NOTICE

According to the provisions of the *Regulation for the investigation of accidents and incidents, the development and improvement of railway safety on the railway and the metro network in Romania*, approved by the Government Decision no. 117/2010, the Romanian Railway Investigating Body performed an investigation concerning the railway accident occured on the 02nd of February 2013, around 01.42, in the activity of the Branch of the Regional Center for Railway Operation, Maintenance and Repairs Timișoara, in the running of the freight train no. 23817 (belonging to the railway undertaking SNTFM „CFR MARFA" SA), in the railway station Pui, due the derailment of all axle of the last two wagons (loaded with coal), due the circular breakage of the wheel's no. 2 web (monobloc wheel) of the wagon no. 81536655875-8.

Through the performed investigation, the information concerning the occurrence of this incident were gathered and analyzed, the conditions were established and the causes determined.

The investigation is performed independently of any inquiry and does not aim to establish the guilt or the responsibility.

Bucharest, the 21th of January 2014

Approved by

Director,
Dan Marcel BARBUT

I ascertain the compliance with the legal provisions concerning the investigation and the drawing up of this investigating report that
I submit for approval
Chief Investigator
Eugen ISPAS

This notice is part of the Investigation Report of the railway accident happened on the 02nd of February 2013, at 01.42, in the activity of the Branch of the Regional Center for Railway Operation, Maintenance and Repairs Timișoara, in the running of the freight train no. 23817 (belonging to the railway undertaking SNTFM „CFR MARFĂ" SA) in the railway station Pui, due the derailment of all axle of the last two wagons (loaded with coal), due the circular breakage of the wheel's no. 2 web (monobloc wheel) of the wagon no. 81536655875-8.

INVESTIGATING REPORT

of the railway accident occurred on the 02nd of February 2013,
in the activity of the Branch of the Regional Center for Railway Operation, Maintenance and Repairs Timișoara, in the running of the freight train no. 23817 (belonging to the railway undertaking SNTFM „CFR Marfă" SA), in the railway station Pui, through the derailment of the last two wagons, due the circular breakage of the wheel's no. 2 web (monobloc wheel) of the wagon no. 81536655875-8.

Final edition
Bucharest, the 21th of January 2014

SUMMARY

A. PREAMBLE

A.1. Introduction

The Romanian Railway Investigating Body, hereinafter reffered as OIFR, performed an investigation, according to the provisions of the *Law no. 55/2006* on the railway safety, *hereinafter referred as Law for Railway Safety* and the *Regulation for the investigation of accidents and incidents, development and improvement of railway safety on the railway and the metro network in Romania*, approved by the Government Decision no. 117/2010, hereinafter referred as *Investigation Regulation*.

The investigation action of OIFR aim's to improve the railway safety and preventing the railway incidents or accidents.

The investigation is performed independently of any inquiry and does not aim to establish the guilt or the responsibility.

A.2. Investigation process

According to the art 19, paragraph 2 from the *Railway Safety Law*, corroborated with the art. 48 from the *Investigation Regulation*, OIFR, for the railway accidents and incidents, has to start an investigation and make investigation commissions for gathering and analyzing the technical information, establishment of the occurrence conditions, including the causes definition and, if case, issuing safety recommendations for the prevention of some similar accidents and for the improvement of the railway safety.

Taking into account the informative note of the Regional Traffic Safety Inspectorate from the Branch of the Regional Center for Railway Operation, Maintenance and Repairs Timisoara, hereinafter referred as CREIR Timisoara, concerning the accident occurred on the 02nd of February 2013, at around 01,42 o'clock, in the running of the freight train no. 23817 (belonging to the freight undertaking SNTFM „CFR MARFA" SA), in the railway station Pui, due the derailment of all axle of the last two wagons (loaded with coal), due the circular breakage of the wheel's no. 2 membrane (cast wheel) of the wagon no. 81536655875-8 and taking into account that the railway event is defined as accident according to the provisions of the art. 7 paragraph (1), point b. from the Investigation Regulation, OIFR director decided to start an investigation and to appoint an investigation commission.

Through the Decision no. 105, from the 04th of February 2013 of OIFR director was appointed an investigation commission, as follows:

- Livius OLTENACU Romanian Railway Investigating Body - investigator investigator in charge;
- Luca PAIȘ Romanian Railway Investigating Body - investigator member;
- Mihai SURU Romanian Railway Safety Authority - state inspector member;
- Viorel MOISA SNTFM „CFR Marfă" SA - central inspector member.

B. INVESTIGATION REPORT BRIEF PRESENTATION

On the 02nd of February 2013, at around 01.42, in the activity of CREIR Timișoara, in the running of the freight train no. 23817 (belonging to the railway undertaking SNTFM „CFR Marfă" SA), at running on line III from the railway station Pui, there was a railway accident consisted of derailment of all axles of wagon no. 81536655875-8 and overturning of wagon no. 81536656212-3, the penultimate, respectively the last of the train.

