NATIONAL TRANSPORTATION SAFETY BOARD

OFFICE OF RAILROAD, PIPELINE AND HAZARDOUS MATERIALS INVESTIGATIONS
WASHINGTON, D. C. 20594

Track & Power Group Factual Report

Location:	Commerce Street Grade Crossing on the Metro-North Harlem Line, Valhalla, Westchester County, New York
Vehicle #1:	2011 Mercedes ML350
Vehicle #2:	Metro-North passenger train 659
Operator #2:	Metro-North Railroad
Date:	February 3, 2015
Time:	Approximately 06:26 p.m. EST
NTSB #:	**DCA15MR006**

Crash Summary

For a summary of the crash, refer to the Crash Summary report in the docket for this investigation.

Track & Power Group Members

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Track Description

The Metro-North Railroad (Metro-North) Harlem Line services commuters between Grand Central Terminal in New York City and points north up to Wassaic in Dutchess County, New York. The Harlem Line is oriented north and south geographically; as well as by timetable. The milepost numbering (MP) on this line begins with MP 0.0 at Grand Central Terminal and increases numerically as the track continues north to Wassaic at MP 82.4; which is the end of track. The Harlem Line utilizes electrified third rail between Grand Central Terminal and MP 54. The collision occurred at MP 26.6 in Valhalla, New York. See figure 1 for the Harlem Line configuration, outlined in blue, within the Metro-North Railroad system.

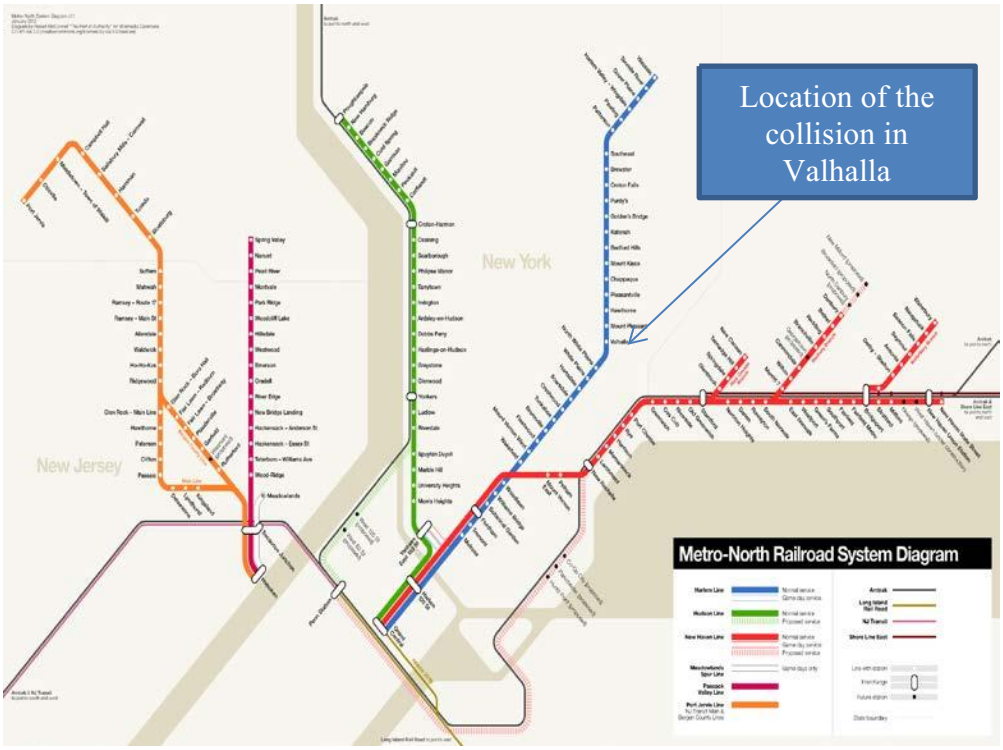


Figure 1-Metro-North Railroad system diagram with the Harlem Line in blue

At MP 17.3, the Harlem Line becomes a two track main with main track 1 being the east track and main track 2 being the west track. The tracks are bidirectional, with trains having the capability to run in either direction on either track. At MP 53.5, it becomes a single track main.

