponds to km 138 $^{+498}$ on the 8th railway line (Fig. 15, pos. 2, fig. 16, pos. 1)



Фиг. 16

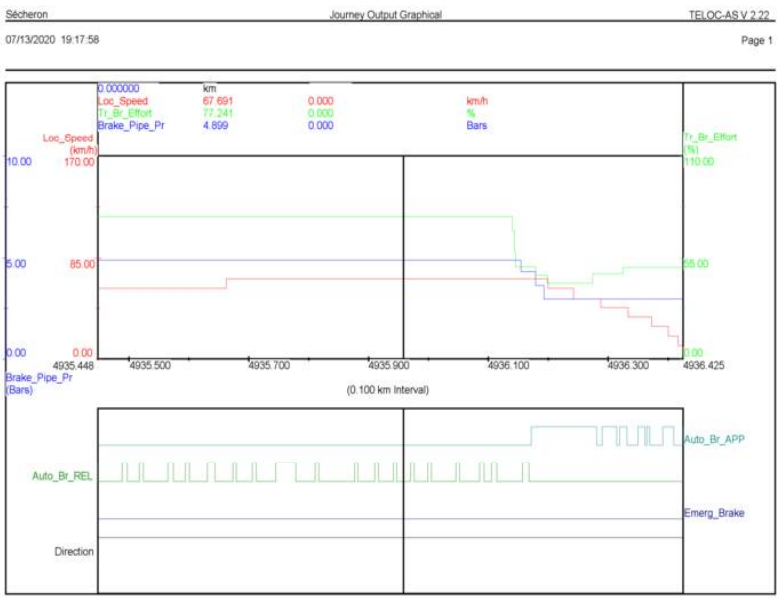


Fig. 17

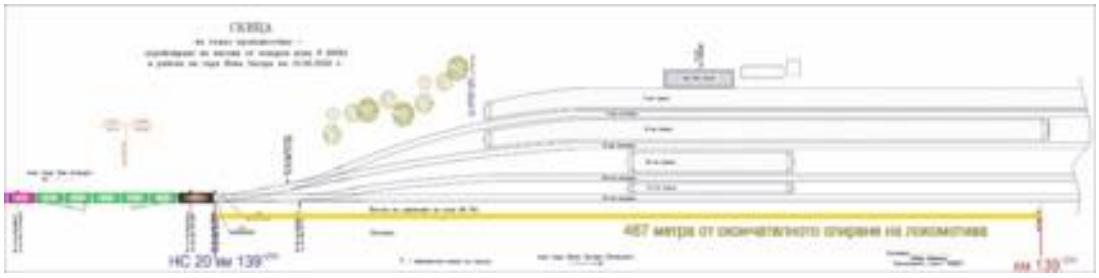


Fig. 18

2. At conditional km 4935,958 at 02:19:15 hrs (conditional time) the locomotive passes through switch № 20 (Fig. 17, Fig. 18 - the figures in green mark the wagons that have not derailed, and those in purple mark the derailed wagons).
3. The locomotive is located 358 meters from the final stop point when wagon № 33 52 080 6001-2 (the sixth in the composition) is on switch № 20 (Fig. 19). This happens at conditional km 4936,067 at 02:19:21 hrs (conditional time). The sixth car derails first with

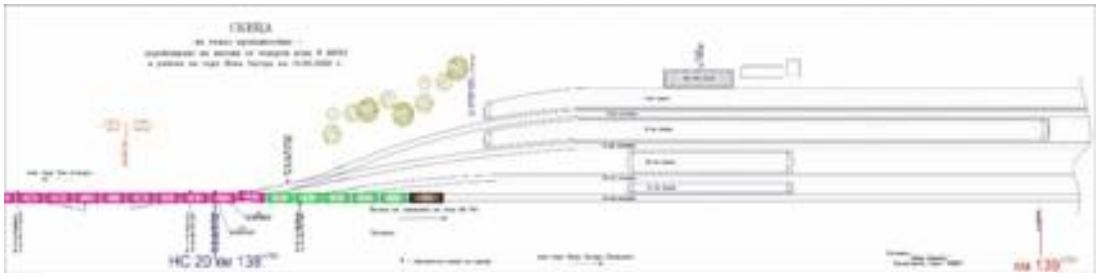


Fig. 19

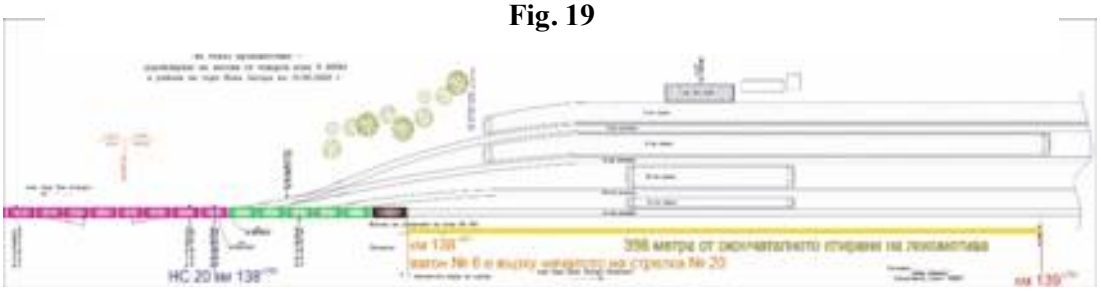


Fig. 20

the second bogie in the direction of travel (Figs. 20, 21, 22). The place where the locomotive is located corresponds to km 138 $^{+892}$ of the 8th railway line;

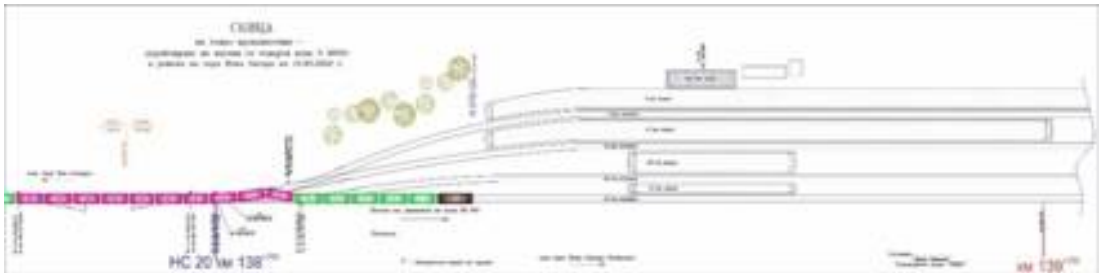


Fig. 21

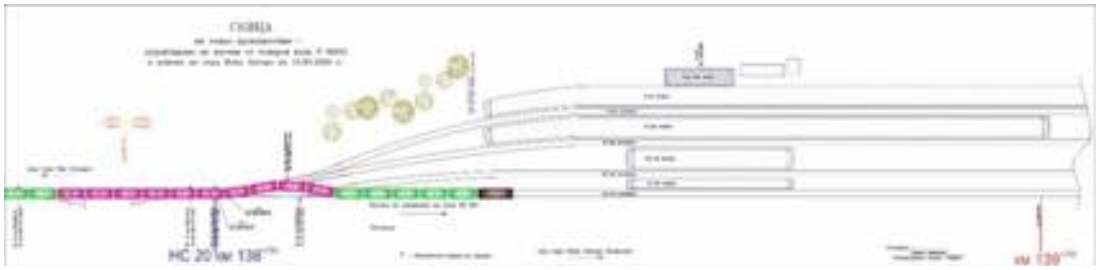


Fig. 22

4. At conditional km 4936,144 at 02:19:25 hrs (conditional time) (281 meters before the final stop, 77 meters after the start of derailment) the locomotive motorman lowers the traction.

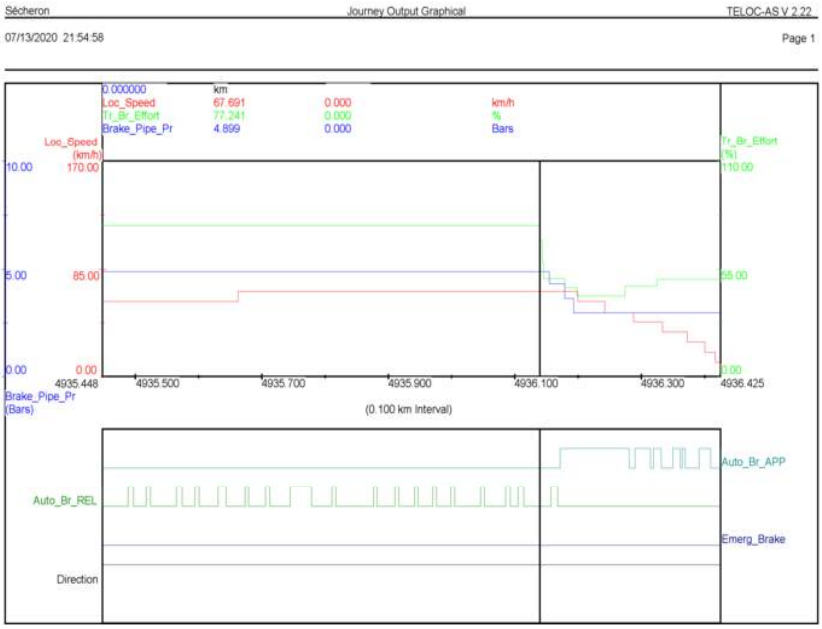


Fig. 23

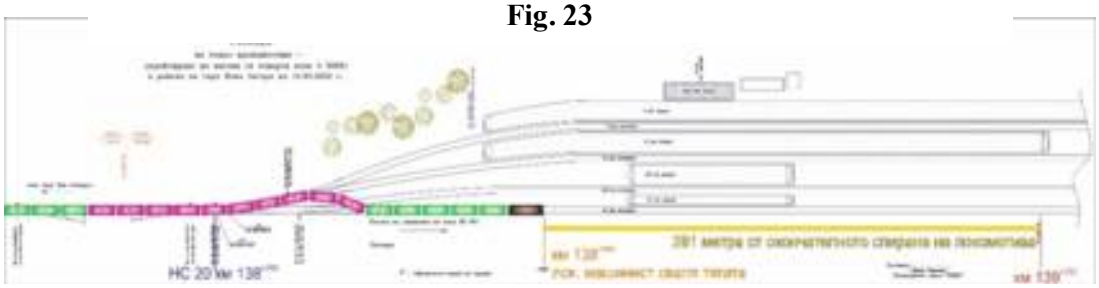


Fig. 24

This is the motorman's first reaction to the accident. The location corresponds to km 138 + 969 of the 8th railway line (Fig. 23, Fig. 24);

5. At conditional km 4936,157 at 02:19:26 hrs (conditional time) (268 meters before the final

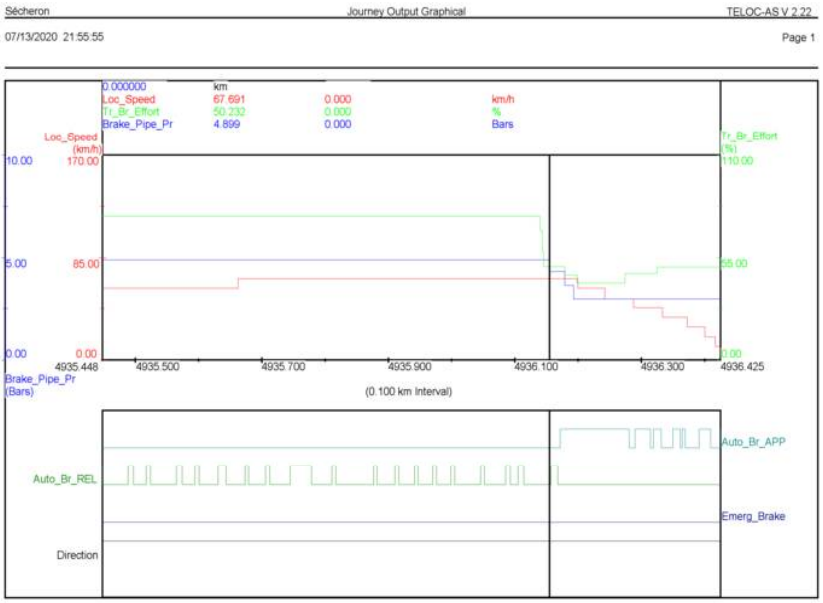


Fig. 25

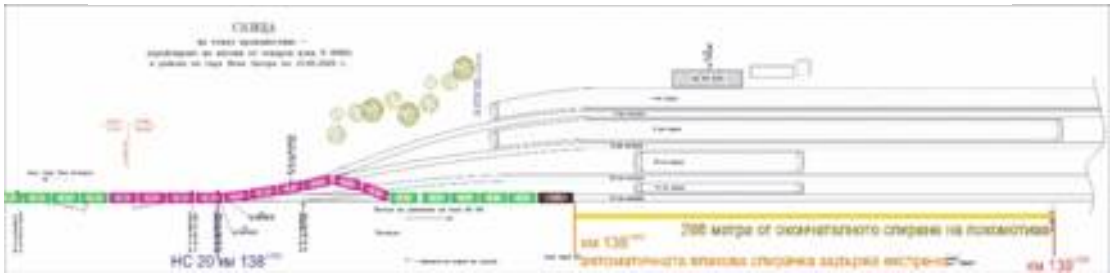


Fig. 26

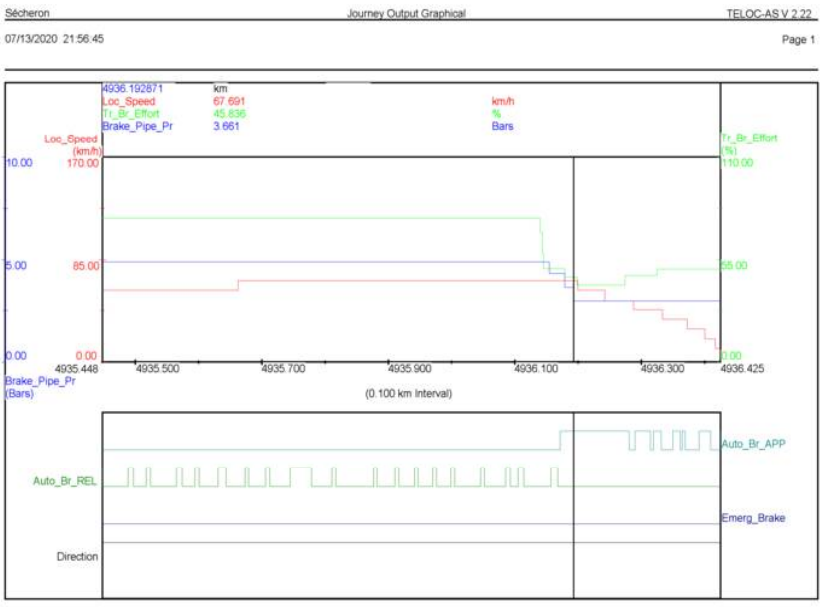


Fig. 27

stop), the pressure in the MAD (emergency stop) begins to decrease (Fig. 25, Fig. 26). The location corresponds to km 138 + 982 of the 8th railway line;

