National Transportation Safety Board
Office of Highway Safety
Washington, DC 20594

HWY24MH005

VEHICLE FACTORS

Group Chair's Factual Report

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A. CRASH INFORMATION

Location: Rushville, Schuyler County, Illinois
Date: March 11, 2024
Time: 11:29 a.m. CDT

B. VEHICLE FACTORS GROUP

Group Chair	Justin Snider National Transportation Safety Board Washington, DC
Group Member	Brock Lewis Illinois State Police

C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Information and Summary Report*, which can be found in the NTSB docket for this investigation.

D. DETAILS OF THE INVESTIGATION

The Vehicle Factors Group Chair's Factual Report is a collection of information regarding vehicles involved in this crash. This report details the post-crash mechanical and operational conditions of the 2020 Micro Bird MB-II (Micro Bird) and the 2001 Mack CH613 truck-tractor in combination with a Vantage Dump Trailers Inc. T91-SS end-dump semitrailer (Mack, or Mack combination).

The Illinois State Police (ISP) conducted preliminary inspections of the Micro Bird and Mack combination while on scene and subsequently on March 12, 2024. These vehicles were towed to Belville's Towing in Beardstown, Illinois, where they were inspected by NTSB investigators in conjunction with the ISP between March 15, 2024, and March 18, 2023. Where present, inspected mechanical systems on the vehicles included:

- Electrical
- Powertrain
- Steering
- Suspension
- Tires and wheels
- Braking

The overall crash damage was documented, as well as any damage or anomalies within the major vehicle mechanical systems. For uniform descriptions, "left" will refer to the driver's side, and "right" will refer to the passenger's side of the inspected vehicles.

E. VEHICLE EXAMINATIONS

1.0 2020 Micro Bird MB-II

1.1 General Information

Chassis Make:	Ford
Model:	Transit 350
Bus Body Make:	Micro Bird
Bus Body Model:	MB-II
Serial Number:	20-26042
VIN:[1]	1FDES6PG9LKA46677
Model Year:	2020
Date of Manufacture:	February 2020
In-Service Date:	November 2021
Mileage:	44,626
GVWR:[2]	10,360 lbs.
GAWR,[3] Axle 1:	4,630 lbs.
GAWR, Axle 2:	7,275 lbs.
Engine:	Ford V-6 turbocharged gasoline
Transmission:	10-speed automatic
Rear Axle Ratio:	3.73:1
Steering Gear:	Ford electric rack and pinion
Brake Type:	Hydraulic disc with antilock braking system (ABS)

[1] Vehicle Identification Number (VIN).
[2] Gross Vehicle Weight Rating (GVWR) is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself, plus fuel, passengers, and cargo.
[3] Gross Axle Weight Rating (GAWR) is the maximum distributed weight that a given axle is designed to support.

1.2 Vehicle Summary

This vehicle was a two-stage manufactured school bus (Figure 1). The first stage consisted of a 2020 model year rear-wheel drive Ford Transit 350 cutaway incomplete chassis with a 156-inch wheelbase and dual rear wheels (DRW). The final stage consisted of the Ford cutaway chassis paired with a 2020 model year 25-passenger school bus body, which was completed in April 2020 by Micro Bird Corporation and delivered to Central Bus Sales, Inc. as a Micro Bird MB-II type A-2 school bus. At its position of rest, the Micro Bird was on its wheels, facing northeast in a grass-covered drainage ditch. The front of the Micro Bird was in contact with the front of the Mack.

Figure 1. An exemplar 2021 Micro Bird MB-II.

1.3 Damage Description

The Micro Bird sustained contact damage to the front, which resulted in crumpling, tearing, and rearward displacement of all components above the front sub frame. The engine was displaced into the occupant compartment. As a result of the post-crash fire, most of the remaining vehicle sustained thermal damage (Figure 2). Refer to the docket for additional damage description and vehicle damage profile.

Figure 2. The condition of the Micro Bird at the time of post-crash inspection on March 17, 2024.

1.4 Weight and Measurements

According to a configuration diagram for the Micro Bird MB II, the empty vehicle weighed 7,178 pounds.[4]

The crash-involved Micro Bird and an exemplar 2021 Micro Bird MB-II were scanned by NTSB investigators using a three-dimensional terrestrial laser scanner and point clouds were created for each vehicle. Refer to the docket for additional information regarding the three-dimensional laser scans. Vehicle dimensions were determined by measuring three-dimensional points in the point clouds using CloudCompare software (Figure 3). According to specifications for Micro Bird T-Series (Ford Transit 350 cutaway) school busses, the undamaged Micro Bird MB-II had an overall length of 274 inches (22 feet 8 inches) and overall width of 86 inches (7 feet 2 inches) and wheelbase of 156 inches (13 feet).[5]

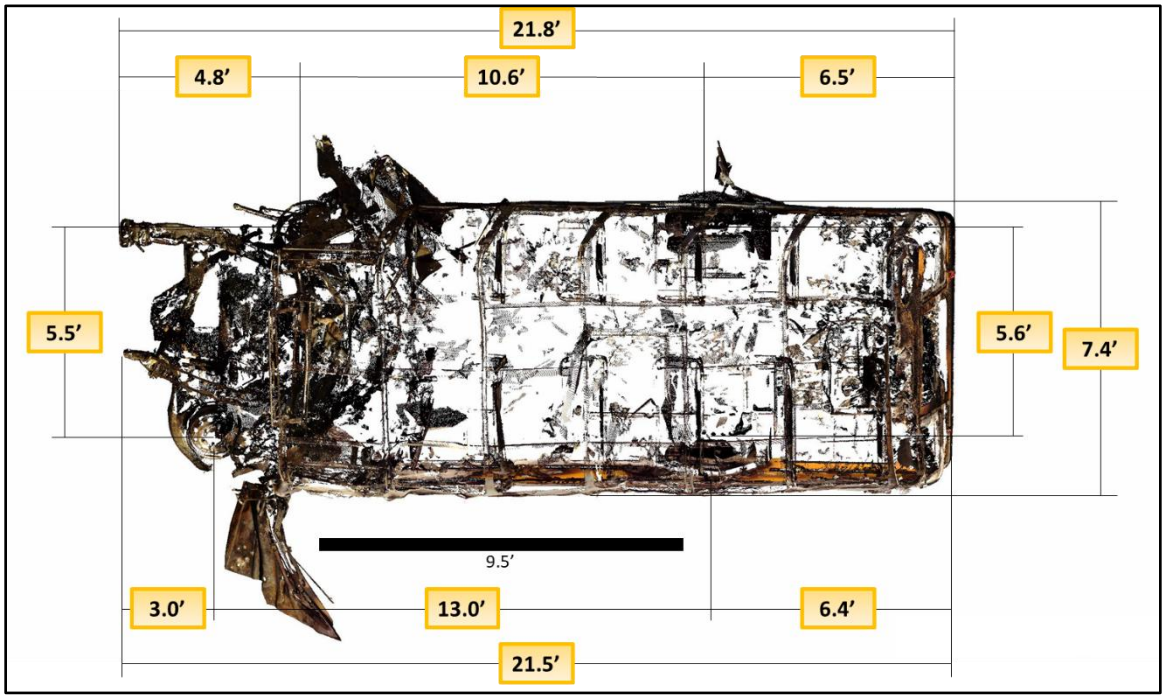

Figure 3. Three-dimensional laser scan of the Micro Bird.

[4] Vehicle Factors Attachment – Micro Bird Configuration Diagram.
[5] Vehicle Factors Attachment – Micro Bird Specifications.

1.5 Driver Controls

The Micro Bird was equipped with a tilt and telescoping steering column. The steering wheel was detached from the upper steering shaft and was not found during the inspection. Due to rearward displacement of the bulkhead and thermal damage sustained by the interior of the Micro Bird during the crash and post-crash fire, the position of the steering column was not determined (Figure 4). All gauges and switches were destroyed during the post-crash fire; therefore, driver control conditions (Figure 5) were not determined.

Figure 4. The condition of driver controls at inspection of the Micro Bird.

The locations of driver controls for an exemplar 2021 Micro Bird MB-II were documented in photographs by NTSB investigators (Figure 5).

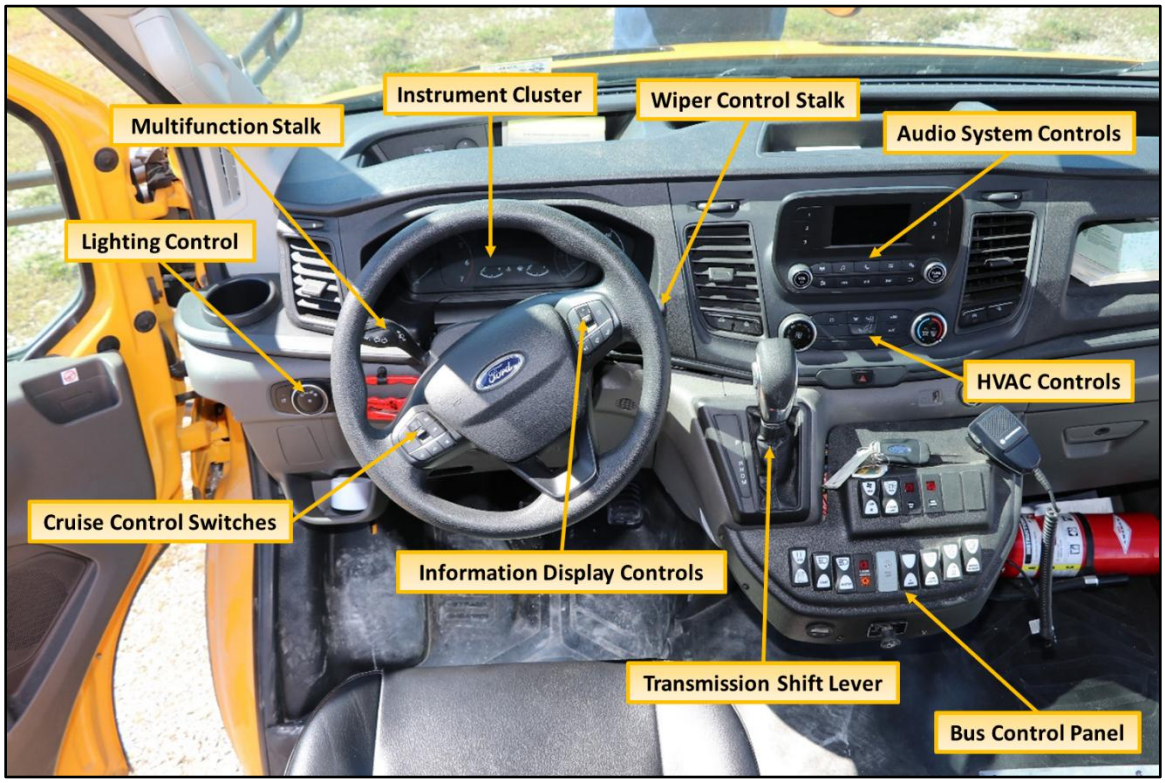

Figure 5. Driver controls for an exemplar 2021 Micro Bird MB-II.

1.6 Electrical System

The vehicle batteries, most lights, and most of the wiring were destroyed during the post-crash fire. Four incandescent warning lights mounted to a panel below the roof on the rear of the vehicle had sustained thermal damage during the post-crash fire but were still in place after the crash. All four lights and most of the panel were missing from the Micro Bird when inspected by NTSB investigators.

1.7 Powertrain

The powertrain consisted of a six-cylinder (V configuration) gasoline engine, 10-speed automatic transmission, a multi-piece propeller shaft,[6] and one rear drive axle assembly (axle 2) with 3.73:1 gear ratio. The engine was mounted longitudinally at the front of the vehicle. The engine and all associated accessories had been displaced rearward, into the occupant space during the crash, and had sustained thermal damage during the post-crash fire (Figure 6). Engine fluids were not inspected. The accelerator pedal assembly, which would have been mounted to the interior side of the bulkhead, was destroyed during the crash and post-crash fire and was not available for inspection. The transmission gear lever, which would have been mounted to the dash (Figure 5), to the right of the steering column, was destroyed during the crash and post-crash fire.