At MP 26.30, there is a highway-rail grade crossing with Lakeview Avenue. Immediately north from this grade crossing, the track begins a 1-degree, 37-minute left-hand curve that is approximately 500 feet in length. The track then becomes tangent continuing to and through MP 26.6, the location of the grade crossing at Commerce Street; the site of the collision. Tangent track continues 300 feet north from this crossing, where the track enters into a 1-degree, 23-minute right-hand curve that is approximately 2,500 feet in length. The track grade is ascending 0.45 percent between MP 26.3 and MP

26.72 (the final resting point of the lead car of train 659). See figure 2 for a Track Chart excerpt from MP 20 and MP 30, depicting the track profiles.

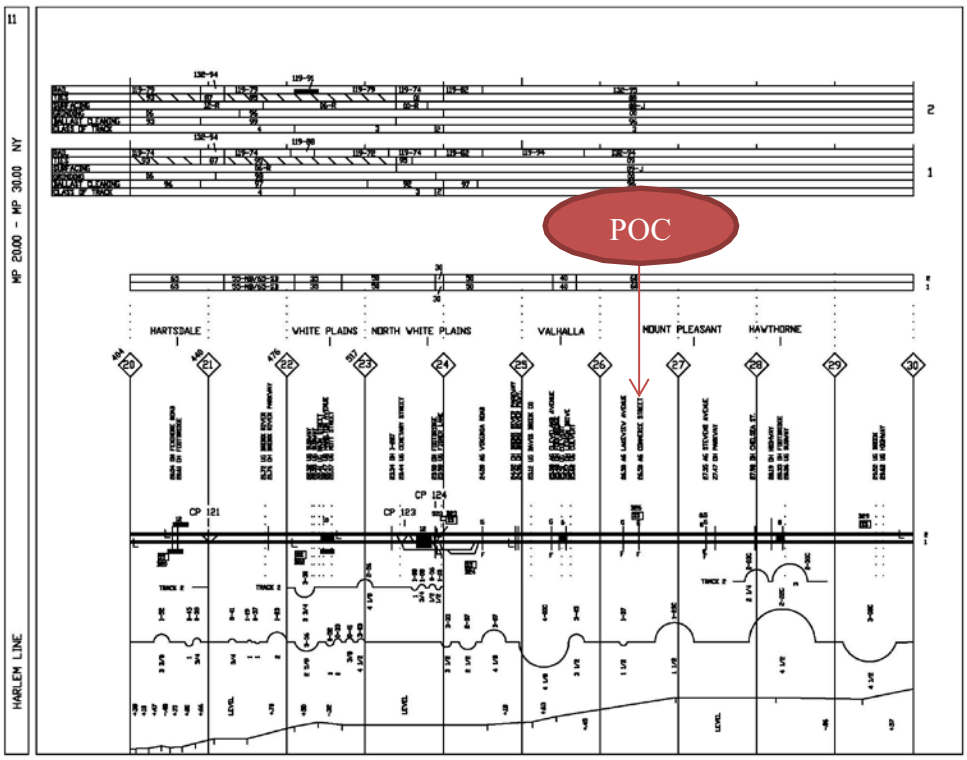


Figure 2-Track Chart excerpt from MP 20 to MP 30, depicting track profiles and location of crash

The annual million gross tons (MGT) through the area is as follows:

CP 124 TK 1 – 11 MGT
CP 124 TK 2 – 10 MGT
CP 130 TK 1 – 8 MGT
CP 130 TK 2 – 8 MGT

Metro-North was required to maintain the track structure in this area to Federal Railroad Administration (FRA) Class 3 track standards, which allow for a maximum authorized speed (MAS) of 60 mph for passenger trains and 40 mph for freight trains. The timetable MAS throughout this segment of track was 60 mph for passenger trains. There were no temporary speed restrictions in effect at the time.

