# REPUBLIC OF BULGARIA

# MINISTRY OF TRANSPORT, INFORMATION TECHNOLOGIES AND COMMUNICATIONS

# DIRECTORATE UNIT FOR AIRCRAFT, MARITIME AND RAILWAY ACCIDENT INVESTIGATION

# SPECIALIZED UNIT FOR RAILWAY ACCIDENT AND INCIDENT INVESTIGATION

# FINAL REPORT

**on**

**completed technical investigation of a railway accident – fire in electric locomotive No. 45-167.4 of train composition No. 3601 Sofia – Burgas at 142+580 km, in the Stamboliiski-Kableshkov inter-station section, on road No. 1, which occurred around 17:55 on 30.11.2009**



**JANUARY 2010**

# FINAL REPORT

**Concerning:** Technical investigation of a railway accident – fire in electric locomotive No. 45-167.4 hauling train composition No. 3601 from Sofia to Burgas at 142+580 km, in the Stamboliiski – Todor Kableshkov inter-station section, which occurred around 17:55 on 30.11.2009 on road No. 1.

**1. The findings of the technical investigation are as follows:**

On 30.11.2009, high-speed fast train No 3601 Sofia – Burgas departed from Sofia station at 16:00 on a regular schedule, the train consisting of 9 coaches, with total weight of 422 t, powered by locomotive No. 45-167.4, with engine-driver No. 1 and engine-driver No. 2, both from the Plovdiv Regional Center for Passenger Transport (RCPT), and a trainmaster and a car attendant, both from Sofia RCPT.

No peculiarities in the train composition were noticed by the train operations officer and the switchmen on duty at 17:53, while the train was passing through the Stamboliiski station without stopping.

After transiting through the Stamboliiski station at a speed of 98 km/h, on road No. 1, in the Stamboliiski – Todor Kableshkov inter-station section, and passing by the station traffic signal installations for the reverse direction, specific smell of burning insulation was felt in the engine-driver’s cabin. The engine-drivers looked through the windows of the doors of the engine compartment, but they did not notice any irregularities. Then engine-driver No. 2 stuck his head out of the right side window and looked back towards the train. He noticed flame coming from beneath the locomotive and immediately initiated emergency breaking, causing the train to finally stop at 142+580 km at 17:55. Engine-driver No. 2 immediately took a handheld fire extinguisher of the “Yatrus-12” type from the cabin of the locomotive and gave it to his colleague, engine-driver No. 2, who turned it on, aimed the nozzle at the burning cables and used the entire quantity of fire-extinguishing powder in the bottle. The flame was extinguished for a while, but after using all the available fire-extinguishing agent, the area caught fire with full strength once again. Engine-driver No. 2 immediately climbed into the rear (in respect of the direction of the train) cabin No. 1 and gave his colleague a second handheld fire extinguisher of the “Yatrus-12” type, which, however, failed to operate despite of the manipulations carried out by the engine-driver. Then both engine-drivers opened the doors between the two cabins and the engine compartment with the aim of taking out the other two handheld fire extinguishers with СО2, but they were confronted by thick, asphyxiating and toxic smoke inside the whole compartment, and could not reach these two fire extinguishers. Engine-driver No. 2 unlocked and pulled the lever activating the stationary powder fire extinguishing installation of the locomotive from cabin No. 1. The installation, however, was not activated. Covering his respiratory tracts with his sleeve, once again he opened the door to the engine compartment and manually released the safety rod from the fast-response head of the transport gas bottle, then he closed the door and switched off the 3-terminal fuse (832) of the battery. Then he climbed into cabin No. 2 and activated the fire extinguishing installation from there as well. Then he dialed 166 and 112 and reported about the fire, requesting help and fire trucks to be sent. At 18:05, the signal about the fire was received by the Regional Fire Safety and Protection of Population Service (RFSPPS) in the town of Stamboliiski. Then he called the train controller and the power supply controller at the Sofia-Plovdiv Computer System for Automated Train Traffic Control (CSATTC) Center, who disconnected the power supply of road No. 1 at 18:11. The traffic on road No. 1 and road No. 2 was halted. The locomotive crew continued its fight with the fire in the area of the sub-bin fan using 5 handheld fire extinguishers of the “Yatrus-12” type from the cars of the train, brought to them by the train crew members who came to help them. The fire extinguishing efforts, however, were inefficient because of the lack of direct access to the fire, which became more intense after the fans stopped working, due to the fact that they had been causing suction of the smoke and fire through the air duct out of the locomotive while they were working. Now the fire expanded into the interior of the engine compartment. The first fire truck from the town of Stamboliiski arrived at 18:17, but at that time the power supply of the adjacent road No. 2 had not been disconnected yet, thus making the area unsafe, and therefore no fire extinguishing actions were undertaken. At 18:30, engine-driver No. 2 called again the power supply controller with a request to switch off the power supply of the road No. 2 network. The power was disconnected at 18:34, and the locomotive crew was notified thereof at 18:37 via the mobile phone provided by the railway company. All safety requirements having been fulfilled, the five fire trucks which had arrived at the site started the fire extinguishing actions, and the fire was put out at 19:30.

