MINISTRY OF TRANSPORTS AND INFRASTRUCTURE
ROMANIAN RAILWAY AUTHORITY - AFER

ROMANIAN RAILWAY INVESTIGATING BODY

INVESTIGATING REPORT

on the fire occurred on the 11th of May 2011 on the range of activity of CF Timisoara Regional Branch, in current line wire II (double line electrified), between hm Merisor and the railway station Banita km. 66+500 at the locomotive EA 40-0791-0 (belonging to SC CARGO TRANS VAGON SA Bucharest) hauling the freight train no. 20936.

Final edition

The 16th of December 2011

NOTICE

With reference to the accident occurred on the 11th of May 2011, at 10.30 p.m., on the range of activity of CF Timisoara Regional Branch, in current line wirer II (double line electrified), between h.m. Merisor and the railway station Banita at the km. 66+500, consisting of a fire at the electric locomotive EA 40-0791-0 hauling the freight train no. 20936, Romanian Railway Investigating Body carried out an investigation, according to the provisions of the Government Decision no. 117/2010. Through the investigation, the information on the respective accident was gathered and analyzed, the conditions were established and the causes determined.

Romanian Railway Investigating Body investigation did not aim to establish the guilty or the responsibility in this situation.

Romanian Railway Investigating Body considers necessary to take corrective measures in order to improve the railway safety and to prevent the accidents, so it included in the report a series of safety recommendations.

Bucharest, the 16th of December 2011

Approved by
Dragoş FLOROIU
Director

I agree the compliance with the legal
provisions on the investigation
performance and drawing up of this Investigation
Report, that **I submit for approval**
Chief Investigator
Nicu PĂLĂNGEANU

This approval is part of the Report for the investigation of the accident occurred on the 11th of May 2011, at 10.30 p.m., on the range of CF Timisoara Regional Branch, in current line wire II (double line electrified), between hm Merisor and the railway station Banita at the km. 66+500, consisting of a fire at the electric locomotive EA 40-0791-0 hauling the freight train no. 20936.

CONTENT

I. PREAMBLE

I.1. Introduction

The accident occurred on the 11th of May 2011, at 10.30 p.m. in the running of the freight train 20396, consisting of a fire at the electric locomotive EA 40-0791-0 is an accident according to art. 7, paragraph (1), letter e) of the Regulations for the investigation of the accidents and incidents, for the development and improvement of Romanian railway and subway safety, approved by Government Decision no. 117/2010, hereinafter referred as "Regulations" in the investigation report.

Taking into account those above mentioned and according to the art. 19, paragraph (2) from the Law no. 55/2006 on the railway safety, corroborated with the art. 48, paragraph (1) of the **Regulations**, an investigation commission was appointed by Romanian Railway Investigating Body.

Through the investigation, the information on the respective accident was gathered and analyzed, the conditions were established and the causes determined.

Romanian Railway Investigating Body investigation did not aim to establish the guilty or the responsibility in this situation.

I.2. Investigation process

On the 11th of May 2011, Romanian Railway Investigating Body was notified by the Regional Inspectorate for Traffic Safety of CF Timisoara Regional Branch by the investigator responsible in the territorial structure, about the occurrence of a railway accident in current line wire II (double line electrified), between h.m. Merisor and the railway station Banita la km. 66+500, consisting of a fire at the electric locomotive EA 40-0791-0 hauling the freight train no. 20936.

After moving to the place of the accident, it observed:

- the electric locomotive EA 40-0791-0, hauling the freight train no. 20396, was stopped in current line wire II at the km. 66+500 between h.m. Merisor and the railway station Banita on the running section Simeria - Petrosani;
- locomotive box on the right and on the left strongly thermally affected;
- installations on the roof thermally affected;
- the electric installation, the monitoring and control devices, the elements of laminated PFL on the inside walls and the floor of the driving stations of the locomotive were burnt;
- the installations, the aggregates, the power and auxiliary wiring in the engines box burnt;
- the bogies with signs of thermal affectation;

- the main and auxiliary air tank thermally affected;
- the power wiring of the traction engines with the insulation burnt;
- the line and the installations in the area of the accident were not affected.

There were no deaths or injuries.

At the accident place were present the representatives of:

- Inspectorate for Emergency Situations Hunedoara – Petrosani subunit;
- Operative Department of Railway Transports Police;
- Romanian Railway Investigating Body;
- Romanian Railway Safety Authority – Timisoara Railway Safety Inspectorate;
- National Railway Company "CFR" SA - CF Timisoara Regional Branch;
- Railway undertaking SC CARGO TRANS VAGON SA Bucharest;

Through the Decision no. 56 from the 12th of May 2011 of the OIFR Director, according to the provisions of the art. 19, paragraph (2) of the Law no. 55/2006 on the railway safety, corroborated with the art. 48(1) of the **Regulations**, the investigation commission was appointed, consisting of:

- Nicu Pălăngeanu – chief investigator - main investigator
- Vladimir Măcicăşan - investigator - member
- Cristian Groza - investigator - member
- Livius Oltenacu - investigator - member
- Mircea Mladin - ROCSC SC Cargo Trans Vagon SA Bucharest - member
- Iulian Turdean – Head of SC REMARUL 16 februarie Cluj-Napoca - member

A. BRIEF PRESENTATION OF THE ACCIDENT

A.1. Brief presentation

On the 11th of May 2011 for the towing of the freight train 20936 on the section Calan Bai-Petrosani was ordered the electric locomotive EA 40-0791-0 in head and the electric diesel locomotive DA 60-0455-0 as pushing. After the train passed through hm Merisor and entered on wire II at the km. 66+500, around 10.30 p.m., the driver on the locomotive EA 40-0791-0 notifies through the RER station the movement inspector from the railway station Banita about the occurrence of a fire at the locomotive EA 40-0791-0. This one calls the unique emergency number 112 asking for the intervention of the firemen of the Inspectorate for Emergency Situations Hunedoara. The fire is extinguished on the 12th of May 2011 at 3.40 a.m.

The locomotive EA 40-0791-0, hauling the freight train no. 20936, belongs to "SC Cargo Trans Vagon SA Bucharest" and was driven in complete team by locomotive driver and driver assistant.
The locomotive DA 60-0455-0 pushing at the train 20396 belongs to "SC Cargo Trans Vagon SA Bucharest" and was driven in complete team by locomotive driver and driver assistant.
The area of the railway accident occurrence is located on the running section Simeria - Petrosani, belonging to CNCF "CFR"-SA – CF Timisoara Regional Branch. The accident occurred at the km. 66+500 wire II on the current line between hm Merisor and the railway station Banita (line in curve, right deviation, with gradient slope of 16.8 ‰ in the running direction).

A.2. Causes of the accident

A.2.1. Direct cause. Contributing factors

Direct cause

Short-circuit between the supply cables of the electric engine operating the screw compressor, caused by bringing into contact of the conductor core of the cables due to the overheating and melting of the insulator sheet.

Contributing factors

- Lack of correlation of the copper cable of the electric engine operating the compressor (DA General Cable 750VF/1x16 mm^2) with the conditions of current, mounting, temperature and ventilation of the cable;
- Non-entry into action of the static converter protections because the value of the current of entry into action of the internal protection at over-current and short-circuit is higher than the value of the maximum current supported by the cable General Cable 750VF/1x16 mm^2 ;
- Lack of protection devices at over-current and short-circuit of the supply electric circuit of the electric engine operating the compressor.

