National Transportation Safety Board

Office of Railroad, Pipeline and Hazardous Materials Investigations

Washington, D.C. 20594

Collision of Southeastern Pennsylvania Transit Authority Trolley Car 9085 with Trolley Car 9101 At 38th Street and Lancaster Avenue in Philadelphia, Pennsylvania January 4, 2017

Mechanical Group Factual Report

Mike Hiller, Mechanical Group Chairman

Accident

NTSB Accident Number:	DCA17FR003
Date of Accident:	January 4, 2017
Time of Accident:	12:47 p.m. (EST[1])
Type of Trains:	Trolley
Railroad Owner:	SEPTA
Train Operator:	SEPTA
Fatalities:	0
Injuries:	46
Location of Accident:	Philadelphia, PA

Mechanical Group Members

National Transportation Safety Board
Group Chairman
Michael Hiller
490 L'Enfant Plaza East, SW
Washington, D.C. 20594
Office: [redacted]
Cell: [redacted]
Email:[redacted]

Pennsylvania Department of Transportation
Daniel Hauber
Program Principal
Cell: [redacted]
Email[redacted]

SEPTA
Richard Ziegler
Assistant Chief Mechanical Officer
Rail Vehicle Maintenance
Cell: [redacted]
Email:[redacted]

SEPTA
Wayne Krahn
Senior Project Engineer
Cell: [redacted]
Email[redacted]

[1] Eastern standard time

Accident Summary

For a summary of the accident, refer to the *Accident Synopsis Report* in the docket for this investigation, NTSB Docket DCA17FR003.

Transit Car Equipment Involved in the Collision

The Southeastern Pennsylvania Transit Authority (SEPTA) trolley cars involved in this collision are 9085 (striking) and 9101. Both trolley cars are light rail vehicles (LRV) manufactured by Kawasaki Heavy Industries beginning in 1980. Both vehicles involved in this collision were electrically powered 600 Volt-Direct Current (DC) single-car LRVs with two trucks, four axles, and four DC traction motors. The service braking system for such LRVs is both friction and dynamic.[2] The friction brake system consists of an inboard friction ring with a pneumatic caliper on each axle and two track brakes on each truck. Track Brake is an electromagnetic mechanism that slows or stops a trolley car or rail transit vehicle by pressing against the running rail. It consists of a spring-mounted mechanism suspended above the rail between the wheels of each truck. Force transfer members, which connect the track brakes on each side of the truck to the truck-side frame, maintain track brake magnets over the center line of the rail. The force transfer members are equipped with friction elements to transmit the braking force generated by the electromagnetic track brake. Each LRV weighs 57,881 lbs., is 50 feet in length and 8-feet 5-inches wide. The LRV data is shown in table 1.

[2] *Friction braking* is a system that uses friction to absorb energy to slow or stop a vehicle. Dynamic braking refers to the use of traction motors of a rail vehicle as an electric brake by reconfiguring the motor into a generator.

Table 1. SEPTA LRV data

Track gage	5 feet 2.25 inches
Electric system	600 Volts DC
Seating capacity	51
Length over anti-climber	50 feet
Overall width	8 feet 5 inches
Height to top of roof	10 feet 10.5 inches
Truck centers	25 feet
Wheel base	6 feet 2.75 inches
Wheel diameter	26 inches
Maximum speed	47 MPH
Fleet size	112
Weight	57,881 lbs.

Service braking is achieved from the use of a brake pedal located on the floor of the LRV under the operator's console. (See figure 1.) when the pedal is depressed, service braking of various output is applied based on the position of the pedal. For service braking, braking effort is a combination of dynamic and friction braking and its ratio depends on speed of the LRV as determined by the propulsion system. When the pedal is fully depressed, an emergency braking application results. A fully depressed brake pedal applies all friction brakes, both disc and track. The primary use of track brakes is for emergency braking or when quick stops are necessary.

Figure 1. Photograph of a SEPTA LRV brake pedal (circled)

Pressing a push-button located on the right side of the operator's console of the LRV activates the emergency brakes. (See figure 2.) When activated, the emergency brake push-button releases brake pipe air through the pneumatic portion of the switch and a push rod in the mechanism actuates an electrical switch. (See figure 3.) Releasing brake pipe air pressure causes the in-board friction brake discs on each axle to fully apply and the actuation of the electrical switch activates the track brakes.