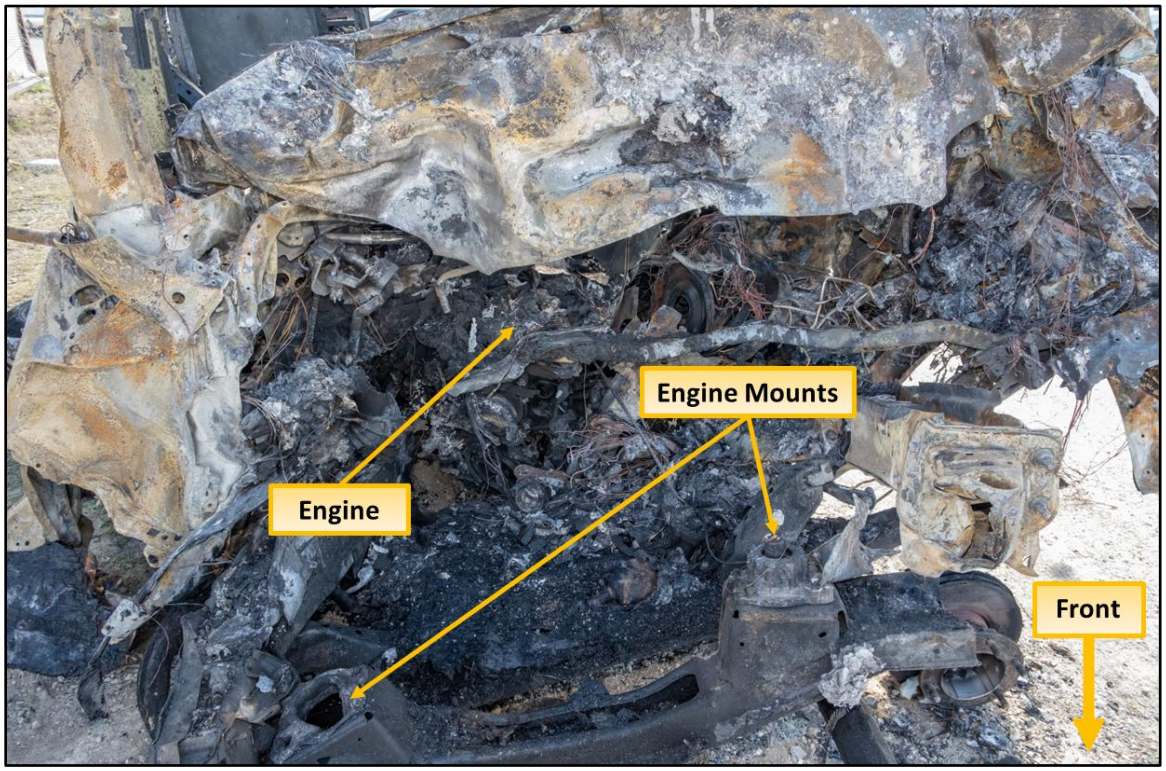

Figure 6. Condition of the engine compartment at inspection of the Micro Bird.

[6] Commonly referred to as drive shafts.

Power was transferred from the output shaft of the transmission to the input at the front of the axle 2 housing through a two-piece propeller shaft assembly connected with universal joints (u-joints) and supported by a carrier bearing near the middle of the assembly. The front propeller shaft was broken into two pieces, with the rear piece remaining attached to the carrier bearing, which was bent and distorted on the underside of the vehicle body (Figure 7). The forward half of the front propeller shaft was detached from the vehicle and found at the tow yard amongst other vehicle debris. The u-joint for the connection to the output shaft of the transmission was missing and the tail end of the broken drive shaft was twisted. The rear propeller shaft was still attached to the input shaft of axle 2, with the front of the shaft hanging from a limiting safety strap and the front u-joint still in place on the propeller shaft.

Engine exhaust was routed from each side of the engine, through left- and right-side catalytic converters into a single muffler and resonator before exiting below the right side of the rear bumper. Due to rearward displacement of the engine, the catalytic converters were disconnected from the muffler and the right-side catalytic converter was displaced to the left into the area previously occupied by the front of the High-density polyethylene (HDPE) fuel tank, which was normally suspended by straps between the left frame rail and propeller shaft (Figure 7).

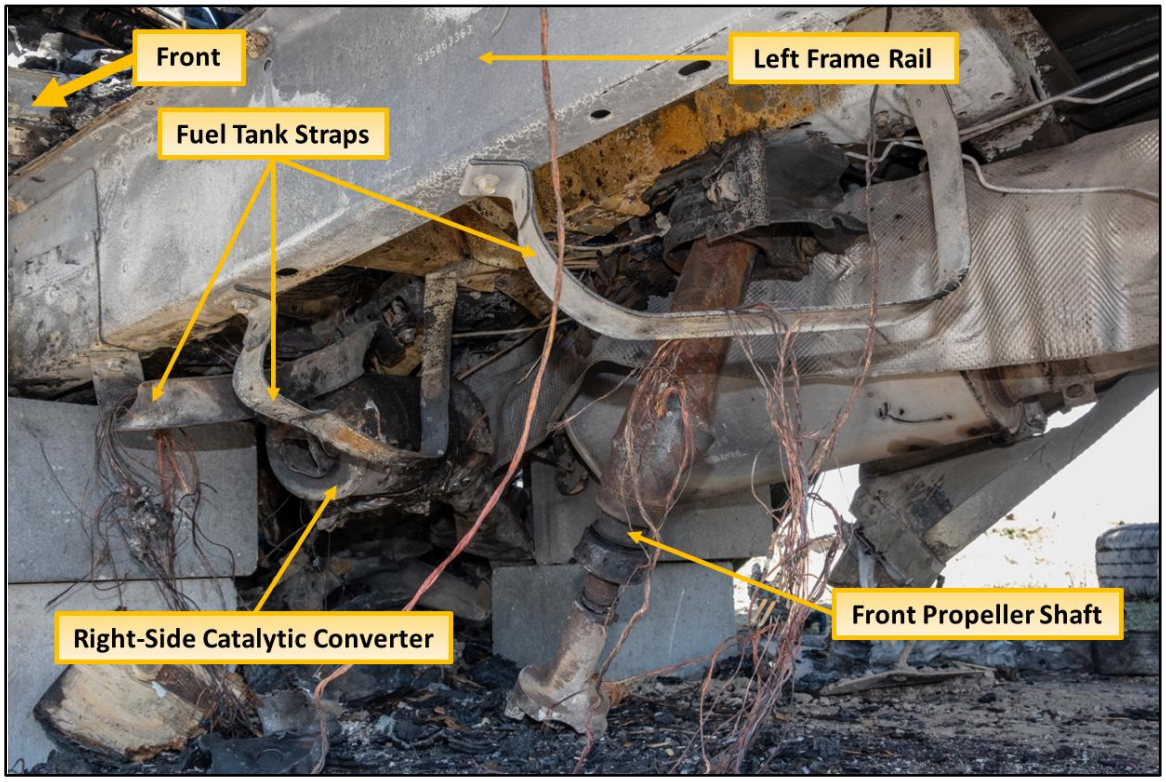

Figure 7. Detached and displaced section of propeller shaft and exhaust components.

1.8 Steering System

The Micro Bird was equipped with an electric rack-and-pinion steering system. The steering wheel was not found during inspection by NTSB Investigators. The tilt/telescoping steering column was in an undetermined adjusted position and had been displaced rearward and upward due to damage sustained by the bulkhead and dash (Figure 4). A section of the multi-piece intermediate shaft, which was normally connected with u-joints, was detached and found within the vehicle debris in the driver's area of the vehicle (Figure 8). The steering gear was intact and securely mounted near the front of the sub frame (Figure 9). The steering gear was normally connected to the left and right spindles through tie rods, which were bent and had sustained thermal damage as a result of the impact and the post-crash fire (Figure 10 and Figure 11). The right spindle was fractured at the tie rod end. The steering gear was removed and stored as evidence by ISP investigators.

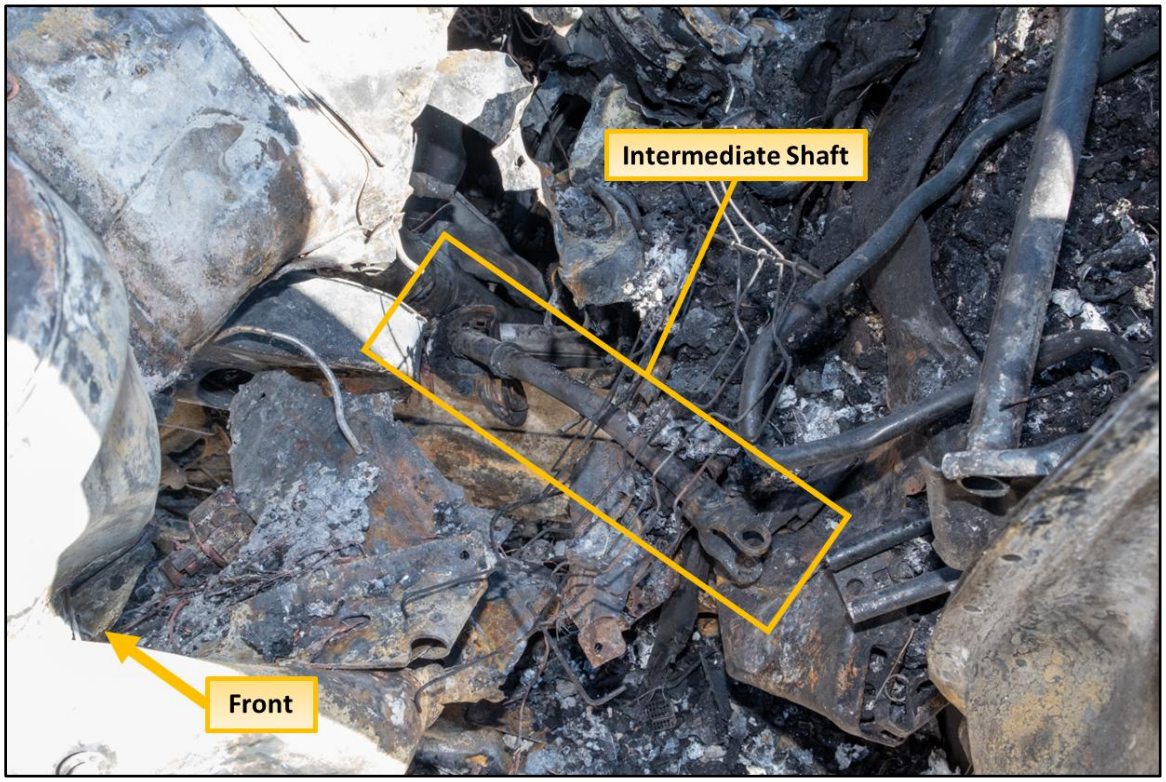

Figure 8. The intermediate steering shaft on the floor of the Micro Bird, forward of the driver seat.

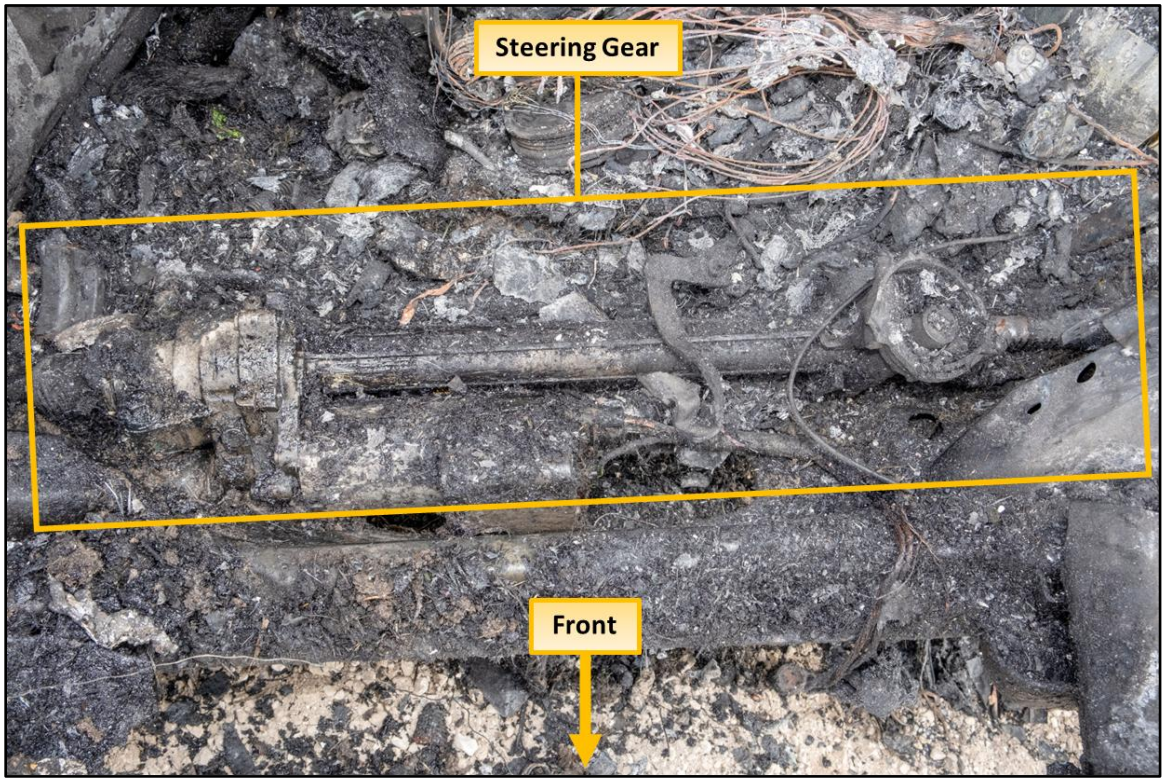

Figure 9. The steering gear mounted near the front of the Micro Bird subframe.

