National Transportation Safety Board

Office of Railroad, Pipeline and Hazardous Materials Investigations

Washington, D.C. 20594

Union Pacific – Rear End Collision

Granite Canyon, Wyoming

October 4, 2018

Mechanical Group Factual Report

Accident

NTSB Accident Number:	RRD19FR001
Date of Accident:	October 4, 2018
Time of Accident:	7:38 p.m. (MDT)
Type of Trains:	Freight
Railroad Owner:	Union Pacific
Train Operator:	Union Pacific
Fatalities:	2
Location of Accident:	Granite Canyon, WY

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Synopsis

On October 4, 2018 at 7:38 p.m., mountain daylight time, an eastbound Union Pacific (UP) freight train collided with the rear of a stationary UP freight train in Granite Canyon, Wyoming at about milepost (MP) 527. The crew of UP freight train (MGRCY 04), reported problems with the train airbrake system; the train crew radioed the UP Harriman Dispatch Center to tell them they had accelerated to 50 mph and were unable to stop their train. The train was traveling on a descending grade leading up to the collision. The crew of the stationary train (MPCNP 03) had de-boarded and cleared the area after receiving instruction from the dispatcher. Three locomotives and 57 cars of the striking train derailed as well as 8 cars of the stationary train. UP initially focused efforts on the recovery of the train crew, the bodies of both train crew members were located near the wreckage. No hazardous materials were released. The accident occurred near MP 527 on the Laramie Subdivision, approximately 35 miles west of Cheyenne, WY. At the time of the accident, the sky was clear, the wind was from the southwest at about 10 mph, and the temperature was about 45° F.

Figure 1 Depicting the front of the striking train (left) and the rear of the struck train (right)

Train Consist

<u>MGRCY 04</u>

The striking train had three locomotives on the head end, 95 loads, and 10 empties for a total of 12,417 tons and was 6,581 feet long.

1 UP 5412	C45ACCTE	Forward
2 UP 5842	C44ACETE	Forward
3 UP 5003	SD70M	Forward

<u>MPCNP 03</u>

The struck train had two locomotives on the head end, UP 7113 and UP 7620, and one mid train DPU, UP 9008. The train had 90 loads and 67 empties for a total of 13,474 tons and was 10,103 feet long.

Pre-departure Inspections

The MGRCY 04 originated in Green River, Wyoming. A Class I Air Brake test and pre-departure inspection was conducted by Union Pacific Qualified Mechanical Inspectors at Green River, Wyoming. The train was built on track 19 and 20 with a jumper hose connecting the two halves and was tested using a yard test device. Yard air was connected on the east end of both tracks with an ETD on the west end of track 20. There were no means to properly verify air pressure on the west end of track 19 with a gauge or other device which is not in compliance with 49 CFR 232.217.c.2 which states *"At a minimum, yard air pressure shall be 60 psi at the end of the consist or block of cars opposite from the yard test device and shall be within 15 psi of the regulator valve setting on yard test device."* The ETD was tested on the rear of the train while the locomotives were not coupled to the train. The outbound engineer performed an application and release test before departing Green River.

Equipment Post-accident Inspections

The mechanical group met on the morning of October 6, 2018, at the accident site. The following observations were made:

- Multiple wheel sets show signs of overheating and sliding in the general pile-up area towards the front of the consist. (figure 2)
- Multiple freight car brake beams show signs of excessive braking as evidenced by brake shoes worn to the backing plate and worn through to the brake head. (figure 3)
- The "A" end intermediate air hose of the 20th car from the head end (SSW87597 – bulkhead flat) show signs of kinking. (figure 4)
- An airbrake test was conducted on the remaining non-derailed cars of the striking train and resulted in no defects that would have affected the train performance, nor contributed to a "0 CFM" air flow reading through the brake pipe.
- The mechanical group met on the morning of October 7, 2018, at the accident site. The following observations were made:
- About 45-50 car wheel sets were marked that showed signs of overheating and sliding. (figure 5)
- A review of the wheel detector report for the subject train indicated that axles 18-54 exhibited higher temperature readings than the remaining axles in the train.
- Axle 54 is placed on the trailing axle of the 9th car from the head end.

Figure 2 A wheel found toward the front end of the consist with bluing.

Figure 3 A worn brake shoe found towards the front of the consist.

Figure 4 The "A" end intermediate air hose from car position 20.

