Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

OPERATIONAL SERVICES BRANCH

ENGINEERING LABORATORY REPORT

LP233/2013

Locomotive Electrical Examination

Montreal, Maine & Atlantic Railway, Train MMA-002

Date of Occurrence: 06-Jul-2013

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1.0 INTRODUCTION

1.1 On 06 July 2013, shortly before 0100 Eastern Daylight Time, eastward Montreal, Maine & Atlantic Railway (MMA) freight train No. 2, which had been parked for the night at Nantes, Quebec, Mile 7.40 of the Sherbrooke Subdivision, started to roll uncontrolled. The train travelled a distance of about 7 miles and over 13 crossings, reaching a speed of 65 mph. At about 0115, while approaching the centre of the town of Lac-Mégantic, Quebec, 63 tank cars carrying petroleum crude oil, UN 1267, and 1 buffer car derailed. As a result of the derailment, about 6 million litres of petroleum crude oil spilled and there were fires and explosions, which destroyed 40 buildings, 50 vehicles and the railway tracks at the west end of Mégantic Yard. A total of 47 people were fatally injured.

1.2 The three lead locomotives were brought to the New Brunswick Southern Railway (NBSR) diesel shop for examination. The Transportation Safety Board of Canada's (TSB) Engineering Laboratory was asked to be present for the electrical examination of the locomotives.

2.0 EXAMINATION

2.1 An electrical examination of the three lead locomotives was conducted at the NBSR diesel shop in Saint John, NB, on 08 to 09 October 2013. Present for the examination were representatives from General Electric (GE), NBSR, and the TSB.

2.2 The three locomotives examined were identified as locomotives 5017, 5023, and 5026; locomotive 5017 was the lead locomotive during the occurrence.

2.3 During the examination, it was noted that the locomotives' electrical systems were modified from their initial manufactured state; however no documentation was available for these modifications. The locomotives were originally equipped with a safety control foot pedal which has been replaced with an electronic system called a reset safety control (RSC). The original BARCO speed indicators have also been replaced with PULSE systems. The locomotives' electrical system was examined with respect to the how it interfaces with the RSC and the overspeed valve (OSV). The dynamic brake valve which had originally been installed on the locomotives had also been removed.

2.4 The original arrangement had power coming from the locomotives' PC bus on the wire labelled "80PC" to the speed indicator which passed the power through to the solenoid in the OSV acting as a normally closed switch. Once the speed indicator acquired a reading above a set limit, it opened the switch preventing power from reaching the OSV's solenoid, causing the OSV to vent resulting in a penalty brake application on the locomotive. Based on information provided by MMA, their locomotives are set to trip at a speed of either 68 or 72 mph; the majority are set to trip at 72 mph.

2.5 The RSC is setup so that it activates when the air pressure drops to about 30 psi, setting off the alarm, venting the RSC valve, which in turn causes the other valves to vent, activating the penalty braking.

2.6 Locomotive 5017

2.6.1 The examination of locomotive 5017 (Figure 1) showed that the OSV was electrically powered as per the original manufactured arrangement through the wire labelled “80PC” which was connected inside a junction box. The RSC was directly connected to the hot side of the battery. The wire for the “Brake Test” (Figure 2) circuitry was physically and electrically connected to the same terminal as the control signal for the RSC (Figure 3); the protective box in which the terminal was located had a cover that was pushed to the side and only held on by one screw.

2.6.2 Testing was initiated by performing a warning time-out test where the RSC circuitry times-out after a predetermined delay; the RSC valve did not vent. It was noted that the OSV cut-off was closed. The cut-off was opened and the test was performed again; the RSC valve vented resulting in a penalty brake application.

2.6.3 The control circuit breaker (Figure 4) was placed in the “OFF” position; none of the valves vented and there was no penalty braking application.

2.6.4 The main electrical cut-off switch (Figure 5) was opened; none of the valves vented and there was no penalty braking application.

2.6.5 The control circuit breaker was opened and the main electrical cut-off switch was placed in the “OFF” position; none of the valves vented and there was no penalty braking application.

2.6.6 Testing showed that the OSV was always powered by the battery and thus did not vent for any of the test conditions.

