



NATIONAL TRANSPORTATION SAFETY BOARD
Investigative Hearing

Washington Metropolitan Area Transit Authority Metrorail train 302 that encountered heavy smoke in the tunnel between the L'Enfant Plaza Station and the Potomac River Bridge on January 12, 2015

GROUP	
EXHIBIT	

Agency / Organization

Title

Series of Events. Train 302.

Car #s: 6134/35-1285/84-3030/31.

Explanation of Train movement after it had lost power:

- At 15:14:24 train left the L'Enfant Plaza station. Distance = 50700 feet.
- At 15:15:15: train came to a stop. Distance 51500 feet.
- Total distance traveled by the train before coming to a complete stop = 51500-50700 = 800 feet.
- Leading 6K car lost the power at 15:14:35, distance traveled from the station = 50900 feet.
- Distance travelled from the station when 6K lost the power: 50900-50700 = 200 feet.
- Distance travelled by the train after 6K lost the power: 800-200 = 600 feet.

Grade Description:

- Leaving L'Enfant Station: Grade = 0% for first 200 feet.
- After first 200 feet, Grade = -2.97% for 900 feet.
- After first 200 feet and then 900 feet, a total of 1100 feet, Grade = 0%.
- When 6K lost power, train was moving and had just entered the Grade of -2.97%.
- Train travelled another 600 feet after losing power due to down grade.

Explanation of difference in Battery Voltage drop between 6K and 3K:

1. At 15:14:24 Train speed was increasing. 6K Battery Voltage = 37.5V.
 2. At 15:14:31: Train speed = 17 mph. 6K Battery Voltage = 37.5 V.
 3. At 15:14:35: Train speed = 15 mph. 6K Battery voltages start decreasing. 3K battery voltage = 37.5 V.
 4. At 15:14:39: Train speed = 15 mph. 6K Battery voltage = 35 V. 3K Battery voltage = 37.5 V.
 5. At 15:14:42: Train speed = 15 mph. 6K Battery voltage = 32 V. 3K Battery voltage = 37.5 V.
 6. At 15:14:55: Train speed = 9 mph. 6K Battery Voltage = 32 V. 3K Battery voltage = 32 V.
- It took 4 seconds for 6K battery to drop from 37.5 V to 35 volts. Another 3 seconds to drop from 35 volts to 32 volts while 3K battery voltage was 37.5V.
 - Thirteen seconds later 3K battery voltage dropped to 32 volts. It was straight and not a gradual decline.
 - The reason it took 4 seconds for 6K battery to drop to 35 volts and then additional 3 seconds to drop to 32 volts is as follow:
 - Each MP of the train has a LVPS and battery.
 - All battery voltages are train-lined.

- The LVPS is 14.1 KW on each fleet.
- It takes 120 milli-Seconds for LVPS to shut down after 750 V are lost.
- It takes 3 to 4 seconds for the output of LVPS to drop from 37.5 V to 32 V due to large capacitor at the output of the LVPS.
- At 15:14:42, the 6 K battery voltage dropped to 35 volts and 3K was at 37.5 V. (It is indicative that 1K & 3K LVPS was still ON). The LVPS on 1K & 3K were feeding power to the battery train-line while 6K LVPS went off line and had its battery connected to the DC bus. At that time the following sources were connected to the battery train-line: 6K Battery, 1K LVPS and 3K LVPS. The 6K battery was at 32 V and 1K and 3K at 37.5 V. The source of 37.5 V was at 150 feet and 300 feet away (150 feet MP length) from the 6K MP. There is voltage drop of approximately 1 V from source to the load in a MP. The combination of 6K battery at 32 V, other sources (37.5V) at 150 and 300 feet made the battery train-line voltage at 6K to be at 35 V.
- The LVPS at 6K have large capacitor at the output i.e. 68000 microfarad. The capacitor at the output along with other DC sources at 37.5 V explains slow decay in the 6K battery bus voltage.
- At 15:14:55, the 3K LVPS goes offline. At that time only batteries from all three MPS were connected to battery train-line. The capacitor at the output of 6K and 1K LVPS had already discharged to the battery voltage level and three batteries were feeding the load of the whole train and there was no other source at 37.5 V. This led to the 3K LVPS output voltage to drop quickly.
- WMATA performed the test on 6K car. We connected the multi-meter at the DC bus and turned off the circuit breaker feeding 750 V to the LVPS. The LVPS turned off almost instantaneously (120 mS). It took 3 to 4 seconds before the LVPS output DC voltage dropped from 37.5 V to 32 V. During the test there were no other cars feeding 37.5 V to the DC bus.