Federal Railroad Administration
Office of Railroad Safety
Accident and Analysis Branch

Accident Investigation Report
HQ-2015-1052

Amtrak (ATK)
Philadelphia, PA
May 12, 2015

Note that 49 U.S.C. §20903 provides that no part of an accident or incident report, including this one, made by the Secretary of Transportation/Federal Railroad Administration under 49 U.S.C. §20902 may be used in a civil action for damages resulting from a matter mentioned in the report.

U.S. Department of Transportation
Federal Railroad Administration

FRA FACTUAL RAILROAD ACCIDENT REPORT

FRA File #HQ-2015-1052

TRAIN SUMMARY

1. Name of Railroad Operating Train #1	1a. Alphabetic Code	1b. Railroad Accident/Incident No.
Amtrak (National Railroad Passenger Corporation)	ATK	137404

GENERAL INFORMATION

1. Name of Railroad or Other Entity Responsible for Track Maintenance	1a. Alphabetic Code	1b. Railroad Accident/Incident No.
Amtrak (National Railroad Passenger Corporation)	ATK	137404

2. U.S. DOT Grade Crossing Identification Number	3. Date of Accident/Incident	4. Time of Accident/Incident
	5/12/2015	9:20 PM

5. Type of Accident/Incident
Derailment

6. Cars Carrying HAZMAT	7. HAZMAT Cars Damaged/Derailed	8. Cars Releasing HAZMAT	9. People Evacuated	10. Subdivision
0	0	0	0	Main Line- New York to Philadelphia (NY

11. Nearest City/Town	12. Milepost *(to nearest tenth)*	13. State Abbr.	14. County
Philadelphia	AN81.62	PA	PHILADELPHIA

15. Temperature (F)	16. Visibility	17. Weather	18. Type of Track
80 ˚F	Dark	Clear	Main

19. Track Name/Number	20. FRA Track Class	21. Annual Track Density *(gross tons in millions)*	22. Time Table Direction
Main 2	Freight Trains-40, Passenger Trains-60	9.5	East

U.S. Department of Transportation
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FRA FACTUAL RAILROAD ACCIDENT REPORT

FRA File #HQ-2015-1052

OPERATING TRAIN #1

1. Type of Equipment Consist:	2. Was Equipment Attended?	3. Train Number/Symbol
Passenger Train-Pulling	Yes	188

4. Speed (recorded speed, if available) R - Recorded E - Estimated	Code	5. Trailing Tons (gross exluding power units)	6a. Remotely Controlled Locomotive? 0 = Not a remotely controlled operation 1 = Remote control portable transmitter 2 = Remote control tower operation 3 = Remote control portable transmitter - more than one remote control transmitter	Code
102 MPH	R			0

6. Type of Territory

Signalization:

Signaled

Method of Operation/Authority for Movement:

Signal Indication

Supplemental/Adjunct Codes:

A, C, B, D

7. Principal Car/Unit	a. Initial and Number	b. Position in Train	c. Loaded (yes/no)	8. If railroad employee(s) tested for drug/alcohol use, enter the number that were positive in the appropriate box.	Alcohol	Drugs
(1) First Involved *(derailed, struck, etc.)*	ATK 601	1	yes		0	0
(2) Causing *(if mechanical, cause reported)*	ATK 601	1	yes	9. Was this consist transporting passengers?		Yes

10. Locomotive Units (Exclude EMU, DMU, and Cab Car Locomotives.)	a. Head End	Mid Train b. Manual	Mid Train c. Remote	Rear End d. Manual	Rear End e. Remote	11. Cars (Include EMU, DMU, and Cab Car Locomotives.)	Loaded a. Freight	Loaded b. Pass.	Empty c. Freight	Empty d. Pass.	e. Caboose
(1) Total in Train	1	0	0	0	0	(1) Total in Equipment Consist	0	7	0	0	0
(2) Total Derailed	1	0	0	0	0	(2) Total Derailed	0	7	0	0	0

12. Equipment Damage This Consist	13. Track, Signal, Way & Structure Damage
9200000	10500000

14. Primary Cause Code

H604 - Train outside yard limits, in block signal or interlocking territory, excessive speed

15. Contributing Cause Code

H604 - Train outside yard limits, in block signal or interlocking territory, excessive speed

Number of Crew Members				Length of Time on Duty	
16. Engineers/Operators	17. Firemen	18. Conductors	19. Brakemen	20. Engineer/Operator	21. Conductor
1	0	3	0	Hrs: 8 Mins: 0	Hrs: 8 Mins: 0

Casualties to:	22. Railroad Employees	23. Train Passengers	24. Others	25. EOT Device?	26. Was EOT Device Properly Armed?
				No	N/A
Fatal	0	8	0	27. Caboose Occupied by Crew?	
Nonfatal	8	219	0		N/A

28. Latitude	29. Longitude
40.001196765	-75.095388293

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CROSSING INFORMATION

Highway User Involved		Rail Equipment Involved
1. Type		5. Equipment
2. Vehicle Speed *(est. mph at impact)*	3. Direction *(geographical)*	6. Position of Car Unit in Train
4. Position of Involved Highway User		7. Circumstance
8a. Was the highway user and/or rail equipment involved in the impact transporting hazardous materials?		8b. Was there a hazardous materials release by
8c. State here the name and quantity of the hazardous material released, if any.		

9. Type of Crossing Warning	10. Signaled Crossing Warning	11. Roadway Conditions
1. Gates 4. Wig wags 7. Crossbucks 10. Flagged by crew 2. Cantilever FLS 5. Hwy. traffic signals 8. Stop signs 11. Other *(spec. in narr.)* 3. Standard FLS 6. Audible 9. Watchman 12. None		

12. Location of Warning	13. Crossing Warning Interconnected with Highway Signals	14. Crossing Illuminated by Street Lights or Special Lights

15. Highway User's Age	16. Highway User's Gender	17. Highway User Went Behind or in Front of Train and Struck or was Struck by Second Train	18. Highway User

19. Driver Passed Standing Highway Vehicle	20. View of Track Obscured by *(primary obstruction)*

Casualties to:	Killed	Injured	21. Driver was	22. Was Driver in the Vehicle?
23. Highway-Rail Crossing Users			24. Highway Vehicle Property Damage *(est. dollar damage)*	25. Total Number of Vehicle Occupants *(including driver)*