After the occurrence of this accident, the railway traffic on line III from the railway station Pui, was closed from the time the accident occurrence until the 08th of February 2013, at 18.45.

As a result of this accident occurrence there were no train delays, because the railway traffic took place on line II.

There were no fatalities or injuries, nor was affected environment.

Direct cause, contributing factors

The direct cause:

- the circular breaking of the monobloc wheel's no. 2 web from the first axle of the first bogie from wagon no. 81536655875-8, left part in the running direction, due a circumferential crack occurred in the connection area between the web and the wheel boss, at a distance of ca. 300 mm from the edge of the wheel boss.

Contributing factors:

- inadequate heat treatment;
- faulty steel structure;
- mechanical properties inferior to those imposed by regulations in force.

Underlying cause

- failure to comply in the manufacturing technology at the developing of cast batch no. 55743 IOB 1991 from which came the steel used at the fabrication of the monobloc wheel no. 2 from the leading axle of the first bogie from wagon no. 8536655875-8.

Root cause

None.

Safety recommendations

The immediate identification of all wagons from the active wagon's stock SNTFM equipped with monobloc wheel made from the cast batch no. 55743 IOB 1991 and those withdrawal from traffic to perform the inspections imposed by the regulations in force at the monobloc wheels to found possibly cracks at the web, rim and wheel boss of those and the applying of the necessary provisions.

C. INVESTIGATING REPORT

C.1. Accident presentation

On the 01st of February 2013, at 21.00, from the railway station Lupeni was dispached the freight train no. 23817, formed from 21 wagons, Fals series, loaded, 84 axles, hauled with electric locomotive ED 016, with complete staff (driver and driver's assistant).

In the railway station Iscroni is attached the electric locomotive EC 110 as banking locomotive and the train depart at 22.05 arriving in the railway station Petroșani at 23.00.

In the railway station Petroșani performs shunting movements, the 21 wagons being restabled over a group of 14 wagons, Fals series, loaded, forming the freight train no. 23817, formed from 35 wagons, Fals series, loaded, 140 axles, 2800 brut tonnage, 1939 net tonnage, 600 meters length, the hauling being ensured in multiple traction by the electric locomotives EC 115 in front, ED 016 second and EC 110 as banking.

In the railway station Petroșani was performed the technical inspection and the partial brake test at the group of 14 wagons coupled at the train in which were the wagons no. 81536655875-8 penultimate, respectively no. 815366562123 last, by a team of two wagon's inspectors, belonging to the Wagon's Maintenance Sidings Petroșani from the Freight Branch Banat – Oltenia of SNTFM "CFR Marfă" SA.

The technical inspection and the brake test were finished on the 02nd of February 2013 at 24.00, certified through signing of the route sheet by the wagon's inspector and then train departed at 00.09 to the railway station Mintia.

The train stopped in the railway station Baniţa, at 00.31, to uncouple the locomotives EC 115 of front and EC 110 banking and depart at 00.55 hauled with the locomotive ED 016.

The train ran on line I in normal conditions, at the passing through the railway stations Merișor, Crivadia and Baru Mare, the movement inspectors didn't found anything that could jeopardize the traffic safety.

At 01.42 at a speed of 37 km/h, in the moment of running on line III, in the railway station Pui, the driver noticed shocks at the train and the suddenly decrease of the air from the brake pipe, followed by the emergency braking.

The driver sent the driver's assistant to found the source of the sudden decrease of the air in the brake pipe, this notified him that the train was broken and the penultimate wagon is derailed by all axles and the last wagon is overturned, proceeding to notify the accident according to the Investigation Regulation.

The accident place is shown in image no. 1

Image no. 1

After the occurrence of this accident, the railway traffic on line III from the railway station Pui was closed from the railway accident until the 08th of February 2013, 18.45.

Following to the accident occurrence were no train delays, the railway traffic took place on line II.

Following the occurrence of the accident were not fatalities or injuries, nor was affected environment.

Following the notification of this railway accident, made according to the provisions of the specific regulations, at the accident place came the specialists of OIFR, Romanian Railway Safety Authority, infrastructure manager CNCF „CFR" SA and of the railway undertaking SNTFM „CFR Marfă SA".

According to the accident classification according to art. 7 (1), point b) from the *Investigation Regulation* the derailment of wagon's no. 81536655875-8 and no. 81536656212-3, the penultimate and the last from the train no. 23817, on the 02nd of February 2013, the **railway accident** is classified according to **art. 7, point 1, point b**.