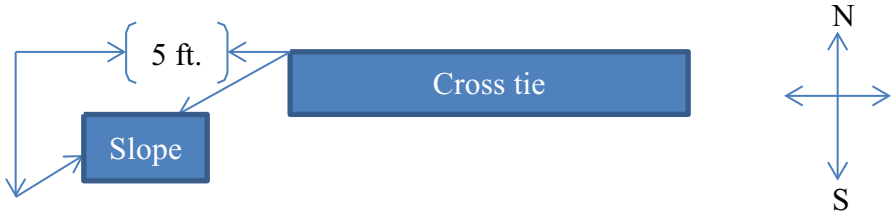
Track Structure

The track through the accident area consisted of steel Continuous Welded Rail (CWR) on treated wood ties secured with double shoulder tie plates and a combination of hairpin spikes and lag screws. The east and the west rails were 132 pound-RE profile rail

section made by Bethlehem Steel in November of 1994 and installed at this location in 1995[1].

The CWR lies on double-shoulder tie plates that were 8 inches wide and 16 inches long, secured by inline elastic rail fasteners to fasten the rail to the plate and four hairpin spikes, one in each quadrant of the plate, fastening the plate to the tie. At some individual locations ties had been replaced and were using a more recently adopted system of fastening the same style plates to the ties with four lag screws, one in each quadrant. The tie plates rested on treated 7 inch by 9 inch wooden ties that were 8 feet, 6 inches long, with an average spacing of 19 inches between tie centers. Every sixth tie was 9 feet, 9 inches long to allow for the attachment of the third rail brackets and the brackets were attached to the tie with three lag bolts. See figures 4 and 6 for a depiction of the 3rd rail attachment.

North of highway-rail grade crossing with Commerce Street the ballasted area between main track 2 and main track 1 was primarily level. Heading north of the crossing the track crosslevel and track curve elevations were measured. In addition, the embankment was measured on the west side of main track 2 to show the slope of the embankment as it related to the pitch of the SUV. See Figure 8 for the resting position of the SUV. This was the side of the track where the vehicle was pushed along the embankment and into the third rail. For consistency, the embankment measurements were taken five feet out from the end of the cross tie and down to the bottom of the ditch line. Also, refer to Figures 4 and 8, to see the embankment slope near the beginning of the west side third rail and at the SUV resting location.



The following are the measurements;

Distance from crossing centerline	Track elevation	Five feet from the end of the third rail support tie; the embankment was:
50 feet	level	18 inches down
100 feet	level	15 inches down
150 feet	level	12 inches down
200 feet	¼ inch west rail high	14 inches down

[1] A 132 pound rail section means 132 pounds per three feet of rail. RE is derived from American Railway Engineering Association (AREA) design specifications for the rail. AREA is now called American Railway Engineering and Maintenance-of-Way Association (AREMA).

250 feet	1/8 inch west rail high	21 inches down
275 feet [beginning of 3rd rail]	level	27 inches down
300 feet	1/8 inch west rail high	33 inches down
350 feet	level	32 inches down
400 feet	1/8 inch west rail high	25 inches down
450 feet	3/8 inch west rail high	25 inches down
500 feet	¾ inch west rail high	30 inches down
550 feet	1 ¼ inch west rail high	25 inches down
600 feet	1 ½ inch west rail high	28 inches down
650 feet [resting point of the lead car face of train 659	1 5/8 inch west rail high	28 inches down

Pre-Crash Track Inspections

FRA reviewed the Metro-North track inspection records for the period beginning December 28, 2014 up to the time of the crash. No exceptions to the required bi-weekly frequency of inspections or the records themselves were found. The records for the last two track inspections at the location show main track 1and main track 2 being inspected from main track 1 on January 28, 2015, as well as main track 1 and main track 2 being inspected from main track 2 on January 30, 2015. These two records noted: "No FRA Defects Found".