26. Locomotive Auxiliary Lights?	27. Locomotive Auxiliary Lights Operational?

28. Locomotive Headlight Illuminated?	29. Locomotive Audible Warning Sounded?

10. Signaled Crossing Warning

1 - Provided minimum 20-second warning
2 - Alleged warning time greater than 60 seconds
3 - Alleged warning time less than 20 seconds
4 - Alleged no warning
5 - Confirmed warning time greater than 60 seconds
6 - Confirmed warning time less than 20 seconds
7 - Confirmed no warning
N/A - N/A

Explanation Code

A - Insulated rail vehicle
B - Storm/lightning damage
C - Vandalism
D - No power/batteries dead
E - Devices down for repair
F - Devices out of service
G - Warning time greater than 60 seconds attributed to accident-involved train stopping short of the crossing, but within track circuit limits, while warning devices remain continuously active with no other in-motion train present
H - Warning time greater than 60 seconds attributed to track circuit failure (e.g., insulated rail joint or rail bonding failure, track or ballast fouled)
J - Warning time greater than 60 seconds attributed to other train/equipment within track circuit limits
K - Warning time less than 20 seconds attributed to signals timing out before train's arrival at the crossing/ island circuit
L - Warning time less than 20 seconds attributed to train operating counter to track circuit design direction
M - Warning time less than 20 seconds attributed to train speed in excess of track circuit's design speed
N - Warning time less than 20 seconds attributed to signal system's failure to detect train approach
O - Warning time less than 20 seconds attributed to violation of special train operating instructions
P - No warning attributed to signal systems failure to detect the train
R - Other cause(s). Explain in Narrative Description

NOTES:

1.DATE OF INCIDENT: 5/12/15, 2115 HOURS.

2.DATE OF FIELD SURVEY: 5/12/15 - 5/15/15

3.FIELD SURVEY PERFORMED BY AMTRAK PERSONNEL, UNDER THE DIRECT SUPERVISION OF CHARLES SZOVATI, P.L.S., UTILIZING TRADITIONAL FIELD SURVEYING METHODS, DIGITAL LASER SCANNING & GNSS RTK DATA ACQUISITION.

4.HORIZONTAL DATUM: PA. STATE PLANE COORDINATES, SOUTH ZONE, NAD '83 DATUM, CONTROL POINTS SHOWN.

5.VERTICAL DATUM: NAVD '88, BENCH MARKS SHOWN.

6. AMTRAK RIGHT OF WAY LINES ARE APPROXIMATE AND FOR ILLUSTRATIVE PURPOSES ONLY.

7.AERIAL IMAGERY:

DATE OF FLIGHT: 5/13/15

TIME: 1200 HRS UTC, 0800 HRS EDST

ALTITUDE: 2570' AGL

Keystone Aerial Surveys, Inc.
Northeast Philadelphia Airport
9800 Ashton Road
PO Box 21059
Philadelphia, PA 19114
215-677-3119

LEGEND:

SURVEY BASELINE

RIGHT OF WAY LINE

-40 0 40 80
GRAPHIC SCALE

National Railroad Passenger Corporation
Track Engineering & Design

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NO.	DATE	BY	DESCRIPTION
2.	05/17/15	CES	ADDITIONAL DATA ADDED
1.	05/15/15	CES	INITIAL ISSUE

REVISIONS

DESIGNED- C.E.S. CHECKED- C.W.H.

REGION- NORTHEAST CORRIDOR

AMTRAK

SUB-DIVISION- MID-ATLANTIC

PHILADELPHIA, PA.

DERAILMENT INVESTIGATION

TRAIN 188

AN LINE - MP 84.62

Office of the Deputy Chief Engineer TRACK

30TH STREET STATION, PHILADELPHIA, PA 19104

APPROVED:

APPROVED:

SCALE: GRAPHIC

DATE: MAY 15, 2015

SHEET: T-01

PLAN NO. 10239

FILE: S:\Track\Surveying & Mapping\Division - Mid - Atlantic\Frankford_Cry_188_Derailment\AmtrakSurveyData - 2D.dgn

SYNOPSIS

On May 12, 2015, at 9:20 p.m., EST, eastbound Amtrak Regional Train Number 188, consisting of 1 head-end locomotive and 7 passenger cars with 258 persons onboard, traveling on the New York to Philadelphia Main Track Number 2, derailed in a 4-degree, left hand curve at Milepost 81.62. This derailment occurred in a populated area in the Frankford section of Philadelphia, Pennsylvania, about 8 miles northeast of Amtrak's 30th Street Station.

The derailment resulted in a total of 235 causalities, including 219 non-fatal passenger injuries, 8 non-fatal railroad employee (5 crew members and 3 commuting railroad employees) injuries, and 8 passenger fatalities. All injured persons were transported to local hospitals for emergency medical treatment.

The train was traveling in multiple main track, Automatic Block Signal (ABS), and Cab Signal territory at a recorded speed of 102 miles per hour (mph) at the time of the derailment. The maximum authorized speed in this area was 80 mph with a 50 mph permanent speed restriction in the curve at the location of the derailment. The locomotive and all seven passenger cars derailed striking four catenary poles resulting in heavy damage and several cars turning on their sides.

Amtrak suspended service for 6 days between Philadelphia and New York from the night of the accident on May 12, 2015, until Monday morning, May 18, 2015, at 5:00 a.m. There were approximately 795 train cancelations, including 401 Amtrak trains, 228 Southeast Pennsylvania Transit Authority (SEPTA) trains, and 66 New Jersey Transit trains using current train schedules. Track Number 4 was returned to service at 4:46 a.m. with overhead catenary power restored at 5:25 a.m. A non-revenue SEPTA train was the first to operate on Track Number 4. Track Numbers 2 and 3 were returned to service for electric operation at 6:09 a.m. with speed restrictions in effect. Amtrak Train Number 110 was the first to operate on Track Number 2 and Train Number 2103 was the first Amtrak train westbound at 7:05 a.m. on Track Number 3.

The weather conditions at the time of the accident were clear, breezy, and 80 degrees Fahrenheit.

The train was traveling in an eastward direction as described in the Amtrak Timetable. Timetable direction and geographical direction are the same and Timetable direction will be used throughout this report.

Damage costs for the derailment are estimated at $19,700,000 with equipment at $9,200,000 and track infrastructure at $10,500,000.

Based on evidence reviewed in the investigation of this derailment, Positive Train Control (PTC) would have prevented this event.

The Federal Railroad Administration's (FRA) investigation determined that the probable cause of the derailment was excessive speed.