At 19:11, diesel locomotive No. 52-73 was sent from the Stamboliiski station to haul back the passenger carriages of the train. At 19:50, the locomotive and the carriages returned to Stamboliiski station. Then the train composition departed for Plovdiv station with a delay of 227 minutes, powered by electric locomotive No. 45-150 and diesel locomotive No. 06-43 in front, and arrived at Burgas station with a delay of 221 minutes.

At 20:02, the train traffic on road No. 2 was restored for diesel-powered trains only, with no electric power supply in the road network, due to safety considerations, in case of occurrence of another fire and need of subsequent fire extinguishing actions. The power supply on road No. 2 was switched on at 22:10, and thus the traffic of electric-powered trains was also restored. The power supply and the traffic of electric-powered trains was also restored for road No. 1, at 23:20.

At 22:04, electric locomotive No. 45-167.4 was moved to track No. 7 at the Stamboliiski station, sealed and placed under prosecutor’s control and police protection. On 02.12.2009, it was moved to the Plovdiv depot, where it remained sealed and under guard until 04.12.2009. On 04.12.2009, at 09:00, the locomotive was unsealed and thoroughly examined by experts and the preliminary investigation bodies. Power cables and diodes from the first rectifying unit and safety fuse No. 204/400A for auxiliary machines, etc., were taken away for expert examination.

**2. Officers involved in the event.**

The following officers were involved in the accident:

2.1. Engine-driver No. 1 – employee of the Plovdiv locomotive depot of the „Bulgarian State Railways (BDZ) – Hauling Rolling Stock (Locomotives)” EOOD, 35-year-old, length of service: 14 years;

2.2. Engine-driver No. 2 – employee of the Plovdiv locomotive depot of the „Bulgarian State Railways (BDZ) – Hauling Rolling Stock (Locomotives)” EOOD, 39-year-old, length of service: 18 years;

2.3. trainmaster – employee of Sofia Regional Passenger Transport Center of „Bulgarian State Railways (BDZ) – Passenger Transport” EOOD, 53-year-old, female, length of service: 32 years;

2.4. train controller – employee of Sofia Regional Passenger Transport Center of „Bulgarian State Railways (BDZ) – Passenger Transport” EOOD, 57-year-old, male, length of service: 16 years;

,,BDZ” EAD is a licensed national carrier for passenger and freight transport, with three enterprises: „BDZ – Hauling Rolling Stock (locomotives)” EOOD, „BDZ – Passenger Transport” EOOD and „BDZ – Freight Transport” EOOD.

**3. Physical condition of the officers involved in the accident.**

3.1. All officers involved in the accident were given the necessary rest period before commencing work, in accordance with the provisions of the Labour Code and Ordinance No. 50 (of 28.12.2001) of the Minister of Transport concerning the working time of managers and employees engaged in the transport of passengers and cargo by rail (promulgated in State Gazette, No. 4 of 2002, amendment in State Gazette, No. 46 of 2004, amendment and supplement in State Gazette, No. 99 of 2006).

3.2. All officers involved in the accident had pre-travel (pre-shift) briefing as well as pre-travel medical examination, by which it was found out that they had not used alcohol or narcotics, and that they were fit for work.

The above officers had psychological examination certificates which were valid and had not expired yet.