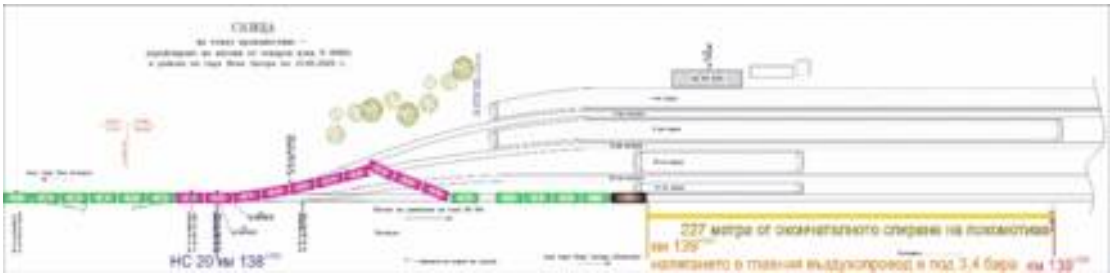


Fig. 28

6. At conditional km 4936,198 at 02:19:28 hrs (conditional time) (227 meters before the final stop), the pressure in the MAD has dropped below 3.4 bar (Fig. 27, Fig. 28). The location

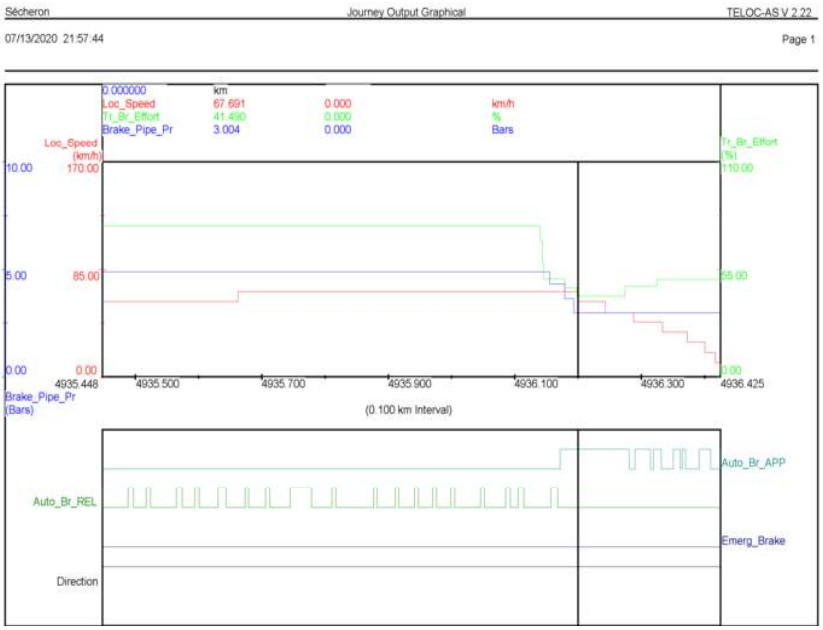


Fig. 29

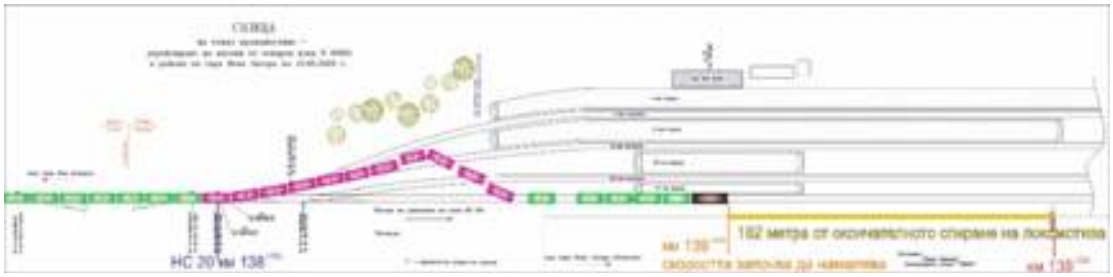


Fig. 30

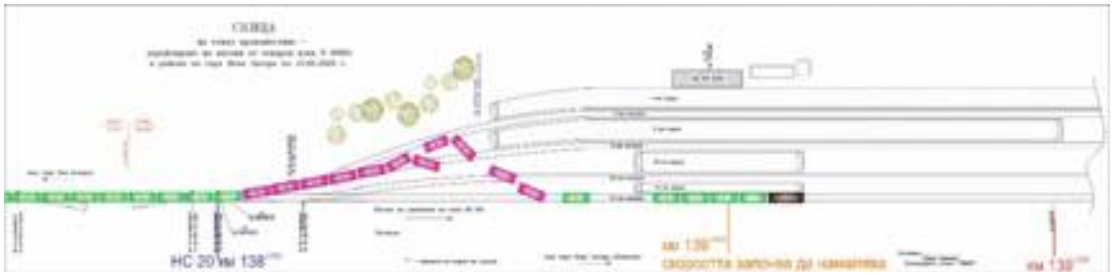


Fig. 31

corresponds to km 139 $^{+023}$ of the 8th railway line;

Fig. 32

Fig. 33

7. At conditional km 4936,243 at 02:19:31hrs (conditional time) (182 meters before the final stop) a decrease in speed begins (Figs. 29, 30, 31, 32, 33). The location corresponds to km 139 $^{+\,068}$ of the 8th railway line;

Fig. 34

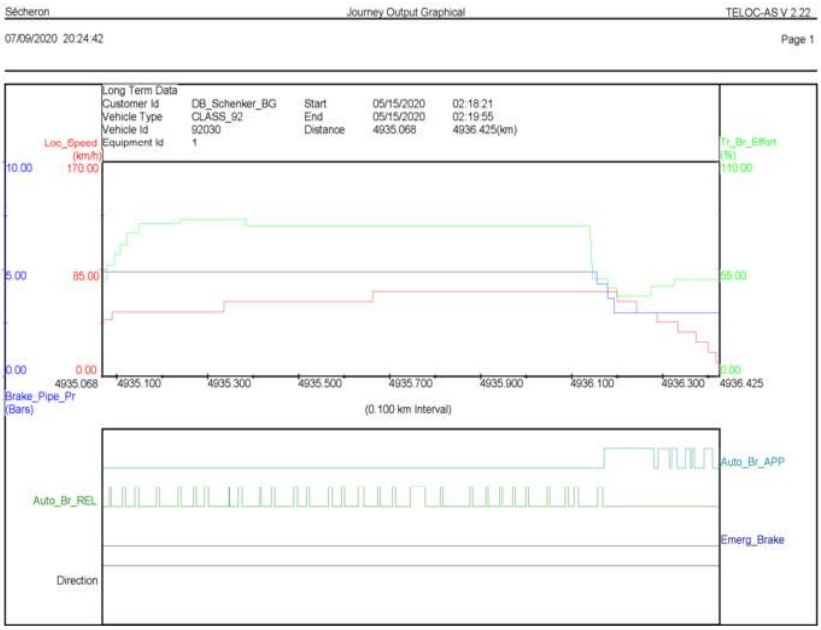


Fig. 35

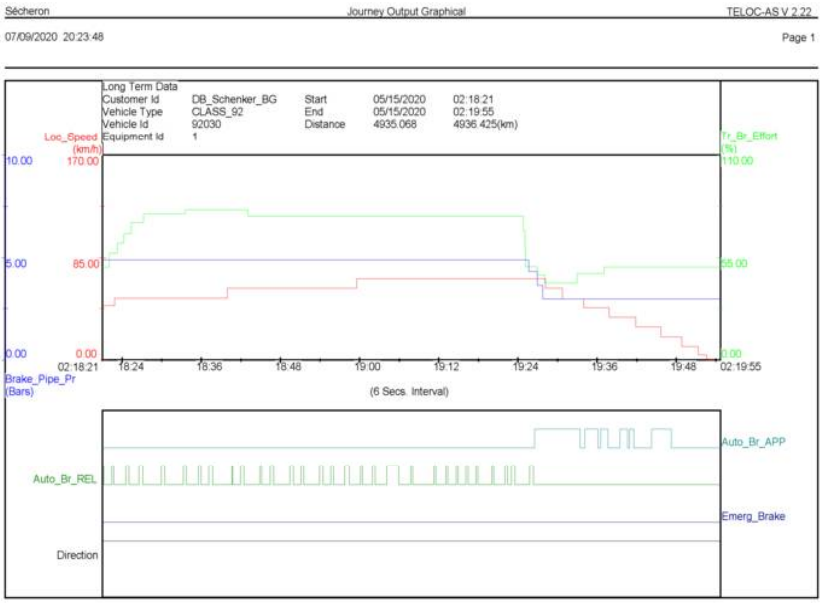


Fig. 36

8. At conditional km 4936,425 at 02:19:53 hrs (conditional time), the train stops at km 139 $^{+250}$ on the fourth track at Nova Zagora station (Fig. 34, Fig. 35, Fig. 36).

14.2.2. Railway analysis.

Technical characteristics of switch № 20 at Nova Zagora station:

The switch is of a type UIC 60 (60E1), with radius R = 300 m, deviation 1: 9, left, with elastic tongues in a rail profile. It is mounted on string concrete sleepers by elastic fasteners SKL-12 and welded joints. It consists of two tongues with a length of 15,240 m, which are of the types left straight and right diverter. The height of the tongue at the tip is 109 mm and for 5.50 m the height reaches 134 mm. In the area of 5.50 m-length and 134 mm height, the tongue has a head width of 54 mm and acquires full bearing capacity.

The right shoulder rail is straight with a length of 15,901 m, and the left one is arched with a length of 15,857 m.

In the tongue part, nine tongue cogs are installed in order to prevent exceeding the gauge in the elastic part of the tongues.

From the second to the nineteenth sleeper, eighteen sleepers are mounted under the two tongues. Single and double rollers are mounted for easier turning of the tongues.

A spring rocker arm with two arms is mounted at a distance of 5.56 m from the top of the tongues to support the movement of the switch's two tongues to the respective direction and to stabilize the position of open and closed tongues relative to the shoulder rail. Thus it should not allow arbitrary vibration and movement in tongues. The Commission finds that the spring rocker arm has been incorrectly adjusted, which is evident from the taken parameters of the left and right toe relative to the adjacent shoulder rails. The right shoulder rail was at a distance of 40 mm from the right tongue at a norm of 65 ± 3 mm. The left tongue, despite allegations of deformation after the derailment, was apparently not attached to the left shoulder rail, which creates opportunities for vibrations of the tongue when passing vehicles.

The switch is fitted with a cutable EPM , which is connected to the Spherolock locking system through a motor and locking rods, as well as long and short control rods, ensuring tongues locking in both positions.

Downloaded data from the performed inspections of the railway up to the moment of the accident:

1. On 16.04.2020, at Nova Zagora station, switch № 20 is measured and it is established that it has no deviations in the parameters (there is no record for checking the spring rocker arms at the station).

2. The railway and the switches are measured with the Measurement Laboratory on 08.01.2020.

3. The last measurement of the rails with non-destructive testing (defectoscopy) is performed on 21.05.2019.

4. According to a protocol from 21.04.2020 an inspection of the railway and the facilities is performed at Nova Zagora station (there is no record for inspection of the spring rocker arms in the station).

The Investigation commission finds that no repairs and maintenance of the spring rocker arm of switch № 20 has been carried out (when the lid was opened, many insect nests were found, and it was in a neglected condition). The Locksmiths on switches, barriers and lubricators (LSBL) have not been trained and issued a document for operating with spring rocker arms, which means that the spring rocker arm of switch № 20 has not been maintained and inspected since its commissioning until the accident.

Railway condition parameters:

The following is recorded in the statement of findings of the operational group for switch № 20 at Nova Zagora station:

1. Track gauge:

The maximum measured track gauge at point -3, point -4 and point -5 has values of +7 mm, the transition to adjacent points is at a distance of 1 m with a 1 mm increase (1: 1000).

2. Transverse level:

The transition on the basis of the first bogie of the sixth wagon with a distance between them of 1.80 m is as follows:

At point tip tongue -3mm, at point 2 = -5mm, difference = 2mm.

The transition $К = \frac{L}{H} = \frac{2000мм}{2мм} = 1000$ with a transition 1:1000.

Based on the central bolts of the two bogies it is as follows:

Tip tongues -3мм; point -11 = 0mm, difference = 3mm.

$К = \frac{L}{H} = \frac{11000мм}{3мм} = 3666$ with slope transition = 1:6666.