NARRATIVE

Circumstances Prior to Accident:

Amtrak Train Number 188 was an Amtrak Northeast Regional train that consisted of one locomotive engineer, a conductor, two assistant conductors and one onboard service attendant. Employee training records indicated that the train crew employees were qualified to federal standards with their medical and training records being up to date including passing scores on rule and test exams. All applicable crew members were certified on the equipment used and the physical characteristics of the territory.

A review of the hours of service records (HOS) indicated that the Engineer, Conductor, and one Assistant Conductor received their required statutory off-duty rest period and went on duty at Penn Station New York, New York, at 1:20 p.m., EST, and worked Amtrak Train Number 2121 to Union Station, Washington, DC.

The second Assistant Conductor also received the required off-duty period and went on-duty earlier in the day at Penn Station, New York at 11:50 a.m. and worked Amtrak Train Number 171 from Penn Station, New York, to Union Station, Washington, DC.

All of the train crew members received their interim break until they were all called back on duty at 6:30 p.m. at Union Station, Washington, DC, to operate Amtrak Train Number 188 back to Penn Station, New York. The only exception to the HOS requirements was the on board Service Attendant whose duties were not subject to the HOS.

The train consist (equipment used for Amtrak Northeast Regional Train Number 188) was one electric locomotive and seven coach cars (i.e., Locomotive Number (Amtrak) ATK 601, Business Coach Number ATK 81528, Passenger Coach Number ATK 82776, Passenger Coach Number ATK 82644, Café Coach Number ATK 43346, Passenger Coach Number ATK Number 82761, Passenger Coach Number ATK 82797 and Passenger Coach Number ATK 82981). All the systems and sub systems worked as intended and was determined that the equipment involved in the derailment of Amtrak Train Number 188 was not a factor, or contributing factor to the cause of the accident.

The train crew took possession of Amtrak Train Number 188 on Track Number 14 at Union Station, Washington, DC, and performed the required air brake test, mechanical and safety equipment inspections. All passengers were boarded and Amtrak Train 188 departed Washington, DC, at 7:15 p.m. Prior to arrival at Philadelphia, Pennsylvania, Train Number 188 made five scheduled station stops at New Carrollton Station, BWI Marshall Airport Station, Baltimore Penn Station and Aberdeen Station, Maryland, and the Wilmington Station, Delaware, with no reported problems.

Amtrak Train Number 188 departed 30th Street Train Station in Philadelphia at 9:10 p.m. and crossed over from Track Number 4 to Track Number 1 and accelerated to 30 mph. At "Zoo Interlocking" Amtrak Train Number 188 received an "approach medium" signal indication and proceeded to "Girard Interlocking" where Amtrak Train Number 188 received an "approach limited" signal indication and crossed over from Track Number 1 to Track Number 2 at 30 mph . At "Mantua Interlocking" Amtrak Train Number 188 received a "clear signal" indication and continued to proceeded east on Track Number 2. After Train Number 188 departed Mantua Interlocking a Southeast Pennsylvania Transit Authority (SEPTA) Train Number 769 was stopped at Milepost (MP) 86 on Track Number 1 and reported to Amtrak's Section 6 Train Dispatcher over the radio that someone either threw or shot something at the train and broke the windshield. The Engineer on Train Number 188 announced over the radio "hot rail track two" to warn the stopped SEPTA crew of his approach on Track Number 2. In addition, Amtrak Train Number 2173 travelling in the opposite direction (westbound) near MP 86 on Track Number 3, reported that a side window of the third car had been damaged.

After Amtrak Train Number 188 pasted SEPTA Train Number 769 received a clear signal at "Lehigh Interlocking" located west of the North Philadelphia Station then received a "clear signal" indication east of North Philadelphia Station at the "Clearfield Interlocking." The last signal indication Amtrak Train Number 188 received prior to the accident was a clear indication at the Distant Signal MP 83.4 about 3 miles west of the accident west of Shore Interlocking. Train Number 188 proceeded through Shore Interlocking at 106 mph and entered the 50 mph restricted curve at 102 mph.

As Amtrak Train Number 188 approached the accident area, the Locomotive Engineer was seated at the controls of Locomotive Number ATK 601 and the Conductor located in the lead car behind the locomotive. The first Assistant Conductor and the on board service attendant were in the café car fourth from the locomotive and the second Assistant Conductor was located in the seventh car last row.

The weather conditions were clear at the time of the accident and the temperature was 80 degrees F. The relative humidity was 41 percent with no precipitation. The wind speed was about 8 mph and the visibility 10 miles.

All wayside and cab signal aspects were in compliance with FRA Regulations found at Title 49 Code of Federal Regulations (CFR) Part 236.

The Accident:

A review of the locomotive event recorder data indicated the Engineer initiated an emergency brake application at 9:20:35 p.m., about 4 seconds before the accident as Amtrak Train Number 188 entered a 4-degree, 2-minute left hand curve with a maximum authorized speed (MAS) of 50 mph. The last recorded speed shown on the event recorder at 9:20:38 p.m. was 102 mph. The forward mounted video camera showed the locomotive tilting to the right then the recording stops.

The locomotive and the seven cars derailed striking several catenary poles. Video footage shows the cars of the consist one through seven topple sideways, no longer in the up position and when the train finally stops the last three cars (five, six and seven) up-right themselves.

The turnover speed inside the 50 mph curve is 98 mph and the last recorded speed shown on the locomotive event recorder was 102 mph resulting in a simultaneous wheel lift and axle unloading forcing the train wheels to leave the rail.

Amtrak Train Number 188 traveled approximately 900 feet beyond the point-of-derailment (POD) striking four catenary poles and all the cars toppled onto their sides dislodging side windows and seats. The first car broke into three pieces resulting in a complete loss survival space. Information gathered to date indicates there were no equipment, track or signal failures and the Engineer was engaged with the operation of the locomotive. Prior to the accident, two trains (a SEPTA and Amtrak) reported being hit with objects resulting in broken windows. These initial reports came from radio transmissions.