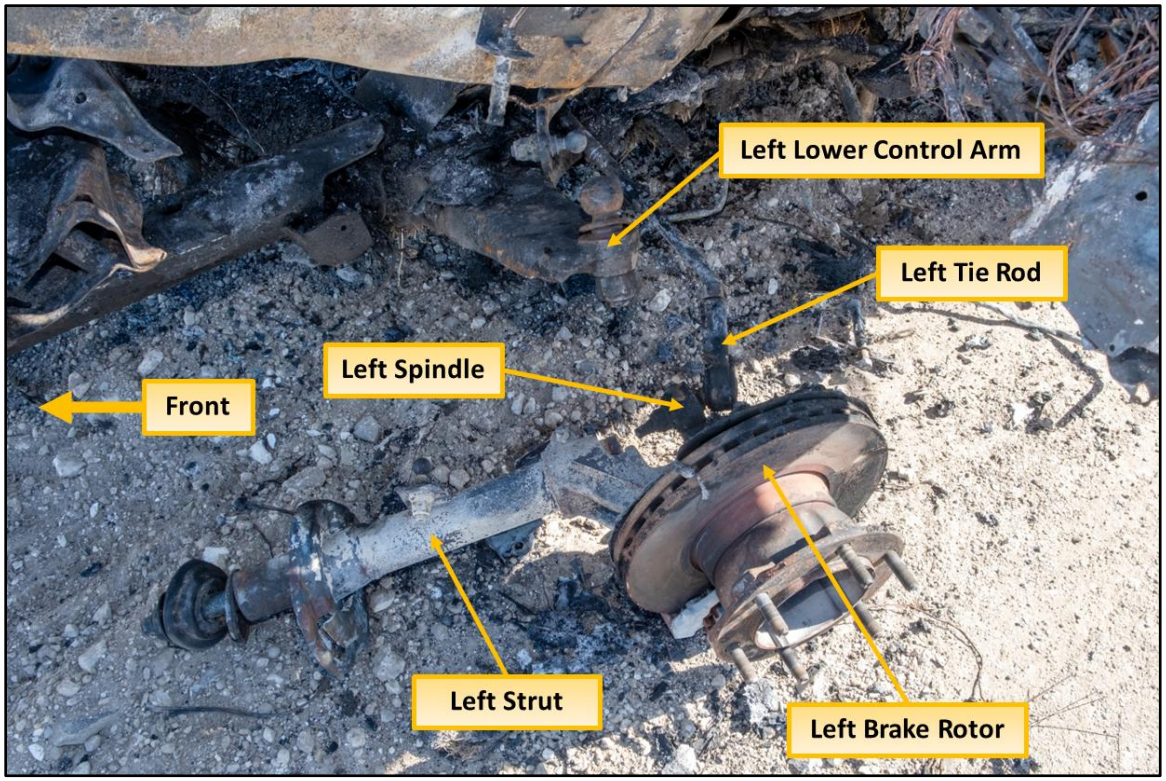

Figure 10. The left-side steering, axle 1 suspension, and brake components of the Micro Bird.

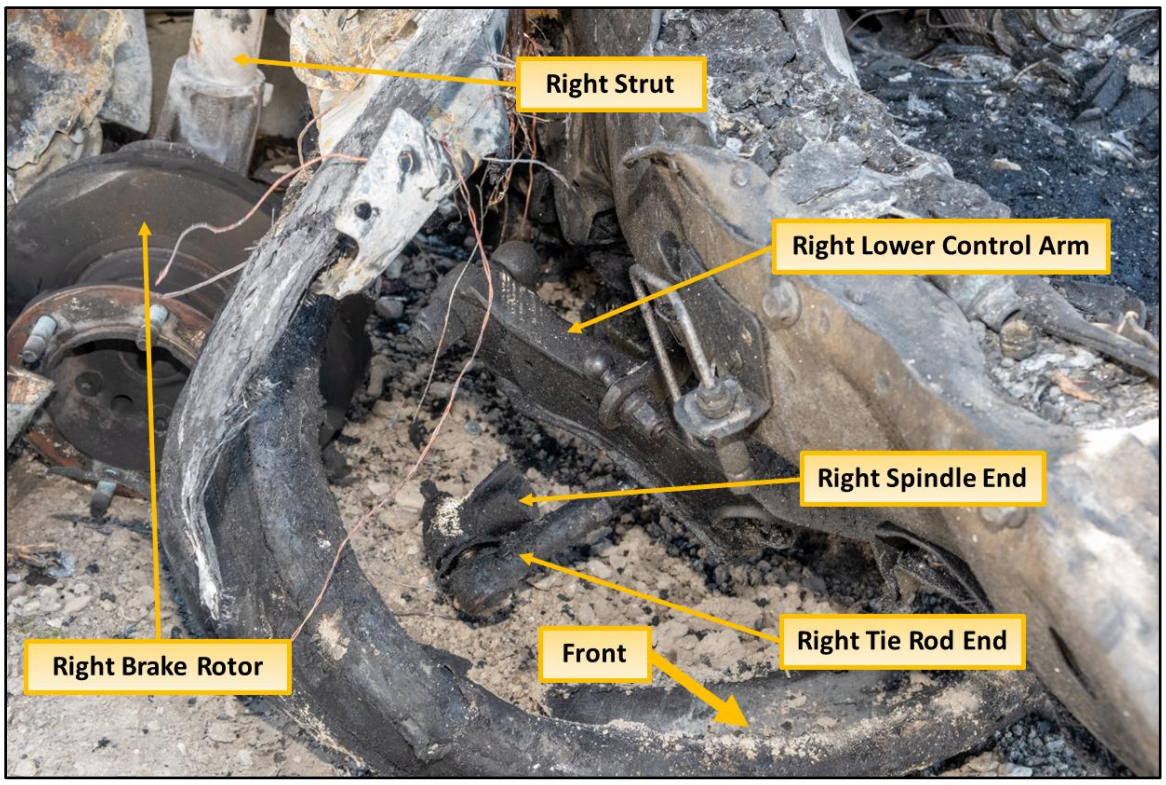

Figure 11. The right-side steering, axle 1 suspension, and brake components of the Micro Bird.

1.9 Suspension System

The Micro Brid was equipped with a MacPherson strut independent suspension at axle 1. On each side of the axle 1 suspension, a strut, comprised of a coil spring and shock absorber, connected the spindle to an upper mount on the vehicle body and a lower control arm connected the bottom of the spindle to the front subframe through a ball joint and bushings. A stabilizer bar, mounted laterally to the front sub frame, connected both struts via end links.

The left strut was detached from its upper mount and the coil spring was missing. The left spindle was detached from the ball joint on the lower control arm and the end link was detached from the stabilizer bar and strut (Figure 10). The top of the right strut remained attached to its upper mount, which was displaced rearward from its pre-crash location. The right spindle was detached from the ball joint on the lower control arm and the end link was detached from the stabilizer bar and strut. The right-side lower control arm was bent and displaced rearward (Figure 11). Combustible components of the axle 1 suspension, such as rubber bushings, were destroyed during the post-cash fire.

The Micro Bird was equipped with a solid axle suspended by leaf springs at axle 2. A spring pack consisting of two primary leaves plus an overload leaf was attached to the top of each side of the axle with u-bolts and to the outboard sides each frame rail, with a fixed forward bushing and a rear-mounted shackle. The leaf springs were supplemented with shock absorbers mounted between the bottom of the axle and the inboard side of each frame rail, forward of the axle. A stabilizer bar was mounted laterally to the rear of the axle and connected to the outboard side of each frame rail with end links. Mounting hardware for axle 2 suspension components was secure, but combustible components had sustained thermal damage from the post-crash fire.

1.10 Tires and Wheels

The Micro Bird was equipped with dual rear wheels. All six tires on the vehicle had sustained varying levels of thermal damage. Recommended tire and wheel information found in documents provided by Ford Motor Company or available to vehicle owners online is presented in Table 1. Rim flanges on both wheels on axle 1 had impact damage in the form of radial bends (Figure 12). General information about each tire and wheel mounted on the Micro Bird at the time of the inspection is documented in Table 2 and Table 3. All wheels were inspected for cracks, welds, and elongated lug nut holes.

Figure 12. Wheels and remaining tires from axle 1.

Although limited information was available for documentation on the axle 1 tires due to thermal damage, remaining tread patterns and conditions were consistent with tires on axle 2. Tires mounted on axle 2 were the same size and load rating as recommended by Ford (Ford Motor Company, 2024).[7]

Table 1. Recommended Tire and Wheel Information

Observation	Axle 1	Axle 2
Tire Size	195/75R16C	195/75R16C
Load Rating	2,149 lbs.[a]	2,039 lbs. (dual)[b]
Pressure	Unknown[c]	Unknown[c]
Wheel	Steel 16x6	Steel 16x6

Notes: [a]Load index 107 for a single wheel. [b]Load index 105R for dual wheels. [c]This characteristic or marking was not visible due to thermal damage sustained during the post-crash fire.

Table 2. Axle 1 (Steer) Tire Information

Observation	Left	Right
Make	Hankook	Unknown[a]
Model	Unknown[a]	Unknown[a]
Size	Unknown[a]	Unknown[a]
Pressure	Deflated	Deflated
Tread Depth[b]	9/32", 11/32", 10/32"	Unknown[a]
DOT #	Unknown[a]	Unknown[a]
Retread (Yes/No)	No	No
Retread #	N/A	N/A
Tire Load Rating	Unknown[a]	Unknown[a]
Wheel Type	Steel	Steel
Wheel Size	16x6J	16x6J
Wheel Load Rating	Not found	Not found

Notes: [a]This characteristic or marking was not visible due to thermal damage sustained during the post-crash fire. [b]Minimum tread depth measured in 1/32" increments (outboard to inboard).

[7] Vehicle Factors Attachment – 2020 Ford Transit Specifications.

Table 3. Axle 2 Tire Information

Observation	Left Outside	Left Inside	Right Inside	Right Outside
Make	Hankook	Hankook	Hankook	Hankook
Model	Dynapro HT	Dynapro HT	Dynapro HT	Dynapro HT
Size	195/75R16C	195/75R16C	195/75R16C	195/75R16C
Pressure	Deflated	Deflated	Deflated	Deflated
Tread Depth[b]	11/32″, 10/32″, 10/32″	10/32″, 10/32″, 10/32″	11/32″, 10/32″, 11/32″	10/32″, 10/32″, 10/32″
DOT #	T7W7HUH1122	T7WHUH____[a]	T7WHUH____[a]	T7W7HUH1122
Retread (Yes/No)	No	No	No	No
Retread #	N/A	N/A	N/A	N/A
Tire Load Rating	2,040 lbs. at 70 PSI (dual)	2,040 lbs. at 70 PSI (dual)	2,040 lbs. at 70 PSI (dual)	2,040 lbs. at 70 PSI (dual)
Wheel Type	Steel	Steel	Steel	Steel
Wheel Size	16x6J	16x6J	16x6J	16x6J
Wheel Load Rating	Not found	Not found	Not found	Not found

Notes: [a]This characteristic or marking was not visible to due thermal damage sustained during the post-crash fire. [b]Minimum tread depth measured in 1/32″ increments (outboard to inboard).

1.11 Brake System

The Micro Bird was equipped with vacuum-boosted hydraulic disk brakes at both axles. Engine vacuum was normally supplied to a brake booster mounted between the bulkhead and a master cylinder and attached brake fluid reservoir. Only the rear of the booster remained mounted on the left side of the bulkhead (Figure 13).

Figure 13. Rear plate of the brake booster.

Ventilated rotors with dual-piston calipers were used at axle 1 and solid rotors with single-piston calipers were used at axle 2. All brake component mounting hardware was secure, but combustible components, such as piston seals, flexible hoses, and guide pin boots, had sustained thermal damage. Cable actuated parking brakes were integrated into the axle 2 calipers. Brake rotor and pad measurements are described in Table 4 and Table 5.