Figure 2. SEPTA LRV operating console with emergency brake push-button circled

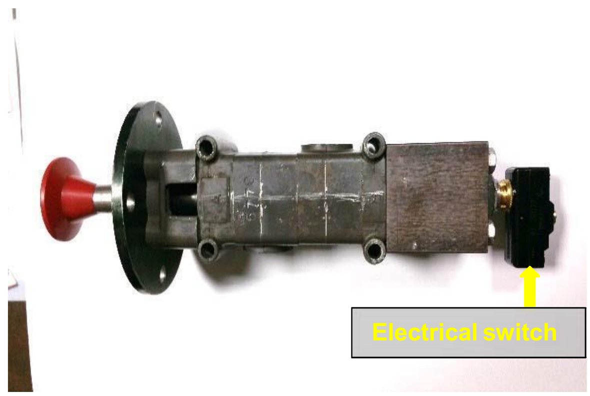

Figure 3. Emergency brake push-button with the electrical switch labeled

Equipment Damages

SEPTA estimated equipment damages of $60,000.00. A summary of the damages is in Table 2 below.

Table 2. Preliminary equipment damage

Disposition	Car Type	Number	Estimated damage
Damaged	LRV	9085	$20,000
Damaged	LRV	9101	$40,000

Equipment Pre-Accident Inspection

Both SEPTA LRVs originated in the Callowhill depot in Philadelphia, Pennsylvania and received a pre-trip inspection on January 4, 2017. LRV 9085 showed no discrepancies in the inspection record and LRV 9101 showed body damage in its inspection record which consisted of scratches in the front and along both sides.[3] Records for both LRVs indicate that the brakes passed the inspection with no defects noted.

In his interview with investigators, the operator reported no problems with the brake system or the performance of LRV 9085 on the day of the accident.

Equipment Post-Accident Inspections

NTSB investigators formed a group of qualified mechanical inspectors to evaluate the mechanical condition of the braking equipment on LRV 9085.

On January 5, 2017, investigators completed visual inspections of SEPTA LRV 9085 in the Elmwood maintenance facility in Philadelphia, Pennsylvania. Investigators observed all wheels to be within their tolerance, and normal wheel tread wear. There were no flat spots on the wheels of LRV 9085 observed which would be an indication of the wheel lock-up during braking. All brake discs appeared normal (no cracks, chips, bluing) and all brake pads and discs were measured and were within tolerance.

The track brake assembly consisted of spring mounted articulated magnetic track brakes which are suspended above the rail between the wheels of each truck. Force transfer members which connect the track brakes on each side of the truck to the truck side frame, maintain the track brake magnets over the center line of the running rail. The force transfer members are equipped with friction elements to transmit the braking force generated by the electromagnetic track brake.

[3] SEPTA's *pre-trip inspections* are a daily requirement for operators. The inspection requires a visual and functional test of several LRV systems such as brakes, lights, damage and horn.

The nominal contact force of each track brake is approximately 16,000 lbs. Investigators observed the spring suspension linkage, wiring, transfer members and friction elements to be intact and within tolerance. (See figure 4.)

Figure 4. SEPTA LRV 9085 truck assembly showing track brake (circled)

Post-accident brake performance tests were completed by qualified SEPTA inspectors and observed by investigators. The incident LRV 9085 was moved to a test track located at the Elmwood maintenance facility and the LRV was subjected to a series of performance tests consisting of accelerations from 0 mph to 20 mph and applying the brakes. Deceleration rates were measured with an independent measurement system provided by SEPTA to verify each brake operation.[4] The following types of brake performance tests were completed:

- A full-service application with dynamics (brake pedal)
- A full-service friction without dynamics (brake pedal)

  [dynamic brake was purposely disabled for this portion of the test-one truck's motor cut out]
- Brake pedal emergency
- Emergency brake push-button and track brake micro-switch

Investigators verified the sanding system and all braking systems functioned properly and met their deceleration rates.[5] Investigators noted no discrepancies with the braking system. See attachment 2 in NTSB docket DCA17FR003.