Amtrak FRA F 6180.55a (Railroad and Injury Report) reported 227 total injuries attributed to the accident (i.e.,

C000 Passengers on Trains 219 REPORTED
B522 Crew Dispatchers (commuter to work) 2 REPORTED
B412 Electrical Workers (B) (commuter to work) 1 REPORTED
A606 Road Passenger Conductors 1 REPORTED
A607 Asst. Road Passenger Conductors and Ticket Collectors 2 REPORTED
A616 Road Passenger Engineers and Motormen 1 REPORTED
A516 Chefs and Cooks (Restaurant and Dining Car 1 REPORTED)

Over 200 hundred local police, 74 fire fighters and several EMS units responded to the scene, as well as dozens of Amtrak personnel. First responders, police and firemen, transported injured passengers to Frankford, Temple, Jefferson, Hahnemann, Episcopal, St. Joseph's, St. Christopher's Children's, Torresdale, and Einstein hospitals. Local residents assisted the first responders and provided assistance to the injured. Due to the large number of injured being transported by the Philadelphia Police the status of the accident moved from a rescue operation to a recovery operation in about 1-hour and 15 minutes.

The Post-Accident Investigation

Analysis and Conclusions

Analysis - Fatigue

FRA obtained fatigue related information for the 10-day period preceding this accident/incident, including the 10-day work history (on-duty/off-duty cycles) for the employees involved. The analysis was based upon answers provided by employees regarding activities and rest.

employees involved. The analysis was based upon answers provided by employees regarding activities and rest.

Conclusion:

Upon analysis of fatigue-related information, FRA concluded that fatigue was not a problem for the train crew.

Analysis - Toxicology

This accident met the criteria for CFR 49 Part 219, Subpart C, Post Accident Toxicological Testing. In accordance with Federal Regulations, following the accident operating crewmembers from Amtrak Train Number 188 was required to undergo post-accident toxicological testing.

Conclusions:

The test results were negative for the crew members tested; therefore, drug and alcohol use was not a factor in this accident.

Analysis - Operating Rule Compliance

The maximum authorized speed for Amtrak Train Number 188 was 50 mph at the accident location. Operating Rules governing employees were reviewed, specifically Amtrak Northeast Operating Rules Advisory Committee (NORAC) Operating Rules, last updated November 6, 2011. Also governing train movements was Amtrak's Timetable Number5 effective November 5, 2012. Temporary Speed Restriction Bulletins, (TSRB), in effect; Wilmington Dispatch Office, Wilmington, and New York Dispatching Office, New York, New York, dated May 12, 2015. The train crew involved was governed by Amtrak operating rules, wayside interlocking signal indications and cab signals.

Conclusion:

Amtrak Train Number 188 was not operated in compliance with Amtrak's permanent speed restrictions and was not compliant with of 49 CFR Section 240.305(a)(2) which states in part (a) "It shall be unlawful to: (2) Operate a locomotive or train at a speed which exceeds the maximum authorized limit by at least 10 mile per hour."

The Locomotive Engineer's certification was subsequently suspended pending the results of a revocation hearing and investigation. The certification hearing normally is conducted in a timely manner applicable to contractual agreements and by mutual agreement between the Brotherhood of Locomotive Engineers and Trainmen (BLET) and Amtrak. The hearing will be scheduled at a later time. The organization is amenable to granting an extension of the applicable time limits prescribed by Rule 21 of the parties Collective Bargaining Agreements (CBA) due to the Engineer presently recuperating from serious injuries sustained in the accident and would not be medically able to present himself for a formal investigation at this time.

Analysis - Post Accident Signal Re-enactment

Amtrak Train Number KP-716 with Locomotive Number ATK 609 is the same type of as Locomotive Number ATK 601 involved in the derailment. Amtrak provided a qualified train crew to operate Amtrak Train Number KP-716. The train crew consisted of an engineer, conductor, and a brakeman and was called for on-duty at 7:00 p.m. The NTSB and FRA rode in the cab of Locomotive Number ATK 609 of Amtrak Train Number KP-716. The group boarded Train Number KP-716 at the 30th Street Station at approximately 9:00 p.m. and Amtrak officials conducted a safety briefing.

The train departed eastbound from the 30th Street at approximately 9:10 pm. Amtrak Train Number KP-716 operated on the same track as the accident train, Amtrak Train Number 188.

Signals were displayed for Amtrak Train Number KP-716 as they were for Amtrak Train Number 188. Measurements were taken at the last three signal locations from the point the aspects were clearly seen by the Engineer to the actual signal locations.

Clearfield Interlocking: 3,940 feet from the point of first visibility to the signal location. This signal location is about 4.5 miles from the accident site.

Intermediate Signal Number 83.4: 1,384 feet from the point of first visibility to the signal location. This signal is located about 3 miles from the accident site.

Shore Interlocking: 2,730 feet from the point of first visibility to the signal location. Shore Interlocking is located about ½ mile from the accident site.

Conclusion:

FRA took no exceptions in the ability to view the approaching curve and the opportunity to apply the trains braking system in sufficient time to comply with the required speed.

Analysis - Locomotive Event Recorder Download

At approximately MP 83.8 at 9:18:29 p.m. to 9:19:11 p.m. (locomotive event recorder time), the engineer made a series of speed adjustments from I (idle) to T-2 to T-6 and back to T-2 (I, T-1 through T-8 represents throttle settings) that increased the speed from 56 mph to 64 mph operating within a permanent 65 mph curve speed restriction from MP 83.8 to MP 83.5. At the intermediate signal located at MP 83.4, Train Number 188 received a "clear signal" indication that allowed a maximum authorized speed (MAS) of 80 mph. At this point, the speed of Amtrak Train Number 188 started to increase and the throttle setting was advanced at 9:19:22 p.m. from T-2 to T-4 to T-8. At 9:19:55 p.m., Amtrak Train Number 188 started to exceed the MAS speed limit of 80 mph for the next 43 seconds and reached a speed of 106 mph past MP 82.1 and into the limits of "Shore Interlocking." At the 2E signal of Shore Interlocking, Train Number 188 received another "clear signal" indication.

The train speed at the time of engineer initiated emergency (EIE) was 106 mph and the last recorded train speed was 102 mph.

Amtrak Train Number 188 speed started to increase above the maximum authorized speed of 80 mph approximately 1.63 miles from the accident site. For the next 40 seconds, the throttle was left in a relative high position until the EIE was initiated at 9:20:35 p.m. (event recorder time) with speed at 106 mph. At 9:20:38 p.m. the event recorder stops with speed shown at 102 mph.

Conclusion:

The recorded speed indicated by the locomotive event recorder on Locomotive Number ATK 601 in the area of the derailment exceeds the published speed limits in Timetable Number 5 with the most recent General Order Number 504, effective Monday, October 6, 2014.