Table 4. Axle 1 Brake Component Information

Observation	Left	Right
Brake Type	Ventilated disc	Ventilated disc
Number of Caliper Pistons	2	2
Measured Rotor Thickness	1.213″	1.212″
Minimum Rotor Thickness[a]	28 mm (1.102″)[a]	28 mm (1.102″)[a]
Pad Material	Semi-metallic	Semi-metallic
Outboard Brake Pad Thickness	13/32″	13/32″
Inboard Pad Thickness	12/32″	13/32″
Minimum Pad Thickness	2 mm (3/32″)[b]	2 mm (3/32″)[b]

Notes: [a]Millimeters converted to the nearest 1/1000 inch at 1 inch = 25.4 millimeters. [b]Millimeters converted to the nearest 1/32 inch at 1 inch = 25.4 millimeters.

Table 5. Axle 2 Brake Component Information

Observation	Left	Right
Brake Type	Solid disc	Solid disc
Number of Caliper Pistons	1	1
Measured Rotor Thickness[a]	0.694″	0.689″
Minimum Rotor Thickness	15mm (0.591″)[a]	15mm (0.591″)[a]
Pad Material	Semi-metallic	Semi-metallic
Outboard Brake Pad Thickness[b]	16/32″	17/32″
Inboard Pad Thickness[b]	16/32″	16/32″
Minimum Pad Thickness	2 mm (3/32″)[b]	2 mm (3/32″)[b]

Notes: [a]Millimeters converted to the nearest 1/1000 inch at 1 inch = 25.4 millimeters. [b]Millimeters converted to the nearest 1/32 inch at 1 inch = 25.4 millimeters.

1.12 Maintenance and Inspection History

An annual inspection of the Micro Bird was conducted on December 11, 2023, at a documented odometer reading of 43,595 miles.[8] No failures in the inspection were noted. The vehicle owner did not keep records or receipts for maintenance performed on the Micro Bird. A log of maintenance performed on the Micro Bird between September 2022 and December 2023 was prepared after this crash and provided to NTSB investigators by the vehicle owner. Maintenance consisted of oil changes, inspections, and replacement of windshield wiper blades and inoperable clearance lights. Tires on the Micro Bird were replaced in October at a reported odometer of 35,169 miles.[9]

The post-crash inspection of the Micro Bird by ISP investigators was documented in a Driver/Vehicle Inspection Report.[10] No violations were noted.

1.13 Documented Recalls and Warranty Claim

No open recalls were found using the NHTSA vehicle search tool for the Micro Bird (2024).[11] A recall had been issued by Micro Bird, Inc. in September 2023 for vehicles equipped with an electric service door.[12] If not repaired, the service door mechanism could misalign, preventing the door panels from opening. No warranty claims had been submitted since for the Micro Bird since it entered service.

1.14 Event Data Recorders

The Micro Bird was equipped with an airbag control module (ACM) with event data recorder (EDR) capability. The ACM was damaged due to rearward displacement of the engine into the occupant compartment; however, the parts of the ACM, including the control board, were found within the vehicle debris in the area occupied by the rear of the engine, within the occupant compartment. The control board was collected by NTSB investigators. Refer to the docket for information about imaging of the control board.

[8] Vehicle Factors Attachment – Micro Bird Inspection Report.
[9] Vehicle Factors Attachment – Micro Bird Maintenance Log.
[10] Vehicle Factors Attachment – Micro Bird Driver/Vehicle Inspection Report.
[11] A safety recall is issued when a manufacturer or the National Highway Traffic Safety Administration (NHTSA) determines that a vehicle, equipment, car seat, or tire creates an unreasonable safety risk or fails to meet minimum safety standards. Most decisions to conduct a safety recall and remedy a safety defect are made voluntarily by the manufacturers prior to involvement by NHTSA.
[12] Micro Bird recall #21-087-DUS, NHTSA recall #21V530.

1.15 Collision Mitigation Technologies

The Micro Bird was equipped with a lane keeping system which used a forward-looking camera at the top of the windshield to determine vehicle position relative to visible lane lines or the edge of the road (Figure 14). The lane keeping system could be turned off or set to vibrate the steering wheel, provide temporary steering assistance toward the lane center, or vibrate the steering wheel and provide steering assistance using a switch at the end of the multifunction stalk on the left side of the steering column (Figure 14).[13] Lane keeping system settings at the time of this crash were not determined.

The lane keeping system may not correctly operate when:[14]

- At least one lane marking or the edge of the road is not detected.
- The direction indicator is switched on.
- There is direct steering input, fast acceleration, or hard braking.
- The vehicle speed is less than 37 miles per hour.
- The ABS, stability control, or traction control systems are active.
- The lane is narrow.

The lane keeping system may not correct lane positioning when:[15]

- High winds are present.
- There are uneven road surfaces.
- The vehicle is carrying a heavy or uneven load.
- Tire pressures are incorrect.

During detection of an unintended lane departure, a lane keeping system operating in the alert and aid mode may provide temporary steering assistance before reverting to vibration of the steering wheel if the lane departure continues.[16]

[13] Vehicle Factors Attachment – 2020 Ford Transit Owner's Manual – Lane Keeping System.
[14] Ibid.
[15] Ibid.
[16] Ibid.

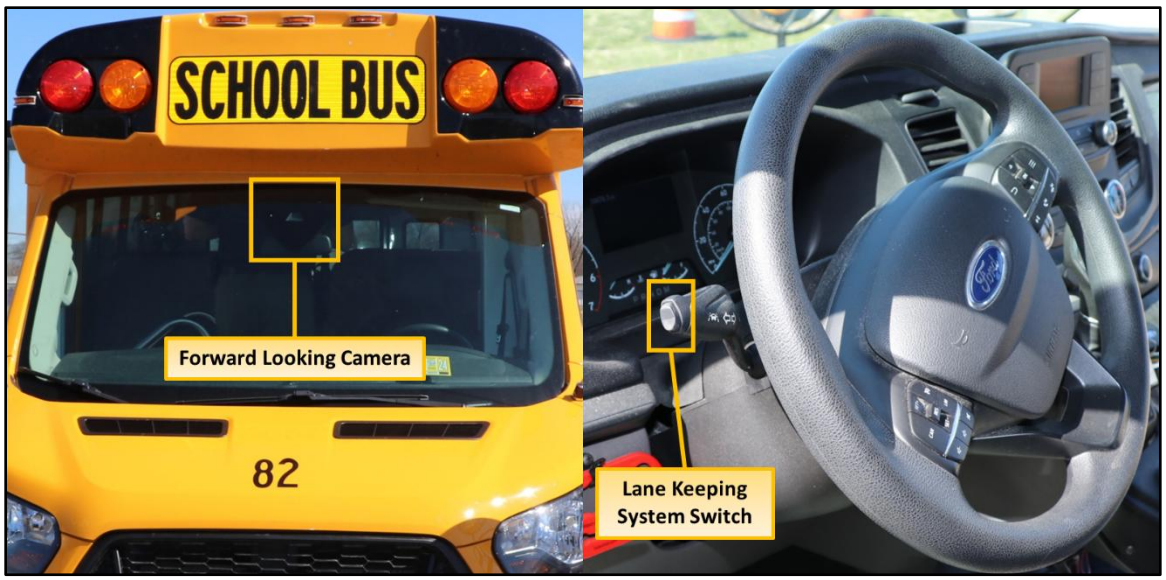

Figure 14. The forward-looking camera and lane keeping system switch on an exemplar Micro Bird.

The Micro Bird also had a pre-collision assist system that used the same forward-looking camera and could provide visual and audible alerts, braking support, or automatic emergency braking. The function of the pre-collision assist system could be changed or the system disabled in the information display controls. The system was not designed to detect vehicles moving in the opposite direction.[17] Pre-collision assist system settings at the time of this crash were not determined.

[17] Vehicle Factors Attachment – 2020 Ford Transit Owner's Manual – Pre-Collision Assist.

2.0 2001 Mack CH613

2.1 General Information

Make:	Mack
Model:	CH613
VIN:[18]	1M1AA13Y81W137002
Model Year:	2001
Date of Manufacture:	March 2000
In-Service Date:	Unknown
Mileage:	Unknown
GVWR:[19]	52,000 lb.
GAWR,[20] Axle 1:	12,000 lb.
GAWR, Axle 2:	20,000 lb.
GAWR, Axle 3:	20,000 lb.
Engine:	Renault E7-355/380, inline 6-cylinder turbocharged diesel (2000 Emissions)
Transmission:	Mack T2090 9-speed manual
Rear Axle Ratio:	3.86
Steering Gear:	RH Sheppard M100
Brake Type:	Air-operated drum with ABS (4S/4M)

[18] Vehicle Identification Number (VIN).
[19] a) Gross Vehicle Weight Rating (GVWR) is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself, plus fuel, passengers, and cargo. b) GVWR and GAWR from manufacturer label affixed the trailing edge of the left door on an exemplar 2002 Mack CH613.
[20] Gross Axle Weight Rating (GAWR) is the maximum distributed weight that a given axle is designed to support.

2.2 Vehicle Summary

This vehicle was a conventional, three-axle truck-tractor (Figure 15). At its position of rest, the Mack was on its front and right-rear wheels, facing west and the semitrailer was on its right side, in line with the Mack, in the grass covered drainage ditch. The front of the Mack was in contact with the front of the Micro Bird.

Figure 15. An exemplar Mack combination.

2.3 Damage Description

The Mack sustained complete thermal damage that extended from the front to axle 2 and partial thermal damage from axle 2 rearward. Observable contact damage to remaining components was limited to crumpling, tearing, and rearward displacement of the front crossmember and the radiator, with attached components, to the engine. Observable induced damage included buckling and twisting of the frame rails in multiple locations (Figure 16). Refer to the docket for additional damage description and vehicle damage profile.

Figure 16. The condition of the Mack at the time of post-crash inspection on March 15, 2024.

2.4 Weight and Measurements

The Mack combination was weighed when the end-dump semitrailer was loaded at 10:45 a.m. on the morning of the crash. The loaded combination weighed 79,680 pounds.[21]

The crash-involved Mack and an exemplar 2002 Mack CH613 were scanned using a three-dimensional terrestrial laser scanner and point clouds were created for each vehicle. Refer to the docket for additional information regarding the three-dimensional laser scans. Vehicle dimensions were determined by measuring three-dimensional points in the point clouds using CloudCompare software (Figure 17). According to the invoice and vehicle specification report for the for the Mack, the undamaged vehicle had a wheelbase of 205 inches (17.1 feet).[22]

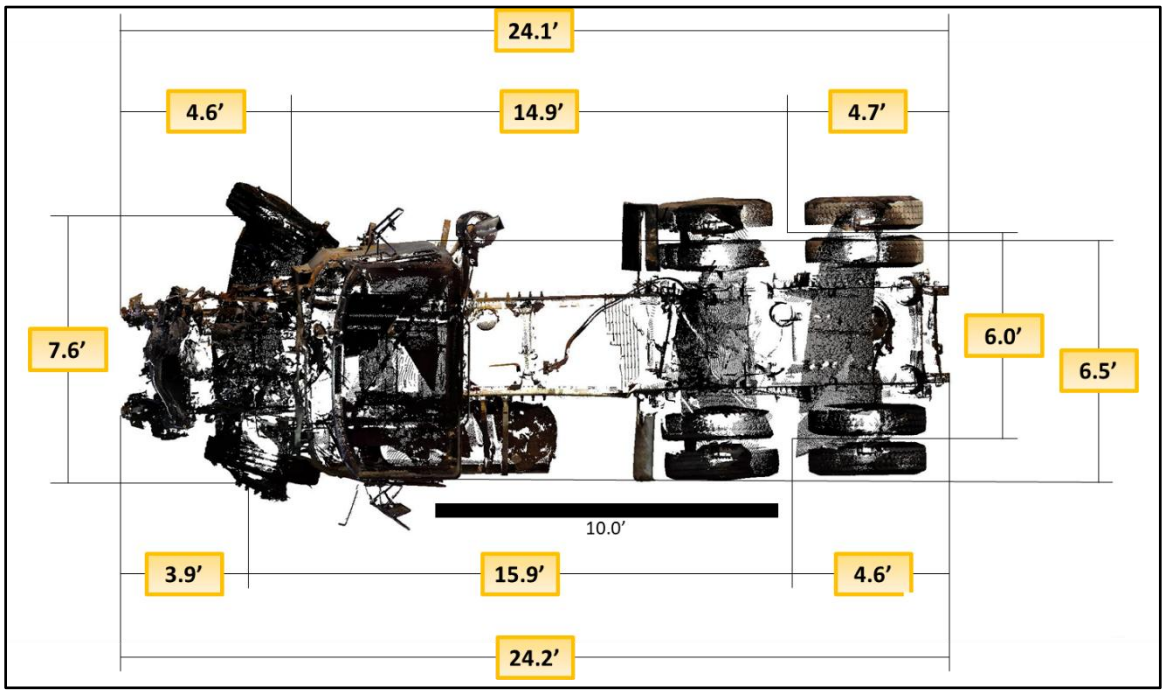

Figure 17. Three-dimensional laser scan of the Mack.