**4. Documents certifying competence and capacity for holding the positions.**

All officers involved in the accident have the required documents for professional qualification and legal capacity for the positions they hold, and have been furnished with respective orders and certificates.

**5. Actions carried out by the officers prior to and during the accident.**

Prior to the accident, all officers acted in accordance with the established legal regulations, by-laws and administrative acts regulating the safety during transport by rail.Under the conditions of intense smoke generation and emission of toxic substances endangering the human health during the accident, the locomotive crew members acted with limited capabilities to activate the fire-extinguishing installation, and they did their best to put out the fire from outside. Due to the fact that the fire started inside the rectifying unit cabinet, the use of fire extinguishers from the outside was inefficient.

**6. Circumstances preceding the accident, relating to the railway, safety equipment, contact network, rolling stock, etc.**

The train cars were in good working order and had no bearing on the railway accident which later occurred.

The railway was in good working order and had no bearing on the railway accident which later occurred.

The contact network was in good working order and had no bearing on the railway accident which later occurred.

The safety equipment in the two neighbouring stations – Stamboliiski and Todor Kableshkov, as well as in the inter-station section, was in good working order and had no bearing on the railway accident which later occurred.

According to the statement of findings produced, locomotive No. 45-167.4 which was powering the train was in good working order, with technically operative running gear, braking system, lighting and audible signal equipment.

**7. Observance of the operating procedures and technologies in the carrier’s system prior to and during the accident.**

Train No. 3601 had the required breaking mass and had been furnished with the necessary train documentation and train dispatch radio communication system, and the locomotive and train service team members had GSM mobile phones provided by the company.

As a result of the analysis of the collected documents certifying the technical condition of locomotive No. 45-167.4, the scheduled repairs and inspections performed, and the explanations provided by the personnel involved in the accident, it was found that there were no violations of the operating organization, procedures and technologies.

Locomotive No. 45-167.4was produced and supplied in 1982. Its book value as of 31.10.2009 was BGN 293 377,65. At the time of the accident, the distances run by the locomotive since the last scheduled repairs and inspections were as follows:

|  |  |  |
| --- | --- | --- |
| Type of repair | Date of release from repair | Distance run since the respective repair |
| Major repair (MR) | 01.08.1994 | 1 988 068 km |
| Mid-life repair (MLR) | 01.12.2001 | 1 002 608 km |
| Hoist-assisted repair (HR) | 27.02.2008 | 318 540 km |
| Small periodic repair (SPRР) | 11.08.2009 | 54 000 km |
| Technical inspection (TI) | 20.11.2009 | 6 040 km |

The last operating inspection of the locomotive was carried out in the Plovdiv locomotive depot, at 08:00 on 29.11.2009.

There is a test protocol (dated 28.01.2008) on the electrical insulation strength, the insulation resistance and the grounding resistance of the rectifier cabinet, in accordance with the rules of factory repair, as well as 5 more protocols concerning the electric equipment of the locomotive, all of them confirming that the results of the measurements meet the standards and requirements.

All repairs of the locomotive have been carried out in accordance with the established repair cycle and the applicable regulations.

The examination of the entries in the log-book and the repair inventory shows that the faults noted in the act orders had been rectified on a timely basis. No information about faults in the electric equipment of the locomotive that could have caused the fire were found in the locomotive passport.

**8. Condition of the railway infrastructure and the rolling stock prior to, during and after the accident.**

The railway infrastructure was in good working order prior to the incident.

The railway section at 142+580 km forms a horizontal curve with R = 1800 m, with rise Н = 65 mm and slope of 3‰ in the forward direction.

No damages to the railway infrastructure elements were found after the accident.

The rolling stock was in good working order prior to the accident.

The accident has caused damages to locomotive No. 45-167.4 – fire in the first horizontal fan and the engine compartment.

**9. Consequences of the accident.**

9.1. Injured and/or killed – nobody.

9.2. Material damages.

The following damages and losses have been caused to the rolling stock and the railway infrastructure:

- Electric locomotive No. 45-167.4 – owned by BDZ EAD – Plovdiv Locomotive Depot – the damages are to be further specified by a commission of experts.

- train cars – no damages;

- railway infrastructure – no damages;

- Plovdiv Passenger Transport Department, as a result of the delay – BGN 849,86;

- contact network – no damages;

- other damages – no damages.