C.2. Accident circumstances

C.2.1. Involved parties

The infrastructure and superstructure of the track where the accident occured are administrated by CNCF „CFR" SA. The maintenance of the superstructure is made by the specialized employees of the District 5 Pui from L9 Section Simeria – The Branch of the Regional Center for Railway Operation, Maintenance and Repairs Timișoara.

The interlocking systems (SCB) from the railway station Pui are maintained by the employees of the District SCB 4 Pui - Section CT 4 Deva – The Branch of the Regional Center for Railway Operation, Maintenance and Repairs Timișoara.

The hauling locomotive ED 016 and the derailed wagon from the train no. 23817 are owned by the railway undertaking SNTFM „CFR Marfă" SA.

The communication equipment from the locomotive is owned by the railway undertaking SNTFM "CFR Marfă SA" and maintained according to the regulations.

C.2.2.Composition and the equipment of the train

The freight train no. 23817, composed from 35 empty wagons, Fals series, 140 axles, 2800 brut tonnage, 1939 net tonnage, automatic/ hand braked accordingly to the timetable 1400/ 392 tones, actually 1664/ 588 tones, 600 meters length, was hauled by the locomotive ED 016, belonging to the railway undertaking SNTFM „CFR MARFA" SA.

C.2.3. Presentation of the railway equipment involved in the accident

C.2.3.1. Lines

Track embankment

From the dispatch railway station Petroșani and until the derailment place, the train runs a distance of 35 km, the embankment of the track being constituted from a succession of curves and alignments (the curve with the minimum radius is of 180 m) and in the longitudinal the maximum declivity is of 21‰, in slope in the running direction of the train.

Superstructure presentation

The superstructure of the track in the derailment area is constituted from the switch (simple switch) no. 7 (type 49 Aa, tg. 1/9, R = 300 m, left deviation), which is part from the double cross-over, composed also from switches TJD 13/15, S9 and S11. The switch S7 is located at km 44 + 310, and his frog is at km 44+280, on line III from the railway station Pui.

The ballast prism is from broken stone, is slightly clogged with coal dust, the sleepers and the fastening rail/ sleeper properly made and active.

The area of the switches is slope (in the running direction), the declivity is of 12 ‰.

C.2.3.2. Installations

The traffic from the railway station Petroșani to the railway station Pui is made on basis of automatic block system (BLA).

C.2.3.3. Wagons

Technical characteristics of the wagon no. 81536655875-8:

- wagon series: Fals;
- automatic brake type: KE-GP;
- bogies type: Y25Cs;
- automatic brake rod adjuster: DRV 2 AT-600;
- wagon's wheel-base brake: 9,00 meters;
- length over buffers: 14,54 meters;
- tare weight: 25,0 tons;
- buffing gear: buffer with round plate;
- draft gear: discontinuous;
- hand brake: handled from the platform;
- loading capacity: 55 tons;
- date of the last overhauls: type RP: 20th of November 2009, 6 REV Simeria; type RC: 9th of November 2012 – LSI;
- date of the last brake intermediate revision (RIF): 9th November 2012 – LSI;

- date of the last wheelset revision (RR): 9th November 2012 – LSI;
- maximum overhaul deadline 6 years.

C.2.4 Communication means

The communication between the driver and the movement inspectors was ensured through radio-telephone equipments.

C.2.5. Start of the railway emergency plan

Immediately after after the railway accident, the intervention plan for the removal of the damages and for the restoration of the traffic was made in accordance with the information flow stipulated in the Investigation Regulation, approved by the Government Decision no. 117/2010, according which, at the accident place came the representatives of the public railway infrastructure manager CNCF „CFR" SA, of the railway undertaking SNTFM „CFR Marfă" SA, of Romanian Railway Authority – AFER and from the Railway Transport Police Operative Department.

C.3. Accident consequences

C.3.1. Fatalities and injuries

None.

C.3.2. Material damages

The value of the material damages, according to the estimations drawn up by the owner of the rolling stock and the railway public infrastructure administrator, is:

Material damages	RON
wagon no. 81536655875-8 - according to the estimation no. RVC 2 /320/13th of February 2013 from the IRV Section Curtici – LR Simeria	272,31
wagon no. 81536656212-3 - according to the estimation no. RVC 2 /319/13th of February 2013 from the IRV Section Curtici – LR Simeria	526,96
the line – according to the estimation no. 475/21th of February 2013 of L9 Section Simeria	162.504,54
interlocking installations (SCB) - according to the estimation no. 123/11th of February 2013 of CT 4 Section Deva	35.386,11
overhead line – according to the estimation no. 2/2/3/4/83/04th of February 2013 from the Electrification Centre Deva	21.213,37
TOTAL	219.903,29

C.3.3. Consequences of the accident in the traffic

Following to the accident occurrence were no train delays, the railway traffic took place on line II.