[21] Vehicle Factors Attachment – Central Stone Company Ticket No: 55018264.
[22] Vehicle Factors Attachment – Mack Invoice and Vehicle Specifications.

2.5 Driver Controls

The Mack was equipped with a telescoping steering column with an 18-inch-diameter steering wheel. Due to thermal damage sustained by the interior of the Mack during the post-crash fire, the position of the steering column was not determined. All gauges and switches were destroyed during the post-crash fire; therefore, driver control conditions were not determined.

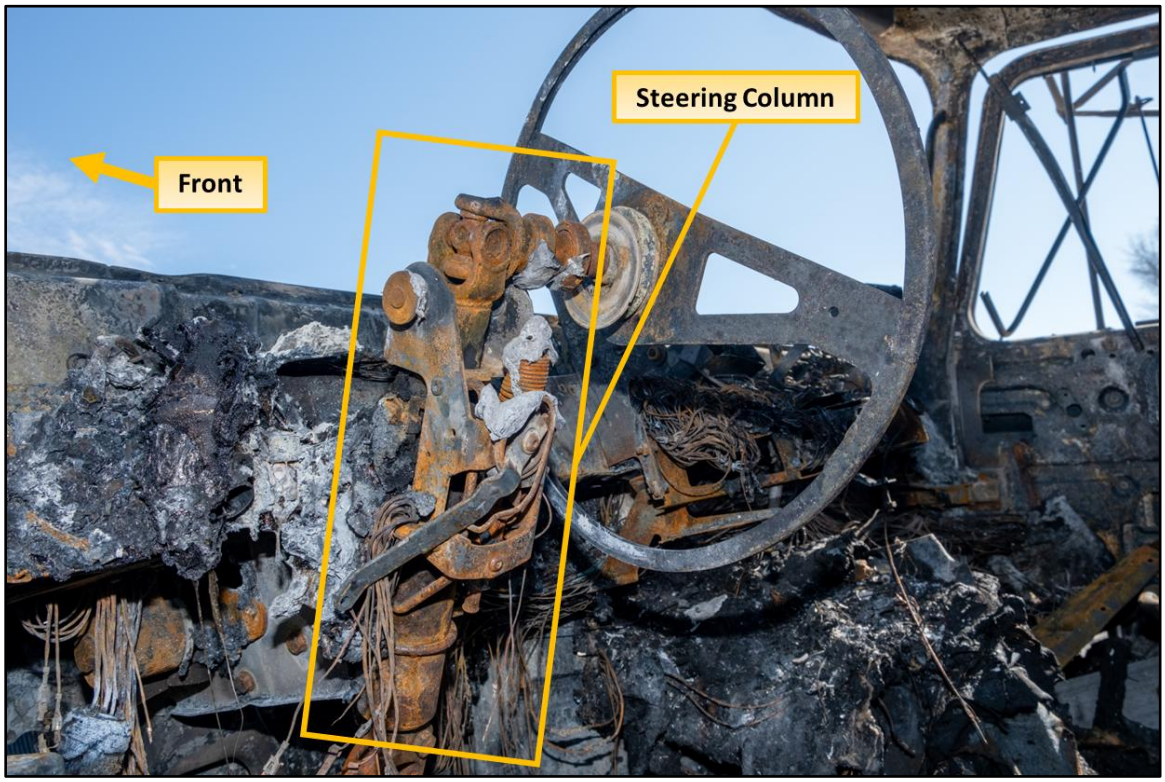

Figure 18. The condition of driver controls at inspection of the Mack.

The locations of driver controls for an exemplar 2002 Mack CH613 were documented in photographs by NTSB investigators (Figure 19).

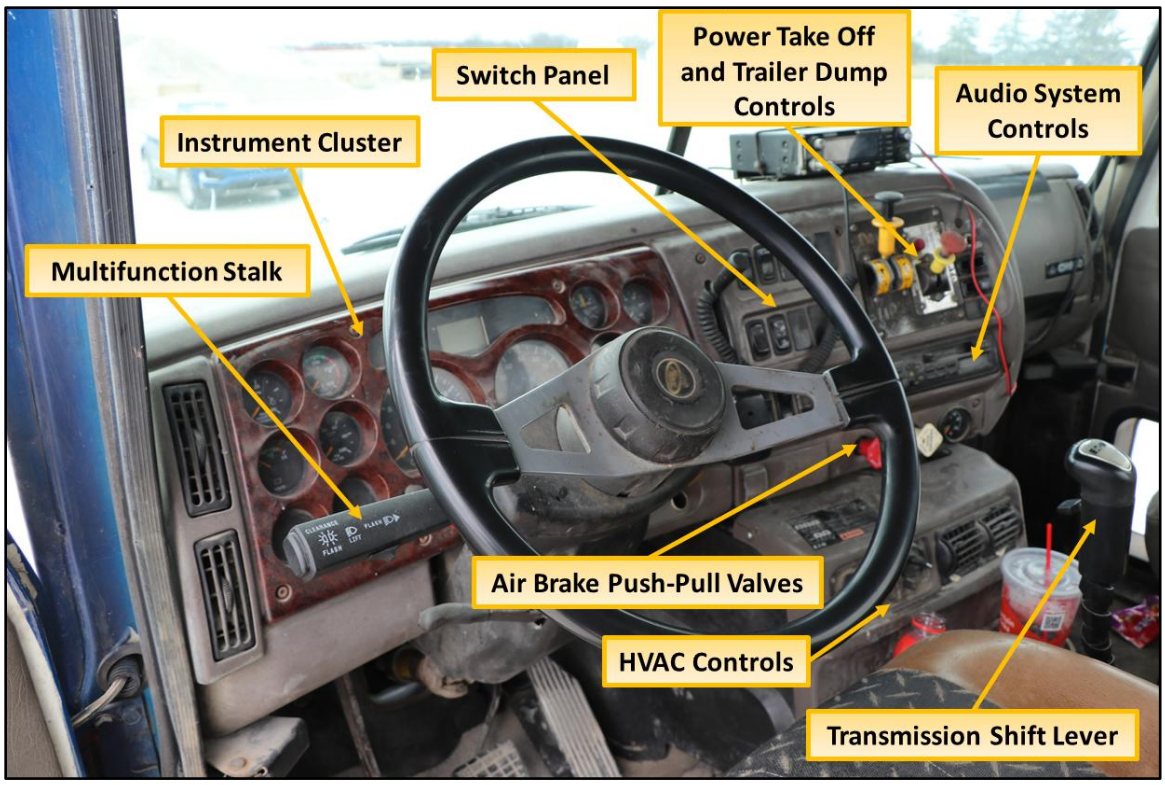

Figure 19. Driver controls for an exemplar 2002 Mack CH613.

2.6 Electrical System

The vehicle batteries, most lights, and wiring were destroyed during the post-crash fire. Taillights mounted to a panel between the frame rails were still intact, but not inspected for functionality.

2.7 Powertrain

The powertrain consisted of an inline-six-cylinder diesel engine, manual transmission, a propeller shaft,[23] and two rear drive axle assemblies (axle 2 and axle 3) with undetermined ratio gears. The engine was mounted longitudinally at the front of the vehicle (Figure 20). The bottom of the forward side of the radiator sustained contact damage, and the whole assembly was displaced rearward, with the engine facing side of the radiator contacting the cooling fan and front of the engine. The engine and attached accessories were destroyed during the post-crash fire. Engine fluids were not inspected. The accelerator pedal was mounted to the floor at the right side of the driver's foot well, the pedal was covered by melted and burned interior component debris that had accumulated on the floor during and after the post-crash fire. Although some debris could be cleared from the pedal, its functionality could not be tested.

[23] Commonly referred to as drive shafts.

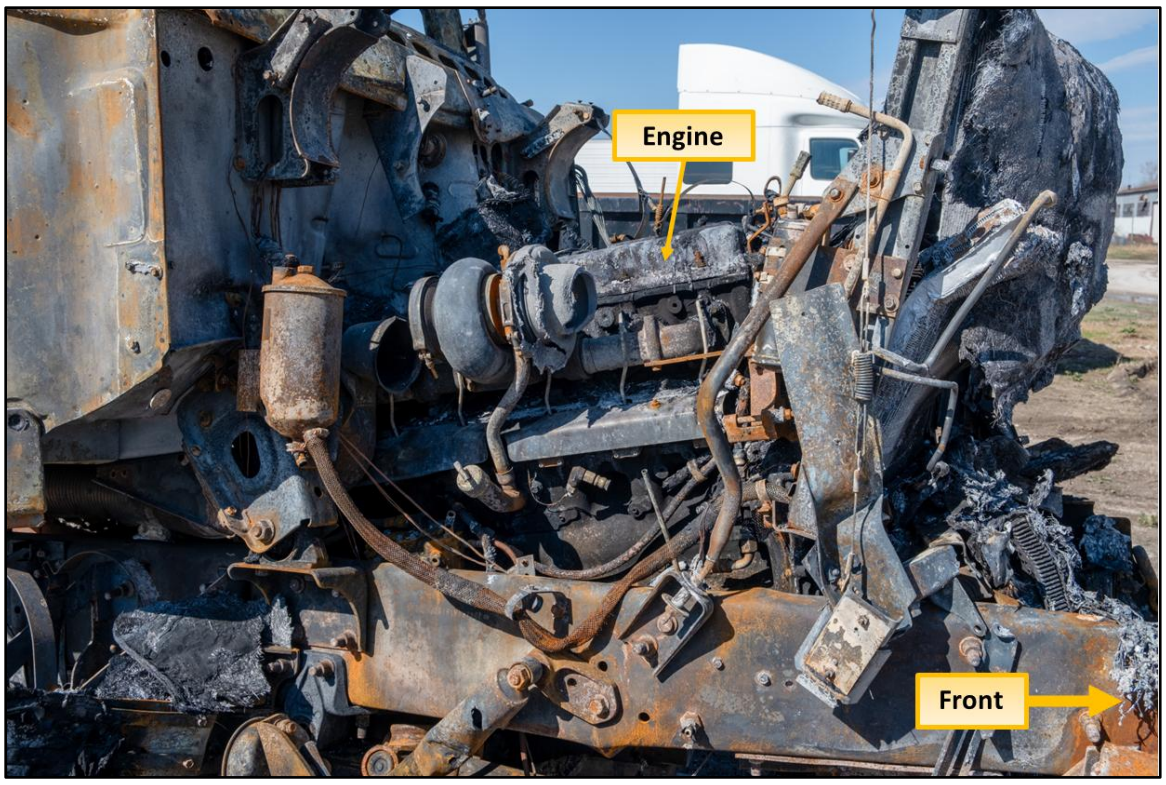

Figure 20. Condition of the engine compartment at inspection of the Mack.

Most of the transmission shift lever, which normally extended from the transmission through the floor between the seats, was destroyed during the post-crash fire; its position was not determined. A clutch pedal was mounted to the underside of the dash, left of the steering column.

Power was transferred from the output shaft of the transmission to the input at the front of the axle 2 housing through a single-piece propeller shaft connected with u-joints at each end and supported by one carrier bearing, which was detached from its mounting location. One of the straps securing the u-joint at the axle side of the propeller shaft to its yoke was missing and the other was broken and twisted away from the yoke. Only one strap remained bolted to the axle housing pinion yoke and the u-joint was missing. The axle end of the propeller shaft had been secured post-crash to a crossmember with a ratchet strap for removal of the vehicle from the crash scene. Power was transferred between axle 2 and axle 3 via a second propeller shaft connected with u-joints at each end to an output shaft on the top of axle 2 and an input shaft on axle 3.

2.8 Steering System

At the scene, the steering wheel was observed tilted forward on the steering column (Figure 18). The 18-inch steering wheel had sustained thermal damage but appeared to be otherwise undamaged. The telescoping steering column was displaced forward, and its adjusted position was undetermined. The upper steering shaft was connected, via a u-joint, to an intermediate shaft, which passed through the bulkhead into the engine compartment. The intermediate shaft was bent upward near its midpoint and the forward end, a u-joint, was disconnected from the steering gearbox.