Analysis - Engineer Certification

The Engineer of Train Number 188 was a certified engineer in possession of a valid certification with an issue date of June 30, 2013. Amtrak hired the Engineer on June 29, 2006. Examination of documents regarding his two most recent locomotive engineer certification cycles revealed no deficiencies.

The documents included:

- State Driving record dated March 18, 2013, and April 20, 2010
- National Driving record dated March 19, 2013, and April 21, 2010
- Vision records dated April 18, 2013, and March 23, 2010
- Hearing records dated April 18, 2013, and March 23, 2010
- Knowledge exams dated November 5, 2012, and March 12, 2010
- Skills test dated May 29, 2013, and October 27, 2010

In 2009, the Engineer began receiving extensive training. The training included subject matter on signals and signal indication on Amtrak, UP, and BNSF. Other subjects included air brake exercises and required brakes tests; identification of components to specific types of locomotives; changing operating ends on various types of locomotives;

included air brake exercises and required brakes tests; identification of components to specific types of locomotives; changing operating ends on various types of locomotives; mechanical components; NORAC, UP, and BNSF color signals; timetables and operating rules; and courses on AED, and CPR training and hearing loss.

The Engineer also completed training on the physical characteristics of the Northeast Corridor (NEC) routes specific to the territory in which he was working on the day of the accident.

All training was passed with high scoring percentages and the supervisors were completely satisfied with the results.

The training and subject matter followed the procedures outlined in Amtrak's 49 CFR Part 240 submission dated April 2014.

Conclusion:

The Engineer of Train Number 188 was fully qualified to work the territory where the incident occurred. FRA reviewed this individuals training history and noted no exceptions.

Analysis - Locomotive and Passenger Car Consist Validation

Amtrak Train Number 188 consisted of one controlling locomotive and six passenger coaches and one café car. The train weighed approximately 955,000 pounds and was about 663 feet in length. The train consist was as follows:

Sequence	Car Type	Number	Capacity
1	Locomotive	601	2
2	Business Coach	81528	62
3	Passenger Coach	82776	72
4	Passenger Coach	82644	72
5	Café Coach	43346	00
6	Passenger Coach	82761	72
7	Passenger Coach	82797	72
8	Passenger Coach	82981	72

The railroad equipment involved in the derailment was Amtrak Locomotive Number ATK 601, an Amtrak Cities Sprinter-64 Siemens electric locomotive commonly referred to as ACS-64. The ACS-64 locomotive consists of a front and rear cab, joined in the center by the locomotive machinery room. The locomotive unit measures 67 feet in length, 10 feet wide, 12.5 feet high, and weighs approximately 210,000 pounds. The ACS-64 is powered by a network of 25kV AC (60 Hz), 12.5kV AC (60 Hz), and 12kV AC (25 Hz) overhead catenary power supplies, depending upon the location in the North East Corridor (NEC). These catenary power sources are accessed through the front and rear pantographs which are mounted on roof panel numbers 1 and 3.

The ACS-64 is an integral monocoque wide-body, double-cab design, suited for push-pull operation. The car body is comprised of four major elements: underfloor, side walls, front and rear cabs, and three detachable roof sections (roof panel numbers 1, 2, and 3). It is designed to allow compression forces of 800,000 pounds (400 tons) of buff load and is equipped with an Association of American Railroads (AAR) F-type coupler with a push-back mechanism to achieve full anti-climber engagement. Crash Energy Management systems are incorporated into the design of the ACS-64.

The Locomotive Engineer is protected by a safety cage comprised of different structural members such as side sills, collision posts, corner posts, structural shelfs, roof rails, top cross member, door posts and front sheathing. In front of the safety cage, crash boxes are designed to deform in a controlled manner to absorb collision energy. In case of an accident with another railroad vehicle, the coupler pushes back and the anti-climber interlocks. The arrangement of anti-climber and coupler complies with AAR standards.

The Amtrak passenger coaches involved in the derailment are designated as Amfleet coaches. The Amfleet coaches are a fleet of single-level intercity railroad passenger coach built by the Budd Company in the late 1970s and early 1980s and have served as the backbone of Amtrak's passenger rail car fleet. The Amfleet car body structure, with the exception of the end underframe which is a Low-Alloy- High-Tensile Steel (LAHT), is constructed entirely of stainless steel. The exterior skin is formed in corrugations for strength and appearance. An Amfleet coach is 12 feet and 8 inches tall (relative to the railhead), 10 feet and 6 inches wide, and 85 feet and 4 inches in length which include the end vestibule diaphragms. Depending on the configuration, an Amfleet coach weighs between 110,000 pounds and 116,000 pounds.

At the time the Amfleet coaches were built, the car body's strength exceeded all applicable AAR and FRA requirements. This included an 800,000-pound compression strength applied at the draft gear and lateral anti-climbers. Additionally, to improve the strength of the cars, the end collision post assemblies were made stronger than AAR requirements of the day by designing these assemblies for an ultimate horizontal load of 300,000 pounds applied 18 inches from the floor and at a 15-degree angle. The vertical end collision posts are constructed of stainless steel and are located on either side of the end door openings. They are fastened securely into a horizontal end plate at the top, and are welded to LAHT steel stubs extending up from the end underframe at the bottom.

Conclusion:

Locomotive Number ATK 601, Business Coach Number ATK 81528, Passenger Coach Number ATK 82776, Passenger Coach Number ATK 82644, Café Coach Number ATK 43346, Passenger Coach Number ATK Number 82761, Passenger Coach Number ATK 82797 and Passenger Coach Number ATK 82981 were properly identified, classified and documented as the equipment involved in the derailment.

Analysis - Equipment Pre-Accident Inspection

Amtrak passenger Train Number 181, which became Train Number 188 upon departing Washington DC, originated in New York, New York. This consist was equipped with Locomotive Number ATK 615 and passed a Class I air brake test by qualified maintenance inspectors (QMI) at 4:00 a.m. on May 12, 2015, and at Washington DC, Locomotive Number ATK 615 was removed to expedite the departure of the northbound Train Number 148. Locomotive Number ATK 601 arrived in Washington on Train Number 171 and was then added to Train Number 188.

Conclusion:

According to Amtrak inspection records, Train Number 188 passed all Federal Railroad Administration (FRA) required pre-departure tests.

Analysis - Equipment Post Accident Inspections

The National Transportation Safety Board (NTSB), FRA, Amtrak, and Siemens formed a mechanical group of qualified personal to evaluate the mechanical condition of the equipment involved in this derailment.