9.3. Traffic interruption:

- on the current road No. 1 between the Stamboliiski and Todor Kableshkov stations – from 18:15 to 20:02 on 30.11.2009;

- on the current road No. 2 between the Stamboliiski and Todor Kableshkov stations – from 18:15 to 23:20 on 30.11.2009.

9.4. Train delays caused.

- Delays – 19 trains;

- Cancelled – 1 train.

**10. Causes of the accident.**

As a result of the examinations carried out after the fire, the collected protocols on scheduled repairs and inspections, protocols on the measurements performed, other documentation relating to this case, as well as the explanations taken from the locomotive and train crews and the employees involved, **the investigation commission concluded that:**

- the reason for the fire in Locomotive No. 45-167.4 cannot be unambiguously determined; it can be clearly seen, however, that the lower section of the rectifier unit of Group 1 of the first horizontal fan – the section accommodating the rectifiers for the auxiliary equipment – was most severely affected by the fire, and on this grounds it can be assumed that t**he fire in the locomotive was most probably caused by a breakdown of a capacitor of the RC groups used to protect the auxiliary rectifier 220 from internal commutation over-voltage.**

During the past 27 years of continuous operation, the nominal performance (capacitance) of the of the capacitors have gradually deteriorated as a result of aging, which is a reason to conclude, with high degree of probability, **that at a certain unpredictable moment there was an explosion (blow-up) of a capacitor caused by an over-voltage pulse, and the resulting sparks caused self-ignition of the capacitor electrolyte. The compact size of the rectifier cabinet (small spacing between the elements) created conditions for a process of avalanche expansion of the fire and ignition of the cables within the rectifier unit, thus causing subsequent blow-up of adjacent capacitors**. Then the fire expanded from the rectifier cabinet to the fan via the air duct, causing ignition of its power supply cables, and this was the fire first seen by engine-driver No. 2 when he stuck his head out of the side window and looked back. While the efforts of the locomotive crew were directed at putting out the fire under the locomotive, the fans were put out of operation, as a result of the disconnection of the main air-break disconnector and the power supply, and the fire expanded inside the engine compartment, filling it with thick asphyxiating smoke from the burning insulation and capacitor electrolyte. This also explains why the engine-drivers’ efforts to take out the handheld СО2 fire extinguishers were unsuccessful. The rapid intensification of the fire and its spreading to the oil-cooling system (oil cooler, pump and oil tubes) of the power transformer and the subsequent melting and burning of the rubber fixtures and seals caused leakage of oil with ignition temperature of 135°C. The ignition of the oil, rubber seals, cable insulation and insulating boards in the rectifier unit under the conditions of intense flow of air caused a rapid rise of the temperature in the engine compartment and intense release of smoke. The breaking of the side windows with the aim of putting the water hoses inside the engine compartment caused inflow of air and subsequent intensification of the fire in the interior.

**- this fire was not caused by violations or omissions in the maintenance (performance of scheduled and emergency repairs) or operation (depot inspections, etc.) of the locomotive, or deviation from the regulatory provisions concerning the condition of the electric circuits (measurement of parameters), or illegal actions of employees.**

**11. Proposals (recommendations) for organizational, technical and other measures aimed at preventing this type of accidents.**

1. BDZ EAD shall give directions to the competent departments to reconsider the location of the СО2 fire extinguishers in the engine compartments of all locomotives being currently used, in view of their possible relocation to a suitable place for easier and unobstructed access in case of their use by the engine-drivers.

2. BDZ EAD shall give directions for inspection of the condition of the fire-alarm and fire-extinguishing systems of all electric locomotives being currently used, and find a technical solution to ensure safer and more efficient way of their activation from the standard places.

3. BDZ EAD shall give directions for the provision of new type of fire-safe dry capacitors for the RC over-voltage protection units of the rectifiers, in view of their replacement during the next scheduled repairs (HR, MLR, MR).

4. A special briefing on fire and accident safety and the actions of the locomotive crews in case of fire in the hauling rolling stock (HRS) shall be conducted by 31.01.2010.

5. By 31.03.2010, BDZ EAD shall notify the chairman of the investigation commission of the measures undertaken with the aim of fulfilling the proposals under the above points 1-4.