Post-Crash Track Inspections

A post-crash track inspection of the track segment was conducted as a special inspection by the Subdivision 5 Track Supervisor before the track was placed back into service. No train service restrictions were observed. In addition, the track was examined by the NTSB and FRA, and no track defects were observed.

Commerce Street Highway-Rail Grade Crossing

The Commerce Street highway-rail grade crossing has the Department of Transportation (DOT) identification number of 529902V. Its railroad location is at MP 26.6. The point of collision on the grade crossing and located at 41.0862756 latitude and -73.7880329 longitude.

The DOT data, last updated on April 4, 2013, showed an average of 1,000 vehicles travel over the Commerce Street grade crossing. Tallies of the scheduled trains

(revenue and deadhead) on the Harlem Line in the November 9, 2014 that travel over the Commerce Street grade crossing are as follows:

WEEKDAY	
Northbound	53
Southbound	54
Total weekday	107
WEEKEND	
Northbound	29
Southbound	29
Total weekend	58
Total Per 7 days	651

There are no other railroads that operate trains over the crossing. These totals do not reflect unscheduled trains, track cars or additional trains on holidays.

There was one previous collision that occurred on October 10, 1984 recorded on the DOT data base. The vehicle was a van and the operator was killed. An emergency responder from the accident was interviewed. He said that the third rail was knocked to the side and did not enter the vehicle or train.

Traction Power Substation Description

Traction power substations B26 and B29 are each four megawatt rectifier substations used to supply power to the third rail system.[2] This power is then used to supply electric train service. Each substation contains electrical switchgear, circuit breakers, Supervisory Control and Data (SCADA) control cabinet, relays, rectifiers, transformers and control battery systems.[3] [4] The substations are supplied by two 13,000 volt alternating current (AC) utility services which are then converted to 700 volt direct current (DC), used by the train consists. Each transit car draws an average of 800 to 1000 amps. The substations are configured to supply power in both the North and South directions for each track. These substations are remotely controlled and monitored from the Power Directors office located at Grand Central Terminal in Manhattan, New York.

There are no security cameras attached to substation B26.

Supervisory Control and Data Acquisition

SCADA from Power Director's office were downloaded. The data showed:

[2] Substation B26 is the closest to Commerce Street and substation B29 is the furthest.
[3] The battery control system provides extended power to operate the circuit breakers during both normal and emergency conditions.
[4] Supervisory Control and Data Acquisition (SCADA) is a system operating with coded signal over communication channels so as to provide control of remote equipment. The control system may be combined with a data acquisition system by adding the use of coded signals over communication channels to acquire information about the status of the remote equipment for display or recording functions.