Investigators assembled at Amtrak's Maintenance Facility in Bear, Delaware. Five passenger cars, one café car, and their truck assemblies involved in the derailment were transported by flatbed trailer and offloaded in a large gravel area of the facility. Investigators documented accident damage to the Amfleet coaches braking systems and trucks and proceeded to make field repairs to those systems requiring minimal intervention. In some cases the tread brake units (TBU) and the disc brake units (DBU) on the truck assemblies that were severely damaged were isolated from the braking system and not repaired.

Once repairs were made, four passenger coaches and the café car were reunited with the original truck assemblies. All air lines were reconnected and brake function tests were completed on each car. After the car tests were completed, air hoses were used to join the main reservoir and brake pipe connections on all five cars. A calibrated single car brake test device was then used to complete a successful Class I brake test. The B-3-B conductor emergency brake valves within the coaches were tested and functioned as designed. Coach Number ATK 82776 was considered unsafe to entire due to exposed asbestos; therefore, this part of the interior test procedure for this coach was not performed.

Conclusion:

The team took no exceptions of the test results.

Analysis - Car Number ATK 81528 first car behind Locomotive Number ATK 601

The Business Coach Car Number ATK 81528 was destroyed and broken into three separate pieces. Each section of the frame was brought to the Bear facility and the air brake valves were removed from the car frame and sent to Amtrak's AAR certified air brake shop for testing.

Conclusion:

The 26C service portion, the Number 8 vent valve, the J-16 B and the E-3 application valve were all successfully tested on Amtrak's air brake test rack. However, the A-1 reduction pipe bracket with a Number 8 vent valve and a B-1 valve, the B-End GV-18 dump valve, the B-end E-3 application valve, both B-3-B emergency valves and the A-end GV-18 valve were either damaged or missing and could not be tested.

Analysis - Emergency Lighting and Public Address Systems

Investigators used a portable power supply (74V coach battery) to test each coach, with the exception of Car Number ATK 81528 and Car Number ATK 82776 to verify the proper function of the emergency lighting and public address systems.

Conclusion:

Both systems functioned as designed and took no exceptions of the results.

Analysis - Wheel Inspection, Brake Rigging, Brake Pads, Brake shoes and Discs.

Investigators examined all the wheels, brake rigging, brake pads, brake shoes and discs on Train Number 188.

Conclusion:

All the components inspected were compliant with all applicable Federal Regulations. The wheel treads showed no evidence of slid flats, or shelled spots. All undamaged brake rigging appeared normal and all brake pads, brake shoes and discs were within the applicable tolerance.

Investigators then assembled at Amtrak's Maintenance Facility in Wilmington, and met with representatives from Siemens to discuss follow up testing on Locomotive Number ATK 601. Investigators wanted to confirm proper operation of the following systems: Friction brake, Event recorder, Propulsion System, Alerter, Automatic Train Control, and Advanced Civil Speed Enforcement System (ACSES)

Analysis - Locomotive Number ATK 601 Friction Brake
Siemens applied 480 volt ground power to Locomotive Number ATK 601 and turned on the air compressor. The locomotive is equipped with a CCBII passenger brake system and is capable of running a portable test unit (PTU) based self-test on the CCBII brake system. Investigators completed both the PTU based self-test and Amtrak's daily departure test, which was manually completed by a Qualified Maintenance Person (QMP).

Conclusion:

The locomotive passed all steps as intended with one exception noted; the parking brake test. The step could not be performed due to damage caused from the derailment of Train Number188.

Analysis - Locomotive Number ATK 601 Event Recorder

Preliminary review of the accident event recorder data from the locomotive showed only three recorded positions of the master controller parameter instead of eight positions. The master controller has eight steps as it moves from idle to full power and the steps are referred to as notch positions. Four train lines are referenced by the onboard event recorder to determine the master controller position. The associated train lines will energize based on the percentage of power requested by the master controller.

Investigators along with engineers from Siemens troubleshot the failure to a feedback wire that was disconnected. The wire that was disconnected was the wire that converted the signal from the Siemens master controller to the WABTEC event recorder.

Conclusion:

Siemens' engineers demonstrated to investigators that signals between the master controller and the WABTEC event recorder were functional but not reporting to the event recorder. After the wire was reconnected and validated the event recorder functioned properly.

Analysis - Locomotive Number ATK 601 Propulsion System

The locomotive is equipped with a traction system that applies tractive force based on the master controller handle. The following main components are contributing to generate the traction needed to move the locomotive. Master controller driving and braking position is used for the generation of traction set values. The own loco's internal set value is generated notch-free and linearly from the handle position (0–100 percent). Central Control Unit (CCU) reads the master controller handle position and generates a traction set value. The CCU then receives the actual tractive force and available tractive force from the Traction Control Unit (TCU) and controls the set value accordingly. The resulting traction set value is processed and limited in kilonewtons (kN) for each axle and then is transmitted to the Traction Control Unit (TCU). The traction set value, is a binary coded set to a corresponding notched handle position (idle, 1 through 8) then transmitted to the locomotive. The train line values are used to generate traction when the train is in a push mode and/or using multiple locomotives. The configured of Train Number 188 was in the pull mode set up. The Traction Control Unit (TCU) generates the torque force set value from the CCU's traction set values. The TCU monitors the motors and inverters and regulates the tractive capacity and reports each axle's actual and available tractive force to the CCU.

Conclusion:

During our testing of the propulsion system, the master controller was moved to each traction position and showed the correct percentage values in the CCU. Investigators were able to view these values on a laptop computer which was connected to the CCU. The tests validated the correct master controller position that was translated into the correct demand of tractive and braking effort. The locomotive could not be moved and the TCU tractive effort readings could not be read. However, the CCU software has been validated and is stable (no alteration possible). The master controller position recorded settings on the event recorder showed the correct tractive effort values.

Analysis - Locomotive Number ATK 601 Alerter Test

An Amtrak QMP released the locomotive brakes from the Engineer's console, using the train operator's display (TOD) and ran an Alerter self-test. This self-test resulted in a penalty brake cylinder application of 64 pounds per square inch (PSI).

Conclusion:

Investigators took no exception and the alerter worked as designed.

Analysis - Locomotive Number ATK 601 Cab Signal & Advanced Civil Speed Enforcement System

The locomotive is equipped with an automatic train control (ATC) system. The system is a combined 9-Aspect ATC and Advanced Civil Speed Enforcement System (ACSES) configuration that ensures safe operation of the locomotive.