The maximum slope should be 1: 6V, but not steeper than 1: 400.

1: 6V = 1: 6.67,7 = 406,2 = 1: 406,2.

3. There are no unilateral and chess falls in the switch.
4. There are no missing and loosed fixings.
5. Lateral and vertical wear of the shoulder rails and tongues are normal.

Analysis of the condition of the railway at the place of derailment.

Посока на движение	Точка на измерване	Заб.1 (мм)	Ниво (мм)	Скрити пропадания на база ..... м (мм)		Между-релсие (мм)	Флеш хорда 20м/10м (мм)	Износване на релсите	
				Лява релса	Дясна релса			вертикално	странично
			H	$H_д$	$H_д$	L	F	ab	ac
1	2	3	4	5	6	7	8	9	10
Посока на движение на дерайлиралото возило / срещу стрелките / по стрелките	-1		-4			+5			
	-2		-5			+6			
	-3		-4			+7			
	-4		-5			+7			
	-5		-5			+7			
	-6	т. на падане	-4			+6			
	-7		-4			+5			
	-8		-3			+4			
	-9		-3			+3			
	-10		-2			+2		0	0
	-11		0			+2			
	-12		+1			+2			
	-13								
	-14	Измервания на ш.път след т. 12 не са направени							
	-15	поради това, че същия е със силно нарушена гео-							
	-16	метрия вследствие на дерайлирането. Замервания							
	-17	по левия релс на стр. №20 също не са правени							
	-18	поради същите причини.							

Fig. 38

As can be seen from the statement of findings of the operational group, the condition of the railway is normal, there are no hidden falls and there is no steep transition with an inadmissible overhang ramp (Fig. 37 and 38).

14.2.3. Safety equipment analysis.

Nova Zagora station is equipped with RRC -H68.

The warning, input and output signals are indicated on the base of the speed signalisation.

Switch № 20 is on the fourth main track and is equipped with electro-hydraulic SOA-550-B with an external tongue lock and a move of 220 mm.

It is possible to adjust the distance between the shoulder rail and the free tongue from 153 mm to 167 mm.

The EPM is cuttable and after cutting the device can be restored to normal because it is reversible.

At switch № 20, the EPM is fitted to an optional Spherolock locking system in both tongues.

The driving force of the EPM is 5000N + 500N.

The friction force of the EPM is 9000N + 1000N.

EPM has an electric motor with a three-phase power supply and a four-wire control circuit.

The reversal time of the tongues is from 5 to 7 seconds.

Instead of a connecting rod which to connect the two tongues, a Spherolock locking system is installed on the railway, which performs external locking of the fitted tongue at a clearance of 2 mm, and the free tongue is locked at 160 ± 2 mm from the shoulder rail without tension in the shoulders of Spherolock. Spherolock is bolted to the EPM rod and is dependent on it.

A spring rocker ram with two arms is mounted in the area of the switch tongues. The purpose of the spring rocker arm is to maintain the open and closed position of the tongues in relation to the shoulder rail. This device is designed to prevent arbitrary vibration and movement of the tongues from the shoulder rails.

A control panel for control of the switches and signals is installed at the station at the DHT, indicating the information about them.

RRC -H68 at the station provides information on three possible switch states:

1. Existence of control;
2. Lack of control;
3. Cut position.

The prepared route of the train comprises entrance on the fourth main track without stopping at the station.

All sealing buttons on the desk, including ARB and SARB, are sealed with regular lead seals according to the requirements of Ordinance № 58.

In the Book for the condition of the facilities of SE form VII-51 there are no records for the use of ARB and SARB on 15.05.2020 after the accident.

In the Book for the condition of the facilities for SE form VII-51 on 10.04.2020 and 13.05.2020, there are registered records by the DHT for the use of a sealed ARB for the restoration of the virtual occupancy of switch № 20 according to the indication on the desk. No protocols are drawn up for the cut position of the switch according to the requirements of Ordinance № 58, as the switch has not been actually cut. After checking the switch only by the SE mechanic, no EPM damage is found. No representative of the railway and equipment (locksmiths of switches, barriers and lubricators) has attended during the inspection and testing. After measurements have been made of the adhesion of the tongue with a 2 mm clearance pattern, the inspection has completed, which is registered through a record in the book for damage to the equipment in SE form VII-51. This information on the virtual occupancy desk of switch № 20 in both cases is obtained after trains of a same number (DFT № 80561) had passed against the tongues of the switch.

It is clear from the readings of the motorman who has operated electric locomotive № 88030, servicing DFT № 80561 on 15.05.2020, that the readings of the signals without stopping are the following:

- warning signal - one green light;
- enter signal - one green light;
- exit signal - one green light;

Switch № 20 has been diverted for the fourth main track.

During the inspection of tripod № 34 for a switch group of switch № 20, in RR, together with the bodies of DPO - Sliven it is found that the relays participating in the route are in their normal state (Fig. 39).

When inspecting the dashboard in the office of the DHT, the indication of the status of the switch indicates a cut position. The controlled area of switch № 20 shows virtual occupancy (Fig. 40).

When inspecting the external equipment of switch № 20, the switch tongues have been turned to the (minus) position for diverting.

Fig. 39

Fig. 40

After opening the EPM cover of switch № 20, it is found that there is no end position control due to a mismatch in the position of the actuator, which is in the extreme plus position, and the switch tongues are turned to the (minus) position. The electronic units are sealed with lead factory seals (Fig. 41).

Fig. 41

After some entries and permits have been made, in accordance with the regulations, the following manipulations are performed:

- The cut position of the switch is restored by activating the ARB and the individual button of switch № 20. EPM did not move due to the virtual occupancy of the controlled section of switch № 20 due to the damaged counting point of the switch in the accident, because the station centralization devices do not allow the switch to divert to an occupied or faulty controlled area.
- An indication of a lack of control of the switch remained on the desk at the station due to a discrepancy between the position of the switch tongues and the state of the EPM.
- With the activation of the SARB and the individual button of switch № 20, an attempt was made to reverse the switch, whereby the EPM actuator moved to position (minus) (without moving the tongues) and the same gave the control for the end position (minus). There was a correspondence between the position of the tongues, the EPM, the relay apparatus in the switch-№-20 group in the RR and the indication of the desk at the DHT.

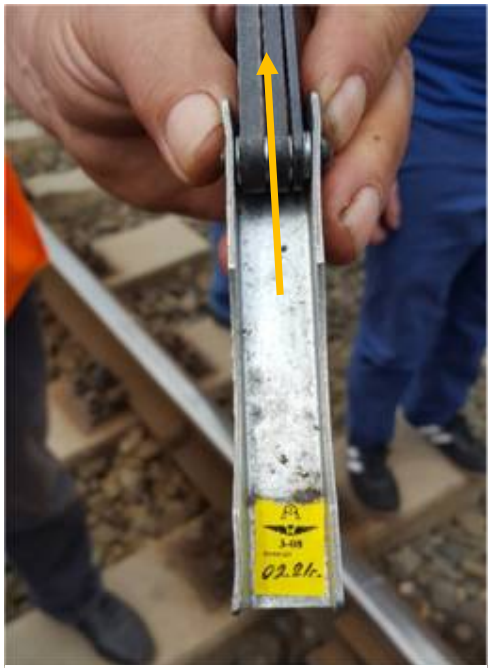


Fig. 42

- After several attempts to reverse in both positions of the switch tongues, a correspondence is found between the actual position of the EPM, the switch tongues and the indication of the desk at the DHT.
- Samples were made with a calibrated template 2 mm and a template 4 mm for adhesion to the shoulder rail (Fig. 42).
- The switch gave control at a clearance of 2 mm for the tongue to adhere to the shoulder rail in both positions, .
- The switch did not give control at a clearance of 4 mm for the tongue to adhere to the shoulder rail for both positions of the tongues.

Fig. 43

It was found that there were fresh traces of mechanical friction on the upper side of the short control rod, on the washer, and the nut of the metal hollow sleeper. The length of the trace is approximately the same as is the stroke of the EPM (Fig. 43).

The short control rod is connected to the left switch tongue and provides the plus control of the switch.

A broken part of the housing protecting the EPM control rods was found due to forces exerted by the left tongue during its spontaneous moving from position (plus) to position (minus) (Fig. 44).

From the performed checks it was established that no command was given for electrical reversal of switch № 20 from the electrohydraulic apparatus, from position (plus) to position (minus) during the train passing through the switch.

The analysis of the RRC work was prepared after checking the desk condition and the position of the relay groups and tripods controlling the highly responsible external objects and systems for direct control and monitoring, after the derailment, in the presence of the Investigation commission and bodies from DPO - Sliven.

The schemes of RRC H-68 are built on a topological principle along the route of the passing train.

The possibility for any incorrect manual intervention and wrong manipulation for turning switches by the DHT or another employee in case of a busy train section is excluded.

During the inspections of switch № 20 it was found that it gives an indication of a cut position, and the switch itself is physically turned for diverting with the two tongues, completely moved to the end position in the farthe left tongue and fully moved right tongue to the shoulder rail. The drive rod of the device, realized by Spherolock, is uncoupled by the cutting mechanism of the device. The drive rod of the device is pulled under the influence of Spherolock, and the cutting mechanism remains in position (plus), for which the switch has received a command and in which it was actually before its reversing.

After the inspection carried out by the Investigation commission in the presence of the bodies from DPO - Sliven, it was established that the safety equipment and the behavior of the relay groups of RRC, managing the technical sites, are in good condition.

The Commission excludes the possibility of a mistake made by the DHT at Nova Zagora station.

14.2.4. Analysis of the control system for overheated jacks and dynamic balance.

The Check Point rolling stock control system consists of different components:

- Derailment Detector (DED);
- Detector for oversized loads in height and width / HWL (Loading Gauge);
- Wheel Scan (WS) - "dynamic balance" system - to detect a "flat spot" and record the load on the wagons;
- Detector for hot axel-boxes and overheated wheels and brake discs (HBD / HWD);
- Master Node (CMN) and Data Concentrator (CPDC);

When a train passes through the area of the SCPS, each of the individual subsystems checks its parameters and transmits the received data to the data concentrators located on site. They in turn send this information to the Master node of the system. There it is processed and submitted for

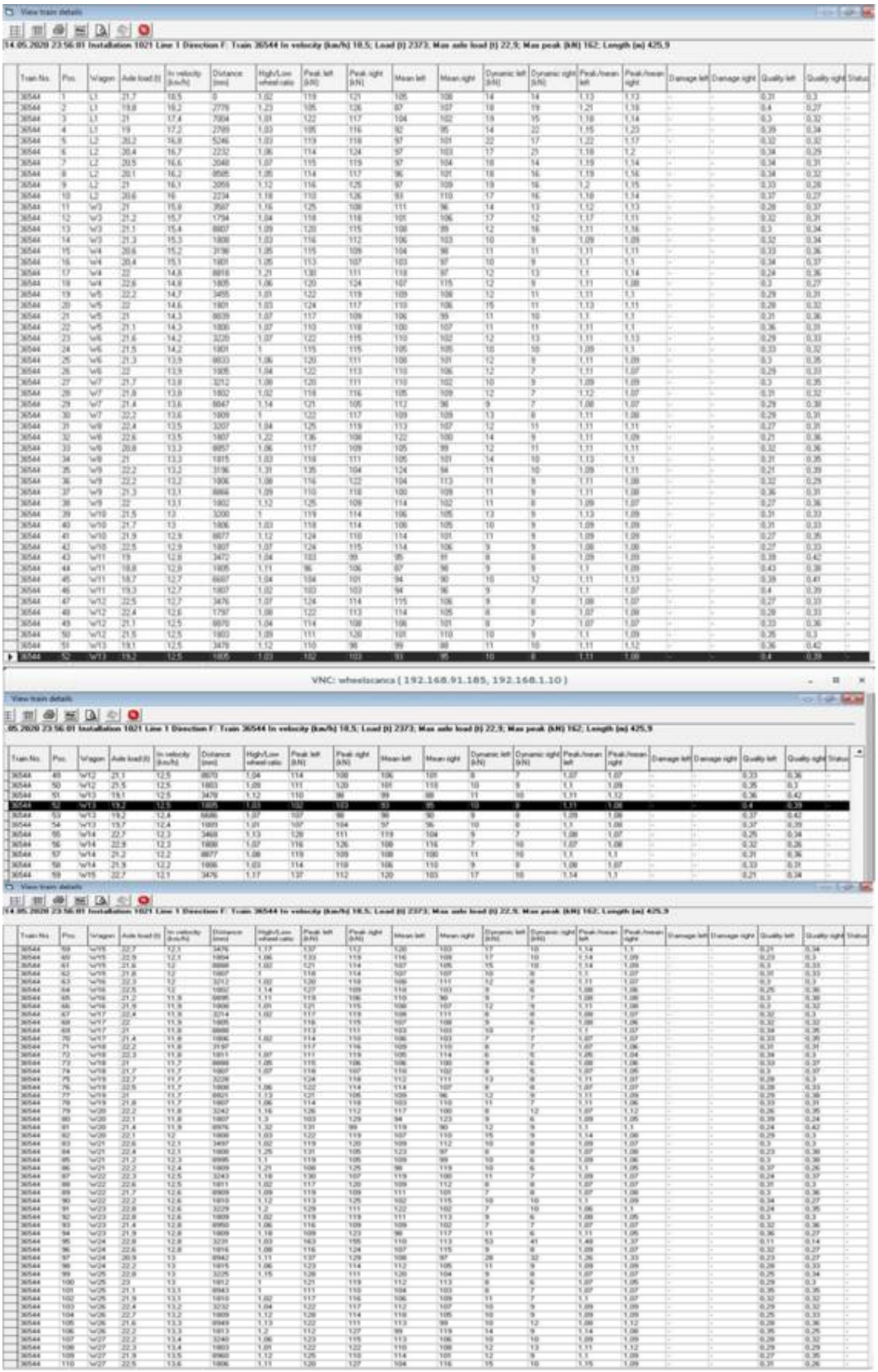


Fig. 45

display on monitors at the stations Septemvri, Pazardzhik, Stamboliyski, Todor Kableshkov and at the train dispatcher's.