A.2.2. Underlying causes

Noncompliance with the standard SR EN 50343:2006 *Railway applications. Rolling stock. Rules for the installation of cables.*

A.2.3. Root causes

None.

A.3. Severity level

According to the provisions of the Regulations, the event is categorized as accident, in accordance with the art. 7, paragraph (1), letter e.

A.4 Safety recommendations

- Checking the heating temperature of the electric circuits of the locomotives by the thermo-vision procedure, at the final tests after the planned repairs;
- Checking the work of the protections for the electric circuits of the locomotives at the final tests after the planned repairs;
- In the technical specifications on the construction or modernization of the rolling stock to be contained the standard SR EN 50343:2006 *Railway applications. Rolling stock. Rules for the installation of cables*.

This report will be sent to Romanian Railway Safety Authority, to Romanian Notified Body, to the National Railway Company "CFR" SA, to the company "SC REMARUL 16 februarie SA" Cluj-Napoca and to the railway undertaking "SC Cargo Trans Vagon SA" Bucharest.

B. INVESTIGATING REPORT

B.1. Description of the accident

On the 11th of May 2011 the electric locomotive EA 40-0791-0 property of SC Cargo Trans Vagon SA Bucharest is taken over from "SC REMARUL 16 februarie SA" Cluj-Napoca where had a repair type RG with modernization, by a locomotive team belonging to the railway undertaking SC Cargo Trans Vagon SA" Bucharest.

At 3.45 p.m. the locomotive EA 40-0791-0 leaves from the railway station Cluj Napoca isolated as train 20934 on the section Cluj Napoca-Coslariu and as train 20701 on the section Coslariu - Calan Bai where arrives at 7.50 p.m.

The locomotive EA 40-0791-0 is introduced in the head of the train 20936 and as pushing locomotive is attached the electric diesel locomotive DA 60-0455-0 the running in this composition going to be performed on the section Calan Bai - Petrosani.

The train 20936 leaves from the railway station Calan Bai on the 11th of May 2011 at 8.33 p.m. and at 10.05 p.m. stops in hm Merisor where remains until 10.11 p.m.

After leaving from hm Merisor and entering on the running wire II towards the railway station Banita, the locomotive staff notices smoke and flame in the engines box taking actions of quick braking. The train stops at the km. 66+500 and the driver seeing the rapid expansion of the fire announces at 10.30 p.m. through the RER station of the locomotive the movement inspector of the railway station Banita. This one calls the unique emergency number 112 asking for the intervention of the firemen in the Inspectorate for emergency situations Hunedoara.

The fire is extinguished on the 12th of May 2011 at 3.40 a.m.

There were no deaths or injuries.

The intervention plan of the rescue and emergency services

On the 11th of may 2011 at 10.30 p.m. the movement inspector from the railway station Banita was notified through the RER station by the driver of the train 20936 about the occurrence of a fire at the

locomotive EA 40-0791-0 and at 10.35 p.m. he notices at 112 the firemen from the Inspectorate for emergency situations Hunedoara who arrive at the place of the fire at 10.55 p.m.

At 10.52 p.m. DEF Deva de-energizes the contact line Banita head Y-PS Crivadia the running wires I and II.

At 11.43 p.m. is allowed the intervention of the firemen to extinguish the fire that is completely extinguished on the 12th of May 2011 at 3.30 a.m.

On the 12th of May 2011 at 4.07 a.m. is re-energized the contact line Banita head Y-PS Crivadia the running wire I.

On the 12th of May 2011 at 8.40 a.m. after checking of the contact line at the place of the fire, was re-energized for electric traction traffic the contact line Banita-Merisor the running wire II.

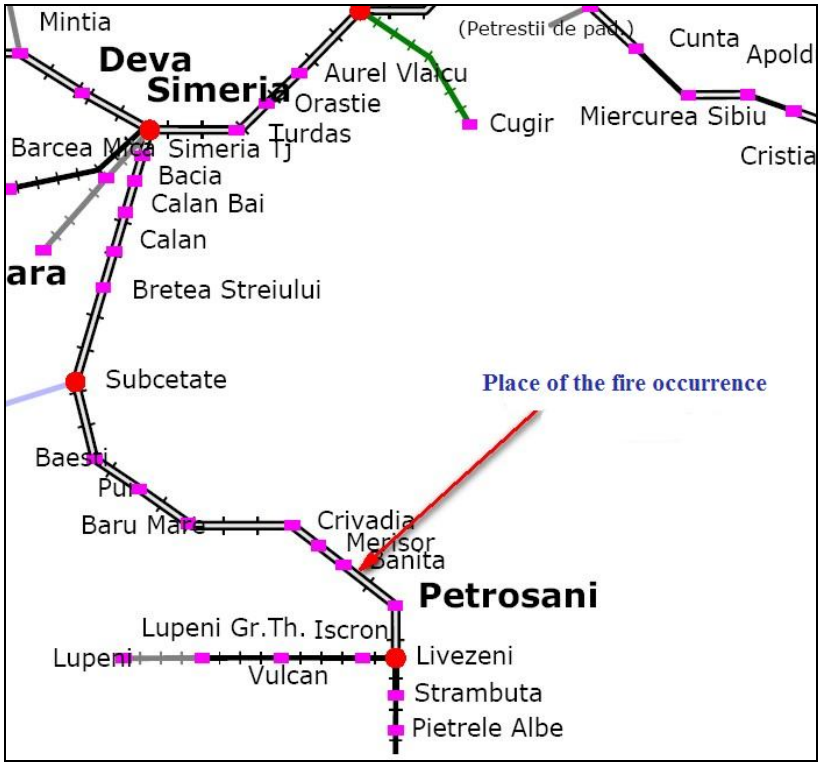
B.2. Circumstances of the accident

B.2.1. Involved parties

The involved staff belongs to the railway undertaking "SC Cargo Trans Vagon SA" Bucharest.

The locomotive EA 40-0791-0 is the property of "SC Cargo Trans Vagon SA" Bucharest and is maintained by the staff belonging to the sections of SC "IRLU SA Bucharest" and SC TEHNOTRANS Srl Constanta with which "SC Cargo Trans Vagon SA" Bucharest has contracts.

The railway infrastructure on which the accident occurred belongs to CNCF "CFR" SA – Timisoara Regional Branch and is maintained by the staff of District 6 Banita of Section L9 Simeria.



Geographical location of the accident

The installation of railway communications on the involved locomotive is the property of "SC Cargo Trans Vagon SA" Bucharest and is maintained by staff belonging to sections of SC "IRLU SA Bucharest" and SC TEHNOTRANS Srl Constanta with which "SC Cargo Trans Vagon SA" Bucharest has contracts.

The investigation commission questioned the employees involved in the driving of the locomotives, the staff who served the freight train no. 20936 and took statements from the involved staff on duty.

B.2.2. Forming and equipments of the train

The freight train no. 20936 was composed of 19 wagons, 76 axles, having 1456 gt, 1003 net tones, the braked weight according to the service book – automatic 728 t, by hand 218 t and in fact - automatic 913 t, by hand 260 t and was towed locomotive EA 40-0791-0 in head and the locomotive DA 60-0455-0 pushing tied to the train and brake, the driving being insured by complete teams of locomotive driver and driver assistant.

The locomotive EA 40-0791-0 involved in the occurred accident belongs to the railway undertaking "SC Cargo Trans Vagon SA" Bucharest.