Figure 5 Marked wheels that show signs of overheating or sliding.

Incidents that occurred – Post-accident

On November 23, 2018, a train crew working west of Cheyenne, WY experienced similar issues while descending heavy grade territory. After reducing the brake pipe pressure in an attempt to apply the air brake on the train, the crew realized that the reduction was not communicated to the rear of the train. The crew then attempted to apply emergency brakes by toggling the emergency brake function on the HOT device and the train went into emergency braking on the third attempt. Upon inspection, employees discovered a kinked trainline hose as seen in figure 6.

Figure 6 Kinked air hose on car west of Cheyenne, WY.

On December 20, 2018, a car that had recently received end hose arrangement repairs from a car repair shop was discovered on an outbound train by inspectors that had a similar kink. The end hose arrangement application was incorrect causing this defect in figure 7.

Figure 7 Kinked intermediate air hose after misapplication.

Post-accident action by Union Pacific

In December of 2018, Union Pacific created training material that covered proper repair and inspection of freight car end hose arrangements. This training contains a multiple point inspection criterion concerning proper air hose supports, pinched air hoses, fittings, valves, brake rigging interference, wear marks, and dimensions. All car department mechanical forces received this training by the end of December.

In Green River, WY, railroad management revised the air brake testing procedures to more closely match the requirements of 49 CFR Part 232 (Brake system safety standards for freight and other non-passenger train and equipment; end-of-train devices). The procedures now require a gauge (or equivalent) to be placed at the end of each block of cars to verify air pressure.

Testing at Union Pacific, Council Bluffs, IA

On November 15, 2018, investigators convened at the Union Pacific repair facility in Council Bluffs, IA to examine similar cars to those involved in the collision. The examination was conducted to gain a better understanding of the coupling and end hose arrangements between two cars involved in the accident and to gather measurements and data which will be utilized at subsequent laboratory tests.

Two cars are of particular interest to the investigation. Car No. SSW 87597 was a 71-foot long bulkhead flat car loaded with steel. Prior to the accident the car arrived in Laramie where it was the first car behind the front locomotives. After a pickup of 19 additional cars in Laramie, it was the 20th car behind the locomotives.

Car No. SP 338282 was a 59-foot long gondola partially loaded with steel rail. This car was added to the striking train, 19 cars behind the locomotive (Coupled to the SSW 87597).

The end hose arrangements, to include a small portion of the brake pipe, secondary hoses, intermediate hoses, angle cocks, EOC trainline brackets, and end hoses were retained from both ends of the SSW 87597 and shipped to the Strato laboratory in New Jersey for testing.

In order to better understand the types of testing to be done and to take measurements of the arrangements for the test rig set up at Strato, two in-service cars closely resembling the destroyed cars were captured and retained by Union Pacific at the Council Bluffs repair facility. As shown in figures below, the bulkhead flat car SSW 87591 represents the SSW 87597 and gondola SP 338286 represents SP 338282.

Figure 6 SSW 87597 shown years prior to the accident.

Figure 7 SP 338282 shown years prior to the accident.

Figure 8 SSW 87591 in Council Bluffs on November 15, 2018.

Figure 9 SP 338286 in Council Bluffs on November 15, 2018.

Initial Observations

It was noted that exemplar Car SSW 87591 (bulkhead flat) had a few notable differences from the accident car. First, both ends of the exemplar car had end hose arrangements that did not utilize the S-4021 bracket, whereas the accident car did have a S-4021 bracket on both ends. This means that the exemplar car did not utilize a secondary hose and the angle cock was located under the coupler as opposed to on the end sill. The Strato representative explained that historically, brackets were welded to the cushioning device to support trainline angle cocks. However, because dissimilar metals were used, and because welding practices varied, cracks often developed in these areas leading to undesired emergencies and equipment not secured properly. Therefore, AAR changed the standards (Field Manual Rule 6) and required a coupler mounted bracket or other mechanical securement to be used in lieu of welding. When a CMB was used, the location of the angle cock had to be changed. The change in standards over time has led to variations between cars, and often between ends of the same car.