C.4. External circumstances

On the 02th of February 2013, between 00.01 and 01.30, the visibility was good, the temperature was of -3 ^{0} C.

The visibility of the light signals was in accordance with the provisions of the specific regulations in force.

C.5. Investigation course

C.5.1. Summary of the involved staff testimonies

The driver of the locomotive ED 016, stated:
- the entry signal from the railway station Pui had the color "permissive green" and the movement inspector communicated through the radio telephone that he can pass on direct line;
- at passing in front of the movement inspector office he felt "two short rebounds in the train after that occurred the sudden decrease of the air in the brake pipe of the train and the emergency brake";

- he sent the driver's assistant on the train to inspect, that notified him that the "last two wagon's from the train are derailed and the last is overturned";
- he advised the event to the Unit Master and the traffic dispatcher and the driver's assistant fastened the hand brakes at the assigned wagons to ensure the train against running.

The driver's assistant of the locomotive ED 016, stated:
- the train run in normal conditions until the railway station Pui, where the entry signal was on "green" and the movement inspector notified through the radio telephone that the train is passing on direct line III;
- at passing in front of the movement inspector office he felt "two short rebounds in the train after that occurred the sudden decrease of the air in the brake pipe of the train, happening the emergency brake";
- he left on the train for inspection and found out the last two wagons are derailed and the last one is overturned;
- he notified the driver about the findings and went for hand brakes fastening to ensure the train the against running.

The movement inspector on duty on the 01st / 02nd of February 2013 in the railway station Pui, stated:
- on the 02th of February 2013, a 01.34, the railway station Baru Mare sent the dispatch advise for the train no. 23817 on line I and recorded the advice in the register "RUCLCM";
- he performed the passing route on direct line III for the train no. 23817;
- he notified through radio telephone the passing of the train no. 23817 through the railway station Pui on direct line III;
- after the running of the train after the entry signal he got out from the movement office for the visual inspection;
- after the locomotive running in front of the movement office he noticed that the train is slowing and stopped;
- he came into the movement office and communicated through the radio station with the driver of the train, that notified him that he felt "a strong shock at the train";
- on the command desk he noticed a white pulsing light at shunting signals M7, M9, M11, M15 and the section 7-15 and 9-21 on the track diagram were occupied.

The wagons inspector which performed the technical inspection and the partial brake test at the group of 14 wagons introduced in train no. 23817, on the opposite part of the station building Petroșani (right in the running direction) on the 01st/02nd of February 2013 stated:
- he performed the technical inspection and the partial brake test at the last 14 wagons introduced in the train no. 23817;
- the technical inspection he performed it on the opposite part of the station building (right in the running direction);
- he performed the partial brake test with the second locomotive, which was in front of the train, the test was ready at 24.00 and he signed in the route sheets of the two locomotives in front of the train;
- he didn't found any defects at the wagons which he performed the technical inspection on the right side in the running direction;
- he didn't found any defects at the penultimate wagon from the train with no. 81536655875-8 both the technical inspection and train visual check on the dispatch.

The wagons inspector which performed the technical inspection and the partial brake test at the group of 14 wagons introduced in train no. 23817, on the part of the station building Petroșani (left in the running direction) on the 01st/02nd of February 2013 stated:
- he performed the technical inspection and the partial brake test at the last 14 wagons introduced in the train no. 23817;
- the technical inspection he performed it on the part of the station building (left in the running direction);
- he performed the partial brake test with the the second locomotive, which was in front of the train;

- he didn't found any defects at the wagons which he performed the technical inspection on the left side in the running direction;
- he didn't found any defects at the penultimate wagon from the train with no. 81536655875-8 both the technical inspection and train visual check on the dispatch.

C.5.2. Safety management system

At the moment of the accident, CNCF "CFR" S.A., as manager of the railway infrastructure, had implemented its own railway safety management system, according to the provisions of the Minister of Transport's Order no. 101/2008 regarding on the granting of the safety authorization to Romanian railway infrastructure administrator/manager, getting**:**

- Safety Authorization – Part A, identification number ASA 09002 – by which Romanian Railway Safety Authority, from Romanian Railway Authority – AFER agrees the acceptance of the safety management system of the railway infrastructure manager;
- Safety Authorization – Part B, identification number ASB 09007 – by which Romanian Railway Safety Authority, from Romanian Railway Authority – AFER agrees the acceptance of the dispositions taken by railway infrastructure manager in order to comply with the specific requirements necessary to ensure the railway infrastructure safety, in the designing, maintenance and operation, including if case, maintenance and operation of the system for the traffic control and signaling.