2.7 Locomotive 5023

2.7.1 The examination of locomotive 5023 (Figure 6) showed that the OSV was electrically powered as per the original manufactured arrangement through the wire labelled “80PC”; the wire was connected outside of the junction box. The RSC was directly connected to the hot side of the battery. The wire for the “Brake Test” circuitry was electrically connected to the same terminal as the control signal for the RSC but physically separate (Figure 7); there was no protective box around the terminals. The OSV cut-off was closed as found but was opened for the testing.

2.7.2 Testing was initiated by performing a warning time-out test; the RSC valve vented resulting in a penalty brake application.

2.7.3 The control circuit breaker was placed in the “OFF” position; none of the valves vented and there was no penalty braking application. When the circuit breaker was on, the voltage measured at the OSV valve’s solenoid electrical connection was measured to be 64 VDC, when the circuit breaker was placed in the “OFF” position it was noted that the voltage dropped to 27 VDC. The locomotive’s speed indicator was disconnected and this voltage dropped to 0 VDC resulting in the OSV venting producing a penalty brake application. The speed indicator was

reconnected and the test was repeated; none of the valves vented. A different speed indictor was installed and the test was repeated; none of the valves vented.

2.7.4 The main electrical cut-off switch was opened; none of the valves vented and there was no penalty braking application. When the speed indicator was disconnected, the OSV vented resulting in a penalty brake application.

2.7.5 The control circuit breaker was opened and the main electrical cut-off switch was placed in the “OFF” position; none of the valves vented and there was no penalty braking application. The OSV vented resulting in a penalty brake application when the speed indicator was disconnected.

2.8 Locomotive 5026

2.8.1 The examination of locomotive 5026 (Figure 8) showed that the wire labelled “80PC” was disconnected and the end was taped over. The OSV was electrically powered through the Pulse system. The RSC was directly connected to the hot side of the battery. The wire for the “Brake Test” circuitry was physically and electrically connected to the same terminal as the control signal for the RSC (Figure 9); the protective box in which the terminal was located did not have a cover. The OSV cut-off was noted to be in the open position.

2.8.2 Testing was initiated by performing a warning time-out test; the RSC valve vented resulting in a penalty brake application.

2.8.3 The control circuit breaker was placed in the “OFF” position; the OSV vented producing a penalty brake application.

2.8.4 The main electrical cut-off switch was opened; the OSV vented resulting in a penalty brake application.

2.8.5 The control circuit breaker was opened and the main electrical cut-off switch was placed in the “OFF” position; the OSV vented resulting in a penalty brake application.

2.9 The testing and examination of the three locomotives is summarized in Table 1.

Table 1: Summary of Locomotive Testing

Test	5017 (lead locomotive)	5023	5026
Warning Time-Out	RSC valve vented; went into penalty	RSC valve vented; went into penalty	RSC valve vented; went into penalty
Cut-Off for OSV	Closed as found, opened for testing	Closed as found, opened for testing	Open
Control breaker switched off	No penalty	No penalty	OSV vented; went into penalty
Main electrical cut-off switch opened	No penalty	No penalty	OSV vented; went into penalty
Main electrical cut-off switch opened and control circuit breaker off	No penalty	No penalty	OSV vented; went into penalty
Speed indicator 1-Unplugged with control breaker opened. 2-Replugged and retested. 3-Changed speed indicator.	N/A	1-OSV vented; went into penalty 2-No penalty 3-No penalty	N/A
80PC Cable	Connected in junction box	Connected outside junction box	Disconnected and taped
"Brake Test" connection to RSC valve	Wire hooked up to same terminal on valve, cover held on by one screw	Wire hooked to separate terminal on valve, no box	Wire hooked up to same terminal on valve, no cover on box

3.0 ANALYSIS

3.1 The wiring modifications performed on the three locomotives were not consistently applied and the venting performance of all three units tested was different.

3.2 All three units had the RSC system hooked up to the hot side of the battery. This means that as long as the battery has power, the RSC will remain powered regardless of the state of the circuit breakers or even the state of the main electrical cut-off switch preventing the RSC from producing an audible alert due to a loss of power.

3.3 The brake test wiring on all three units is electrically connected directly to the RSC connection. This allows the brake test to override the function of the RSC system. Because of this, a single failure in the brake test system can prevent the RSC from performing its function. For example, if the brake test switch was

forgotten in the on position, the unit will never vent regardless of the RSC command.