Car No. SP 338286 had a few differences as well. The B-end of the car had a S-4021 bracket, whereas the accident car did not. The A-end of the exemplar car had a bracket which is similar to the accident car. Secondly, it was noted that the B-end intermediate hose had an observable kink in a vertical direction. There was wear on the hose where it had contacted the center sill and/or cushioning unit. While this is different than the sister gondola car, it is similar to what the bulkhead flat car SSW 87597 was found with post-accident. Also, the B-end arrangement appeared to be installed improperly, with missing components replaced with a cotter key and a large water trap (low spot in the hose) formed in the intermediate hose.

Figure 10 SSW 87591 A-End (left) and SP 338286 B-end (right).

<u>Examination</u>

Representatives from Strato and Union Pacific began by taking measurements of the SSW 87591 to determine the proper set up for the laboratory testing scheduled at Strato. Investigators took note of brake pipe/hose, angle cock, hook anchors, any obstructions, as well as potential hose support locations. Most of these locations can be correlated with the accident train scenario within a reasonable degree.

The laboratory test rig must also account for the location of the hose support, a chain and strap device connecting the intermediate hose to the car body. Based on the preliminary information from the accident and manual manipulation of the hoses, including applying the same bracket to the sister car, it was ultimately decided that the location of the hose support just prior to the accident cannot be determined at this time. Strato representatives will attempt to make a test rig which can vary the location of the attachment for examination in the laboratory. The evidence suggests that the location of the strap on the hose and the location of the chain on the car body could be a factor in the forces and pinch points in the hose system.

Testing Hoses at Strato

On December 20, 2018 the mechanical group convened at the Strato facility in Piscataway, NJ, to examine the hose assemblies from car SSW 87597 as well as representative new components and assemblies. The examination was conducted to further the group's understanding of the physical relationships of end hoses, intermediate hoses, secondary hoses, support arrangements, in-train forces and their effects on air flow, brake signal propagation, and brake function.

Initial Observations

Preliminary examination of the subject intermediate hose support chain interface is consistent with the support chain not moving along the length of the intermediate hose before or during the accident. Preliminary evidence is also consistent with the chain support having been disconnected from the car body and wrapped around the hose causing premature wear prior to the accident.

Figure 11Wear marks on the intermediate hose

Intermediate hoses consist of an inner rubber layer, 2 layers of metal wire reinforcement and a textile reinforcement layer (each separated by a thin layer of rubber) and a rubber cover. They are rated for 300 psi, tested at 600 psi, and used in freight rail operations at 90 psi.

Examination

The mechanical group used data taken from the previous Council Bluffs inspection to arrange a demonstration rig. This platform allowed the group to observe normal and worst case operational situations.

Figure 12 Test rig example at Strato.

Based on the measurements of the sister cars in Council Bluffs, the car did not have any components that would have caused hose interference of obstruction, however the group recreated obstructed flow scenarios by putting the test rig in different buff and draft positions and placing the hose support in different locations in a manner to induce kinking. An air flow meter was connected to the rig to observe any air flow fluctuations while conducting these tests. The pressure in the hose was 90 psi and the flow was reduced to approximately 24 CFM. Initial event recorder data shows that previous to the incident, air flow readings were recorded between 20 to 27 CFM. Based on that data, investigators agreed to conduct testing at 24 CFM.

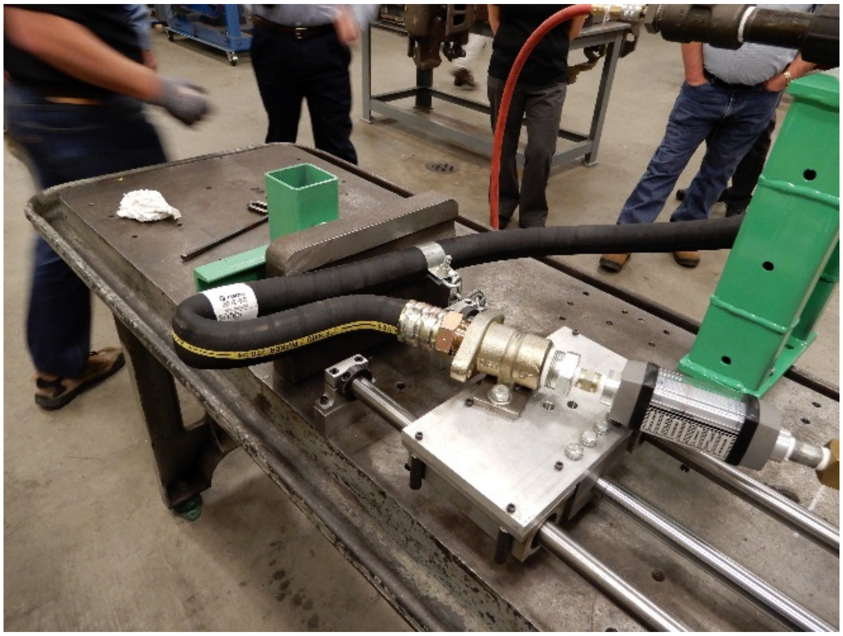

Figure 13 Pinched hose demonstration to study airflow. Not based on subject car geometry.