An RH Sheppard M100 steering gearbox was securely mounted to the outboard side of the left frame rail (Figure 21). The top of the steering gearbox, with the input yoke for the intermediate shaft u-joint, was broken from the body and hanging from one of the steel braided hydraulic fluid lines. One of the ears for the u-joint yoke at the input shaft to the steering gearbox was bent outward. The pitman arm was securely attached to the sector shaft of the steering gearbox. The end of the pitman arm, which would normally be connected to the drag link with a ball joint, was broken. A ball joint connected the drag link to the left steering knuckle. A tie rod was connected by ball joints at both ends to the bottom of each steering knuckle. The tie rod was bowed near its midpoint. All ball joints utilized castellated nuts and cotter pins, which were securely fastened.

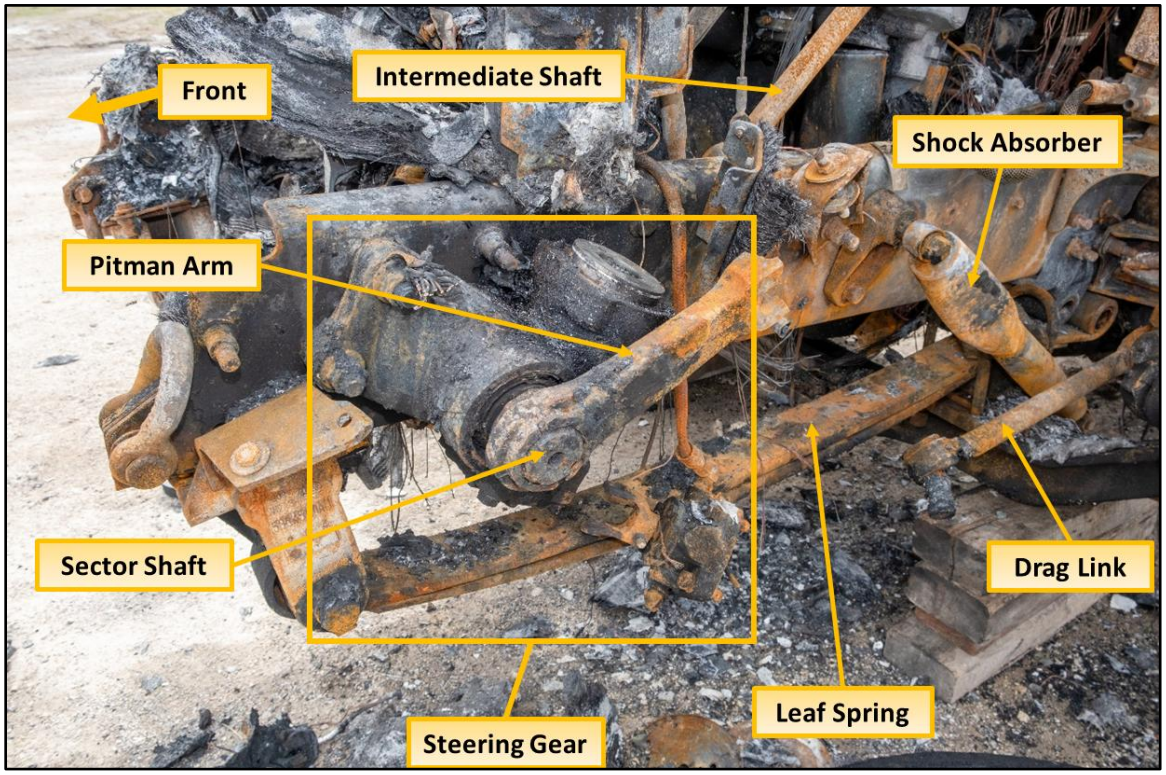

Figure 21. Steering and axle 1 suspension components on the left side of the Mack.

2.9 Suspension System

The steer axle (axle 1) was suspended at each end by a full taper spring pack consisting of two leaves (Figure 22). The leaf springs were connected to the axle with u-bolts and blocks. The axle was displaced rearward on both springs and the springs were bent upward above the axle. The u-bolts were loose, and upper blocks, which would hold the tops of the u-bolts in place above the springs, moved freely on the springs. The springs were free of visible cracks. Spring hangers at the trailing ends of the springs were broken. The left-side spring hanger was missing, but the mount was secured to the left frame rail. The right-side spring hanger was attached to the trailing eye of spring pack via a spring eye bushing, but detached from the mount, which was secured to the right frame rail. The fractured ends of the broken pin used to attach the spring hanger to the frame mount was visible within the mount. The leaf springs at axle 1 were supplemented by shock absorbers mounted to the outboard side of each frame rail and the rear of axle 1 at each u-bolt. Both shock absorbers were bent, and the body of the right shock had holes torn in the body. All non-metal components of the axle 1 suspension had melted during the post-crash fire.

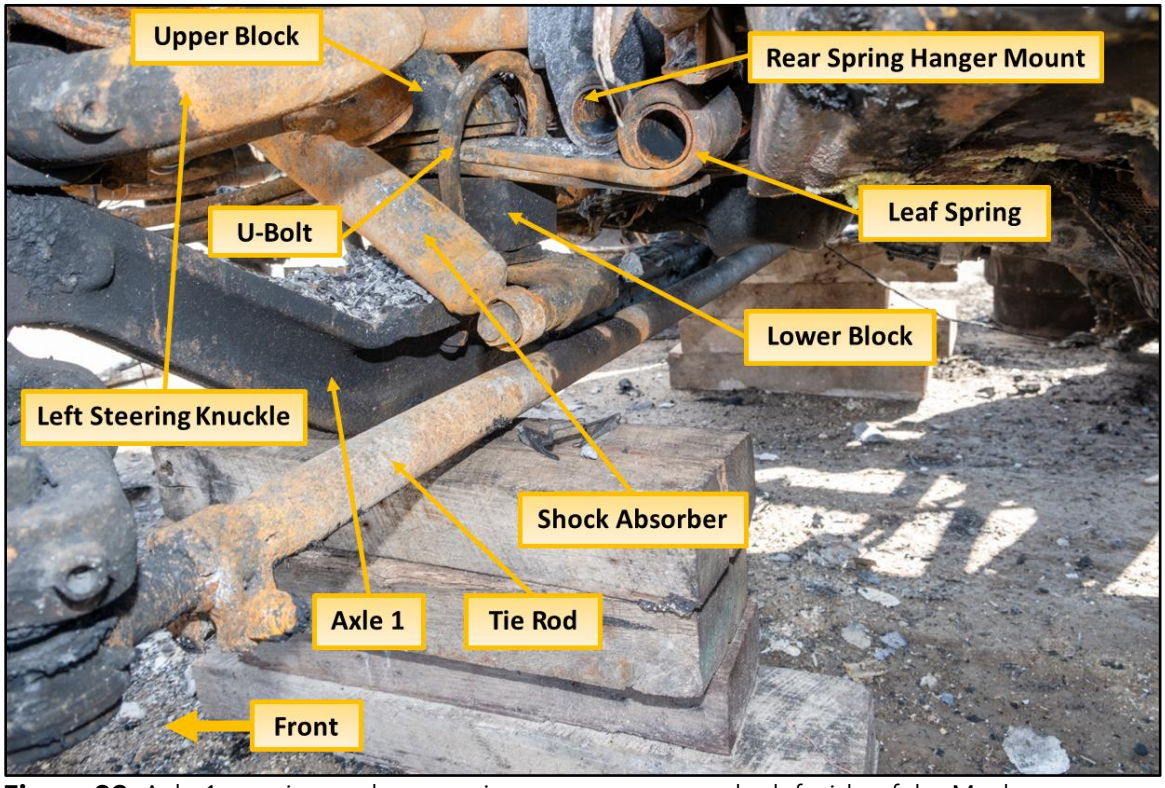

Figure 22. Axle 1 steering and suspension components on the left side of the Mack.

Each drive axle (axle 2 and axle 3) was suspended by control arms mounted at each end to the top of the axle with u-bolts and blocks. Bar pins connected torque arms to the top of each axle to the control arm mounts, below the control arms. Left-side torque arms were adjustable and right-side torque arms were fixed length. A suspension airbag was mounted between each control arm, behind the axle, and the associated frame rail. The suspension airbags were supplemented by shock absorbers mounted to the outboard side of each frame rail and the trailing edge of each control arm. The airbag and the upper bushing of the shock absorber on the left side of axle 2 had sustained thermal damage during the post-crash fire. Axle 2 and axle 3 were located laterally using torque arms above the axles. The torque arm above axle 2 was securely mounted using bar pins to the left side of the axle housing and the inboard side of the right frame rail. The torque arm above axle 3 was securely mounted using bar pins to the right side of the axle housing and the inboard side of the left frame rail.

2.10 Tires and Wheels

The Mack was originally equipped with 295/75R22.5 load range G tires, mounted on 22.5X8.25 rims at all positions.[24] General information about each tire and wheel mounted on the Mack at the time of the inspection is documented in Table 6,Table 7, and Table 8. All the wheels were inspected for cracks, welds, and elongated lug nut holes.

Tires at all positions except the right side of axle 3 had sustained varying degrees of thermal damage due to the post-crash fire. Balance rings[25] were in place between the wheels and drums on axle 1. An object was stuck in an inboard tread block of the left inside tire on axle 3 (Figure 23). The tire was not unmounted from the wheel to determine if the object penetrated the inner liner.

[24] Vehicle Factors Attachment – Mack Invoice and Vehicle Specifications.
[25] Balance rings are intended to improve tire and wheel balance where mounted.

Figure 23. Object stuck in the tread of the left inside tire on axle 3.

Table 6. Axle 1 (Steer) Tire and Wheel Information

Observation	Left	Right
Make	Unknown[a]	Unknown[a]
Model	Unknown[a]	Ameristeel
Size	Unknown[a]	Unknown[a]
Pressure	Deflated	Deflated
Tread Depth[b]	Unknown[a]	20/32", 18/32", 15/32"
DOT #	Unknown[a]	Unknown[a]
Retread (Yes/No)	No	No
Retread #	N/A	N/A
Tire Load Rating	Unknown[a]	Unknown[a]
Wheel Type	Alloy	Alloy
Wheel Size	Not found	Not found
Wheel Load Rating	Not found	Not found

Notes: [a]This characteristic or marking was not visible to due thermal damage sustained during the post-crash fire. [b]Minimum tread depth measured in 1/32" increments (outboard to inboard).

Table 7. Axle 2 Tire and Wheel Information

Observation	Left Outside	Left Inside	Right Inside	Right Outside
Make	Unknown[a]	Cooper	Yokohama	Ameristeel
Model	Super Steel RY6__[a]	Work Series	Super Steel RY617	S360
Size	11R22.5	Unknown[a]	11R22.5	11R22.5
Pressure	Deflated	Deflated	Deflated	84 PSI[b]
Tread Depth[c]	Unknown[a]	14/32″, 15/32″, 15/32″	16/32″, 15/32″, 15/32″	16/32″, 17/32″, 14/32″
DOT #	Unknown[a]	1CR3TLWP13820	Unknown[a]	133TKY7D4919
Retread (Yes/No)	Yes	Yes	Yes	Yes
Retread #[d]	Unknown[a]	RYXC1822CIA	Unknown[a]	RYXC2521CIA, RYX2623CIA
Tire Load Rating	Unknown[a]	Unknown[a]	6,008 lbs. (dual)[e]	6,008 lbs. (dual)[e]
Wheel Type	Alloy	Alloy	Alloy	Alloy
Wheel Size	22.5″ x 8.25″	22.5″ x 8.25″	Not found	Not found
Wheel Load Rating	7,300 lbs. at 120 PSI	7,300 lbs. at 120 PSI	Not found	Not found

Notes: [a]This characteristic or marking was not visible to due thermal damage sustained during the post-crash fire. [b]Measured using a high-pressure gauge by ISP investigators on March 12, 2024. [c]Minimum tread depth measured in 1/32″ increments (outboard to inboard). [d]Multiple retread numbers indicate the tire was retreaded more than once. [e]Load index 143L for dual wheels.