The safety and vigilance equipment (DSV), the equipment for the point control of the speed and hitchhiking (INDUSI) in the equipment of the locomotive EA 40-0791-0 from the driving stations I and II had entirely burnt and at the pushing locomotive DA 60-0455-0 The safety and vigilance equipment (DSV) was in function.

B.2.3. Railway equipments

The involved railway infrastructure is managed by CNCF "CFR" SA – CF Timisoara Regional Branch and maintained by the District 6 Banita of Section L9 Simeria.

The current line wire II between hm Merisor and the railway station Banita, in the area of the km. 66+500 is electrified, in curve right deviation, with ramp slope of 16.8 ‰ in the running direction, with rail type 49, wooden sleepers and indirect clamping type K.

B.2.4. Means of communication

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

B.3. Consequences of the accident

B.3.1. Deaths and injuries

None.

B.3.2. Material damages

Following the fire, the damage and expenses incurred amounted to ……, detailed as follows:

- at the locomotive – 758 504 lei according to the estimate no. 108/410/2011 of REMARUL 16 Februarie S.A. Cluj
- train delays – according to the estimate no. 1855/2011 of CF Timisoara Regional Branch – Traffic Division, amounted to 1 938.13 lei ;
- at the lines according to the estimate no. 1032/2011 of the section L9 Simeria – none;
- at the installations according to the estimate no. 659/2011 of the section CT4 Deva – none;
- at the technical assistance to re-energize the contact wire according to the estimate no. 2/2/3/4/310/2011 of the Center for electrification Deva – 3 437.80 lei
- at the environment – none;

B.3.3. Consequences of the accident in railway traffic

The current line wire I on the distance between h.m. Merisor and the railway station Banita was closed for railway traffic from the 11th of May 2011 at 10.30 p.m. to the 12th of May 2011 at 4.07 a.m.

The current line wire II on the distance between h.m. Merisor and the railway station Banita was closed for railway traffic from the 11th of May 2011 at 10.30 p.m. to the 12th of May 2011 at 8.40 a.m.

Train delays:

Following the occurrence of this accident 4 passenger trains and 12 freight trains were delayed by a total of 5350 min.

B.4. External circumstances

On the 11th of May 2011, at the time of the railway accident occurrence, the visibility was good, clear sky, moderate wind and the air temperature of about 18^{0} C.

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

The accident occurred in current line double electrified on the running wire II between h.m. Merisor and the railway station Banita, in the area of the km. 66+500, in curve right deviation, with ramp slope of 16.8 ‰ in the running direction, with rail type 49, wooden sleepers and indirect clamping type K.

B.5. Investigation course

B.5.1. Summary of the involved staff statements

The locomotive driver who drove the locomotive EA 791, stated as follows:

- during the entire running there was a strong smell of fresh paint and thinner that caused burning eyes. He ran with the window of the driving station opened

- at the railway station Merisor he stopped for a minute and as he did not notice anything special he continued the running towards the railway station Banita
- at the entry into tunnel, because the driver assistant noticed smoke and flame, he stopped the train and intervened with the fire extinguishers and the firemen had been notified and arrived in about 10 minute
- the inspections performed by the driver assistant in the engines box were visual, without entering the engines box because of the strong smell of paint
- during the running did not enter any protection and did not appear any signalization on the display
- before the railway station Merisor, he talked on the phone with the guard who dais he had seen smoke. Following the conversation he checked in the engines box and he did not see anything special. Then he stopped the train and checked outside the locomotive in the area of the bogies, but he did not notice anything special
- at taking over the locomotive in REMARUL Cluj , the specialists performed also works of painting and mounting at the mechanical part and at the electrical installations
- at taking over the locomotive were also performed some operation tests of the locomotive
- during the running occurred an abnormal operation of the DSV installation, he called at REMARUL Cluj and then the locomotive driver opened an electric cable from the ring because the DSV installation did not disconnect from the automatic fuse
- before the hm Merisor there was no problem with the circuit breaker connection and disconnection and there were not noticed wheel slip phenomena

The driver assistant who served the locomotive EA 791, stated as follows:

- running towards the railway station Banita, at the km. 66+500 he noticed on the side window next to the engine 4 flame under the locomotive, he took actions to stop the train and he intervened with fire extinguishers
- during the running he performed total and partial inspections. At the total inspection performed before the railway station Merisor, he did not find smoke or burnt insulation smell, the locomotive being in normal operating condition
- in hm Merisor he checked the locomotive at the outside
- when taking over the locomotive in REMARUL Cluj, there had been performed works of painting and mounting at the electrical installations and at the mechanical part
- after leaving with the locomotive from REMARUL Cluj, the DSV installation entered into action without reason. The ring of the DSV installation was continuously ringing and he did not manage to disconnect it from the DSV automatic fuse, being necessary to dismantle an electric cable from the ring

The technical inspector of wagons who assisted the train no. 20936, stated as follows:

- he was in the opposite station of the running direction of the locomotive EA 791 together with the guard
- the driver of the locomotive EA 791 stopped the train in the railway station Merisor to check the locomotive from under which was coming out some smoke. After the check they ran further.
- after about 10 minutes from the left from the railway station Merisor, he heard at the radio-telephone the driver of the locomotive EA 791 shouting fire
- on the window towards the engines box he noticed something like 2-3 hob resistors lied transversely on the aisle
- in the locomotive smelled all the time fresh paint
- the locomotive drivers tried to extinguish the fire with the fire extinguishers in the equipment
- the smell of smoke appeared after leaving from the railway station Merisor
- the stop from the railway station Merisor and the locomotive check were performed as consequence as the fact that the guard had communicated to the driver of the locomotive EA 791 that he had seen some smoke at the locomotive

The guard on duty at the rain no. 20936, stated as follows:

- leaving from the railway station Calan Bai he noticed in the locomotive a strong paint smell
- after crossing the neutral area before the railway station Merisor, he noticed smoke at the locomotive and he announced the driver by phone
- the locomotive driver checked the locomotive and considered he could continue driving
- at the entry into the tunnel from Banita the train stopped and descending he saw there was dripping incandescent material
- he insured the train against moving after it had been withdrawn back by the pushing locomotive
- during the running of the train he stayed at the opposite station of the running direction with the technical inspector of wagons
- in the railway station Merisor he noticed at the locomotive a smoke release without flame next to the front bogie
- in the railway station Merisor the driver checked around and considered he could continue driving
- he noticed for the first time smoke release when he looked through the window after the neutral area and he only smelled fresh paint, without burnt insulation

The driver assistant from the pushing locomotive LDE 455, stated as follows:

- he does not know the causes of the fire

- he heard from the driver of the locomotive EA 791 that it caught fire without signal on board or any protection on
- he heard at the radio-telephone from a freight train that passed in opposite direction that smoke was coming out from the locomotive EA 791 and its driver took immediate actions to stop the train

The locomotive driver from the pushing locomotive LDE 455, stated as follows:

- the train ran in good conditions up to the railway station Banita, where the driver of the locomotive EA 791 told him to take over the driving of the train because he had fire at the locomotive
- he drove the train to a passage for the firemen access
- the train was stopped in the railway station Merisor, but he does not know the reason, because he did not hear conversations on the radio-telephone

The railway Energy Dispatcher from the Center for electrification Deva, stated as follows:

- he was notified at 10:50 p.m. that the locomotive EA 791 caught fire on the distance Banita - Merisor
- after talking to the IDM from the railway station Banita, he de-energized the contact line at 10.52 p.m.
- at 10.53 p.m. he announces the Head of the Center for electrification Deva and the driver of trolley-pantograph to go to the place of the fire
- at 10.56 p.m. the Shift Leader from the Traffic Controller asks the re-energizing of the contact line for the shunt of a train remained over the switches in the railway station Merisor
- after talking to the IDM from the railway station Banita, he re-energizes the contact line and confirms this by phone at 10.59 p.m. to the Shift Leader from the Traffic Controller
- at 11.05 p.m. the Operator from the Traffic Controller asks in written the de-energize of the contact line
- at 11.05 p.m. de-energizes the contact line and announces in written the Traffic Controller about the de-energizing at 11.08 p.m. and mentions that the contact line is not tied to the rail until the arrival of the trolley-pantograph
- he did all the actions of de-energizing and re-energizing the contact line through the IDM in the railway station Banita
- the trolley-pantograph arrived at the railway station Banita at 11.42 p.m.
- at 11.43 p.m. he transmitted the admission at work of the firemen team to extinguish the fire with all the means
- at 4.07 a.m. as after the withdrawal of the firemen team he re-energizes the contact line

- before the occurrence of the fire he did not have signals on the synoptic panel or tripping by protection of the supply feeders from the substation Petrosani

The IDM on duty in the railway station Merisor, stated as follows:

- scrolling the train 20936 he strongly smelled hot paint
- the locomotive driver stated that he had no problem and the smell was because the locomotive had just been painted
- the train stopped in the railway station Merisor at 10.00 p.m. and left at 10.14 p.m.
- around 10.30 p.m. he heard the driver of the train 20936 asking to the railway station Banita to call 112 and to ask for the firemen because the locomotive caught fire
- he immediately announced the Station Manager and the Shift Leader from RC

B.5.2. Safety management system

In carrying out their responsibilities and duties, the public railway infrastructure manager (CNCF "CFR" SA – Regional Center of Operation, Maintenance and Repairs Cluj) and the railway undertaking (SC Cargo Trans Vagon SA Bucharest) had implemented their own safety management system.

In this context, CNCF "CFR" SA and SC Cargo Trans Vagon SA Bucharest provide the control of the risks associated with the activity of administrator, respectively railway undertaking.

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

In the investigation of the railway accidents one took into account:

- minutes concluded by the commission on spot with reference to the condition of the rolling stock, lines and equipments;
- photos taken immediately after the railway accident by the members of the investigation commission;
- statements of the locomotive driver and of the driver assistant from the fired locomotive, of the witnesses traveling at the opposite station of the running direction, of the locomotive staff from the pushing locomotive and of the staff from the branches Movement and Electrification on duty on the date of the accident occurrence;
- questioning of the staff operating the involved rolling stock;
- photos and minutes concluded by the members of the investigation commission after the accident occurrence;
- documents on the locomotive repair provided by the repairing plant and by the equipments suppliers;
- inspection and interpretation of the technical condition of the elements involved in the accident;
- Tests report 3052-040 from the 14th of September 2011 on the electric cables used;
- SR EN 50343:2006 Railway applications. Rolling stock. Rules for the installation of cables
- Specification of equipments-electric installation LE 5100 kw With integration of INDA equipments

B.5.4. Work of the rolling stock

B.5.4.1. Generalities

The locomotive EA 40-0791-0 was modernized at the repair type RG. Through the equipments of new type mounted on the locomotive are listed:

- the static convertor CSA–LE 45 K-1700T to supply the engines of the auxiliary services
- the screw compressor ECE 3,5 LE
- Equipment of protection, signaling, displaying and recording EPS-LE

B.5.4.2. Static convertor CSA–LE 45 K-1700T

The induction motors to drive the auxiliary services are divided into 4 groups:

- screw compressor motor
- motoventilator compressor, motoventilator main transformer, oil pump motor main transformer

-motoventilator braking resistances block S9, motoventilator group I blocks S1-S6

-motoventilator braking resistances block S10, motoventilator group II blocks S1-S6

The motors of the auxiliary services are supplied by a static frequency converter with nominal power of 45 KW. The converter is supplied through the cables 103 (socket d3), 105 (socket d5), 110 (socket e) from the supply winding of the auxiliary services T1.12. The converter debits a balanced three-phase system with variable frequency (0-50 Hz) and voltage (0-380 V).

On the front panel of the converter are mounted light-emitting diodes, for signaling the following emergency situations:

-OVERVOLTAGES- voltage in the intermediate circuit over the admitted limit, grounding

-SHORTCIRCUIT- short-circuits on output, output grounding

-OVERLOAD- mechanically blocked motor

-OVERTEMPERATURE- maximum admitted temperature on the radiators of power electronic components was exceeded

The convertor receives from the control consoles of the locomotive the orders:

-ON/ OFF

-INTERLOCK, through which the switch on of the converter is conditioned by the implementation of the driving scheme in the locomotive.

<u>Main technical characteristics</u>

Input values:

-nominal voltage: 662 V±20%, 50 Hz±2%

-maximum absorbed current: 75 A

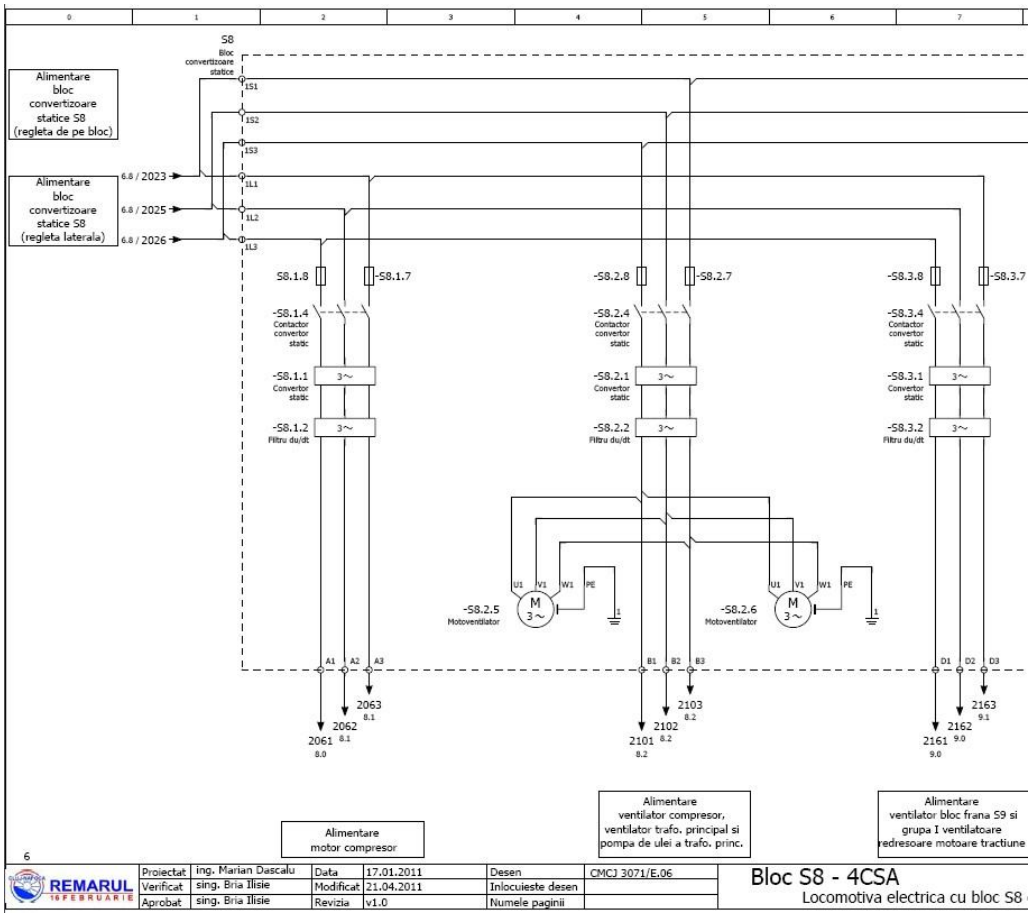
Output values:

-output voltage: 3x (0-380 V_{ca})

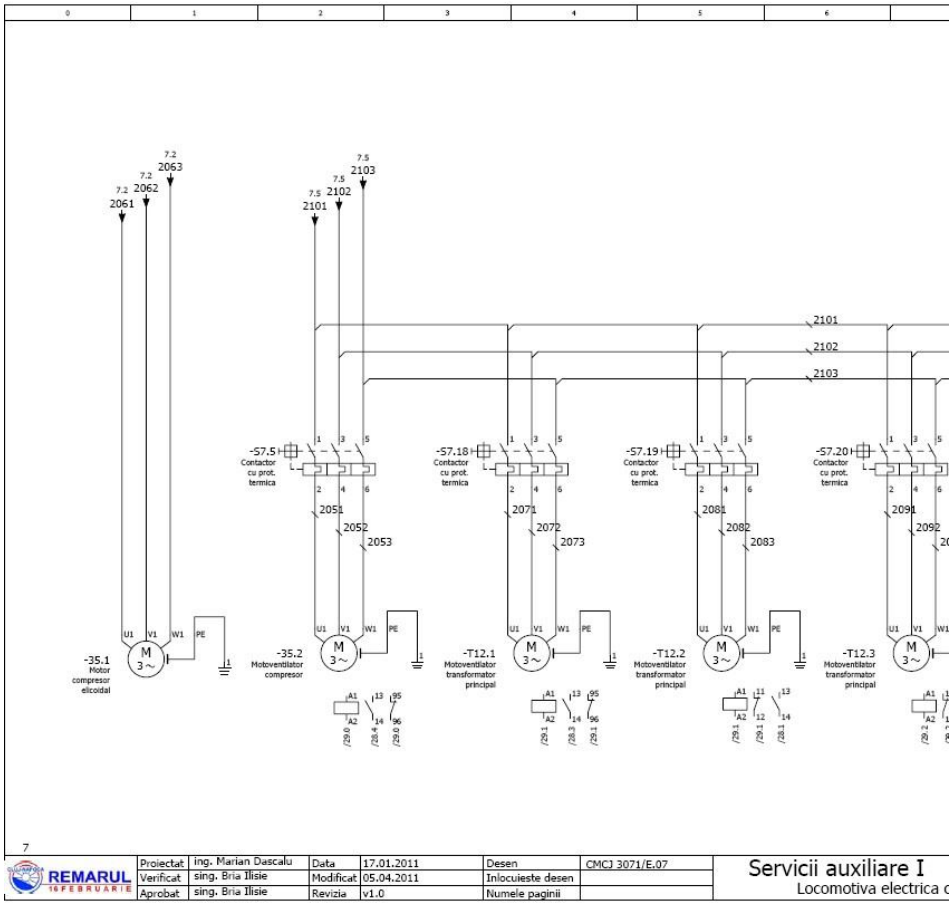
-output power: 45 KW

-nominal load current: 91 A

- maximum current: 136 A, 10 seconds



Static converter wiring diagram and connections to the compressor



Wiring diagram of the electrical circuit supplying the electric motor of the compressor

NOTE: According to the diagram, the electric motor driving the screw compressor is electrically connected directly to the output terminals of the static converter. Thus, it appears that the electrical circuit of the screw compressor motor is not provided with contactor with thermal protection or other type of safety at over-current or short-circuits.

B.5.4.3. Screw compressor ECE 3.5 LE

The compressor and the electric acting motor are placed on a common chassis and coupled through an elastic coupling with bolts and rubber rings. The chassis is made in welded construction of steel laminates. The compressor and the electric moor have the axes in extension and parallel with the chassis axis. The two semi-couples are relatively centered through relative displacement of the compressor and electric motor and then fixed.

The aspiration and the discharge of the cooling air are made through a forced circuit with a fan mounted on the shaft of an electric motor with vertical axis, mounted above the air and oil cooler. The cooler is placed inclined 5 degrees to the horizontal and the cooling air flows from top to bottom through the cooler. The cooling air is discharged down through two ducts that pas by the main electric motor. On the locomotive, the cooling air is channeled at the fan and cooler from outside the locomotive through a special duct with diameter of 430 mm and discharged through the floor under the locomotive, through the compressor duct that passes by the main electric motor.

The electro-compressor has a compact control panel that includes the control, protection and signaling gear of the electro-compressor. Startup and shut down are performed on board of the locomotive.

<u>Main technical characteristics</u>

-cooling system: with re-circulated oil

-theoretical flow necessary cooling air: 6720 kg/h

-fan motor power: ~2 KW

-transmission type between the motor and the compressor: elastic coupling with bolts

-operating regime: intermittent load/empty and stop after a preset idle time

-idle time: ~5 minutes

B.5.4.4. Equipment of protection, signaling, displaying and recording EPS-LE

The equipment monitors and stores the purchased protections, making it through a user interface. The interface is provided by a screen, graphic and color type, to display various information about the operating condition of the locomotive, four operational keys for information management and validation of some actions, two keys for adjusting image quality and a sensor for automatic brightness adjustment depending on the environment. The operations of displaying, reset and memory download are

available from the units placed in each driving station. The saving is on type of protection, together with the moment of time when the protection was operated, respectively when it has been reset, with the possibility of further investigation. The system reset from the driving stations eliminates the inconvenience of moving of the locomotive driver in the engines box. The equipment does not modify and does not influence the priority of the protection elements that disconnect the circuit breaker, its disconnection in case of a failure not being influenced by its operation.

The equipment is composed of: central control unit (UCC), two units signaling and dialogue (USD), mounted in the driving stations.

Sizes and events displayed: graduator level, train heating current, network power, parameters characteristic to the traction engines (medium current, current consumed by each engine, slip, voltage), auxiliary services current.

It can record about 3000 equipments. There are stored: the name of the activated protection, the moment of activation/deactivation/reset of the protection, data regarding the occurrence of the events.

Main technical characteristics

-nominal voltage: 110 V_{cc} (-30% + 25 %)
-power: 15 W (central unit), 5 W (each unit signaling and dialogue)
-real time clock features: year, month, day, hour, minute, second
-precision measuring and recording: 4 seconds/ 24 hours
-storage capacity: over 3000 events
-input digital signals UCC: 48 digital inputs/max 400 mA
-input analog signals UCC: 12 analog inputs
-output digital signals/ 8 digital outputs
-data transfer: serial with laptop (notebook)

B.5.5. Data found by the investigation commission on the locomotive EA 40-0791-0

B.5.5.1. Data resulted from the checks at the locomotive

B.5.5.1.1 Locomotive box on the outside (Photo 1)

- the front side corresponding to the driving stations on the upper half has the paint burnt and the sheet thermally deformed and the windows glass broken; (Photo 1)
- on the side, the box is thermally affected from the chassis upwards, with the paint burnt and the sheet deformed;
- the most thermally affected side area of the locomotive box (on the left and on the right of the locomotive) id placed towards the station 2, above MET 4;

- at the upper side, the roof is thermally affected, the pantograph 1 strongly thermally affected and the pantograph 2 less thermally affected;

Photo 1 – Locomotive box on the outside

Locomotive roof

- pantograph no.1 is thermally affected, useless; (Photo 2)
- pantograph no.2 and the support insulators are in proper condition;
- the circuit breaker thermally affected at the control part;
- the discharger, by appearance, corresponds;
- the rods are appropriate;
- the overload measuring transformer 25 KV with the housing melted, useless;
- the bushing broken;
- the roof separators are appropriate;
- the support insulators of pantograph no. 1 damaged;
- the bar support insulators damaged;
- the sheet on the roof and on the side walls thermally affected and deformed.