In the course of the investigation, an analysis was made of the data obtained from the SCPS. It was found that when the freight trains pass through the control zone, an unjustified decrease of the speed for the section, below the limit for detection of irregularities on the rolling stock occurs. The probable but hitherto unproven reasons are of a subjective nature, as when a problem is fixed, the movement of the train is being stopped until it is removed, which is not profitable for all carriers. The passage of trains at a lower speed than the lower limit of 3 km / h (according to instructions) through the RSCS does not register data from the passed stock.

At each activated alarm the motorman of the respective train is obliged to assess the technical condition of the locomotive and the wagons in the train composition depending on the activated alarm.

There are cases of unregulated stopping of trains in the area of RSCS, which leads to errors in reading of passing trains - incorrectly listed axels, reports in the system "dynamic scale" with empty rows at zero speed, reporting as if several trains pass for a few minutes.

In this regard, the Investigation Commission found a discrepancy in the Instruction for work with RSCS in the section September-Plovdiv. The requirements for correct reading of the system is minimum speed of 3 km / h and maximum - of 400 km / h.

From the Information received from NRIC for the movement of DFT № 80561, passed on 14.05.2020 at 23:58 hrs through RSCS at post 2, road 1 in the interstation Stamboliyski - Todor Kableshkov, the following registrations are presented - the train is composed of 110 axles including (1 pc. 4-axle locomotive, 1 pc. 6-axle locomotive and 25 4-axles wagons).

The recorded data showing the axle load of the wheels are shown in Figure 45 (successively from 1st to 52nd axle; from 49th to 59th and from 59th to 110th):

The first axle has passed through post 2 at a speed of 18.5 km / h, and the last 110th axis - at a speed of 13.6 km / h (Fig. 45.1).

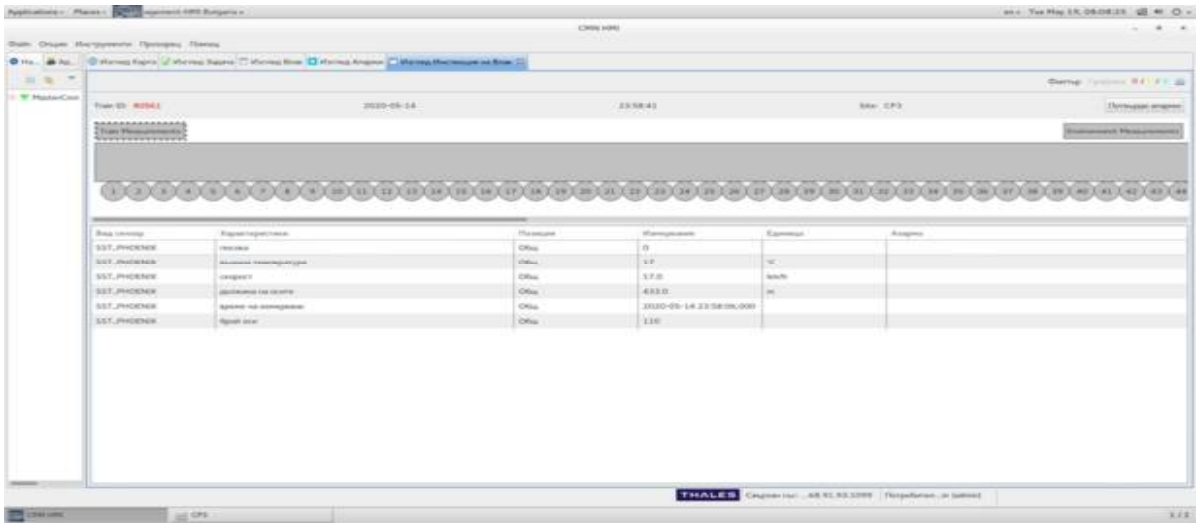


Fig. 45.1

As can be seen from the Reference for DFT № 80561, passed on 14.05.2020 at 23:28 hrs through RSCS at post 1, road 1 in the interstation Septemvri - Pazardzhik, in figure 46;

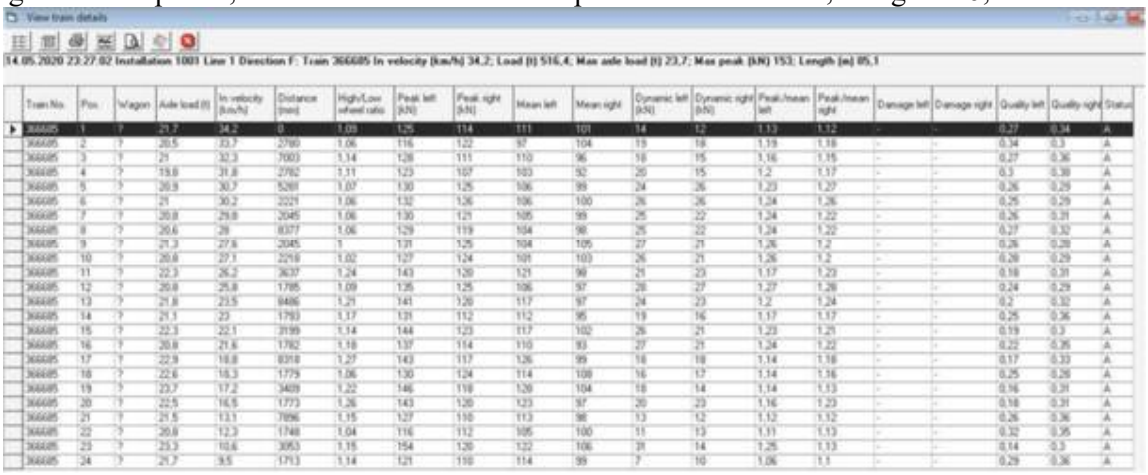


Fig. 46

The train has consisted of 110 axles, but the system has registered only its first 24 axles. The first axle has passed through post 1 at a speed of 34.2 km / h, the 24th axle has passed at a speed of 9.5 km / h. Subsequent axles from 25 to 110 have not been measured and registered, because the speed drops below 9.5 km/h after the 24th axis, nevertheless no measurements have been registered.

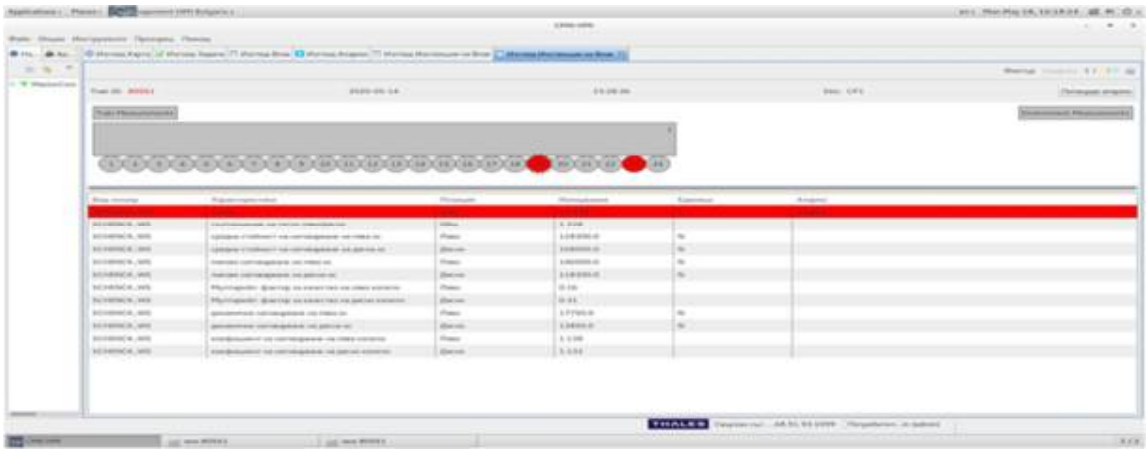


Fig. 47

The system sets alarms on the 19th and 23rd axles, i.e. 9th and 13th axles of the wagon stock, and 1st axle of the 3rd car and the 1st axle of the 4th car, shown on Figures 47 and 48:

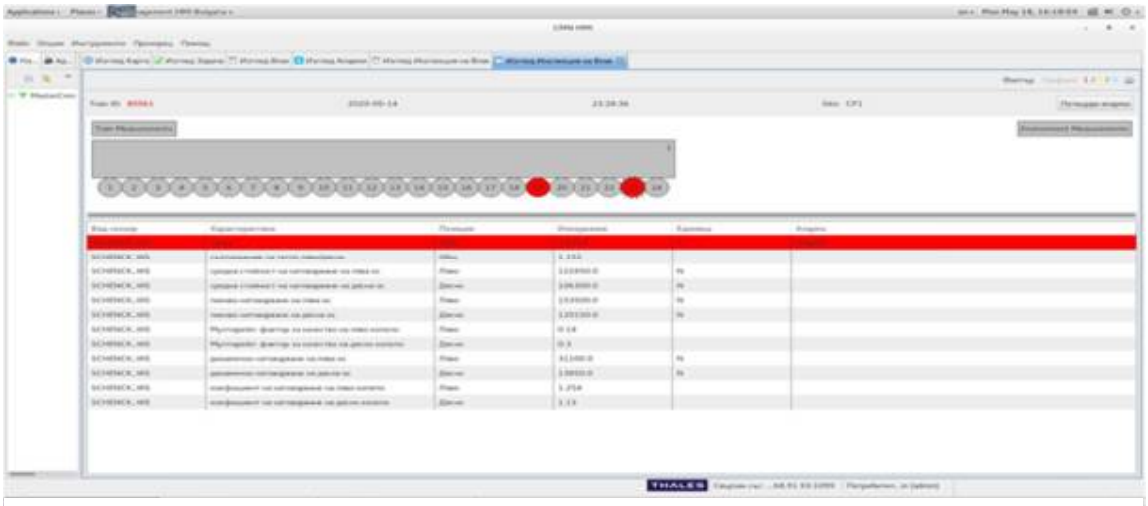


Fig. 48

The train passes through post 2 30 minutes after post 1, where the number of registered axles is 110.

The report of the first category OG, drawn up on 08.06.2020, presents the registered data for DFT № 80561 passed through the SCPS:

1. Local points of RSCS have been built and put into operation in the interstation Septemvri - Pazardzhik at km.110 $^{+200}$ (post 1) and in the interstation Stamboliyski - Todor Kableshkov at km.141 $^{+800}$ (post 2).

2. From the verification made for the passing of DFT № 80561 through RSCS (the exact speed values are given above in the diagrams) it can be seen that:

- On 14.05.2020, the same has passed RSCS at km.110 $^{+200}$ (post 1) with reduced speed and stopping, entering with 34 km / h (no registered measurement of the speed of the last 110th axle, and the speed indicated in the OG report is of the 24th axle).

- At a speed of 17 km/h it has entered the RSCS at km 141 $^{+800}$ (post 2).

3. According to the presented analysis of the registering and recording device of the leading locomotive № 86016 the train departs from Septemvri station for Pazardzhik station at 23:19 hrs / along road №1 /, the train accelerats to 78 km/h, and after 2770 meters a stop is registered and a stay from 23:27 to 23:28 hrs. This is followed by a gradual increase in speed from 12 to 15 km/h, followed by an acceleration and movement of the train at a speed of 77.79 km/h. According to the written statements of the locomotive motorman who has driven the locomotive, he has slowed down and stopped because he has noticed "flashing headlights too close to the railway". The presented journey form of the locomotive does not give a note about this feature.

4. According to the analysis of the registering and recording device of the leading locomotive № 86016 the train passes Stamboliyski station and at a distance of 1980 meters after the station the speed decreases to about 12 ÷ 15 km/h for one minute (from 23:56 to 23:57 hrs) and again accelerates to 67 km/h. There is a stop at Todor Kableshkov station at 00:04 hrs, a stay of 16 minutes and the train leaves for Plovdiv station at 00:23 hrs.

As can be seen from the Schedule Book (in force from 15.12.2019 to 12.12.2020), DFT № 80561 is supposed to leave Zlatitsa station at 18:58 hrs and arrive at Burgas station East District at 09:19 hrs. The accident occurs at 03:18:25 hrs at Nova Zagora station. According to this schedule, the train can pass through post 1 of RSCS (at km 110 $^{+200}$) and through post 2 of RSCS (at km 141 $^{+800}$) with a maximum permissible speed of 80 km/h.

In this respect, the significant decrease in the speed of DFT № 80561 recorded during the passage through Post 1 and Post 2 of the SCPS seems inexplicable. Decreasing the speed below 9.5 km/h (and not at speeds below 3 km/h, as written in the NRIC Instruction) when passing through post 1 practically "switches off" the registration system. Despite passing at a low speed, the system detects alarms on the 19th and 23rd axles of the train.

14.2.5. Divergences in the load of the 6th wagon from DFT № 80561.

The requirements for the permissible divergences in the vertical loads of wheels and axles of wagons are given in SAFETY MANAGEMENT SYSTEM, WP - 4.10 Working procedure "Instruction for freighting and transportation of oversized and heavy loads via the railway network of the Republic of Bulgaria" NRIC Date of issuance: 01.10.2018. (www.rail-infra.bg/upload/1447/РП-4.10.pdf)

"SECTION I GENERAL REQUIREMENTS FOR WAGON FREIGHTING

Art. 46, para. 3 *The load must be distributed as evenly as possible, observing the following proportions:*

1. the maximal ratio of the load of the wheels on the same wheel axle, in the transverse direction ***is 1,25: 1*** *(lateral displacement of the load);*

2. the maximal ratio of axle (bogie) loads in the longitudinal direction is:

a) for two-axle wagons **- maximum 2: 1;**

(b) in the case of tow wagons, a **maximum of 3: 1**.*"*

It has been requested and received from NRIC information about DFT № 80561, which has passed on 14.05.2020 at 23:58 hrs through RSCS at post 2, road 1 in the railway section Stamboliyski - Todor Kableshkov. This information contains data on the load of each wheel of the train (passed 2 locomotives - 10 axles and 25 wagons - 100 axles)[1] (Fig. 45 and Fig. 45.1).