Also, SNTFM "CFR Marfă" SA, as railway undertaking had implemented its own railway safety management, according to the provisions of the Law for Railway Safety and of the Minister of Transports' Order no. 535/2007 for the approval of the norms for the granting of the railway transport licenses and the safety certificates in order to perform railway transport on Romanian railways, got:

- Safety Certificate – Part A, no. CSA0024 – by which Romanian Railway Safety Authority, from Romanian Railway Authority – AFER agrees the acceptance of safety management system of the railway undertaking, in accordance with the national legislation;
- Safety Certificate – Part B, no. CSB0060 – by which Romanian Railway Safety Authority, from Romanian Railway Authority – AFER agrees the acceptance of the dispositions taken by the railway undertaking in order to comply with the specific requirements necessary for the safety operation on the relevant network, in accordance with the Directive 2004/49/EC and the national legislation.

C.5.3. Norms and regulations. Sources and references for the investigation

In the investigation of the railway accident one took into account the next norms and regulations:

- Regulations for the train running and railway vehicle shunting no. 005, approved by Minister of Transports, Constructions and Tourism's Order no. 1816 from the 26th of October 2005;
- Instructions for the technical inspection and the maintenance of the wagons in operation no. 250, approved by Minister of Transports, Constructions and Tourism's Order no. 1817 from the 26th of October 2005;
- Instructions for the activity of the locomotive staff no. 201, approved by the Minister of Transports, Constructions and Tourism's Order no. 2229 from the 23th of November 2006;
- Instruction for terms fixing and of the order in which the track inspection must be performed no. 305, approved by the Minister of Transport's Order no. 71 from 17th of February 1997;
- Instruction of norms and tolerances for the track construction and maintenance – lines with standard gauge no. 314/1989.

In the investigation of the railway accident one took into account the next sources ad references:

- copies of the documents enclosed to the investigation file;
- photos taken soon after the railway accident by the members of the investigation commission;
- the documents concerning the line maintenance, provided by the persons in charge with their maintenance;
- the documents concerning the wagon no. 81536655875-8 repairs;

- results of the measurements made soon after the accident at the superstructure and at the derailed wagons;
- examination and interpretation of the technical condition of the elements involved in the accident: infrastructure, installations and train;
- questionnaires of the employees involved in the accident.

C.5.4. Operation of the technical equipment, infrastructure and rolling stock

C.5.4.1. Data on the lines

Findings and measurements at the line, after the derailment

1. at the date of the accident occurrence, the traffic speed on the combined double cross-over S7 – TJD 13/15 – S9 – S11 from line III from the railway station Pui was of 60 km/h for freight trains and 80 km/h for passenger trains;
2. the first trace of derailment was found on the crossing frog from the simple switch no. 7 (type 49 Aa, tg. 1/9, R = 300 m, left deviation) after the running of the flange of the wheel no. 2 from the left side in the running direction afferent to the pair of wheels 1-2 of the bogie no. 1, from wagon no. 81536655875-8, penultimate from the front of the train, on the trench afferent to the deflecting traffic and climbing of the rail from deflection which forms the frog in the right of the last shims at km 44 + 280 (Photo no. 1 and 2);

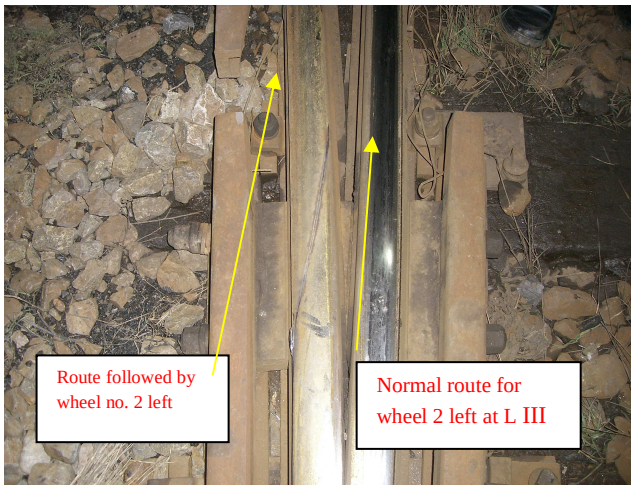

Photo no. 1

Photo no. 2

3. after the derailment is running a distance of 120 meters over TJD 13/15 and line III until km 44+160, according to the Photo no. 3 from below;

Photo no. 3

4. according to the regulations in force it was measured the switch no. 7 in the characteristic points, resulting following values:

	Pj	*Point of switch tongue*	*Cd*	*Ca*	*Cm*	*Vid*	*Via*
Gauge (E)	3	2	16	23	15	0	2
Transversal level (N)	9	10	2	0	2	4	5

5. after the verification through the gauge and the transversal level measuring in the characteristic points of switch no. 7 were found values over the admitted tolerances (heel point on direct and deflecting and the curve at middle) of the Instruction of norms and tolerances for the track construction and maintenance – lines with standard gauge no. 314/1989, values which are framed in the defects category, but which didn't influenced the derailment. It is specified that the train route included only the value of + 16 mm from the measuring point Cd (heel points on direct), value which is framed as gauge defect (wide of gr. 3 from 15-20 mm);
6. wasn't found any wear of the metal parts of the simple switch no. 7 which could determinate or favored the accident occurrence.