Photo 2 - Pantograph no. 1

B.5.5.1.2 Locomotive box inside and equipments

- all wires (of power. Auxiliary and command) have burned insulation; (Photo 3)
- the driving stations have the floor, the walls, the roof, the devices and the wires thermally affected; (Photo 4)
- the driving stations with all the components and cables in their equipment totally burnt;
- inside the engines box all the equipments, the floor, the walls and the roof are thermally affected;
- the blocks S1….S10, have all the cables and components thermally affected (burnt) totally, useless. (Photo 5)

Photo 3 – Wiring with burnt insulation

Photo 4 – driving station

Photo 5 - Blocks S1- S10 burnt

The main air compressor (Photo 6)

- the housing of the compressor is overheated and with signs of rust inside;
- the command block had all the components burnt and damaged;
- the devices corresponding to its operation and protection (filters, valves, pressure switch, combistat, etc.) completely damaged, most of them being burnt;
- helical rotors (the snails) of the compressor have signs of overheating and rust;
- the helical rotor bearings thermally affected because of the fire, one having signs of overheating being bluish (NSK HM 88649 JAPAN), the other having signs of rust and a tendency to lock (SKF M 8454842 MEXICO) and one being blocked on the axis (it could not be dismantled);
- the bearings housings overheated and without signs of friction or treads.

The electric motor of the compressors

- the terminal board is completely burnt;
- the insulation on the cables of the terminal board is completely burnt;
- the rotor bearings thermally affected by the fire;
- stator winding insulation burnt;

The electric motor of the fan

- at the electric motor dismantlement the stator remained blocked on the rotor;

- the rotor overheated, having the aluminum bars melted and the aluminum leaked to the bottom of the engine (in the shield from the fan);

- the plastic fan blades missing due to their full melting;

- the stator winding insulation burnt;

- the bearings on the rotor axis thermally affected by the fire, one being blocked (NSK 6206 Z POLAND).

Photo 6 – The screw electro-compressor ECE 3.5 LE

The main transformer (Photo 7)

- TP was found with oil up to the level of the upper valve;

- on the outside it has the wiring completely burnt and the pipelines thermally affected;

- the output insulator broken do to overheating;

- the contactors K1…K4 thermally affected and the extinguishing rooms completely burnt;

- the switching resistance T4.1 thermally affected;

- the substation oil cooling hood thermally affected (checked by dismantlement);

- the selector on the inside does not have signs of abnormal operation;

- the main transformer winding does not have signs of overheating (check made through the access cover);

- the flattening safe id thermally affected, with the connection plates removed due to the fire (checked by dismantlement);

- the motors for the cooling fans: AMV 1.1, AMV 1.2, AMV 1.3 are thermally affected.

AMV 1.1 was dismantled and there were not found signs of abnormal operation.

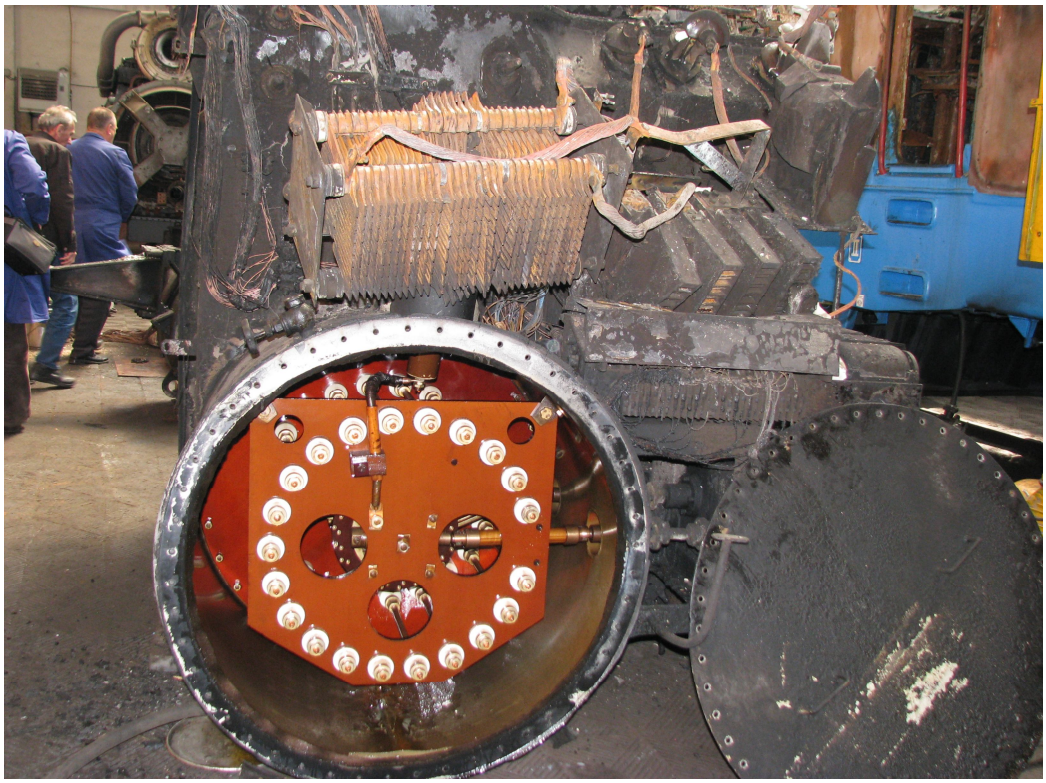


Photo 7 - The main transformer

Auxiliary services wiring:

The stranded copper wiring of section 16 mm^2 with the numbers 2061, 2062, 2063 in the wiring diagram, cables that supply the electric motor activating the main compressor have the insulation burnt at 100%.
The mentioned wiring is connected to the terminal block of connections from the block S8, browse the wiring channel placed above the access lane on the right of the locomotive, up to near the compressor, where they are interrupted. In this interruption point the mentioned cables have copper melt accumulated in drops and two are welded together (Photo 8). The portion between the wiring channel and the silica battery is missing on an estimated length between 7 cm and 15 cm and continues on the silica battery where it has on the first part the same copper melt accumulated in drops (Photo 9). The wiring continues to the output of the silica battery where it is interrupted again and has copper melt accumulated in drops.
Checking the supply cables of the ventilation electric motor of the compressor with the numbers 2051, 2052 and 2053, with the section of 4 mm^2 and the cables from the panel monitoring the operation of the compressor with the section of 1.5 mm^2, it is found that above the silica battery they are interrupted in 7 points with copper melt accumulated in drops.
On the floor, under the silica battery was identified a bundle of wires from the circuit supplying the ventilation electric motor of the compressor and from the circuit monitoring the work of the compressor melted and welded together by the melted copper (Photo 10).