The information is provided by NRIC in graphic format (**jpg**-files) and after appropriate (**OCR**) processing a table in numerical format (Excel) is generated. This allows the calculation of absolute, percentage and relative values of the divergences in wheel loads of each RS unit (locomotive or wagon) of the DFT composition № 80561. In Table 1 it is shown an excerpt from the data table only for the 6th wagon of the composition (№ 335208060012), axles numbers 31, 32, 33 and 34 (column 1, "**Pos**.").

Table 1

Train No.	Pos.	Wagon	Axle load [t]	Left + Right Peak [t]	Left + Right Mean [t]	In velocity [km/h]	Distance [mm]	High/Low wheel ratio	Peak left [kN]	Peak right [kN]	Mean left [kN]	Mean right [kN]	Mean left - Mean right [kN]	Mean left - Mean right (%)	Mean left / Mean right (-)
0	*1*	*2*	*3*	*4*	*5 ≡ 3*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
36544	31	W8	**22.4**	24.9	**22.4**	13.5	3207	1.04	125	119	113	107	6	5.5	**1.06**
36544	32	W8	**22.6**	24.9	**22.6**	13.5	1807	1.22	136	108	122	100	22	19.8	**1.22**
36544	33	W8	**20.8**	23.0	**20.8**	13.3	8857	1.06	117	109	105	99	6	5.9	**1.06**
36544	34	W8	**21.0**	23.3	**21.0**	13.3	1815	1.03	118	111	105	101	4	3.9	**1.04**

Columns 4, 5, 13, 14 and 15 are additionally inserted (marked in blue on the background of the cells) for analytical clarity and are defined as follows:

- **№ 4** – sum[2] of the peak loads on the left and right wheels in one wheel from columns № 9 (**Peak left**) and № 10 (**Peak right**);
- **№ 5** – sum[3] of the so-called static loads on left and right wheels in one wheel axle from columns **№ 11** (**Mean left**) and **№ 12** (**Mean right**). It can be seen that the values in column **№ 3** coincide with the values in column **№ 5**;
- **№ 13** - absolute value of the divergence between the left and right wheel in one wheel in dimension [kN];
- **№ 14** - percentage value of the difference between left and right wheel of one wheel axle;
- **№ 15** - ratio between the load of the left to the right wheel in one wheel axle.

From column **№ 15** it is evident that the requirements of **Art. 46, para. 3, item 1** (ratio of the load on the wheels of the same wheel axle, in the transverse direction is a maximum of **1.25: 1**) are **satisfied**, having the respective values**: 1.06** for the first axle; **1.22** for the second axle; **1.06** for the third axle and **1.04** for the fourth axis)[4].

From column **№ 3** it is evident that the requirements of **Art. 46, para. 3, item 2** b), (*ratio of the axle (bogie) loads in the longitudinal direction is: for bogie wagons - maximum **3: 1***) are **satisfied**, as the maximum ratio between the loads of the 4 axles **is below 1.09**, as the permissible value is **3**.

The passing of the train at very low speed remains unexplainable through:

[1] After Plovdiv station, the 4-axle locomotive is uncoupled and the train continues with locomotive № 088-030 at the head

[2] Converted from [kN] to dimension [t]

[3] Converted from [kN] to dimension [t]

[4] The numbers in the last column of the table and shown in purple

- RSCS at post 1, road 1 in the section Septemvri - Pazardzhik (folder CP1) on 14.05.2020 at 23:28 hrs;
- RSCS at post 2, road 1 in the interstation Stamboliyski - Todor Kableshkov (folder CP3) on 14.05.2020 at 23:58 hrs.

While the permissible speed for the section, according to the timetable is 80 km/h, the speed of passing through post 1 even falls below 9.5 km/h (which is the reason why the system registers only 24 passed axles out of a total of 110), and the speed of passing through post 2 is in the range from 18.5 km/h to about 13 km/h.

14.2.6. Analysis of wagon freighting, weight balance and load distribution - copper pyrite.

The freighting of the wagons with copper pyrite is carried out at an industrial department of the mine "Dundee Precious Metals Chelopech" EAD. The freighting technology is as follows: A shunting brigade of DB Cargo Bulgaria EOOD positions empty wagons at a specific place under the conveyor tape through which the wagons are loaded. The tape has a weight sensor and computer control. Before starting the freighting, the required weight and the useful length for freighting the wagon are set and the tape itself loads the set quantity, distributing the load in the wagon basket. The tape is managed by a mine operator, and a wagon inspector from DB Cargo Bulgaria EOOD visually controls the distribution of the load in the wagons. After the completion of the freighting process, the wagons are measured on an electronic scale, owned by Dundee Precious Metals Chelopech EAD. Most of the wagons with which DB Cargo Bulgaria EOOD serves the mine have a permissible axle load of 22.5 t / axle, for which there is a corresponding marking of the wagon. This axle and linear load corresponds to the load capacity of the railway lines type D4 - 22.5 t / axle and 8 t / m. From the provided certificates for granulometry and humidity, the characteristics of the load are present, as 98% of the granules have a size below 90 μm (90.10-6 m) and a humidity below 6%. Under more extreme operating conditions (derailment or collision of wagons), although the load is extremely homogeneous and takes the shape of a wagon basket, it is susceptible to displacement and scattering. The control of the load remains with the loading company, which controls and reports the load of each individual wagon with the wagon scale, on which the following metrological measurements and inspections have been performed:

- Protocol from subsequent periodic inspection AU-29 № 45477 / 12.08.2019, performed by the Bulgarian Institute of Metrology (BIM);
- Service protocol № 0025000446 / 18.02.2020 of Internal inspection with reference weights ESIT;

14.2.7. Analysis of the left tongue of switch № 20 - expert opinion prepared by IMSETHC-BAS appointed by DPO - Sliven:

I. Tasks of the expertise

1. To perform in situ a macroscopic analysis of a part of the left tongue of switch № 20, located in the area of the railway station Nova Zagora.
2. To determine whether there are traces of a wagon wheel on the head on the left tongue of switch № 20 at Nova Zagora station in the section from the 4th to the 6th meter.

II. Technical part

The left shoulder rail and the left tongue of switch № 20 are located in the area of Nova Zagora railway station. Due to the prolonged stay outdoors on the surfaces of the rails, an oxide corrosion product has formed.

The studied element - the left tongue is part of the railway switch № 20, The section from the fourth to the sixth meter from the tip of the tongue has been examined. The inspection and research took place on 15.07.2020 at a place near the scene of the derailed train (Fig. 49).

Fig. 49. General type and location of the studied element

On July 14, 2020, the shoulder rail and the tongue are moved from the scene of the accident to the area of the station. When moving, the surfaces of the left tongue have been severely abraded. Traces of the incision have been visible, clearly visible from the tip of the left tongue along its entire length, including the places where the examination and analysis of the surface of the tongue had to be performed (Fig. 50). The mechanical influences on the examined surface made it difficult to prepare the expert opinion on the tasks thus set.

Most of the traces of incision were at an angle of 60º relating to the axis of the rail (Fig. 50 a-g), but there were also such that meandered along the studied section of the rail (Fig. 50 d-g). These traces had a metallic sheen (Fig. 50 h), no corrosion products were deposited on them, which shows that they are quite fresh - obtained by moving (dragging) the tongue the day before the examination (Fig. 50 h, i, j).

a.

b.

c.

d.

e.

f.

g.

h.

i. j.

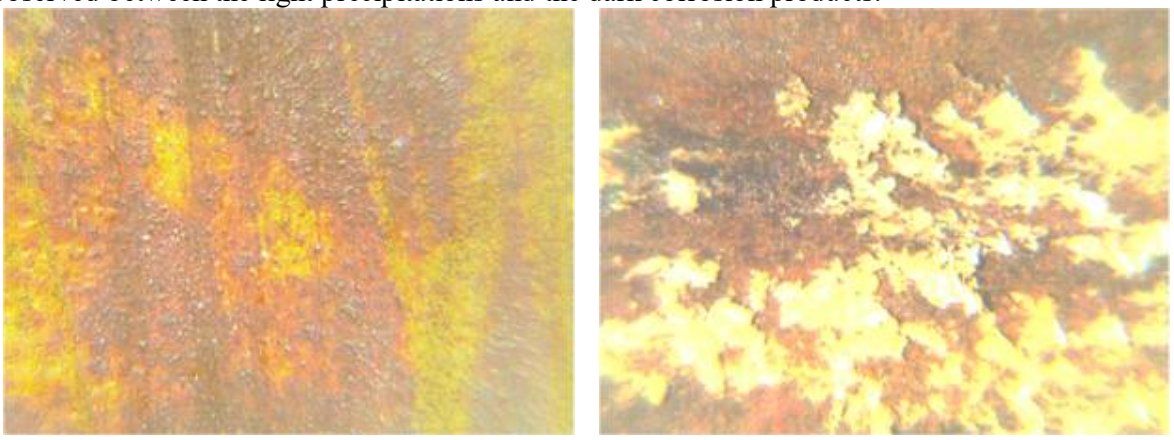
Fig. 50. Surface of the head of the left tongue of switch № 20 between the 4th and 6th meter

At a distance of 4.50 m from the beginning and about 50 cm after the place marked with chalk 4 m along the rail there were lighter coloured traces (Fig. 50 b, 51 a) with corrosion products precipitated on them.

For the purposes of technical expertise, the tongue's head was cleaned of superficial, brown-colored corrosive products by chemical treatment, and microscopic observation was performed (Fig. 51). Precipitations of light yellowish and white color (Fig. 51 b) were found, which are not characteristic of iron oxide products in open atmospheric conditions.

Dark brown and black dense corrosion products were clearly visible beneath the light precipitations - magnetite and lepidocrit, which are result of prolonged atmospheric corrosion of iron.

No traces of scratching or other mechanical impact on the surface of the tongue head were observed between the light precipitations and the dark corrosion products.



a. **b.**

Fig. 51. Microscopic image of the scratch marks before (a) and after (b) removal of the surface corrosion products.

Visual inspection revealed that there were traces of two wheel ledges between the left shoulder rail and the left tongue on the support wedges. These traces are documented in Figure 52:

- On support wedge I - trace of abrasion on the side of the wedge (Fig. 52 a);
- On support wedge II - traces of beating on the upper plane of the wedge (Fig. 52 b);
- On support wedge III - traces of beating of two ledges and one rim on the upper plane of the wedge (Fig. 52 c)
- On support wedge IV - traces of beating of two ledges and one rim on the upper plane of the wedge (Fig. 52 d);

- On support wedge V - traces of beating of two ledges and one rim on the upper plane of the wedge (Fig. 52 e);
- On support wedge VI - traces of beating of two ledges and one rim on the upper plane of the wedge (Fig. 52 f);
- On support wedge VII - traces of beating of two ledges and one rim on the upper plane of the wedge (Fig. 52 g);
- On support wedge VIII - traces of beating of two ledges and one rim on the upper plane of the wedge (Fig. 52 h);
- On support wedge IX - traces of beating of two ledges on the upper plane of the wedge (Fig. 52 i).

a. Support wedge I

b. Support wedge II

c. Support wedge III

d. Support wedge IV

e. Support wedge V

f. Support wedge VI

g. Support wedge VII

h. Support wedge VIII

i. Support wedge IX

Fig. 52. Traces of abrasion on the support wedges of the rail

III. Conclusion

On 15.07.2020, during the visual inspection and examination of the surface of the left tongue, part of switch № 20, located in the area of Nova Zagora station, no traces of wheel lifting on the head of the left tongue were found. Only traces of mechanical impact were visible (abrasion along the length of the tongue) due to its replacement, from the switch to the research site on 14.07.2020.

Traces of ledges and rims of the wagons, wheels were found along the line of support wedges, with the first being mounted 6.72 meters from the top of the tongue.

14.2.8. Analysis of a spring bolt from the spring suspension of the first axle of the first bogie of wagon № 33 52 080 6001-2, expert opinion prepared by IMSETHC-BAS assigned by DPO - Sliven:

I. Tasks of the expertise

1. To perform spectrometric, metallographic and fractographic analysis of a sample of a torn hinge of a spring of freight wagon № 33520806001-2 in the composition of FT № 80561, derailed while entering Nova Zagora station on 15.05.2020.
2. What are the results and conclusions of these analyzes?
3. Based on the results obtained, indicate the reasons for the rupture of the hinge.

II. Technical part

1. Research subjects for preparation of the expert opinion

The studied item is a sample of a torn hinge of a spring of freight wagon № 33520806001-2 in the composition of FT № 80561, derailed at the entrance of Nova Zagora station on 15.05.2020, submitted on 10.07.2020 to “Testing and analysis ” sector at IMSETHC - BAS.

1. Tests performed

For the purposes of the technical expertise, the following tests and analyzes were performed:

1. Determination of the chemical composition of the metal of the tested item (Test report № 194-2 / 14.07.2020, issued by LMTC at IMSETHC - BAS).
2. Metallographic analysis of the metal of the tested item (Test reports № 194-3 / 15.07.2020 and № 112 - HA / 15.07.2020, issued by LMTC at IMSETHC - BAS).
3. Fractographic analysis of the destroyed part of the tested item (Test report № 194-1 / 15.07.2020, issued by LMTC at IMSETHC - BAS).