C.5.4.2. Data found out on the rolling stock and its technical equipment

Findings at the wagons of the train:

- the freight/passengers and empty/load levers were in the suitable position to the wagons condition, respectively the positions "Freight" and „Loaded";
- the train had 3 wagons with isolated automatic brake, without "off" brakes;
- wagon's coupling was suitable;
- the functional couplings of the draft gears were corresponding fastened for freight trains;
- there were no uninsured parts which could jeopardize the traffic safety.

Findings at the wagon no. **81536655875-8** at the accident site:

The penultimate wagons from the train, derailed by both bogies, was bended at 45° to the right in the running direction (photos no. 4 – 5)

Photo no. 4

Photo no. 5

Technical characteristics:

- brake type KE being in action and the freight/passengers and empty/load levers in corresponding position, also the angle cock;
- beam adjuster type DRV 600;
- bogies type: Y25Cs, with wheelbase of 1800 mm, the wheels of the wheelset of monobloc wheel type;
- length over the buffers: 14,54 m;
- the wagon's base: 9,00 m;
- at the end without of the hand brake, the bogie no. 2 in the running direction, equipped with wheel sets having the wheels no. 5-6 and 7-8;
- the reversing rods and the connection from the freight/passengers and empty/load levers were deformed.

Bogie no. 1, first in the running direction, equipped with the wheelsets with the wheels no. 1-2 and 3-4;

- the wheelset with the wheels no. 1-2 had axle with serial no. **3767392**, manufactured by IOB from the cast batch no. 33064.1, the data read from the axle journal, after it was dismantled the cover from the axle box (photo no. 6)

Photo no. 6

Photo no. 7

- the wheel set with wheels no. 1-2 with wheel no. 2 derailed in the exterior left rail of the track, in the running direction, having the web circular broken on the entire circumference (the length of the circle being of ca. 1200 mm), being deformed to the exterior with an arrow of 20 mm on a length of 220 mm due the impact between this and the wheels boss, occurred after the complete break of the web (photo no. 8 and 9);

Photo no. 8

old crack

Photo no. 9

- at the visual inspection in the breaking section was found an **old crack** (Photo no. 9) on the entire circumference with a width of ca. **60% from the web thickness**, the crack was propagating from the interior to the exterior of the wheel. This crack was at a distance of 30 mm in relation with the wheel boss;
- the circular crack was in the connection area of the membrane with the wheel boss (Photo no. 10);
- the wheels no. 1 and 2 don't have transversal movement traces on the axle's body;
- it was found the axle collar, mounted on the axle, this had illegible writings about the axle series and the date of the overhaul;
- the body support from wheel no. 2 broken and at wheel no. 4 being deformed and detached from welding;
- three brake beam deformed;
- the safety staps pieces from the axle with the wheels no. 3-4 are deformed.

Findings at the wagon no. **81536656212-3**, at the accident site:

- wagon series Fals;
- date of the last overhaul type RP: 25th of June 2012, 6 REV Simeria;
- date of the last repair type DA: 24th of September 2012 – SPC;
- the wagon was he last in the train composition, derailed by both bogies, was overturned on the right side beside the track, in the running direction (photo no. 11).

Photo no. 10

Photo no. 11

Technical characteristics:

- brake type KE being in action and the freight/passengers and empty/load levers in corresponding position, also the angle cock;
- beam adjuster type DRV 600;
- bogies type: Y25Cs, with wheelbase of 1800 mm, the wheels of the wheel set of monobloc wheel type;
- length over the buffers: 14,54 m;
- the wagon's base: 9,00 m.

Following were found:

- the hose from the penultimate wagon was snatched from the brake pipe;
- the brake type KE being in action and the freight/passengers and empty/load levers in corresponding position, also the angle cock;
- the bogie no. 2 in the running direction (wheels no. 5-6 and 7-8) rotated with 180° beside the wagon's box;
- one brake beam's bearing – vertical crowbars, broken new;
- drawbar from the beam adjuster, broken new.

C.6 Analysis and conclusions

C.6.1 Conclusions on the technical condition of the track superstructure

Taking into account the track characteristics, described at chapter *C.2.3.1, Lines*, presented in *Presentation of the railway equipment involved in the railway accident*, and the findings and measurements made at the track, after the derailment, described in chapter *C.5.4.1. Data on the lines*, one can stated that the technical condition of the track superstructure and switch could not influence the derailment.