The ATC portion of the system includes Automatic Speed Control (ASC) and Automatic Train Supervision (ATS) capabilities. The ASC feature protects the locomotive from exceeding speed limits established by track signals. The ATS feature ensures that the Locomotive Engineer recognizes and acknowledges track signal (aspect) downgrades. A downgrade is a signal change that becomes more restrictive.

The ACSES portion of the system includes civil speed enforcement and Positive Train Stop (PTS) enforcement capabilities. The civil speed enforcement feature of ACSES protects the locomotive from exceeding civil speed limits. Civil speed limits are established by the presence of permanent and temporary wayside transponders. The PTS enforcement feature ensures that the locomotive stops at home signals when an absolute stop aspect is present.

Daily ATC and ACSES departure tests are required by FRA no later than every 24 hours. Each test must be conducted or verified by the Locomotive Engineer or QMP prior to the day's initial service run. Investigators used an inductive transmitting (test device) loop suspended under the ATC track receiver bars under the front end (F-End) cab was the lead cab during the derailment to simulate the speed codes into the ATC system. The bars were bent as a result of the derailment however, still functional. The full test was completed with the exception of the opposite end of the locomotive rear end (R-End) cab of the locomotive.

Conclusion:

All systems on the locomotive worked as designed. The ACSES system was not installed in the track that Train Number 188 was on at the time of derailment. Investigators took no exception to the findings.

Analysis - Track

The POD was determined to be on Track Number 2 at MP 81.62 on the south rail in full body of a left hand curve, identified as curve Number 298 by Amtrak. Inspection of the track revealed that there were marks on the south rail (high side of curve). It appears the flange of the Locomotive Number ATK 601 climbed the gage face of high rail, traveled approximately 22 feet, and dropped onto the concrete ties on the field side of the south rail. Locomotive Number ATK 601 was the first piece of equipment derailed and it came to rest upright and approximately 900 feet from the POD. The rail marks were attributed to the wheel flanges, which were on the right (south) side of Locomotive ATK Number 601 lead truck. There was no evidence at the POD the wheels on the inside of the curve contacted the ties in the gage. However, there was sand and arching marks on the inside rail just west of the POD that showed evidence of wheel lift.

The curve at MP 81.6 is a 4-degree 2-minute, left hand curve with a designed super elevation of 4 ¾ inches. The track is constructed with continuous welded rail (CWR) directly fixed onto concrete ties with Pandrol "e" clips and insulators. The concrete ties were manufactured by Rocla in 1992. The south rail in the curve (high side) was 136 pound-RE controlled cooled (CC) rail section manufactured by Bethlehem Steel Company in Steelton, PA in August of 1995. The north rail (low side) was 140 pound-RE CC also manufactured by Bethlehem in May of 1980. The ballast section is crushed granite. The tie cribs were full with an average of 12 inches of shoulder ballast. There is a gage face rail lubricator at MP 81.82 approximately 155 feet west of the curve Number 298. Grease lubrication was found on the rail gage face throughout the length of the curve.

On May 13, 2015, Amtrak, FRA, and the NTSB conducted a walking inspection of damages following the derailment. The POD was identified and Amtrak took track measurements for gage, cross level, and alignment. FRA and the NTSB observed and verified the measurements and no exceptions for Class 3 track were found. Amtrak visually inspects the track twice a week required by Federal Track Safety Standards. The last visual inspection on Track Number 2 was on May 12, 2015. A review of the records determined that Amtrak was in compliance of the required inspection frequency. Also, the inspection records showed that the track conditions in the curve demonstrated worn rail that caused a maintenance gage condition, but not a track defect.

Amtrak conducted track geometry car tests over the NEC twice a month. The last two geometry inspections were conducted on May 12, 2015 and on April 21, 2015. No track geometry defects were noted in the derailment area for the May 12 test. The data showed that a maximum maintenance gage of 57.63 inches was recorded approximately 171 feet east of the POD. FRA's maximum gage limit is 57 ¾ inches and Amtrak's maintenance limit is 57 ½ inches. Amtrak stated that the maintenance gage was a reflection of the curve worn rail, and the rail was scheduled for replacement in 2016. In addition, the new replacement rail was previously delivered and was lying east of the derailment.

The geometry car data included rail profile measurements. Near the POD, the rail profile showed a gage face wear angle of 24.1 degrees and Amtrak's maximum allowable gage face wear angle is 30 degrees. With a vertical head loss of 0.14 inches, Amtrak's maximum gage face wear limit is 0.6875 inches and the data showed 0.44 inches. Amtrak is not required to conduct a gage restraint measurement system (GRMS) test in curve Number 298; however, a test was conducted on May 19, 2014, and no track geometry defects were recorded in the curve. Amtrak's frequency for internal rail inspection is twice annually. The last two internal rail inspections for defects were on October 26 and on April 27, 2014, and no internal rail defects were detected in curve Number 298.

Conclusion:

The curve Number 298 at the POD was properly super-elevated (banked) for the posted Timetable Number 5 speed. No geometry defects were discovered during the post-accident inspection and the prior internal rail inspection did not find any exception near the POD. There are no indications of any rail or track defects that would be a cause or contributing factor in this derailment.

Analysis - Signal and Train Control (S&TC)

The method of operation between Matua and Holms Interlocking is Automatic Block Signal (ABS) with Cab Signal System (CSS). All main tracks, Track Numbers 1, 2, 3, and 4 on the NEC are equipped with cab signals and all trains operating on the NEC are equipped with Automatic Train Control (ATC) consisting of cab signals with speed control. The ATC system provides for train separation in compliance with FRA Regulations at 49 CFR Part 236.

On May 13, 2015, the NTSB, FRA, and Amtrak started a series of post-accident investigation inspections at Shore interlocking located near MP 82.1 on Amtrak's NEC. To expedite the inspections, two FRA S&TC Inspectors worked on site for several days resulting in multiple inspection reports. Shore Interlocking was the last signal control location Train Number 188 passed before the accident. Event recorder logs were downloaded at Shore Interlocking and Amtrak Centralized Electrification and Traffic Control (CETC) Operation Center in Wilmington. The time line of events were compared and this revealed a plus 6-minute, 40 second time off set between the event recorder at Shore Interlocking and the CETC operations event log.