On January 8, 2017, LRV 9085 returned to the accident location at Lancaster Avenue and 38th Street, Philadelphia, Pennsylvania for sight distance observations and brake performance tests. Four braking tests were completed. Investigators also used a radar gun to measure the speed of the train at the POC.[6] For test run four, the speed of the train was measured at the start of the

[4] Deceleration rates were measured with a *Vericom VC3000* which is an electronic accelerometer computer that provides vehicle brake testing and acceleration or performance testing. The calibration of the VC3000 equipment is an automatic internal function.

[5] A *sanding system* assists with traction during periods of reduced adhesion

[6] SEPTA calibrated the equipment using a tuning fork prior to the beginning of the tests.

braking run to verify that train's speedometer was accurate; no inaccuracy was noted. See Table 3 below for the tests and respective stopping distances.

Table 3. Accident site brake performance testing results.

Test run	Brake test	Speed at start of braking	Speed at POC	Braking distance
1	Brake pedal emergency application	23 mph	13 mph	71-feet, 9-inches
2	Brake pedal emergency application with one second pause before emergency	23 mph	13 mph	86-feet, 4-inches
3	Emergency push button application	23 mph	13 mph	112-feet, 5-inches
4	Emergency push button application	22 mph	22 mph	102-feet, 6-inches

Investigators observed that the track brake did not function during tests 3 and 4 when using the emergency brake push-button. After post-accident brake performance testing, investigators returned LRV 9085 to the Elmwood maintenance facility to troubleshoot the inoperative track brake. Investigators removed the inspection panel under the operator console and found a broken electrical switch no longer attached to the emergency brake push-button.[7] (See figure 5.)

[7] The micro-switch for the emergency brake push button functioned properly as part of the post-accident braking testing performed at Elmwood maintenance facility and witnessed by investigators on January 5, 2017.

Figure 5. Broken emergency brake push-button electrical switch

The electric switch is a type of plunger switch with a threaded portion inserted in the end of the emergency stop push-button. (See figure 6.) When the emergency stop push-button is depressed, the plunger on the electrical switch is depressed thus activating the electromagnetic track brake. The track brake was not functional for brake test numbers 3 and 4 because the switch was damaged.

Figure 6. Exemplar emergency brake push-button electrical switch

Qualified SEPTA technicians installed a new electrical switch into the emergency stop push-button and function tested the track brake. The track brake operated as designed. (See figure 7.)