C.6.2 Conclusions on the technical condition of the train wagons

At the running gear of the derailed wagon bogies were not found defects which could exist before the dispatch of the train from the railway station Petroșani.

From the data put at the commission's disposal by the owner of the wagon no. **81536655875-8** are resulting following:

1. on the 05th of November 2009 the wagon was introduced in the repairing yard SC REVA SA Simeria for the overhaul (RP) and got out from revision on the 20th of November 2009. With this occasion the wagon was equipped with following wheel sets:
   - the wheel set with the monobloc wheels no. 1-2 with series 3767392, having the wheel nr. 2 **manufactured in 1991 by IOB from cast batch no. 55743;**
   - the wheel set with the monobloc wheels no. 3-4 with series 3744052, manufactured in 1980;
   - the wheel set with the monobloc wheels no. 5-6 with series 3667177, manufactured in 1986;
   - the wheel set with the monobloc wheels no. 7-8 with series 3760404, manufactured in 1991.
2. **on the 09th of November 2012, the wagon was introduced in SIRV Curtici – Repair Line Simeria to execute the brake intermediate revision (RIF), wheel set revision (RR) and overall repair (DA), where it was performed the complete ultrasonic control at the wheel set with series no. 3767392, 3744052, 3667177 and 3760404 and according with the writings from "Running gear measuring sheet (code FP04.018 Rev.1)" results that those were corresponding.**

C.6.3. Analysis and conclusions on the derailment of the train

From the analysis the findings of the accident site, the technical condition of the wagon involved, photographs taken at the accident place, the testimony of employees involved **and the results of laboratory tests performed on steel from which the broken monobloc wheel was manufactured**, the following conclusions:

I. Event dynamics

1. The monobloc wheel web no. 2, afferent to the axle with wheel no. 1-2 from the first bogie in the running direction of the wagon no. 81536655875-8 had an old circular crack in the transition area with the wheel boss which, due the dynamic loadings at which the wheels was subject in operation, it propagated in section at ca. 60% from the web thickness on the entire circumference.
2. Before the engaging of the axle with the wheels no. 1-2 over the frog of the switch no. 7 from the railway station Pui happened the circular breakage of the monobloc wheel web no. 2.
3. At the frog from the simple switch no. 7, where the wheel no. 2 must be guided by the check rail from direct, through the wheel no. 1, on the trench corresponding to the running direction on direct, this followed with the flange on the afferent trench for deflecting line.
4. After the follow of wheel no. 2 on the trench for the deflecting line, wheel no. 1 was guided by the check rail, determined wheel no. 2 to cross over the rail corresponding to the short point of the frog and the fall of wheel no. 2 in the exterior of the rail on the left part in the running direction of the train, time when it is engaged in the derailment and wheel no. 1 in the interior of the rails of the track (photo no. 12).

Photo no. 12

Photo no. 13

5. The derailed axle no. 1 with wheel no. 2 in the exterior rail of the track and wheel no. 1 in the interior, running on the length of the switch TJD 13/15, engaging in derailments the axle with wheels no. 3 - 4 of the first bogie in the running direction.

6. In the right of the simple frog of switch no. 15, the derailed wheels snatched the check rail from direct line of the simple crossing frog, place where occurred the derailment of bogie 2 from wagon 81536655875- and also the derailment no. 81536656212-3 (photo 13), followed by the breakage of the train, emergency braking and the overturning of the two wagons.

II. Conclusions referring to: heating treatment, structure and characteristic of the material from which was made wheel no. 2:

1. STEEL NORMALIZATION HEATING TREATMENT:

Was not correctly performed, because:
- not finished and not uniform grain perlite-ferrite;
- not eliminate dangerous needle morphology of ferrite.

This fact is evidenced by the microstructure consists of overlarge grains, emerged from the *microstructure examination*.

2. MATERIAL STRUCTURE:

2.1 wheel boss:
- impurities in high volume, which contributes to the steel weakening;
- on the wheel boss fine sulfur points, relative uniformly distributed and some sulfur concentration (in bigger points), agglomerated to the lateral surfaces of the wheel boss, in the pores or fine cracks of the material, which are not corresponding with the standard no. 2.

2.2 on the wheel's web:
- fine sulfur points (continued to the rupture), relative uniformly distributed and some sulfur concentration (in bigger points) in the pores or fine cracks of the material, which are not corresponding with the standards no. 1, 2, 3 and 4.

2.3 on the wheel's rim and the web:
- sulfur fine points, relative uniformly distributed and small sulfur concentrations in the pores and fine cracks of the material, relative isolated, to the exterior lateral surface of the rim, which correspond at limit with the standard no. 4.

This aspects resulted after the performing of the *macro graphic examination of the material (Baumann mark)*.