The melting phenomenon of the cables and accumulating in drops of the melted copper comes most probably from the occurrence of an electric arc.

We mention that following the checks there were not found on other electric circuits (of power, auxiliary and command) the phenomenon of cables melting and accumulating in drops of the melted copper.

Photo 8 – The cables of the electric motor activating the compressor – welded over the access lane

Photo 9 – The cables of the electric motor activating the compressor – placed above the silica battery – have copper melt

Photo 10 – Bundle of wires from the supply circuit of the ventilation electric motor of the compressor and the monitoring circuit of the compressor operation, melted and welded together by the melted copper

B.5.5.1.3 Bogies

- the brake wheelhouse and the rolling part do not show signs of abnormal heating;
- the frame of the bogie II has signs of burning on the upper side in the area MET 4 (Photo 11);
- the bandages from the wheels of the axles 3 and 4 have signs of smoke (Photo 12);

Photo 11 – frame of the bogie II has signs of burning on the upper side, in the area MET 4

Photo 12 – the bandages from the wheels of the axles 3 and 4 have signs of smoke

The traction engines MT1….MT6, have the supply cables with the insulation completely burnt.

The rotors from all the MTs are appropriate, without having signs of heating or pinches on the collectors, do not have signs of abnormal operation at the collecting brushes (Photo 13).

The housings from the MT3 and MT4, on the upper side, have a stronger heating due to the temperature existing in the engines box (Photo 14).

At the stators of the MTs, nothing special was found.

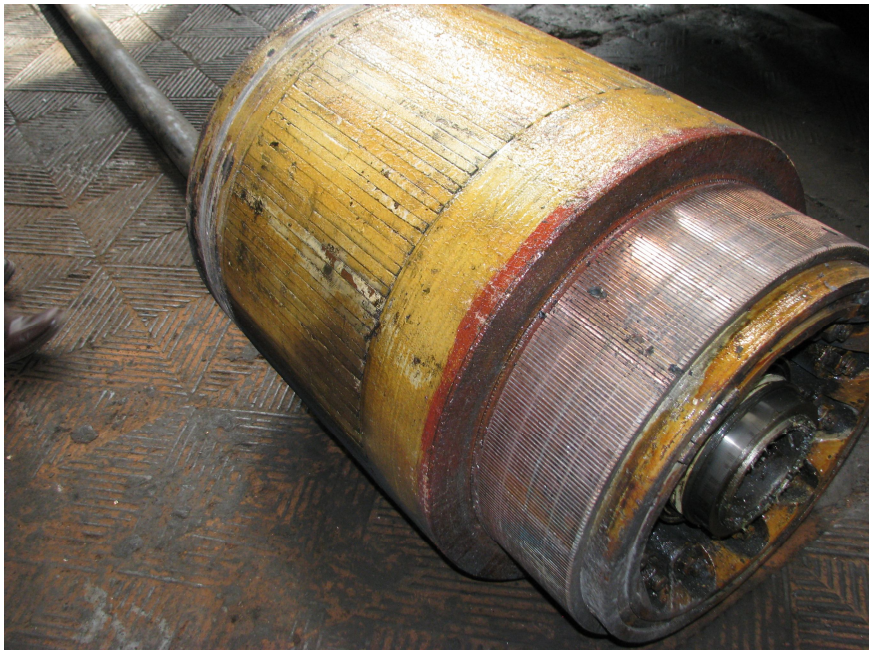


Photo 13 – Rotor from the traction engine

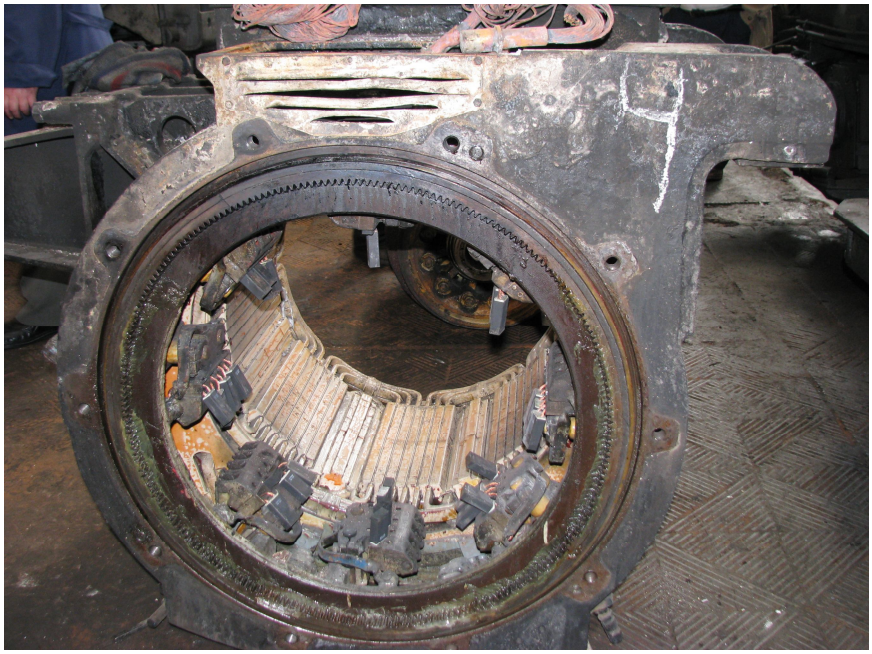


Photo 14 - stator from the traction engine

B.5.5.2. Data resulted from the documents asked from the railway undertaking:

The last repair type RG was performed on the 11th of May 2011 at SC REMARUL 16 februarie Cluj-Napoca.

The locomotive was used without having the Authorization for the release to function of the structural subsystem “Locomotive LE modernized”.

B.6. Analysis and conclusions

B.6.1. Analysis on the supply wiring of the electro-compressor

The maximum admitted intensity of the current for the cable DA General Cable 750VF/1x16 mm^2 used on the supply circuit of the compressor is of $83A/40^0C$ (pg. 3 of the Technical offer 614/15.12.2004 of SC Venus 2000) ;

The electric cables of power and command of the electro-compressor were drawn together, through a duct (Photo 15).

Photo 15 - The electric cables were drawn together, through a duct (Photo taken during the mounting of the electro-compressor).

Given the use in cable shafts with insufficient cooling of the stranded tinned copper conductors insulated in PVC, the current density is 1...2 A/mm^2 with the condition that the maximum operation temperature do not be exceeded (cf. pg. 5 of the Tests report 3052-040 from the 14th of September

2011). In the investigated case it results **The current carrying capacity = 16 mm^2 X 2 A = 32 A**;

The cable DA General Cable 750VF/1x16 mm^2 to supply the electric motor of the compressor has a number of 118 conductors of tinned copper, less than the conditions imposed by the fiche UIC895 OR:1976 of minimum 126 conductors (pg. 3 of the Tests report 3052-040 from the 14th of September 2011);

The cable DA General Cable 750VF/1x16 mm^2 to supply the electric motor of the compressor has the total section of **14.83 mm^2**, less than the section mentioned of 16 mm^2 (pg. 3 of the Tests report 3052-040 from the 14th of September 2011) resulting an **Admissible current=14.83 mm^{2}x 2A =29.66 A**

B.6.2. Analysis on the electric engine operating the electro-compressor

The nominal current (the catalog) of the electric engine used to operate the compressor is of 71 A (pg. 6 of ST 373 – 2001);