III. Results of the performed tests and analyzes

1. The chemical composition of the material of the studied item is determined under the method of optical emission spectrometry of the optical emission spectrometer "Spectrolab M3". The results are presented in Table 2:

Table 2

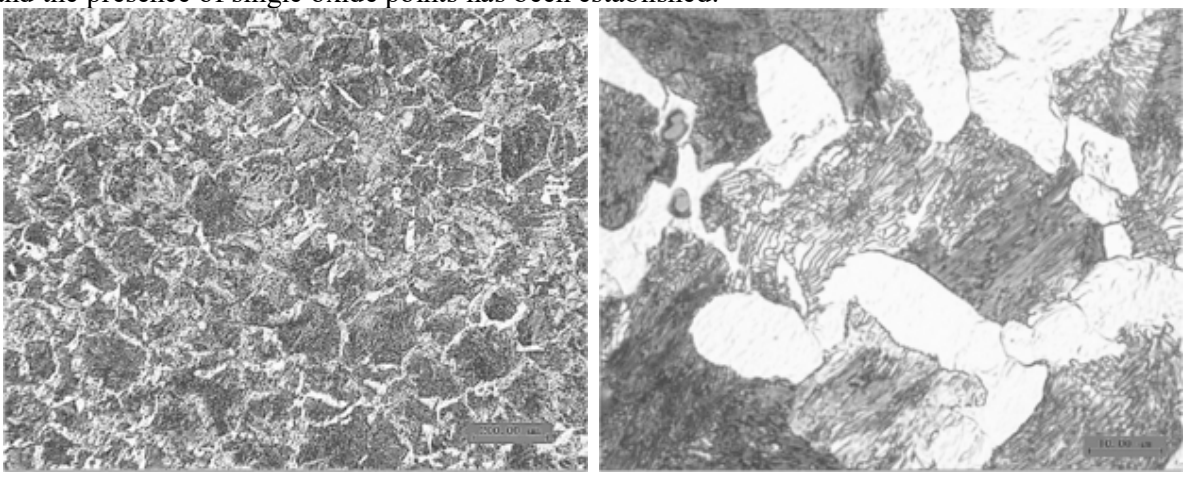
Chemical composition [% by mass]							
C	Si	Mn	P	S	Cr	Ni	Cu
0,465 ± 0,040	0,210 ± 0,019	0,635 ± 0,042	0,015 ± 0,004	0,020 ± 0,007	< 0,499	< 0,084	0,242 + 0,043

From the obtained results it can be concluded that the spring hinge is made of steel, which in chemical composition corresponds to the grade C45 according to BDS EN 10027-1 “Systems for marking steels. Part 1: Name on steel “or to steel 45 according to GOST 1050-88 - high-quality carbon structural steel.

To confirm the steel grade, additional Brinell hardness tests have been performed, which have showed an average result of 229 HB, which corresponds to the specified grade C45.

2. The microstructure of the metal of the item under study has been determined by the method of light microscopy (OM), Test reports № 194-3 / 15.07.2020 and № 112-HA / 15.07.2020, issued by LMTC at IMSETHC - BAS).

It was found that the microstructure of the metal is pearlitic-ferritic (Fig. 53). The percentage of the amount of perlite to the amount of ferrite is % P, /% F = 65/35. The dispersion of lamellar perlite corresponds to grade 6 - medium-lamellar perlite with a distance between the plates of 1μm. The grain size is grade 2. An assessment of the non-metallic inclusions in the steel has been performed and the presence of single oxide points has been established.



a. Perlite / ferrite ratio **b. Perlite dispersity**

Fig. 53 Steel microstructure, OM.

3. Fractographic examinations of the destroyed part of the item have been performed using a Technoval light stereo microscope (OM) and a scanning electron microscope HIROX 5500 (CEM), (Protocol № 194-1 / 15.07.2020, issued by LMTC at IMSETCHA - BAS).

The hinge has collapsed perpendicular to its axis. No macroplastic deformation of the fracture is observed. For the purpose of the research, a sample containing the destroyed surface is

cut from the item. It is well distinguished by a large fatigue zone (A) with a relatively smooth relief (Figs. 54, 55, 56, 57) and with clearly defined fatigue grooves (Figs. 54, 55). Photos show that the spread of the fatigue grooves starts from the outer surface of the sample. Due to the development of fatigue fracture, the bearing section, resp. the bearing capacity of the hinge decreases, after which accelerated propagation of the crack under a fragile mechanism begins, zone B. In the disruption zone the relief becomes more pronounced and elongated hills are observed, oriented in the direction of crack propagation (Fig. 54). This leads to the complete destruction of the hinge. Figure 57 clearly shows the transition between the fatigue zone and the fragile fracture zone. Figure 58 illustrates the morphology of zone B, in which destruction occurs under a fragile mechanism. The percentage ratio between the fatigue fracture surface and the accelerated fracture surface is approximately 15:85.
Evidence that the destruction of the hinge has begun gradually under a fatigue mechanism is the relatively smooth surface of the fracture around the initial disruption center, the presence of fatigue grooves and corrosion products on them.
The most probable reason for the beginning of the destruction are defects on the surface of the hinge, which play the role of stress concentrators.

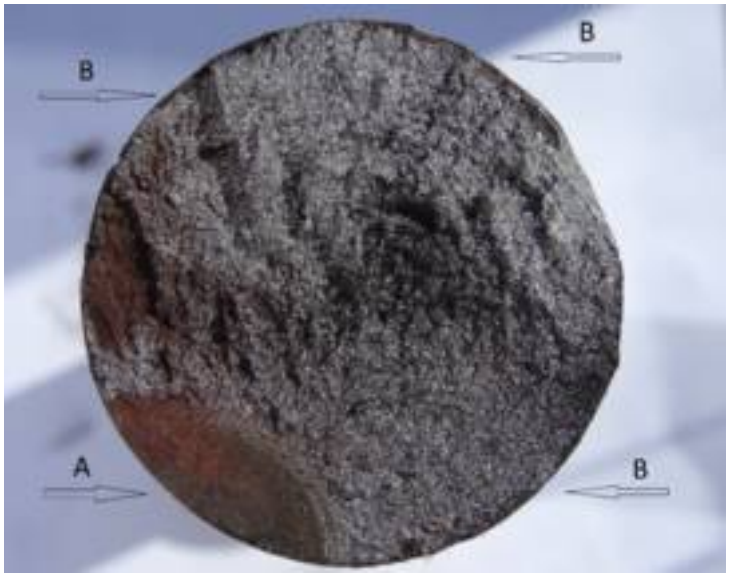


Fig. 54 General look of the disrupted hinge's surface

Fig.55. Fatigue grooves in zone A (OM)

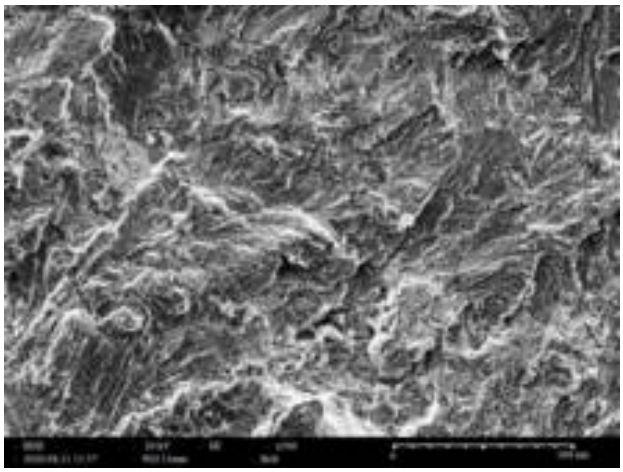
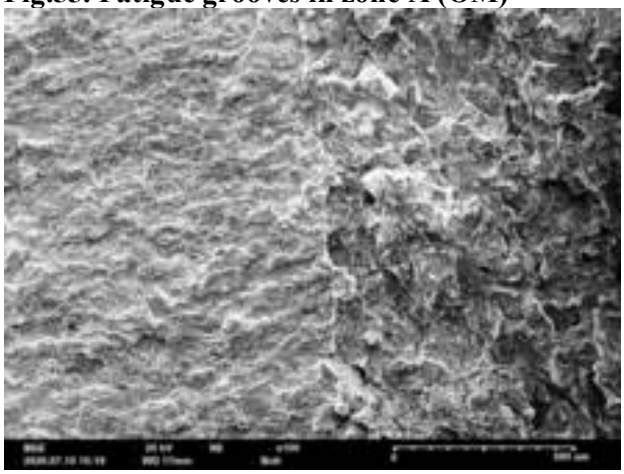
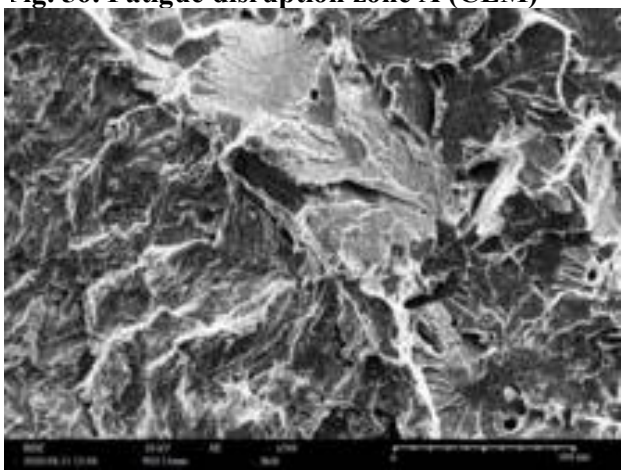


Fig. 56. Fatigue disruption zone A (CEM)



a.



b.

Fig. 57 Transition from a fatigue disruption zone to a fragile disruption zone(CEM)

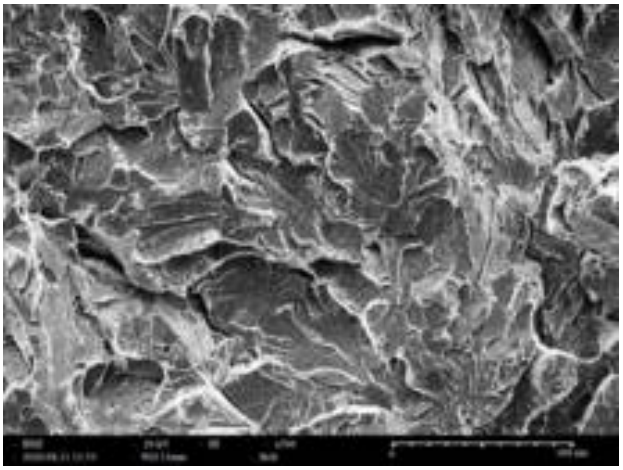


Fig. 58 Fragile disruption zone B (CEM)

1. Conclusions

1. The material from which the broken hinge is made is low-alloy steel C45, according to the requirements of BDS EN 10027-1 for the designation of steels in accordance with their chemical composition.

2. The microstructure of the metal of the studied item is perlite-ferrite, in the ratio between the amount of perlite to ferrite 65/35.

3. The destruction of the hinge has started under a fatigue mechanism in one area of the outer surface of the hinge, and the most probable reason for the formation of cracks is the presence of a defect on the surface. Due to the reduction of the bearing section and the critical reduction of the bearing capacity of the hinge, the fracture has continued under accelerated propagation of the crack under fragile mechanism. This has led to the complete destruction of the hinge.

14.2.9. Analysis of DFT № 80561 rolling stock condition.

The electric locomotive № 88030, leading the train, is technically sound. The motorman has complied with the permissible speeds in the section, operated the train in accordance with the regulatory requirements and good practices.

The locomotive and the first five wagons of the train has passed unobstructed through switch № 20. The Investigation Commission has inspected the first five wagons and found faults only in fourth wagon of the train, № 31520806485-9 - broken traction hook (Fig. 59).

Fig. 59

Fig. 60

Fig. 61

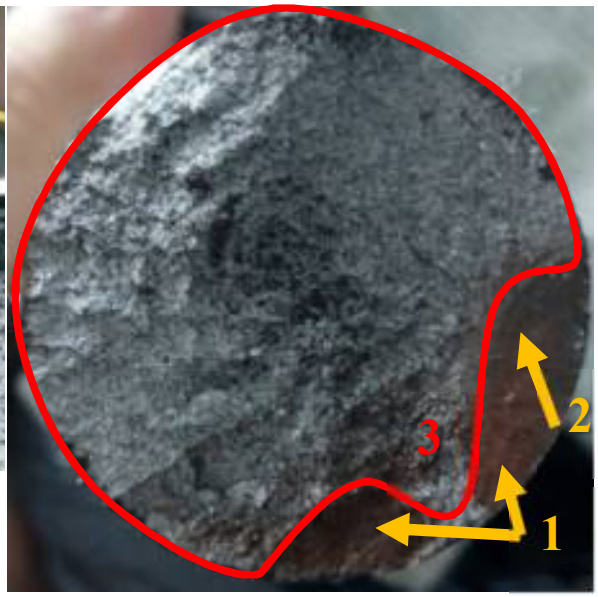


Fig. 62

The Investigation Commission has inspected all derailed wagons, reviewed the findings of the OG and found the following:

1. 1. Wagon № 33520806001-2 - sixth of the composition: the first derailed wagon (Fig. 60). Positioned between the third and fourth tracks, derailed with the four wheels, with deformed rear frontal beam and punctured transverse wall of the basket due to the impact of the seventh car, damaged bogies and wheels, loose bolt on the front screw coupling (to the fifth car), broken spring bolt on the rear earring of the first bogie of the first wheel on the left side, according to the direction of movement (Fig. 61). A brief analysis of the condition of the fracture after the disruption of the spring bolt: the structure of the fracture clearly shows the presence of the characteristic fracture zones due to fatigue of the material. A fragile disruption is observed in the base part of the section, characterizing sudden destruction by excessively high sudden loads, many times exceeding the nominal ones for the respective section (Fig. 62, pos. 3). The analysis of the condition of the bolt prepared by BAS shows that it is broken due to the increased forces acting on the running gear during the derailment together with the oblique movement of the wagon on the ballast prism between the 3rd and 4th track. During the inspection, the bolt has been in its place and it had not changed the condition of the spring suspension of the car, therefore it cannot be considered as the root cause of the derailment. During the additional inspection in WRF Karlovo, unrolling is found on the ledge of the left wheels of the second bogie and traces of contact with the rails and the ballast prism due to derailment (Fig. 63). From the statement of findings of the Operational Group it was established that the controlled dimensions of the axles are normal, but it is noteworthy that the wheels with even numbers (left in the direction of travel) have values of the criterion for vertical trimming (qR) close to the limits - wheel 2 - 8 mm, wheel 4 - 7 mm, wheel 6 - 7.5 mm, wheel 8 - 8 mm (Fig. 64). The car is subject

Fig. 63

to restoration. After the accident, the bogies are replaced and the wagon is moved to the Locomotive Depot Stara Zagora, where a control measurement of the static load on the axles and wheels of the wagon is performed. The following results are obtained during the measurement (Fig. 65, item 1): first wheel axle - left wheel: 12 920 kg, right wheel - 10 025 kg (divergence 1447 kg, 12.6%); second wheel-axle - left wheel: 12 258 kg, right wheel - 9 003 kg (divergence 1627 kg, 15.3%); third wheel-axle - left wheel: 11 759 kg, right wheel - 7 950 kg (divergence 1904 kg, 19.3%); fourth wheel-axle - left wheel: 9 668 kg, right wheel - 10 747 kg (divergence 540 kg, 5.3%.)