2.4 compactness defects:
- not identified compactness defects visible with the eye (cracks, pores), which could constitute incipient breaking cracks on the wheel boss or on the wheel rupture circumference by the wheel's web;

This fact resulted after the performing of the *penetrant liquid's control*;
- the sample surface presented as compactness defects, visible with the eye pores and cracks (of very small dimensions) agglomerated at the connection of the wheel web with the wheel boss (breaking place) and to the exterior lateral surface of the rim, the highest density being noticed in the wheel boss. Additionally was performed a more deeper chemical attack with an Oberhoffer reactive, observing on the wheel boss surface fine fibers, interrupted, which are not perfectly follow the sample contour, which indicates that the plastic deformation was not correctly conducted.

The principal dimensions measured on the radial section of the wheel:

The measured wheel part	Dimension measured [mm]
Height (thickness) of the rim in front of the flange	82
Rim's wideness	136
Flange wideness until the connection with the running surface	29
Height of rim's exterior surface	39
Web's wideness immediately under the connection with the rim	27
Web's wideness in the middle area	22; 20; 21
Thickness of the wheel boss at the ends	46; 41
Wheel boss's wideness	181

This dimensions resulted after the performing of the *macroscopic examination.*

Other compactness defects beside those from the surfaces – material overlay and internal cracks – from plastic deformation at heat, which favored the wheel breaking, there are the microvoids – contraction defects during the solidification of the ingot.
This conclusion resulted after the *microstructure examination.*

- the detachment of the wheel from the wheel boss occurred circular, at the connection of the web with the wheel boss, in section were noticed deformed and beveled traces of some cracks developed repetitive on the whole circumference of the wheel boss, which opened and went through the whole thickness of the web, the last portion of the fragile rupture being constituted from a circular band of ca. 6-7 mm thickness.

This conclusion resulted after the performing of *the visual inspection of the area with defects and identification.*

2.5 chemical composition:

- the determinate values are inferior to the values imposed for the chemical element (on product) from the UIC leaflet no. 812-3/84 and STAS 8824/1-91, table 1 and SR EN 13262+A2:2011, table 1.

This aspects resulted from the *determination of the chemical composition.*

3. STEEL CHARACTERISTICS, RESULTED AFTER THE TESTS:

3.1. Brinell hardness on radial section:

- some of the values measured at the rim are lower than those imposed on products BY SR EN 13262 + A2:2011, point 3.2.2.1.

3.2. tensile test:

- the values measured are inferior to the values required for the breaking strength in SR EN 13262 + A2:2011 and relative elongation at breaking from UIC leaflet no.812-3/84, table 1 or STAS 8824/1-91, table 3 of SR EN 13262 + A2:2011, point 3.2.2.1.

3.3. bending test through shock on the bending sample Charpy (resilience to +20°C):

- determinate values of the absorbed energy at shock measured are inferior to the values imposed for the chemical element (on product) from the UIC leaflet no. 812-3/84, point 4.3 or STAS 8824/1-91, point 2.2.3 and SR EN 13262 + A2:2011 point 3.2.2.1.

D. <u>ACCIDENT CAUSES</u>

D.1. Direct cause, contributing factors

The direct cause:

- the circular breaking of the monobloc wheel's no. 2 web from the first axle of the first bogie from wagon no. 81536655875-8, left part in the running direction, due a circumferential crack occurred in the connection area between the web and the wheel boss, at a distance of ca. 300 mm from the edge of the wheel boss.

Contributing factors:

- inadequate heat treatment;
- faulty steel structure;
- mechanical properties inferior to those imposed by regulations in force.

D.2.Underlying cause

- failure to comply in the manufacturing technology at the developing of cast batch no. 55743 IOB 1991 from which came the steel used at the fabrication of the monobloc wheel no. 2 from the leading axle of the first bogie from wagon no. 8536655875-8.

D.3.Root cause

None.

E. SAFETY RECOMMENDATIONS

The immediate identification of all wagons from the active wagon's stock of SNTFM "CFR Marfă" SA equipped with monobloc wheel made from the cast batch no. 55743 IOB 1991 and those withdrawal from traffic to perform the inspections imposed by the regulations in force at the monobloc wheels to found possibly cracks at the web, rim and wheel boss of those and the applying of the necessary provisions.

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This Investigating Report will be transmitted to Romanian Railway Safety Authority, to the public railway infrastructure manager CNCF „CFR" SA and to the railway freight undertaking SNTFM „CFR Marfă" SA.

Members of the investigation commission:

▪ Livius OLTENACU	Romanian Railway Investigating Body - investigator	investigator in charge
▪ Luca PAIȘ	Romanian Railway Investigating Body - investigator	member
▪ Mihai SURU	Romanian Railway Safety Authority - state inspector	member
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