1. 02/03/15 at time 18:26:21 [during the SCADA time] with the corresponding sequence of events (SOE) time 18:26:17.191; B26 substation, track 2 north breaker indicated a protective relay trip,[5]
2. 02/03/15 at time 18:26:23 [during the SCADA time]; B26 substation, track 2 north breaker indicated it is opened at the power control,
3. 02/03/15 at time 18:26:26 [during the SCADA time]; B26 substation, track 2 north breaker indicated protective trip normal and the third rail sensing energized [breaker re-closure],
4. 02/03/15 at time 18:26:28 [during the SCADA time]; B26 substation, track 2 north breaker indicated closed,
5. 02/03/15 at time 18:26:50 [during the SCADA time] with the corresponding SOE time 18:26:41.277; B29 substation, track 2 south breaker indicated a protective relay trip,
6. 02/03/15 at time 18:26:51 [during the SCADA time]; B29 substation, track 2 south breaker indicated it is opened at the power control and breaker locked out,
7. 02/03/15 at time 18:27:02 [during the SCADA time]; B29 substation, track 2 south breaker, commanded open by power control and confirmation,
8. 02/03/15 at time 18:27:50 [during the SCADA time]; B26 substation, track 2 north breaker, commanded open by power control,
9. 02/03/15 at time 18:27:56 [during the SCADA time]; B26 substation, track 2 north breaker, confirmation of breaker open and third rail sensing de-energized
10. 02/03/15 at time 18:35:53 [during the SCADA time]; B26 substation, track 1 south breaker, commanded open by power control,
11. 02/03/15 at time 18:35:56 [during the SCADA time]; B26 substation, track 2 south breaker, commanded open by power control,
12. 02/03/15 at time 18:35:59 [during the SCADA time]; B26 substation, track 1 and track 2 south breaker, confirmed and indicated open and third rail sensing de-energized at power control,
13. 02/03/15 at time 18:36:00 [during the SCADA time]; B26 substation, track 1 north breaker, commanded open by power control,
14. 02/03/15 at time 18:36:06 [during the SCADA time]; B29 substation, track 1 south breaker, commanded open by power control,
15. 02/03/15 at time 18:36:07 [during the SCADA time]; B26 substation, track 1 north breaker, confirmed and indicated open at power control,
16. 02/03/15 at time 18:36:10 [during the SCADA time]; B29 substation, track 1 south breaker, confirmed and indicated open and third rail sensing de-energized at power control,
17. 02/03/15 at time 18:36:14 [during the SCADA time]; B29 substation, track 2 north breaker, commanded open by power control,
18. 02/03/15 at time 18:36:15 [during the SCADA time]; B32 substation, track 2 south breaker, commanded open by power control,
19. 02/03/15 at time 18:36:17 [during the SCADA time]; B29 substation, track 1 north breaker, commanded open by power control,
20. 02/03/15 at time 18:36:19 [during the SCADA time]; B32 substation, track 1 south breaker, commanded open by power control

[5] Sequence of events is actual time stamp referenced to Greenwich Mean Time.

21. 02/03/15 at time 18:36:20 [during the SCADA time]; B32 substation, track 2 south breaker, confirmed and indicated open and third rail sensing de-energized at power control,
22. 02/03/15 at time 18:36:21 [during the SCADA time]; B29 substation, tracks 1 and 2 north breakers, confirmed and indicated open at power control. In addition, third rail sensing de-energized for track 2 north breaker at power control,
23. 02/03/15 at time 18:36:22 [during the SCADA time]; B32 substation, track 1 south breaker, confirmed and indicated open and third rail sensing de-energized at power control,
24. 02/03/15 at time 18:36:26 [during the SCADA time]; B29 substation, track 1 north breaker, confirmed and indicated third rail sensing de-energized at power control and,
25. 02/03/15 between time 18:36:52 and 18:39:00 [during the SCADA time]; all of the above mentioned breakers were tagged [per lockout/tag out procedures] by power control.

The following is a summary of above 25 events;

- The SUV struck the west third rail of track 2 at time 18:26:17.191. (See above item 1 and Figure 3). The fault was detected by the protective relaying circuit at substation B26 and substation B29. At substation B26 the track 2 circuit breaker tripped on an instantaneous protective relay target (see Attachment 1 [picture B26] and Attachment 1A [oscillography B26 breaker 2N]). As the train continued and the SUV physically damaged the west third rail and transposition jumper 2266 causing the east and west third rails to become electrically disconnected. This in turn resulted in substation B26 to become electrically isolated from the damaged, faulted west third rail. As a result of this damage the load measuring circuitry at substation B26 for the track 2 north circuit breaker identified clear, good third rail on the east side of the train. This east third rail was then re-energized when the track 2 north breaker reclosed. When this occurred, the last four cars (two married pairs), which were contacting the east third rail, was re-energized.
- At substation B29 the protective relaying initially identified a value of electrical current that is consistent with a train load. This train load lasted for 14 seconds and then increased to an overload condition; this appeared to happen when the train stopped. The overload condition activated the Time over Current target, allowed 10 seconds of overload and then tripped the track 2 south circuit breaker. Since the damaged west third rail was still electrically connected to the B29 substation reclosing was attempted, never occurred and the breaker locked out (see above item 3, Attachment 2 [picture B29] Attachment 2A [oscillography B29]. At this time, DC power to the third rail in front of the train was shut off.
- Following the striking of the west third rail and 24 seconds later using SOE time the breaker at substation B29 for track 2 south opened (see above item 5), and locked out (see above item 6).
- Twelve seconds later power control sent an open command for breaker at B29 for track 2 south as a procedural confirmation of lockout.