3.4 On locomotive 5017, the OSV was directly powered by the battery. This meant that as long as the battery had power, the OSV solenoid was always powered preventing it from switching states so the OSV never vented for any of the test conditions. This would indicate that when subject to overspeed conditions, the OSV in its presently installed condition would not vent and thus would not produce a penalty braking application.

3.5 In addition, on locomotive 5017, while the battery had power, none of the power loss conditions tested produced a penalty braking application.

3.6 As the RSC was connected directly to the battery, if the independent brake were applied and power was lost, such as from the circuit breaker being placed in the "OFF" position or the main electrical cut-off switch being opened, the RSC would not produce an alarm or vent as the battery would still be powering the solenoid.

3.7 Locomotive 5023 had a unique condition somewhere within its systems that would keep voltage applied to the OSV's solenoid regardless of the circuit breaker state. When the circuit breaker was switched "OFF", the voltage dropped, but was still sufficient to keep the solenoid from changing states preventing the OSV from venting. Although the exact source of the voltage was not identified, it was determined that it was related to the speed indicator system as when the speed indicator was removed, the voltage would drop to 0 VDC. The issue was not the speed indicator itself but something in the system as when a known good speed indicator was installed in the locomotive the voltage level jumped back up again.

3.8 Locomotive 5026 performed as expected, producing a penalty brake application for all test conditions.

4.0 CONCLUSION

4.1 The OSV was set to activate at a speed of either 68 or 72 mph.

4.2 All three locomotives were modified from their original design.

4.3 The wiring modifications performed on the three locomotives were not consistently applied.

4.4 The venting performance of all three locomotives was different.

4.5 The RSC was connected directly to the battery so would remain powered even if the main electrical cut-off switch were opened.

4.6 The "Brake Test" wiring on all three locomotives was connected directly to the RSC connection allowing the brake test to override the RSC system.

4.7 As installed on locomotive 5017, the OSV would not produce a penalty brake application when subject to overspeed conditions.

4.8 Locomotive 5017 did not produce a penalty brake application under any of the power loss conditions tested.

4.9 The OSV on locomotive 5023 would not vent due to an unidentified anomaly in the system. The valve itself performed as designed when the speed indicator was removed from the system.