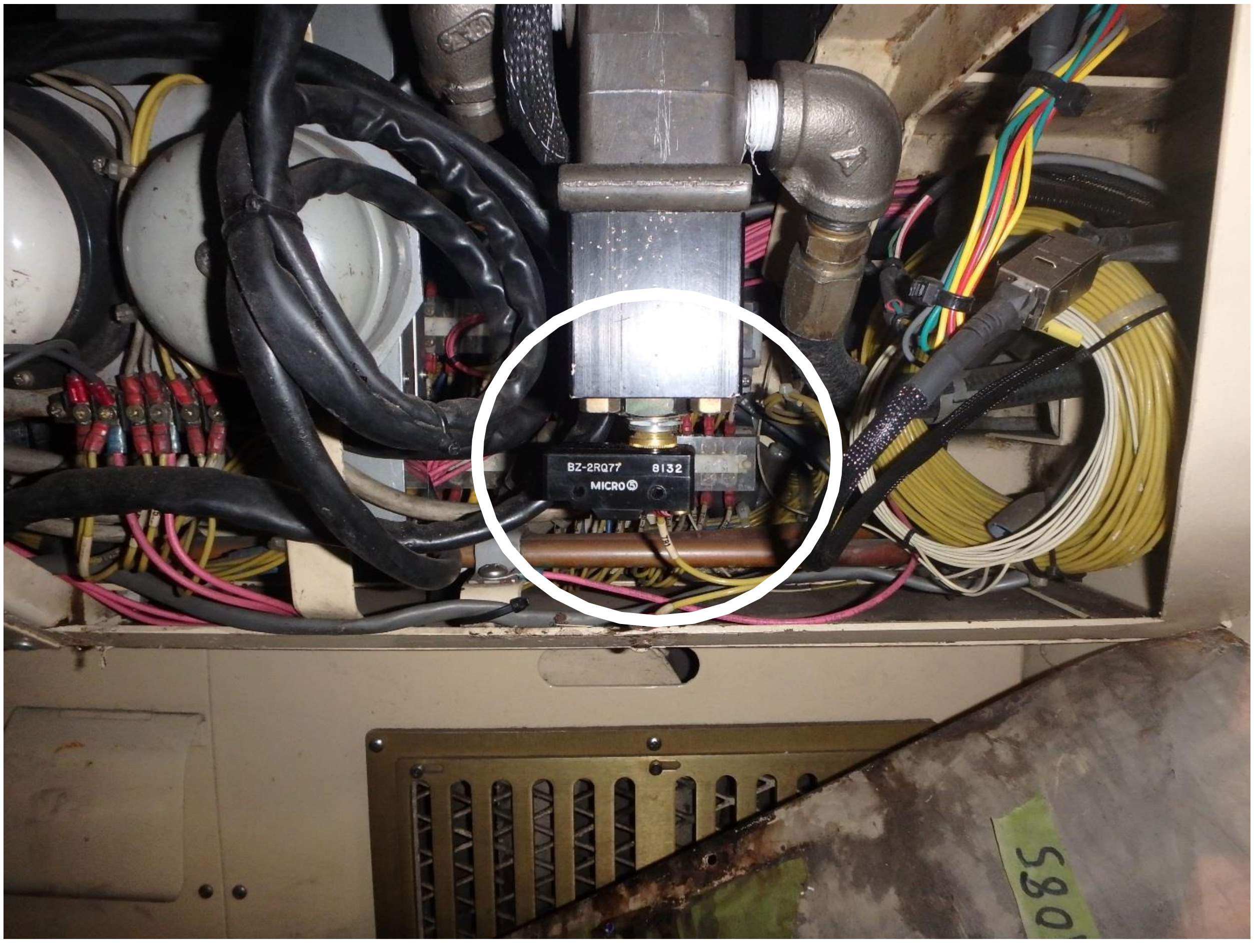

Figure 7. Emergency brake push-button electrical switch switch installed

SEPTA Postaccident Actions

In January 2017, SEPTA completed a fleet inspection of all LRVs equipped with an emergency brake push-button to ensure the electrical switches were unbroken, correctly installed and performed as designed. On February 3, 2017, SEPTA developed an engineering change notice for the electrical switch detailing an installation procedure along with the addition of a support bracket to mitigate future switch failure potential. A copy of their procedure appears as attachment 3 in the NTSB Docket, DCA17FR003.

NTSB Postaccident Actions

Although the emergency brake push-button on the accident LRV was not was not used at the time of the accident, the circumstances of the failed electrical switch in the emergency brake push-button could contribute to accidents or incidents on other LRVs or rail transit vehicles across the United States with similar emergency brake electrical switch designs. Investigators contacted the manufacturer of the emergency brake push-button electrical switch, WABTEC Corporation, concerning this issue. Because of the NTSB outreach, WABTEC published a service bulletin that explained the proper installation and adjustment of the electrical switch. WABTEC distributed this service bulletin to all of its customers who use this design in rail transit. A copy of their bulletin appears as attachment 4 in NTSB Docket, DCA17FR003.

The NTSB is very concerned about latent defects of any kind that may exist in rail transit systems, such as the failure of the emergency brake push-button electrical switch found during follow-up testing as part of the investigation of this accident. The expectation that rail transit vehicle brake systems are performing as designed is achievable only through proper maintenance, thorough inspection, periodic brake performance testing, and independent oversight. In response, investigators developed and the NTSB issued a Safety Alert (SA) after WABTEC developed and issued their service bulletin. (SA-063 April 2017) The goal of the SA is to help transit operations: (1) identify vehicles that may use comparable designs, and (2) prevent or reduce the severity of accidents that may result from an emergency brake push-button electrical switch failure. This SA will further assist the FTA and designated state safety oversight agencies in identifying this potential hazard in other rail transit vehicles. Additionally, the NTSB issued an early safety recommendation (R-17-04) to the FTA to exercise its authority under Title 49 CFR 670.25, and immediately issue a general directive that would require all State Safety Oversight Agencies (SSOAs) to direct rail transit agencies to periodically test the performance of their rail transit vehicles' braking systems to detect potential latent system failures.

[END OF REPORT]

Attachments

1. LRV 9085 and 9101 Pre-trip inspection record
2. Post-accident brake performance testing record
3. SEPTA engineering change
4. WABTEC service bulletin