Table 8. Axle 3 Tire and Wheel Information

Observation	Left Outside	Left Inside	Right Inside	Right Outside
Make	Ameristeel	Cooper	Cooper	Cooper
Model	D460	Work Series RHA	Work Series RHA	Work Series RHA
Size	11R22.5	11R22.5	11R22.5	11R22.5
Pressure	87 PSI[b]	Deflated	90 PSI[b]	88 PSI[b]
Tread Depth[c]	14/32″, 14/32″, 15/32″	15/32″,15/32″, 15/32″	15/32″, 16/32″. 14/32″	16/32″, 16/32″, 15/32″
DOT #	A331L9122816	1CR3TLNP____[a]	1CR3TLWP13720	1CR3TLWP1410
Retread (Yes/No)	Yes	Yes	Yes	Yes
Retread #	Unknown[a]	Unknown[a]	RYXC2023CIA	RYXC2023CIA
Tire Load Rating	5,840 lbs. at 105 PSI (dual)	Unknown[a]	6,005 lbs. at 120 PSI (dual)	6,008 lbs. (dual)[d]
Wheel Type	Alloy	Alloy	Alloy	Alloy
Wheel Size	22.5″ x 8.25″	22.5″ x 8.25″	22.5″ x 8.25″	22.5″ x 8.25″
Wheel Load Rating	7,400 lbs. at 130 PSI	7,300 lbs. at 120 PSI	7,300 lbs. at 120 PSI	7,300 lbs. at 120 PSI

Notes: [a]This characteristic or marking was not visible to due thermal damage sustained during the post-crash fire. [b]Measured using a high-pressure gauge by ISP investigators on March 12, 2024. [c]Minimum tread depth measured in 1/32″ increments (outboard to inboard). [d]Load index 143L for dual wheels.

Tires with remaining markings were identified as size 11R22.5, which had loaded radii slightly larger than the originally equipped 295/75R22.5 size tires.

2.11 Brake System

The Mack was equipped with air-actuated, S-cam drum brakes at all axles. Air pressure was normally provided to the brake system by a Bendix TF550 style compressor, which was securely mounted to the right side of the engine and directly driven. The compressor and hoses had sustained thermal damage during the post-crash fire. Compressed air was routed from the compressor through an air dryer mounted to the inboard side of the right frame rail, behind the cab, to reservoir tanks mounted that would have been mounted laterally to the outboard side of the right frame rail, forward of the right fuel tank, and on to a series of valves at various locations around the vehicle and individual brake chambers. Mounting straps for the reservoir tanks were present, but both tanks were missing at the time of inspection.[26] An antilock braking system (ABS) was present on the Mack, with wheel speed sensors located at wheel positions on axle 1 and axle 3.

The brake pedal assembly (treadle valve) was securely mounted to the bulkhead, to the left of the accelerator pedal. The treadle valve passed through the bulkhead, where it was would have been connected to supply and delivery air lines for primary and secondary circuits routed to the rest of the air brake system. Air hoses had sustained thermal damage during the post-crash fire.

Due to damage sustained by brake system components during the crash and post-crash fire, individual brake chambers were isolated and directly supplied with 135 PSI of shop air for testing by ISP investigators on March 12, 2024.[27] Pushrod travel measured during testing of the brakes was within adjustment limits for tested positions. Brake chambers at axle 1 and the left side of axle 3 were not tested due to thermal damage sustained by the axle 1 brake chambers and stripped threads on the input port on the axle 3 brake chamber. When air was applied to the left brake chamber on axle 2, ISP investigators noted pushrod travel of only 1/4 inch and the sound of air bypassing the brake chamber diaphragm. If pre-existing, an audible air leak at the brake chamber would be a violation of Title 49 of the *Code of Federal Regulations* (49 *CFR*) Part 396.3 (a)(1) and an indication of a defective brake chamber for the purpose of determining whether or not out-of-service criteria were met for the combination.[28]

[26] Reservoir tank location was identified on an exemplar 2002 Mack CH 613.
[27] Brake adjustment inspections should be conducted at 90 to 100 PSI (Commercial Vehicle Safety Alliance, 2023)
[28] Two defective brakes out of the ten brakes on the combination would be an out-of-service condition.

Wheels and brake drums were removed at each position to inspect brake shoes and drum friction surfaces. Cam rollers were in contact with brake cams, and return springs were in place at all positions. Holes rusted through the return-spring sides of the brake chambers on the brake chambers on axle 2 and axle 3 were observed (Figure 24). The holes would eventually lead to failure of the brake chambers and were a violation of the 49 *CFR* Part 396.3 (a). The condition did not otherwise affect the function of the brakes.

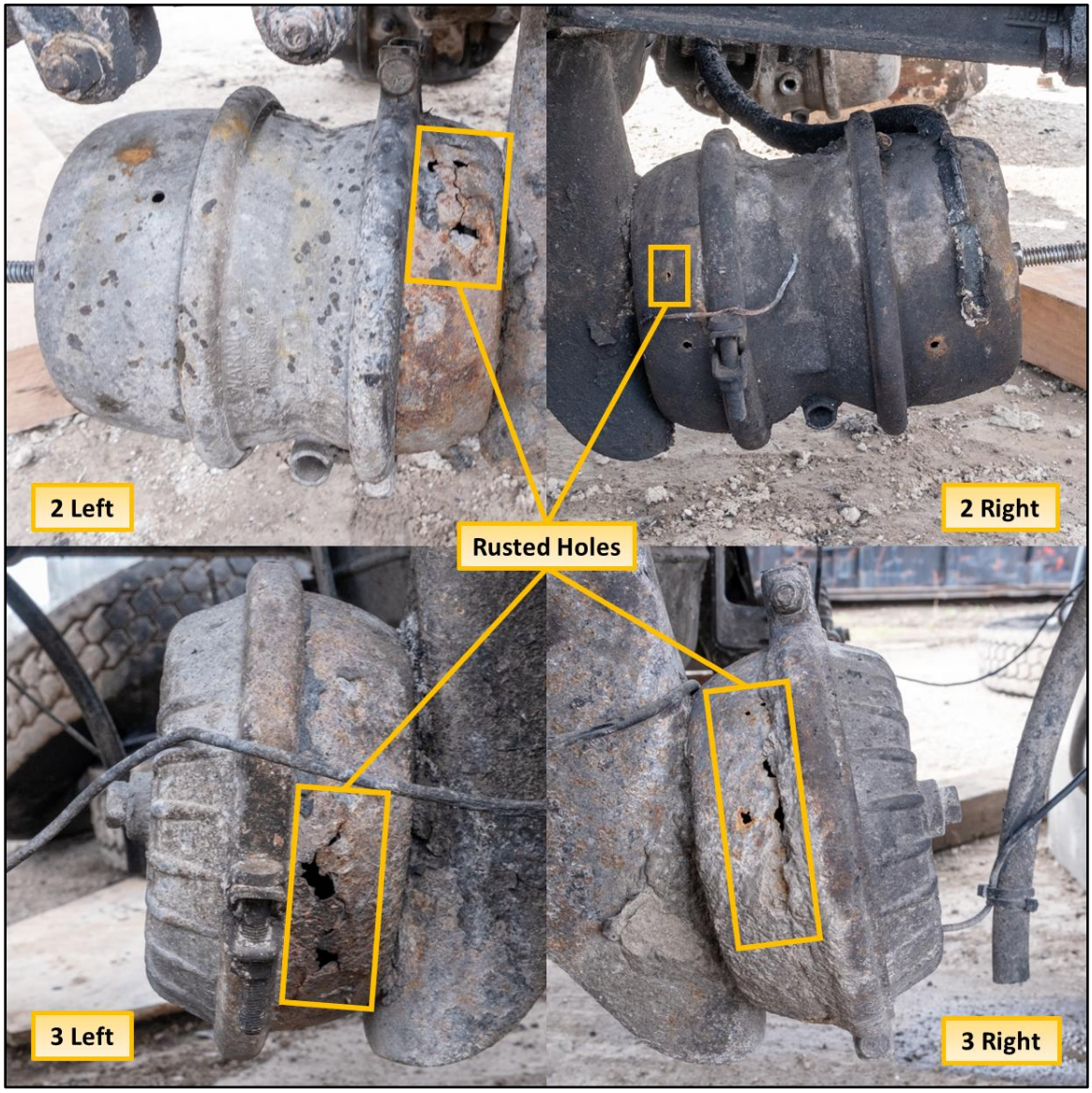

Figure 24. Rusted holes in brake chambers at axle 2 and axle 3.

There were discernable ridges and heat checking on the friction surfaces of all drums (Figure 25). Measured drum diameters were less than the maximum diameter identified by markings embossed on the external surfaces of the drums. The right brake drum on axle 3 was cracked due to impact with a tool used by a service technician during removal for the post-crash inspection.

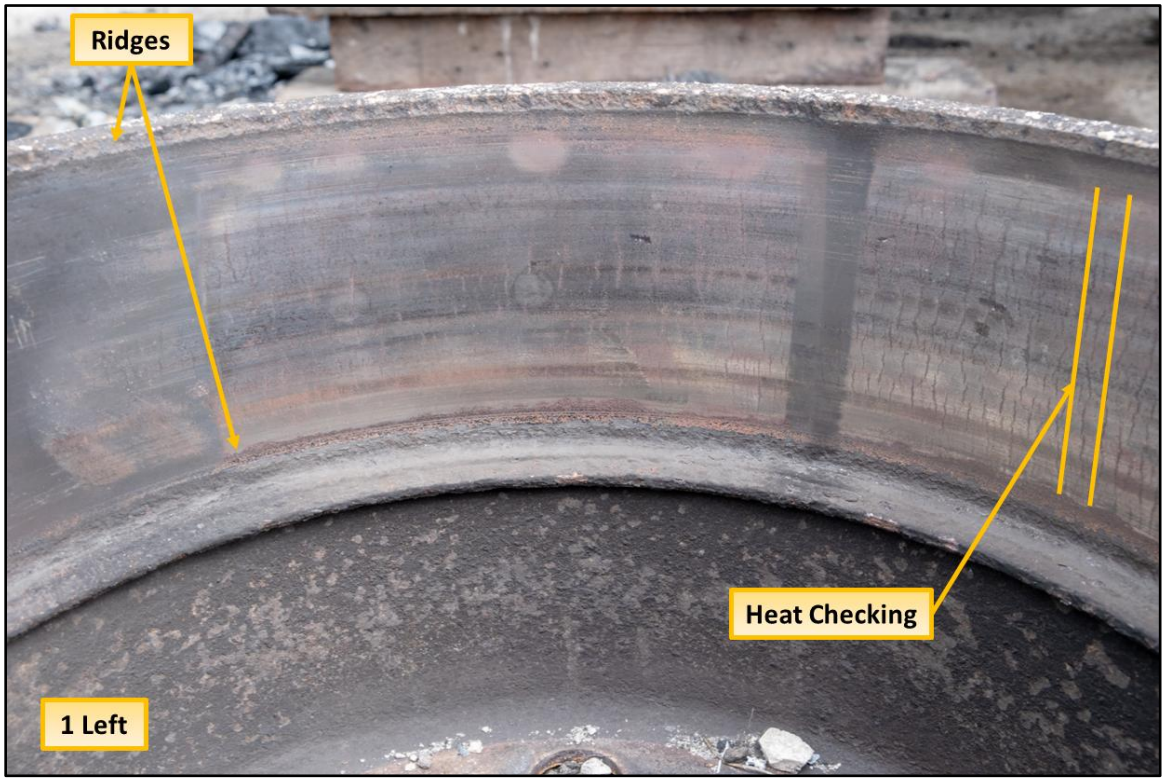

Figure 25. Inspected condition of the left friction surface of the brake drum on axle 1.

Brake linings were securely attached to all shoes. Minimum brake lining thicknesses were above inspection limits specified in 49 *CFR* Part 396.47 (d)(2). Pushrod travel, brake lining thickness, and drum diameter measurements taken by ISP and NTSB investigators are presented in Table 9, Table 10, and Table 11.

Table 9. Axle 1 Brake Component Information

Observation	Left	Right
Brake Type	S-Cam Drum	S-Cam Drum
ABS	Yes	Yes
Upper Brake Lining Thickness[a]	19/32″, 22/32″, 14/32″	17/32″, 20/32″, 15/32″
Lower Brake Lining Thickness[a]	19/32″, 21/32″, 15/32″	18/32″, 19/32″, 13/32″
Brake Lining Inspection Limit	1/4″	1/4″
Measured Drum Diameter[b]	15″	15″
Maximum Drum Diameter	15.12″	15.12″
Brake Chamber Type	20C	20C
Measured Pushrod Travel[c]	N/A	N/A
Adjustment Limit[d]	1 3/4″	1 3/4″
Slack Adjuster Length	5.5″	5.5″
Slack Adjuster Type	Automatic	Automatic

Notes: [a]Brake lining thickness measured to the nearest 1/32 inch at leading edge, middle, and trailing edge. [b]Inside drum diameters were measured using a brake drum gauge to the nearest 1/8 (0.125) inch. [c]Not tested due to thermal damage sustained by the brake chambers during the post-crash fire. [d] (Commercial Vehicle Safety Alliance, 2023).