Investigators observed no changes in the air flow on the subject hoses from car SSW 87597 or on new hoses tested in multiple scenarios in an attempt to kink them. It was also observed that flow through the subject hoses was possible in nearly any configuration due to the material's tendency to form a figure eight (8) shape variance when kinked or compressed. (See figure 14) Investigators were unable to kink any hoses while pressurized to reduce the flow to 0 CFM.

Figure 14 Demonstrating figure eight (8) shape while compressing the hose using a vice.

Testing at Wabtec, Germantown, MD

On February 12, 2019, investigators gathered at the Wabtec facility in Germantown, MD, to test the components collected from the subject trains lead locomotive, UP 5412. These three components were evaluated by Wabtec (The manufacturer) to evaluate the functionality of these components and determine if they function as designed.

Air Brake Power Supply

The FastBrake Power Supply Unit houses the airbrake's central computer and contains the time-stamped history log of airbrake events and faults. The Power Supply Unit was severely damaged; however, it was still operational when powered up and the history log and software part number and version number were able to be downloaded. There were no discrepancies observed that would indicate a faulty unit.

Brake Valve Controller

The Brake Valve Controller was damaged, however both Automatic and Independent handles could still be moved through their full operating range. The controller was connected to the FastBrake Power Supply Unit previously described and was tested using a laptop software tool. Proper communication to the Brake Valve Controller was achieved, and both handle encoders worked properly, indicating correct encoder counts for the respective handle positions. The emergency, bail off, and two release limit switches all worked per design.

Brake Pipe Portion

The brake pipe portion was severely damaged. The outer case of the portion had been smashed in, pushing the center of the PC board out. Several chips and components were either broken and smashed, or popped off the board, so due to the damaged board, the portion was not operational and could not be fully tested; however, a portion of the test procedure was used to test the pneumatic functions of the BP portion. Wabtec tested the diaphragm relay valve, solenoid valves, transducers, and checked the portion for leaks. All the relay valves functioned as intended. The transducers all worked and were in calibration. The relay valve, the cutout valve, and the emergency valve all functioned per design. The complete portion was tested for leakage. One very small leak on the emergency solenoid valve exhaust was noted later in the test, however this leak has no impact on the functionality of the valve and the emergency function worked properly.

Testing at Parker, Wickliffe, OH

Parker is the manufacturer of the hose material that Strato uses to assemble their hose assemblies. The subject hoses from car SSW 87597 were shipped from the Strato facility to the Parker facility in Wickliffe, OH for non-destructive examinations. On March 6, 2019, Parker representatives conducted a video recorded borescope observation and pressure testing.

The borescope revealed no anomalies within the inside diameter of the hose assemblies. The hoses were also pressure tested with nitrogen at 100 psi. No leakage was observed during testing.

On May 14, 2019, Parker representatives also conducted a video recorded borescope observation while applying 29.9 Hg of vacuum to the hoses to induce any internal delaminations of the material. No applicable anomalies were observed.

On May 23, 2019, Parker representatives X-rayed the subject hose to identify if any internal anomalies existed. The results indicated that there were no anomalies observed that could have obstructed the flow of air.

Air Brake Functionality

Mechanical group investigators drafted a list of questions for the lead locomotive (UP 5412) manufacturer, General Electric, and the air brake manufacturer, Wabtec, to further analyze the trains performance.