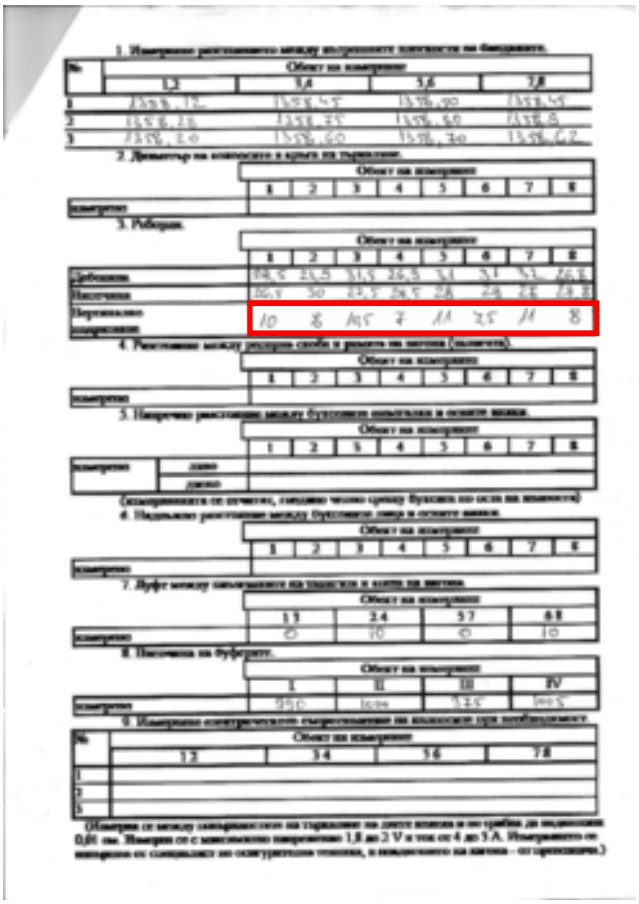


Fig. 64

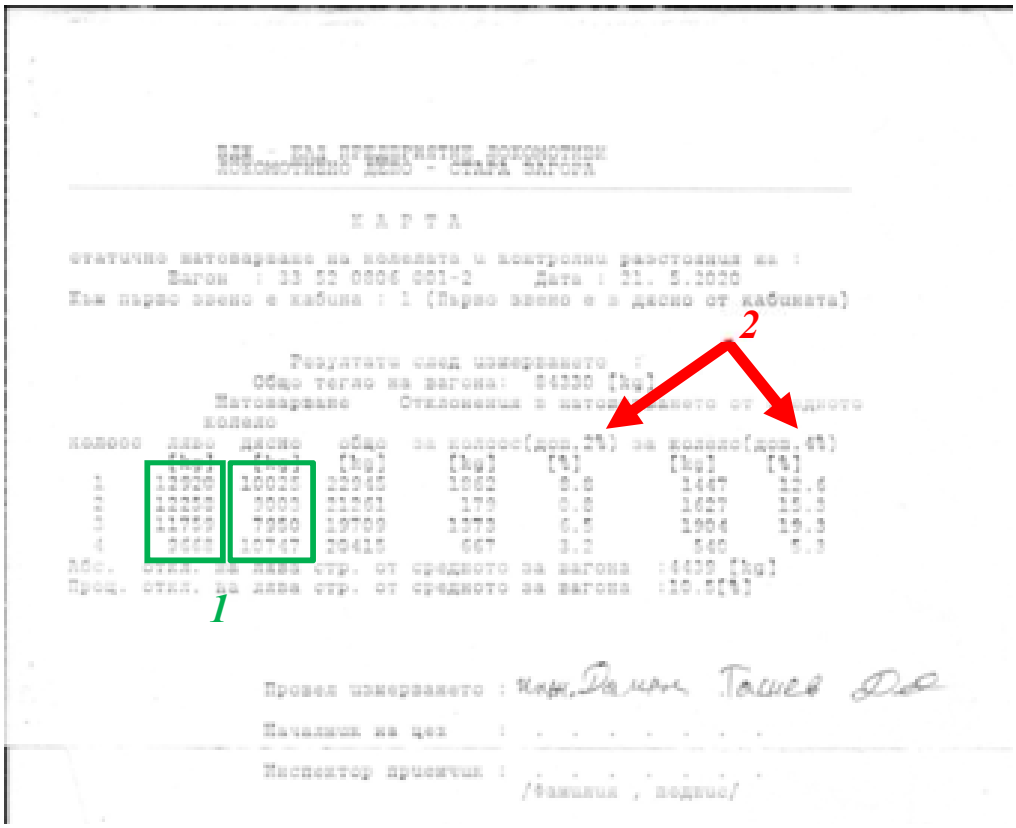


Fig. 65

Wagon is measured on a stationary facility for measuring the load on locomotive wheels by axles (4-axles and 6-axles). Due to this reason the type of the **Cart for locomotive static wheel load** (fig. 65) complies with the requirements of **RLS 414 of BDZ PT**, instead of **WP - 4.10** Working procedure *"Instruction for freighting and transportation of oversized and heavy loads via the railway network of the Republic of Bulgaria"",* NRIC. For example, the permissible percentage differences in the wheel loads of one axle (additional 2%) and for the axles (additional 4%) refer to locomotives (Fig. 65, item 2).

Table 3 is filled in, based on the measured loads on the 8 wheels of the wagon (Fig. 65, item 1). , The Left / Right (Right / Left) wheel ratio is calculated in the last column.

Table 3

wheelaxle №	Load on Left wheel, (kg)	Loa on Right wheel, (kg)	Axle Load, (kg)	Ratio Left/Right wheel
1	12920	10025	22945	**1.29**
2	12258	9003	21261	**1.36**
3	11759	7950	19709	**1.48**
4	9668	10747	20415	**1.11**

It follows from the obtained results that for three of the wheel axles the ratio is higher than the admissible one (1.25), and only for the 4th wheel axle it is **1.11 <1.25**.

From the fourth column of the table (**Axle load, (kg)**) it is evident that the ratios of the axle loads in the longitudinal direction of the wagon have values much smaller than the permissible maximum of 3: 1.

These results are only for control, given the following main circumstances (Figs. 65.1 and 65.2):

- ✓ After the derailment the bogies of the wagon are replaced;
- ✓ Undercutting is found on the wagon basket in the area above the buffer, which confirms the conclusion that the 7th wagon with one of its buffers has hit the 6th wagon;
- ✓ It has been established that there is a so-called "Slope" in the rear of the floor of the wagon, which is at a certain slope, i.e. the floor area of the wagon is not tightly filled. It is obvious that as a result of the impact the bulk cargo has moved forward and to the right in the direction of travel;

Fig. 65.1

Fig. 65.2

An authoritative conclusion can be made only on the basis of an analysis of the data registered for DFT № 80561, passed on 14.05.2020 at 23:58 hrs through RSCS at post 2, road 1 in the Stamboliyski - Todor Kableshkov railway section.

With regard to the stationary system for measuring the load on the locomotives' wheels in the Locomotive Depot Stara Zagora, it should be noted that it is not a commercial scale and it can not be subject to the requirements set out in the Law on Measurements (In force from 09.11. 2002, last amended and supplemented, SG No. 72 of 13 September 2019).

The stationary system is an internal facility (the requirements for which are set in internal regulations, such as RLS 414 of BDZ PT), and it also controls not the absolute values of the wheels loads and axles loads, but the values of the allowable percentage of differences (for example : respectively 5% for left to right wheels, 3% for wheel axles and 5% for the sum of the loads of all left to all right wheels).

2. Wagon № 33520806190-3 is the seventh of the composition. It has derailed with four axles, positioned between the second and third track of Nova Zagora station on the ballast prism (Fig. 60). The wagon has a slightly deformed frame and basket, a slightly deformed frame of the first and a strongly deformed frame of the second bogie, with missing and damaged towing equipment and damaged axles. All controlled wheel axle sizes are normal.
3. Wagon № 33520806475-0 is the eighth of the composition. It has derailed with four wheels, positioned between the first and second tracks partly on the platform between the two tracks, lying on its left longitudinal side in the direction of movement (Fig. 60). The wagon has a strongly deformed basket, a strongly deformed second bogie, with missing towing equipment and damaged wheels. All controlled wheel axle sizes are normal.
4. Wagon № 33520807974-1 is the ninth of the composition. It has derailed with four axles, positioned on the first track, longitudinally, lying on its left longitudinal side in the direction of movement (Fig. 60). The frame and the basket of the wagon are strongly deformed, with missing towing and deflecting equipment, with numerous injuries on the wheels and the bent third wheel. All controlled wheel axle sizes are normal.
5. Wagon № 33520806460-2 is tenth of the composition. It has derailed with four axles, positioned on the second track, transverse to the axis of the railway (Fig. 60). The car has a strongly deformed frame and basket, missing towing and deflecting equipment, damaged wheels. All controlled wheel axle sizes are normal. The car is offered for scrapping.
6. Wagon № 33525928508-8 is the eleventh of the composition. It has derailed with four axles, positioned on the second track, transverse to the axis of the railway (Fig. 60). The wagon has a strongly deformed frame and basket, missing towing and deflecting equipment, damaged axles, with a missing axle № 4 and strongly deformed bogies. All controlled wheel axle sizes are normal. The car is offered for scrapping.
7. Wagon № 33520802020-6 is the twelfth of the composition. It has derailed with four axles, positioned between the first and second track, at an angle of 30 ° to the longitudinal axis of the second track (Fig. 60). The frame and the basket of the wagon are severely deformed, there are no towing and deflecting equipment, damaged wheel axles. All controlled wheel axle sizes are normal. The basket and one of the carts are offered for scrapping.
8. Wagon № 33520806004-6 is the thirteenth of the composition. It has derailed with four axles, positioned on the second track, longitudinally to the axis of the track (Fig. 60). The wagon has deformations on the longitudinal and transverse beams of the frame and basket, with missing towing and deflecting equipment, with damaged wheels. All controlled wheel axle sizes are normal. The wagon basket and its second bogie have been offered for restoration.
9. Wagon № 33520806296-8 is the fourteenth of the composition. It has derailed with four axles, positioned on the second track, longitudinally to the axis of the track (Fig. 60). The car has a strongly deformed frame and basket, with missing towing and deflecting equipment, with damaged wheels. All controlled wheel axle sizes are normal. The wagon basket and its first bogie are offered for scrapping.
10. Wagon № 33520806251-3 is the fifteenth of the composition. It has derailed with four axles, positioned on the second track, longitudinally to the axis of the track (Fig. 60). The frame and the basket of the wagon are slightly deformed, there are no towing and deflecting

equipment, the bogies are in good condition. All controlled wheel axle sizes are normal. The car is offered for restoration.

14.3. Conclusions.

14.3.1. Immediate (direct) and main causes of the accident, including additional factors (prerequisites) related to actions taken by the persons involved in it, or the condition of the rolling stock or technical facilities;

After passing the locomotive and the first five wagons of DFT № 80561, the sixth wagon, № 33 52 0806 001-2, when passing, with switch № 20 being between its first and second bogies, a spontaneous reversal of the switch has happened, from position for the fourth main track to position for the second track of the station, where the first bogie continues its movement on the fourth track, and the second bogie is directed on the shoulder rails and in gauge about 1520-1530 mm the left wheels of the second bogie have derailed, and subsequently the right wheels.

The tongues of the switch have moved due to the strong transverse (horizontal) dynamic impacts on them in the area of the spring rocker arm, as it has been currently in an equilibrium position, i.e. the left tongue has not been firmly attached to the left shoulder rail and the right free tongue has been at a distance of 40 mm, while the norm is 65 ± 3 mm. The impacts from the left wheels are directed to the working part of the left tongue and the impacts from the wheels of the passing locomotive and five wagons, including those of the first bogie of the sixth wagon, are directed to the non-working part of the right tongue. These horizontal transverse forces (whiplash) have caused strong oscillations to the tongues. The forces have been significantly greater than the values of the locking forces of the tongues. Under such circumstances, the left tongue is unlocked and detached from the left shoulder rail. With this movement it provokes the movement of the right tongue to the right shoulder rail from position (plus) to position (minus).