The current absorbed by the electric engine, at the reception test from SC Timpuri Noi S.A., is of 50 A at the discharge pressure of 10 bars (Protocol reception tests from the 2nd of September 2010 of the electro-compressor series 614);

The maximum admitted current that can be absorbed by the electric engine at the discharge pressure of 10 bars, can be 56 A (Protocol reception tests from the 2nd of September 2010 of the electro-compressor series 614);

In the documents is not mentioned the maximum current absorbed by the electric engine during the time necessary to start the electro-compressor;

On the supply electric circuit of the electro-compressor are not mounted protection devices at over-current and short-circuit, dimensioned proportionally with the operation currents of the electro-compressor (cf. drawing CMCJ 3071/ E.06 and drawing CMCJ 3071/ E.07 designed by SC REMARUL 16 Februarie SA);

The technical specifications of the new equipments, mounted at the modernizing works of the locomotive are reference documents to manufacturing (according to TECHNICAL SPECIFICATION Code: ST LE 5100 RR RG M. ELECTRIC LOCOMOTIVE OF 5100 kW. TECHNICAL REQUIREMENTS FOR PLANNED REPAIRS TYPE RR, RG AND MODERNIZATIONS)

In the compressor assembly diagram it is mentioned that the part of power and protection of the electric engines must be provided by the manufacturer of the locomotive (According to the NOTE listed in the detailed diagram, Annex 1, pg. 1/3 of Technical Specification S.T. 373-2011 of the screw compressor)

The automatic switch (for the short-circuit protection) and the thermal relay (for the overload protection) of the electro-compressor, must be included in the documentation LE 5100 kW of the locomotive manufacturer (According to the NOTE included in the detailed diagram, Annex 1, pg. 2/3 and 3/3 of the Technical Specification S.T. 373-2011 of the screw compressor)

The over-load and short-circuit protection on the electric motor circuit operating the compressor is provided only by the internal output protection of the static converter (pct. 7 of the document SC Timpuri Noi entered in AFER with the no. 16068/10.08.2011 and pct. 2.4 from the Technical Book 0710D00003-March 2011 of the Converter 4XCSA LE 45K-1700T);

B.6.3. Analysis on the static converter 4XCSA LE 45K-1700T and on the equipment of protection, signaling, displaying and recording EPS-LE

The converter ids protected at the accidental occurrence of the short-circuit on the AC output and at the accidental occurrence of the overload on the AC output (pct. 2.4. from Technical Book 0710D00003-March 2011 of the Converter 4XCSA LE 45K-1700T);

The nominal load current is 91 A at the converter output;

The maximum output current on the converter is 1.5 X IN/7 sec. namely 136.5 A/10 sec. (pct. 2.2. from Technical Book 0710D00003-March 2011 of the Converter 4XCSA LE 45K-1700T);

The short-circuit current at the converter output is not mentioned in the existing documents;

The control method at the electric engine start from the compressor is PWM with the constant maintenance of the flow through the machine (pct. 2.3. from Technical Book 0710D00003-March 2011 of the Converter 4XCSA LE 45K-1700T).

From the witnesses statements results that the protections of over-current and short-circuit on output of the static Converter CSA–LE 45 K-1700T did not enter into operation.

From the witnesses statements results that there was no warning message at the over-current and short-circuit occurrence from the equipment of protection, signaling, displaying and recording EPS-LE;

B.6.4. Conclusions

The maximum current supported by the cable DA General Cable 750VF/1x16 mm^2 supplying the electric motor from the compressor has the value less than the threshold of protection at over-current on output from the static converter CSA–LE 45 K-1700T;

The maximum admissible current stated by the manufacturer (83 A la 40 Celsius degrees) from the supply cable of the electric motor of the main air compressor is lower than the operating current of the internal protections from the static converter (1,5X 91 = 136,5 A/10 sec). In this case, the cables could overheat without entering into operation the over-current protections.

The cable DA General Cable 750VF/1x16 mm^2 supplying the electric engine from the compressor has an insufficient section to the conditions of current, mounting and ventilation. (Tests report 3052-040 from the 14th of September 2011)

The supply cable of the electric engine of the compressor resists at a maximum current of 83 A if it is mounted single and ventilated. Mounting the cable in duct decreases the maximum admissible current due to insufficient cooling. In this case the current supported decreases at 36A and is lower than the rated current absorbed by the electric engine that is supplied (50 A) and may led to the wiring overheat.

The cable DA General Cable 750VF/1x16 mm^2 supplying the electric motor from the compressor has insufficient section to the conditions of ambient temperature.

The normal operation temperature of the compressor of 70 ^{0}C – 110 ^{0}C and the operation temperature of the static converter of 70 ^{0}C near it, combined with the heat releases occurred inside the cables by the electric current, led to the wiring overheating over the prescribed operation temperature of 40 ^{0}C, resulting the thermal racing of the wiring and affecting the PVC insulation.

There are missing the protection devices at over-current and short-circuit mounted on the electric circuit of the electric engine operating the compressor, which results also from the integration schemes of the INDA equipments in the electric installation LE 5100 kw.

The technical specification of the electro-compressor, mandatory for the locomotive manufacturer, provides the mounting of some protection devices at over-current and short-circuit, on the electric circuits of the electro-motor. The existence of these devices would have cut the electric supply in case of abnormal operation of the electro-compressor or in case of a short-circuit occurrence at the electric cables.

B.7. Causes of the accident

B.7.1. Direct cause. Contributing factors

Direct cause

Short-circuit between the supply cables of the electric engine operating the screw compressor, caused by bringing into contact of the conductor core of the cables due to the overheating and melting of the insulator sheet.

Contributing factors

- Lack of correlation of the copper cable of the electric engine operating the compressor (DA General Cable 750VF/1x16 mm^2) with the conditions of current, mounting, temperature and ventilation of the cable;
- Non-entry into action of the static converter protections because the value of the current of entry into action of the internal protection at over-current and short-circuit is higher than the value of the maximum current supported by the cable General Cable 750VF/1x16 mm^2 ;
- Lack of protection devices at over-current and short-circuit of the supply electric circuit of the electric engine operating the compressor.

B.7.2. Underlying causes

Noncompliance with the standard SR EN 50343:2006 *Railway applications. Rolling stock. Rules for the installation of cables.*

B.7.3. Root causes

None.

B.7.4. Severity level

According to the provisions of the Regulations, the event is categorized as accident, in accordance with the art. 7, paragraph (1), letter e.

C. Safety recommendations

- Checking the heating temperature of the electric circuits of the locomotives by the thermo-vision procedure, at the final tests after the planned repairs;
- Checking the work of the protections for the electric circuits of the locomotives at the final tests after the planned repairs;
- In the technical specifications on the construction or modernization of the rolling stock to be contained the standard SR EN 50343:2006 *Railway applications. Rolling stock. Rules for the installation of cables.*

This report will be sent to Romanian Railway Safety Authority, to Romanian Notified Body, to the

National Railway Company “CFR” SA, to the company “SC REMARUL 16 februarie SA” Cluj-Napoca and to the railway undertaking “SC Cargo Trans Vagon SA” Bucharest.

Members of the investigation commission:

- Nicu Pălăngeanu – chief investigator - main investigator
- Vladimir Măcicăşan - investigator - member
- Cristian Groza - investigator - member
- Livius Oltenacu - investigator - member
- Mircea Mladin - ROCSC SC Cargo Trans Vagon SA Bucharest - member
- Iulian Turdean – Head of SC REMARUL 16 februarie Cluj-Napoca - member