All appropriate signal tests were performed at Shore Interlocking. Ground readings were taken on all busses and all track circuits in Shore Interlocking were 0.06 ohm shunt and verified. The switch obstruction, point detector, and switch correspondence tested for the crossovers. The switch and signal indication locking, route, time, traffic locking, time release intervals, signal lamp voltage readings, cab signal axel current readings, all insulated joints, and associated fouling sections were inspected. Current relay and cable test records were also reviewed. These inspections were carried out over 7 days generating FRA Form F 6180.96 inspection report numbers 48, 49, 50, 51, 52, 53, and 54 from one inspector and FRA F 6180.96 report numbers 31 and 32 from the other inspector.

A Post-accident S&TC inspection was performed at Amtrak's Wilmington Maintenance Facility in Wilmington, on May 19, 2015, on Locomotive Number ATK 601. The inspection consisted of checking seals on cab signal and positive train control cut-outs, performing a software management control plan (SMCP) audit, and observing Amtrak personnel performing a periodic test on the cab signal system. The cab signal pick-up current could not be accurately tested because the receiver bars were bent and no longer within tolerance. The front end cab signal system was tested and found to be working as intended. The rear end of Locomotive Number ATK 601 cab signal system could not be tested because the rear end cab was damaged.

The SMCP audit was performed by comparing Amtrak's SMCP Inventory to the cab signal and positive control equipment on Locomotive Number ATK 601. The audit revealed that the onboard software revisions matched the revisions shown on Amtrak's inventory. FRA F 6180.96 inspection report Number 34 was generated and one defect was noted for an ineffective seal on the alerter cut-out switch. The download showed that the alerter was cut-in at the time of the derailment. Twelve months of MAP 100 (Daily and After Trip Test) and MAP 8 (Periodic Test) test records were obtained from Amtrak's Ivy City Maintenance Facility in Washington, DC. The records were reviewed and FRA F 6180.96 inspection report Number 35 was generated. Two minor defects were noted for information missing from two MAP 100 test records.

Conclusion:

All the testing and inspections revealed no abnormalities that would contribute to the train accident. There was no damage sustained to the signal equipment as a result of this accident.

It is noted that during the investigation of Amtrak's derailment, a violation was cited for missing safety equipment associated with an electric locked hand crossover switch within Shore Interlocking, not part of the NEC. This defective condition was discovered on non-electrified track and Train Number 188 did not operate over this route. This hand crossover is located between the NJ Transit Atlantic City Line and Conrail Delair Branch.

S&TC Locomotive inspection defects noted on FRA inspection reports Number 34 and Number 35 were non-contributory to the derailment of Train Number 188.

During this investigation, it was noted that a train accident involving excessive speed in a speed restricted curve occurred at Boston's Back Bay Station on December 12, 1990. Amtrak reviewed all curves on the NEC where trains might reach overturning speed if the operator failed to reduce speed from normal speed as the train approached the restricted curve. There were 10 curves where this could possibly occur between Boston and Washington, DC. On each of these curves where the overturning speed of the curve was less than the normal speed approaching the curve, a cab signal change point was added to down grade the cab signal from clear to approach medium for a calculated period of time. The time was calculated such that a train traveling at normal speed would be forced to slow down to the curve speed or well below overturning speed before the cab signal was upgraded back to clear. The maximum authorized speed for Train Number 188 between 30th Street Station and Shore interlocking was 80 mph, which was below overturning speed of 98 mph for the 50 mph speed restricted curve east of Shore Interlocking. No cab signal code change was ever installed eastward.

Overall Conclusions

FRA's post-accident investigation of the equipment involved test records, inspections and maintenance performed prior to the accident revealed no contributing cause.

The inspection of the signal system included records of tests and maintenance performed prior to the accident that indicated the signal system was working as intended.

The crew was current with regard to physical and test exams, training and certification.

Measurements of the post-accident track geometry and a review of previous automated track geometry records in the vicinity of the derailment site demonstrated that the track geometry was in compliance.

A review of Amtrak's track inspection reports, periodic inspection reports and rail inspection records indicated that Amtrak was in compliance with the frequency of the required inspections, the reporting of exceptions and taking the required remedial action in a timely manner.
Human factor elements of the train crew with regard to rest periods and fatigue were analyzed and no exceptions were taken.

Information is missing regarding the minutes before the accident because the Engineer stated that he sustained a head injury and cannot remember any details of what he was thinking or doing after passing Septa Train Number 769 or more precisely after passing the North Philadelphia Train Station.

A review of Locomotive Number ATK 601 event recorder demonstrated that train speed exceeded the maximum authorized speed listed in Timetable Number 5.

The NTSB took possession of the Engineer's cell phone and was provided a copy of T-Mobile phone record data. The cell phone records were subpoenaed by the FRA. Although at first the records appear to indicate calls were made, text messages sent, and data used at the time of the accident, an analysis of the phone records indicated otherwise. The analysis demonstrated that no calls, texts, or data usage occurred during the time the Engineer was operating the train.

Reports of vandals throwing rocks or shots fired at passing trains, SEPTA Train Number 769 and Amtrak Train Number 2173, near the North Philadelphia Station minutes before the accident, lead investigators to request an FBI team to investigate windshield damage to Amtrak Locomotive Number ATK 601 and explain a possible distraction to the Engineer of Amtrak Train Number 188. Test results from this investigation and analysis of the Locomotive Number ATK 601 windshield did not show evidence of ballistic residue. The damage to the windshield was caused from the derailment.

The parties to the investigation include the NTSB, FRA, Amtrak; the Philadelphia Police Department; the Philadelphia Office of Emergency Services; the Philadelphia Fire Department; BLET; the International Association of Sheet Metal, Air, Rail and Transportation Workers, and the Brotherhood of Maintenance of Way Employees.

Probable Cause

FRA's investigation determined that the cause of the derailment was due to the train traveling at an excessive speed entering a speed-restricted 4-degree, 2-minute left hand curve identified as Curve Number 298 and referenced by FRA Train Accident Cause Code H604 (Train outside yard limits, in block signal or interlocking territory, excessive speed).

Curve Number 298 was assigned a speed restriction of 50 mph. The curve was structured with a super elevation of 4 ¾ inches and the turn over speed inside the curve was designed for 98 mph. The excessive speed in the curve caused "high-lateral-wheel forces" to develop and forced the wheels on Locomotive Number ATK 601 to climb the south rail and lift off the north rail (wheel unloading) that resulted in an overturn of Train Number 188 at 102 mph. Based on the results of the investigation and the available information reviewed, no other contributing causes were discovered.