4.10 Locomotive 5026 performed as expected, producing a penalty brake application for all test conditions.

Figure 1: Locomotive 5017's airbrake compartment

Figure 2: "Brake Test" components in locomotive cab

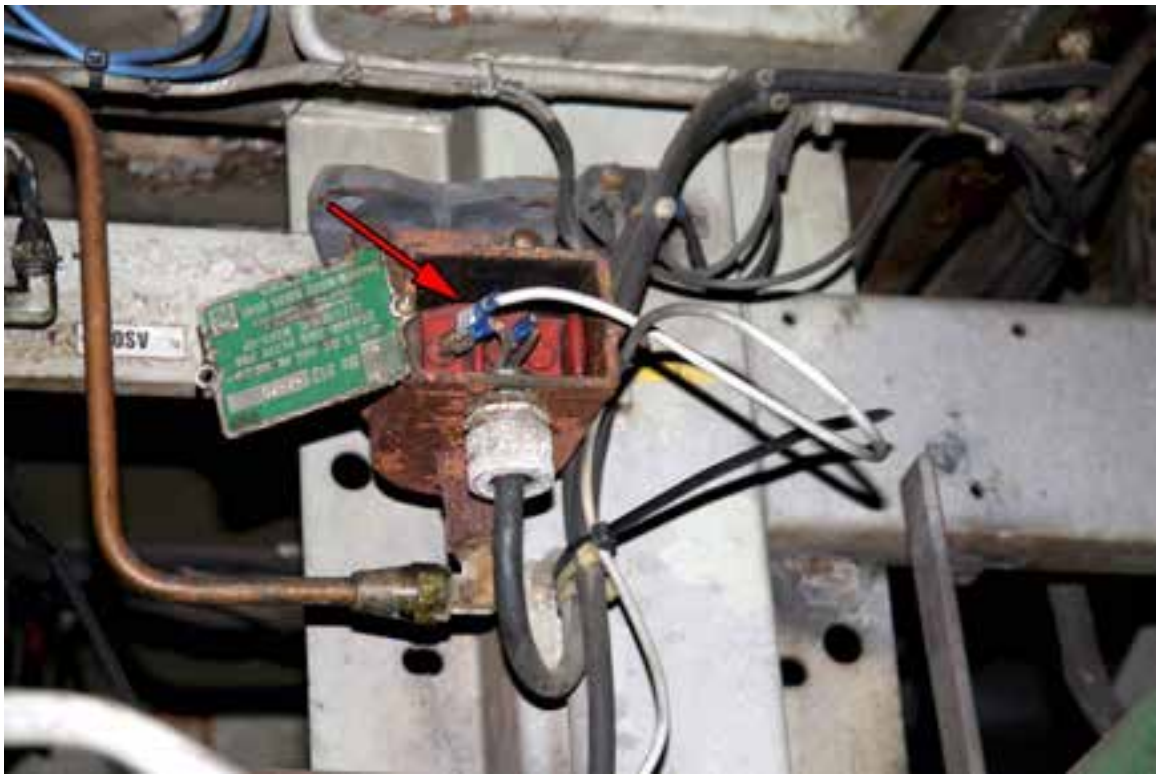

Figure 3: “Brake Test” connection for locomotive 5017

Figure 4: Control circuit breaker in locomotive cab

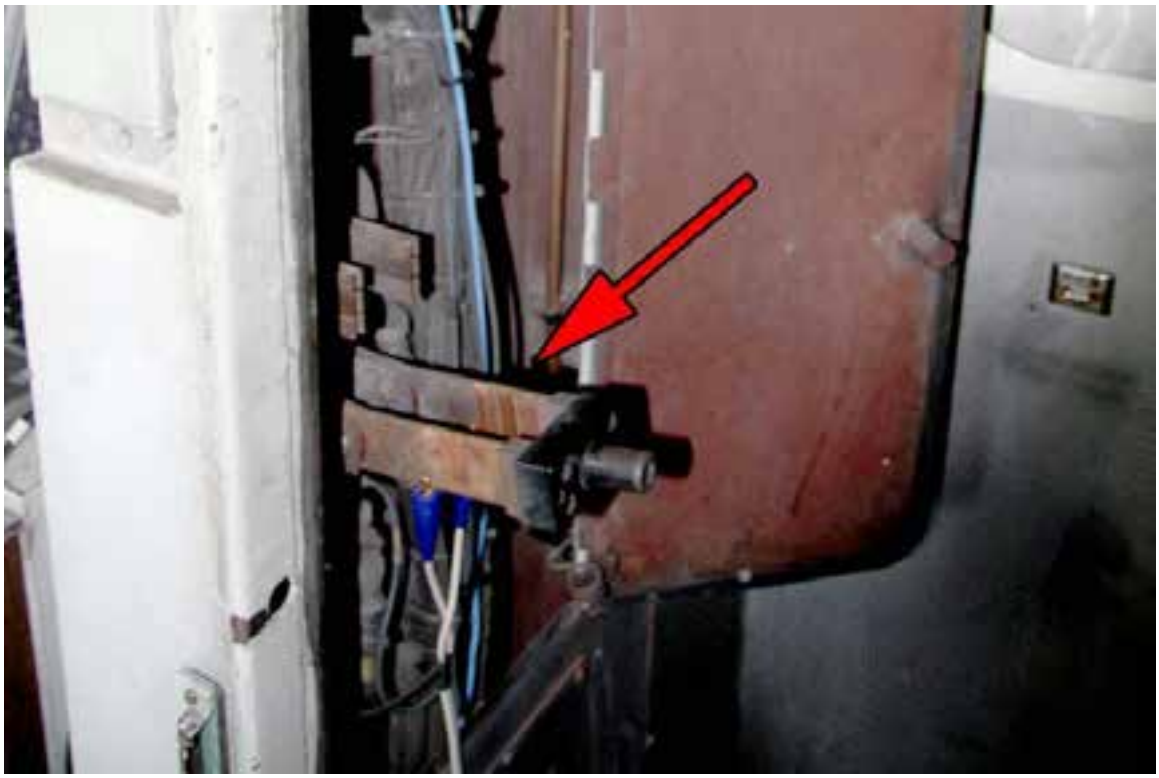

Figure 5: Main electrical cut-off switch

Figure 6: Locomotive 5023's airbrake compartment

Figure 7: “Brake Test” connection for locomotive 5023

Figure 8: Locomotive 5026’s airbrake compartment

Figure 9: “Brake Test” connection for locomotive 5026