- Attached are two oscillography attachments downloaded from the protective relays of the track 2 circuit breakers at substations B26 and B29. These graphs are plots of the fault events surrounding the incident and were downloaded that night. The "Y" axis of the graph represents electrical current, while the "X" axis represents time.
- Forty eight seconds later power control sent an open command for breaker at B26 for track 2 north. The DC power for the train between substation B26 and under the last four cars was now off.
- Between 18:27:50 and 18:36:26 [9 minutes and 36 seconds] the breakers are opened between CP 124 and CP 130 (substations B 26 and B 29 are located between these two CP locations for both tracks 1 and 2) (see above items 8 thru 24) per emergency request.

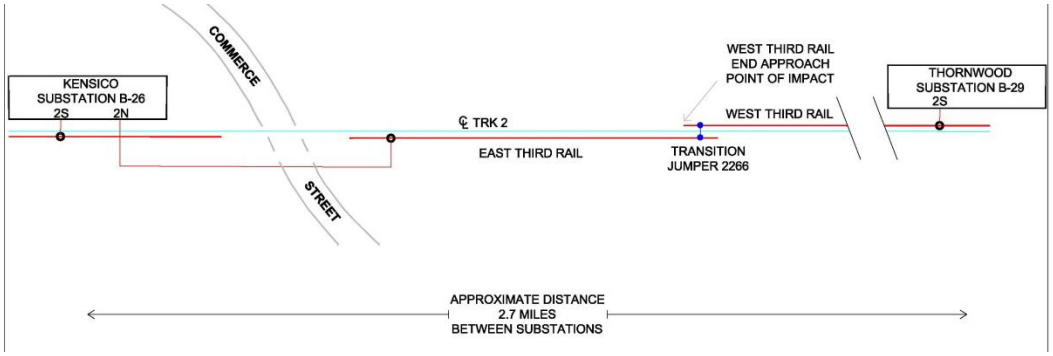


Figure 3-Sketch of substations B-26 and B-29 locations with respect to the third rail electrical transmission rail for main track 2

Third Rail Arrangement

The 3rd rail is 150 pounds per three foot section of a rolled thick flange beam. Each section is 39 feet long, but the length may be adjusted as required during maintenance.[6] Connected to the leading edge of the beam is a 6 foot cast tapered end approach beam. These components are attached to a bracket and the bracket is then attached to every sixth tie (approximately every 10 feet) that supports the third rail. The contact surface of the third rail is on the bottom of the section. The third rail has a protective cover to keep the elements off the top section of the rail. See Figures 4, 5, and 6.

[6] The 3rd rail that entered the lead railcar varied in lengths. See heading Postaccident Third Rail Recovery for exact measurements. Metro-North now purchases 3rd rails in lengths of 40 feet.

Figure 4-Northward view of the third rail assembly that replaced the damaged sections.