In this position of the switch (semi-reversed) the ledges of both left wheels of the second bogie have been cut between the left shoulder rail and the left half-open tongue, and the right wheels continue their movement on the right shoulder rail. With this movement of the wagon, between the left shoulder rail and the left tongue, the switch has been fully reversed from position (plus) to position (minus).

The sixth wagon, with its first bogie, has continued its movement on the fourth track, and with its second bogie, has continued on the two shoulder rails of the switch, as the left wheels have derailed at the second support wedge. The sixth wagon has fully reversed the tongues to the end minus position and all next wagons - from the seventh to the fifteenth have continued their movement in deviation to the second track.

Fig. 66

The switch has reversed in three stages, as can be seen from the fixed oiled rings on the piston of the Spherolock locking device (Fig. 66):

- Initially, the reverse is caused by the dynamic horizontal blows of the left wheels on the tongue in the area of the spring rocker arm;
- The second stage of the reversal is caused by the two wheels of the second bogie, which cut between the left tongue and the left shoulder rail and then derail;
- The third stage of reversal is performed by the external locking device Spherolock, which has passed the equilibrium reversal point and has moved the tongues to the end (minus) position.

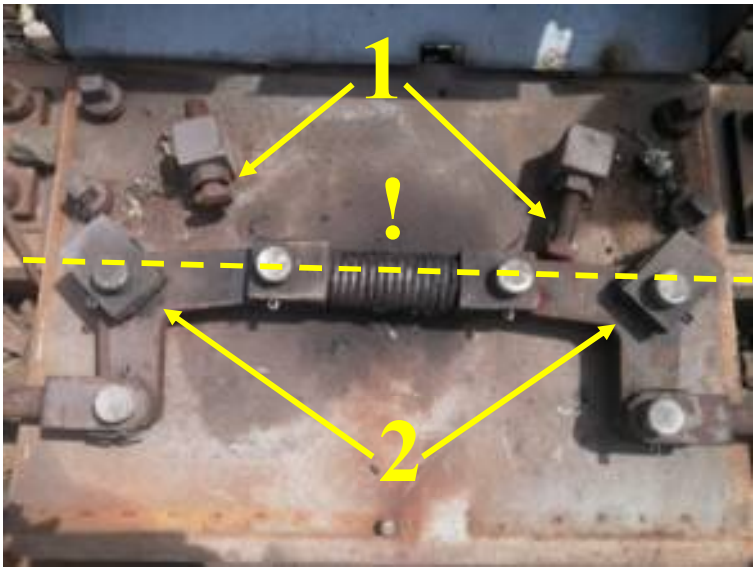


Fig. 67

14.3.2. Hidden (concomitant) causes of the accident, related to skills, procedures and maintenance.

The Investigation commission has find:

- the spring rocker arm of switch № 20 has not been adjusted correctly. When switch № 20 reverses for the straight track, the spring rocker arm takes the equilibrium position (Fig. 67), (not allowing the left tongue to fit snugly to the left shoulder rail - Fig. 68). When a heavier train (as is in this case) passes, than the dynamic horizontal impacts from the wheels onto the area of the rocker arm, lead to strong oscillations in the tongues, which are being passed to the Spherolock locking system, forcing it to disengage from the position it is set in.

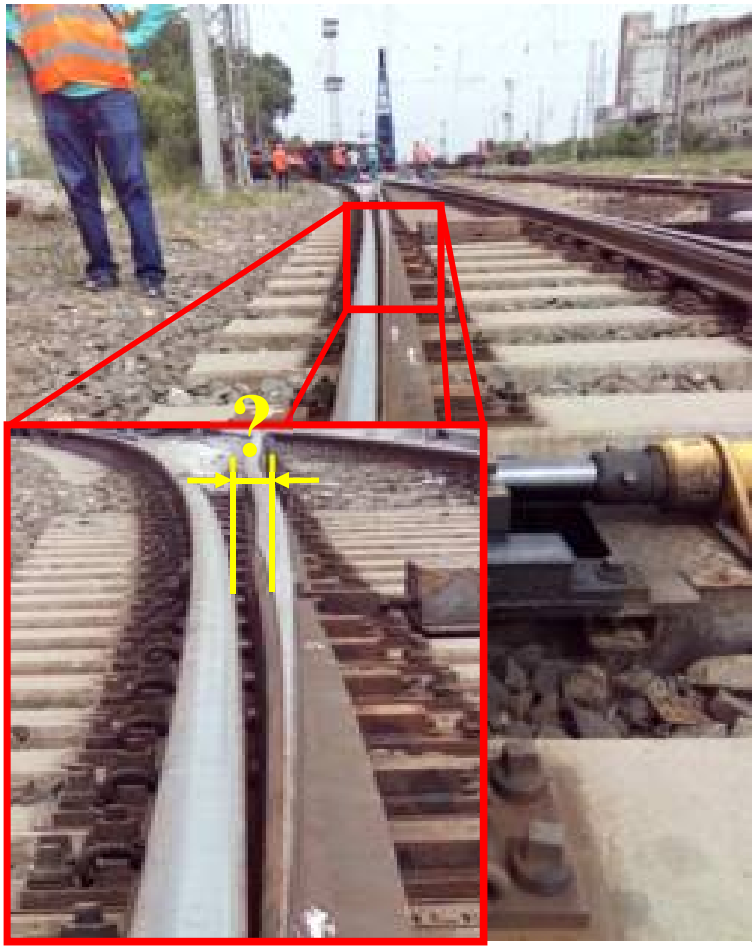


Fig. 68

- The support bolts (fig. 67, pos. 1) of the rocker arms (fig. 67, pos. 2) of the spring rocker arm of switch № 20 are incorrectly calibrated, which leads to non-adherence of the left tongue to the left shoulder rail and the free right tongue remains at a distance of 40 mm from the right shoulder rail while the norm is 65 ± 3 mm. When heavier trains pass, indications for cut switch appear occasionally on the desk at the station (registered in previous cases) (Fig. 68).

- The connecting rods of the spring rocker arm are incorrectly calibrated(Fig. 69, item 1).

- During operation, the adhesion of the tongues to the shoulder rails changes and for this purpose, it is necessary to periodically to be checked and calibrated. NRIC personnel are not trained to maintain this type of auxiliary reversing and spring apparatus. There are no protocols for training

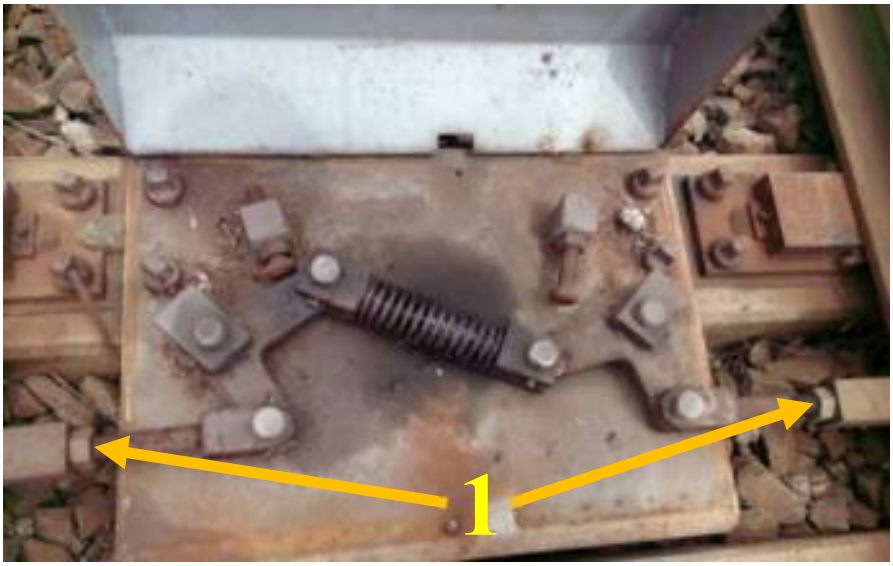


Fig. 69

the staff to work with the newly introduced facilities and devices and documents certifying such their qualification.

- There are no entries in books proving periodic inspections of the spring rocker arms on the switches in Nova Zagora station, from their commissioning to the moment of the accident.

- NRIC has not required to enter data and parameters in the regulatory framework for calibrating the equipment in the event of a change in operating conditions in connection with the introduction of new devices that ensure safe operation of the switches.

- Dispersion of maintenance of the three UIC60 switches has been established: EPM is supported by the Signaling and Telecommunications division, and the spring rocker arm and the Spherolock mechanical locking device are supported by the Railway and Facilities division.

14.3.3. Other findings and observations related to regulatory infringements identified during the investigation, but irrelevant to the causes.

1. In the Book for the condition of the facilities for SE form VII-51 at Nova Zagora station on 10.04.2020 and 13.05.2020 there are some registered records by DHT for use of the restoration button in cut switch № 20 according to the desk display. No protocols have been compiled for the cut position of the switch, as there is no actual cut of the same. After an inspection, only by a technician-mechanic of ST, no damage is found on EPM and after measurements for the adhesion of the tip of the tongue with a 2 mm clearance pattern the inspection is completed, which is registered by a note in the Book for equipment damage form VII -51. This information on the desk for cut switch № 20 has been obtained in both cases after the passing of freight trains with the same number (№ 80561) running against the switch tongues and clearly indicating that the switch had a problem with passing trains with a large axle load.

In view of the two registered cases leading to indications on the control panel at the station for loss of electrical control of switch № 20, for one month in similar circumstances, the "Signaling and Telecommunications" and "Railway and Facilities" divisions at NRIC, have not been notified and therefore the reasons that have led to the indicated cut of the switch have not been analized in order necessary measures to be taken.

2. The locomotive personnel who has operated electric locomotive № 88030 has not been trained by an accredited institution for training locomotive drivers and certifying the professional qualification for the respective series of locomotives in accordance with the requirements of Art. 18, item 6 of the Vocational Education and Training Act and Art. 44, para. 1, item 1 of Ordinance № 56 of 14.02.2003.

3. During servicing DFT № 80561 with the locomotives of the railway carrier DB Cargo Bulgaria EOOD at Vakarel station and at Todor Kableshkov station no short test "D" of the automatic train brakes has been performed in accordance with the requirements of Ordinance № 58,, Regulations for train movement and shunting work"and PR 22-02-01" Procedure and manner of testing the brakes of DBCB trains ", part of the SMS of DB Cargo Bulgaria EOOD.

15. Description of already taken measures as a result of the accident.

1. Measures taken by NRIC:

- After the accident, , a joint working group is assigned by order № 942 of 05.06.2020 of the NRIC General Director to perform a technical inspection of the equipment supplied and installed by Voestalpine Railway Systems Bulgaria OOD, describing their current condition in control sheets.

2. Measures taken by the railway carrier DB Cargo Bulgaria EOOD;

- The employees of the railway carrier in the industrial branch of Dundee Precious Metals Chelopech EAD, participating in the freighting of the wagons with copper pyrite, have been instructed to increase the control over the freighting and maintenance of the wagons.

16. Recommendations issued in order to avoid accidents upon the same reasons.

In accordance with the requirements of Art. 94 para. 1 and para. 3 of Ordinance № 59 from December 5, 2006 in order to improve safety in railway transport, the Investigation commission proposes to EA "Railway Administration" to order to DB Cargo Bulgaria EOOD and NRIC to implement the given safety recommendations.

1. Recommendation 1 proposes to conduct an extraordinary briefing of the personnel related to the safety of the transport in “DB Cargo Bulgaria” EOOD and NRIC, to be acquainted with the content of the final report.

2. Recommendation 2 proposes to NRIC to re-equip the platform scales in the operating points of wagons freighting for precise and accurate measurement of the loaded wagons both on axles and on wheels.

3. Recommendation 3 proposes NRIC together with Voestalpine Railway Systems Bulgaria OOD to amend and supplement the “Manual for installation, operation and maintenance of a spring rocker arm with two arms”, to write down the parametric data for repair and maintenance in compliance with the norms for railway switches safe operation.

4. Recommendation 4 proposes NRIC to allocate to the "Railroad and Railway Equipment" and "Signaling and Telecommunications" Units responsible for the maintenance of UIC 60 switches equipped with a 550-B turn out switch device , Spherolock locking system and spring rocker ram with two arms, the manipulations for the repair and maintenance of the electrical and mechanical part to be performed jointly according to their competencies.

5. Recommendation 5 proposes, in order to improve the safety of the railway infrastructure, that NRIC should entrust the maintenance of certain stations equipped with UIC 60 switches to Voestalpine Railway Systems Bulgaria OOD, which should be responsible for their maintenance and technical condition in compliance with the norms for safe operation.

6. Recommendation 6 proposes NRIC to update the Instruction for work with the rolling stock control system in the section Sofia - Plovdiv, in the part minimum speed for measuring and registering the parameters of passing rolling stock, in order to accurately and completely data registering.

7. Recommendation 7 proposes to DB Cargo Bulgaria EOOD to conduct training of the locomotive personnel in an accredited institution for acquiring professional qualification for the respective series of locomotives in accordance with the requirements of Art. 18, item 6 of the Vocational Education and Training Act and Art. 44, para. 1, item 1 of Ordinance № 56 of 14.02.2003.

With reference to the implementation of Art. 94 para. 4 of Ordinance № 59 from December 5, 2006 on Railway Safety Management, the Investigation commission at AMRAINB gives the recommendations set out in the Final report. The addressees shall notify in writing the Investigation commission chairman for the implementation of the given recommendations.

The Investigation commission assigned at AMRAINB has finished the final report on 18 November 2020.

Chairman:
Dr. Eng. Boycho Skrobanski
Vice-President of NAMRAIB

Members:

1.....(S).....(External expert)
2.....(S).....(External expert)
3.....(S).....(External expert)
4.....(S).....(External expert)