<u>Wabtec</u>

> <u>Why is the AFM not recorded on the event recorder below 20 CFM?</u>
>
> *The air flow data sent to the locomotive computer would be one of the requirements designed into the airbrake system, typically driven from the locomotive builder and/or end railroad user.*
>
> <u>Is there a procedure to extract CFM data from any equipment below 20 CFM?</u>

The airbrake determines flow by measuring the difference in pressure on either side of and orifice in the L-19 flow block. The L-19 flow block has a 19/64th inch orifice that is placed between the Main Reservoir and BP control valve. When BP is not being charged, air pressure on both sides of the orifice is equal. As the BP supply valve begins to open, air starts to flow through the orifice. This causes resistance to the air flow and the MR side of the orifice pressure becomes higher than the downstream side of the orifice, or the BP side. We calculate the flow from this differential pressure. We send unfiltered differential pressure to the locomotive over the LSI communications protocol, but the calculated flow, also sent over the LSI message, is clipped at 20 CFM.

<u>How Accurate is the AFM through its full range?</u>

We have not checked accuracy throughout the air flow's full range, it is only checked for calibration at the 60 CFM level, since that is the value that is used for acceptable BP leakage requirements. Many factors affect air flow accuracy. One of the major contributors is the locomotive MR piping configuration, and since locomotive piping varies from model to model, accuracy and precision throughout the full range would also vary or have different curves for each configuration.

<u>How is air flow measured? What is the source?</u>

See answer above.

<u>What does the operator see on the display panel when the CFM is below 20?</u>

This display field is under the locomotive builder's control, but I believe it displays 0 on flow levels below 20 CFM.

<u>General Electric</u>

<u>Why do we not record any value under 20 CFM for the AFM data? Is it any different for Fastbrake, EPIC and CCBII?</u>

The Wabtec Fastbrake and NYAB CCB-II Electronic Air Brake (EAB) systems *report air flow in the LSI 197/64 message as 0 cfm when the air flow is below approximately 20 cfm. The Wabtec EPIC EAB system reports the air flow value as 0 cfm when the air flow is below approximately 10 cfm. This behavior is to address air flow measurement limitations within the EAB system when there is low air flow.*

<u>What is the order of magnitude that the data is accurate to below 20 CFM? Is it any different for Fastbrake, EPIC and CCBII?</u>

Wabtec Railway Electronics and NYAB express difficulty in quantifying the measurement accuracy of air flow below 20 cfm for Fastbrake and CCB-II and 10 cfm for EPIC EAB systems.

<u>According to the air brake team of Wabtec the information below 20 CFM is passed in the LSI Protocol. Is that recorded anywhere that we can pull?</u>

Refer to the response for question 1. While the UP Version 7 and 8 event recorder datasets record EAB air flow, this parameter directly correlates to the air flow reported by the EAB system in the LSI 197/64 message. The Fastbrake, EPIC, and CCB-II EAB systems do not record air flow.

<u>According to Wabtec Airbrake they send an unfiltered differential pressure for CFM to the locomotive over the LSI communications protocol, but the calculated flow, is also sent over the LSI message. Is the unfiltered differential pressure stored in any location?</u>

The EVO locomotive control system is able to transmit the Air Flow Differential pressure to the event recorder; however, it is not defined in any UP event recorder dataset. Furthermore, the Air Flow Differential pressure is not defined in AAR S-591 as a component of the engineer's display and the EVO locomotive control system only displays it for vacuum brake systems.

Freight Car Maintenance

After review of the car maintenance history records, investigators discovered that 6 of the 19 cars that were picked up in Laramie, WY, were overdue a single car air brake test as required in 49 CFR 232.305.c which states in part *“Each car shall receive a single car air brake test no less than every 5 years.”*

Evidence Collected

UP 5412

- LDARS sn:1215578
- IPM sn:0605wa02143
- CIO sn:17fl455a1r
- FOT sn:0380306
- FB power supply sn:530462
- BP control portion sn: N/A
- Auto brake valve sn:050502

UP 5842

- LDARS sn:1215578

UP 5003

- LDARS sn:1208041

SSW 87597

- “A” and “B” brake pipe hose assembly

Train

- EOT UP rq65471

Documentation Received

- Locomotive wheel sizes
- Locomotive blue cards

- Locomotive daily inspection records
- Locomotive maintenance and repair records (6 months)
- Locomotive software upgrade versions and history
- Locomotive diagrams
- GE locomotive health log
- Train consist for both trains
- Wheel detector report
- Repair records for the leading 20 cars (1 year)
- SCT records for the leading 20 cars
- Air brake test records
- Class I EOT test procedures
- CRB report
- EOT maintenance records
- EOT download
- Record of the EOT testing
- Movement history of the 10 MoW cars