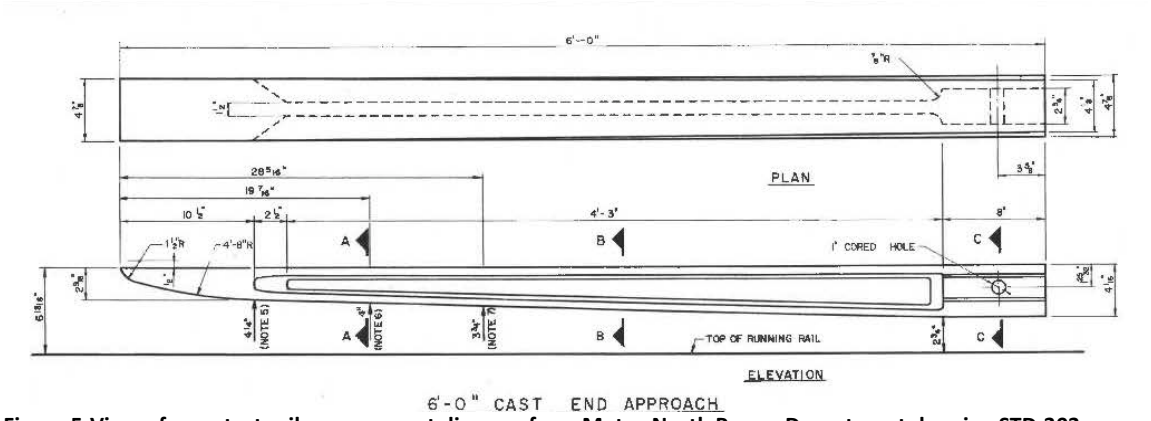


Figure 5-View of a contact rail arrangement diagram from Metro-North Power Department drawing STD-303

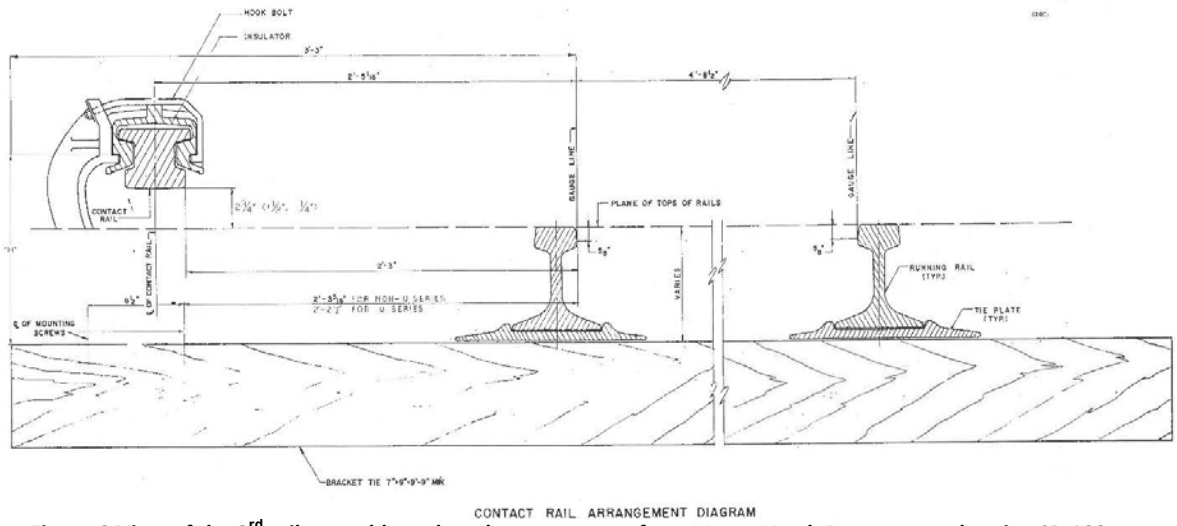


Figure 6-View of the 3rd rail assembly and track arrangement from Metro-North Department drawing SP-102

The third rails that supply electrical power (highlighted in red) to both main tracks 1 and 2 are located in areas between the tracks at Commerce Street. See Figure 7 for the north and south distances the third rails are from the centerline of Commerce Street and the location where the third rail jumpers [**2266**] over to the west side of main track 2.

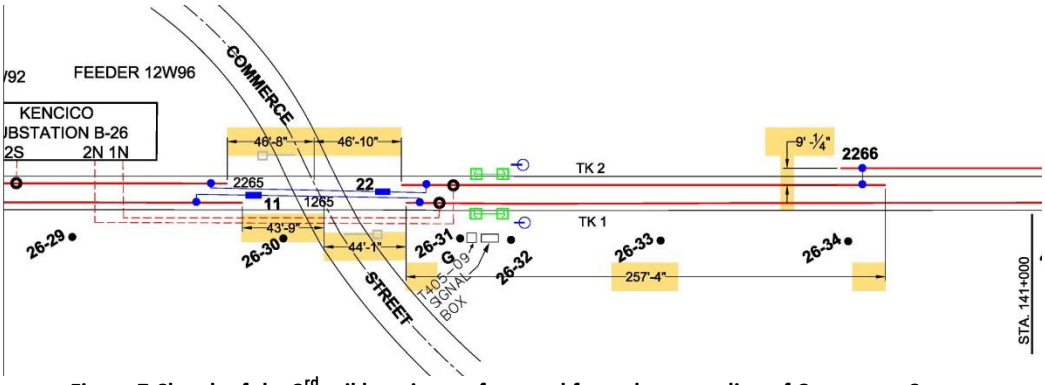


Figure 7-Sketch of the 3rd rail locations referenced from the centerline of Commerce Street

Third Rail Inspections

The Metro-North Power Department's Standard of Maintenance manual requires the third rail to be inspected once per year. However, inspections and repairs are performed at a greater frequency. This is accomplished by performing proactive and reactive inspections.

Proactive inspections include patrols to identify both loose or missing insulator hook bolts, broken or loose fasten bolts, worn insulators, broken or missing protection cover, broken third rail splice bars, broken brackets and planned work.

Reactive inspections include searching for dropped joints, low voltage conditions, reports of arcing, reports of burning brackets, circuit breaker trips, and reports of trains missing current collector shoes.

The following inspections were conducted between CP 124 and CP 130; substations B26 and B29 are located between these CP locations:

Date	Operating Order Number	Track Numbers
• 12/02/14	4946	Track 1
• 12/08/14	4570 and 4571	Track 2
• 08/21/14	2964	Track 2
• 06/03/14	1924 and 1925	Track 2
• 06/20/14	2170 and 2173	Track 2
• 05/19/14	1721 and 1728	Track 1
• 04/29/14	1428 and 1429	Track 2
• 03/03/14	0639	Track 2
• 03/06/14	0678	Track 2
• 03/07/14	0705	Track 1
• 03/18/14	0803	Track 1

• 03/20/14	0843	Track 1
• 02/14/14	0483	Track 1
• 02/24/14	0569	Track 1
• 02/28/14	0621	Track 1
• 01/30/14	0291	Track 2

Post-Crash Third Rail Recovery

During the grade crossing crash sequence of events, the third rail entered the two lead transit cars of vehicle 2, (MN 4333 and MN 4332) respectively, and vehicle 1, the SUV. See Figure 8 to view the third rail passing through the SUV and entering the passenger car. Prior to removal, the rail segment locations were documented within their respective vehicles. After the rails were removed from the vehicles, they were measured and rebuilt in sequence of entry from their railroad wayside location. The following is a description of the third rail segments;

Entry Sequence	Location Description-Facing Forward	3rd Rail Lengths
• 1	nose piece 1st car, between 1st and 2nd row of seats, left side	72 ½ inches
• 2	center middle 1st car	421 inches
• 3	floor center 1st car	469 inches
• 4	second car ceiling area, right side	157 ½ inches
• 5	between 1st and 2nd car, right side	14 ½ inches
• 6	first car ceiling area, right side	296 inches
• 7	floor left side 1st car	362 inches
• 8	on seats right side 1st car	469 inches
• 9	on floor right side 1st car	409 inches
• 10	on ceiling support right side 1st car	469 inches
• 11	above sequence #10 upper right side 1st car	468 ½ inches
• 12	above sequence #11 upper right side 1st car	469 inches
• 13	wedged in floor and on front seats left side 1st car	240 inches
• 14	between 1st car and SUV	138 inches
• 15	inside SUV frame	125 inches
• 16	between SUV and installed 3rd rail	75 inches

Figure 8-West side view of the third rail passing through the SUV and entering passenger car MN 4333.

Damages

Metro-North replaced approximately 468 feet of third rail, one 6-foot end approach [nose piece], one transposition jumper and ancillary components.

Total Power Department damages = $90,000.00
No track damages were sustained.

End of Factual Report