Table 10. Axle 2 Brake Component Information

Observation	Left	Right
Brake Type	S-Cam Drum	S-Cam Drum
ABS	Yes	Yes
Upper Brake Lining Thickness[a]	17/32″, 18/32″, 13/32″	14/32″, 16/32″, 13/32″
Lower Brake Lining Thickness[a]	15/32″, 15/32″, 12/32″	16/32″, 16/32″, 11/32″
Brake Lining Inspection Limit	1/4″	1/4″
Measured Drum Diameter[b]	15.50″	15.50″
Maximum Drum Diameter	16.62″	16.62″
Brake Chamber Type	30/30C	30/30C
Measured Pushrod Travel	1/4″	3/4″
Adjustment Limit[c]	2″	2″
Slack Adjuster Length	6″	6″
Slack Adjuster Type	Automatic	Automatic

Notes: [a]Brake lining thickness measured to the nearest 1/32 inch at leading edge, middle, and trailing edge. [b]Inside drum diameters were measured using a brake drum gauge to the nearest 1/8 (0.125) inch. [c] (Commercial Vehicle Safety Alliance, 2023).[29]

[29] Commercial Vehicle Safety Alliance (CVSA) provides guidance, education, and advocacy for enforcement and industry in North America as a nonprofit organization comprised of local, state, provincial, territorial, and federal commercial motor vehicle safety officials and industry representatives (CVSA, 2024).

Table 11. Axle 3 Brake Component Information

Observation	Left	Right
Brake Type	S-Cam Drum	S-Cam Drum
ABS	Yes	Yes
Upper Brake Lining Thickness[a]	13/32″, 12/32″, 10/32″	17/32″, 9/32″, 8/32″
Lower Brake Lining Thickness[a]	13/32″, 14/32″, 12/32″	13/32″, 10/32″, 13/32″
Brake Lining Inspection Limit	1/4″	1/4″
Measured Drum Diameter[b]	15.50″	15.50″
Maximum Drum Diameter	16.62″	16.62″
Brake Chamber Type	30L	30L
Measured Pushrod Travel[c]	Unable to test	1 7/8″
Adjustment Limit[c]	2 1/2″	2 1/2″
Slack Adjuster Length	6″	6″
Slack Adjuster Type	Automatic	Automatic

Notes: [a]Brake lining thickness measured to the nearest 1/32 inch at leading edge, middle, and trailing edge. [b]Inside drum diameters were measured using a brake drum gauge to the nearest 1/8 (0.125) inch. [c] (Commercial Vehicle Safety Alliance, 2023).

2.12 Frame

An eight-inch-long longitudinally aligned crack was observed on the left frame rail at the mount for the axle 3 lateral torque arm (Figure 26). There was a crack that extended from the web, through the radius, and into the bottom flange of the right frame rail, below the cab, in an area that would normally be obscured by the right-side fuel tank (Figure 27). Rust was observed on the edges of the crack. The right frame rail had buckled at the upper flange, above the crack. Located at a mounting point for the lateral torque arm, the pre-existing crack on the left frame rail adversely affected the support of functional suspension components; an out-of-service violation of 49 *CFR* Part 393.201 (a). The crack in the right frame rail, if pre-existing, would also be an out-of-service violation of 49 *CFR* Part 393.201 (a).

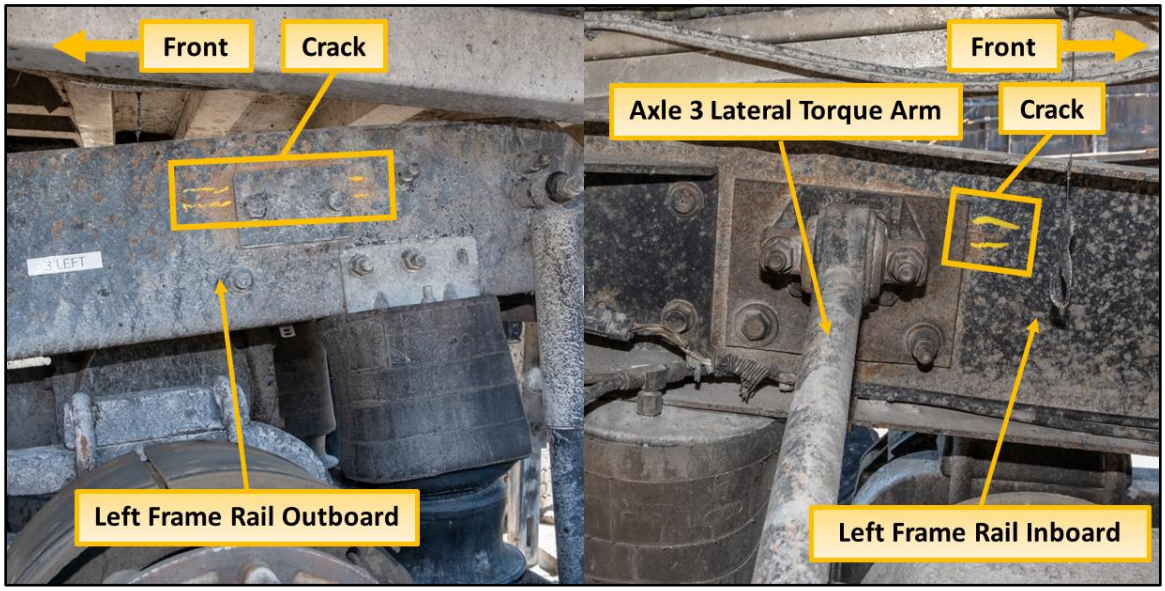

Figure 26. Crack in the left frame rail of the Mack.

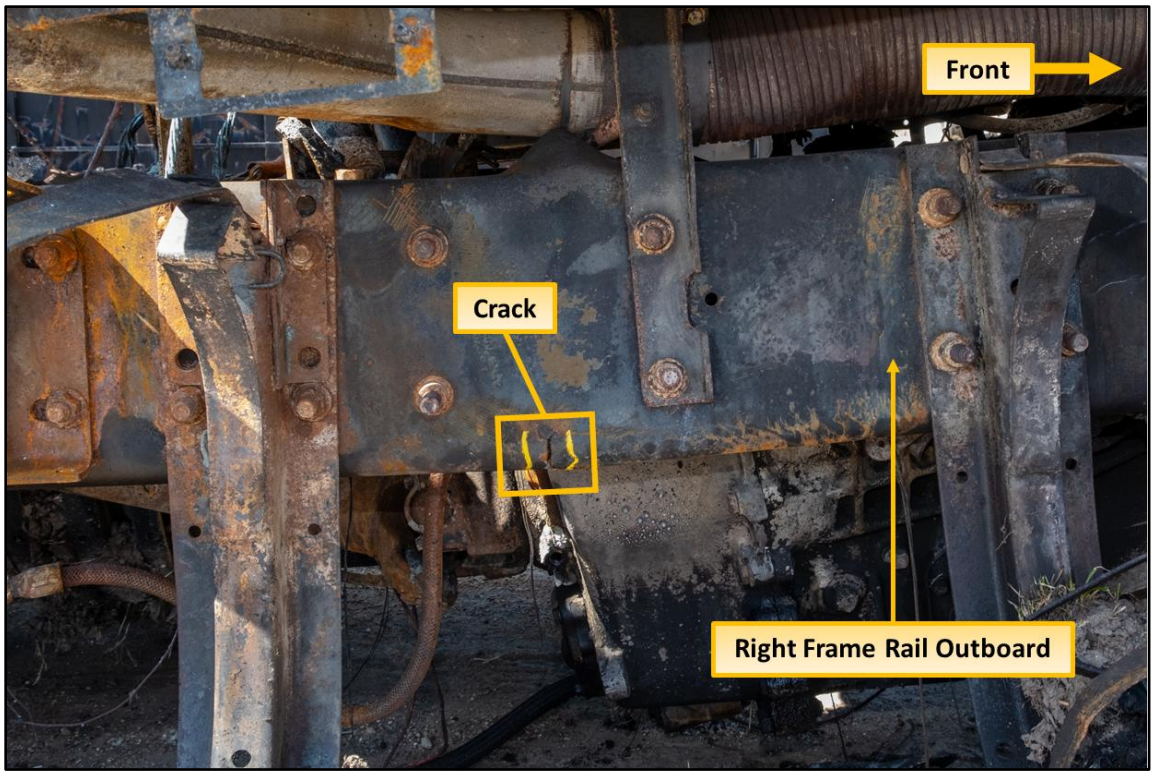

Figure 27. Crack in the right frame rail of the Mack.

2.13 Maintenance and Inspection History

Maintenance and inspection records were obtained by the Motor Carrier Group Chairman from Beaird Transport. The latest annual inspection was completed in March 2023.[30] No discrepancies were noted on the annual inspection report. An annual inspection decal was not found on the vehicle. A log of maintenance performed on the Mack documented routine maintenance and repairs performed on the vehicle between June 2019 and March 2024.[31] Notable documented maintenance performed on the Mack included, but was not limited to:

- Left side brake chambers were replaced on August 3, 2023.
- The left frame rail was welded at the torque bar on August 3, 2023.

Evidence of welding was not present in the vicinity of the crack observed at the axle 3 lateral torque arm mount on the left frame rail. Had the crack been present at the time of the annual inspection in March 2023, the deficiency would have been observable and should have resulted in failure of the annual inspection.

The post-crash inspection of the Mack combination by ISP investigators was documented in a Driver/Vehicle Inspection Report.[32] Six violations were noted for the Mack, with one of the violations coded as out-of-service (Table 12), with none of the violations marked as post-crash conditions.

Table 12. Violations Documented by ISP Investigators for the Mack.

Violation [49 *CFR*]	Description	Out of Service [Yes/No]
396.3A1	Inspection/repair and maint parts & accssries; axle 3 p/side brake chamber rust hole	No
396.3A1	Inspection/repair and maint parts & accssries; audible air leak air chamber axle 3 dside[a]	No
396.3A1	Inspection/repair and maint parts & accssries; rust hole in brake chamber axle 2 d/side	No
393.11TL	Tt lwr rr mud flaps retro sht/reflex mfg> 7/97; missing mud flap reflective	No
396.3A1BOS	Brakes out of service: defective brakes = or > 20 percent	Yes
396.3A1	Inspection/repair and maint parts & accssries; axle 3 d/side brake chamber rust hole	No

Notes: [a]Axle 2 left side chamber identified as the source of an audible air leak by ISP at the time of the NTSB inspection.

[30] Vehicle Factors Attachment – Mack Annual Inspection Report.
[31] Vehicle Factors Attachment – Mack Maintenance Log.
[32] Vehicle Factors Attachment – Mack Driver/Vehicle Inspection Report.

2.14 Documented Recalls and Warranty Claims

Five recalls were found using the NHTSA vehicle search tool for 2001 Mack CH series truck-tractors (2024); however, no open recalls were listed for the subject Mack using the VIN in the Mack Trucks safety recall search tool (2024).[33]

Warranty claim information was not available for the Mack.

2.15 Event Data Recorders

The Mack was equipped with an engine control module and vehicle engine control unit (VECU) with EDR capabilities. Both modules were found by NTSB investigators during their initial inspection of the vehicle; however, due to thermal damage sustained by the modules during the post-crash fire, it was determined there was no chance of data recovery from the modules. Both damaged modules were left with the vehicle.

2.16 Collision Mitigation Technologies

The Mack was not equipped with collision mitigation technology.

[33] A safety recall is issued when a manufacturer or NHTSA determines that a vehicle, equipment, car seat, or tire creates an unreasonable safety risk or fails to meet minimum safety standards. Most decisions to conduct a safety recall and remedy a safety defect are made voluntarily by the manufacturers prior to involvement by NHTSA.

3.0 2001 Vantage End-Dump Semitrailer

3.1 General Information

Make:	Vantage
Model:	T91-SS
VIN:	4EPAA39261ATA3791
Model Year:	2001
Date of Manufacture:	August 2000
In-Service Date:	Unknown
GVWR:	68,000 lbs.
GAWR, Axle 4:	20,000 lbs.
GAWR, Axle 5:	20,000 lbs.
Brake Type:	Air-operated drum
Recommended Tire Size:	11R22.5 at 100 PSI (dual)
Recommended Wheel Size:	22.5" x 8.25"

3.2 Damage Description

The end-dump semitrailer sustained contact damage to its right side in the form of crumpling and tearing of fenders above axles 4 through 5, which was consistent with its orientation at its position of rest (Figure 16). Other damage sustained by the end-dump semitrailer included detachment of parts of the hydraulic dump structure, including the hydraulic ram, at the kingpin (Figure 28), and thermal damage to the front and portions of both sides of the vehicle.

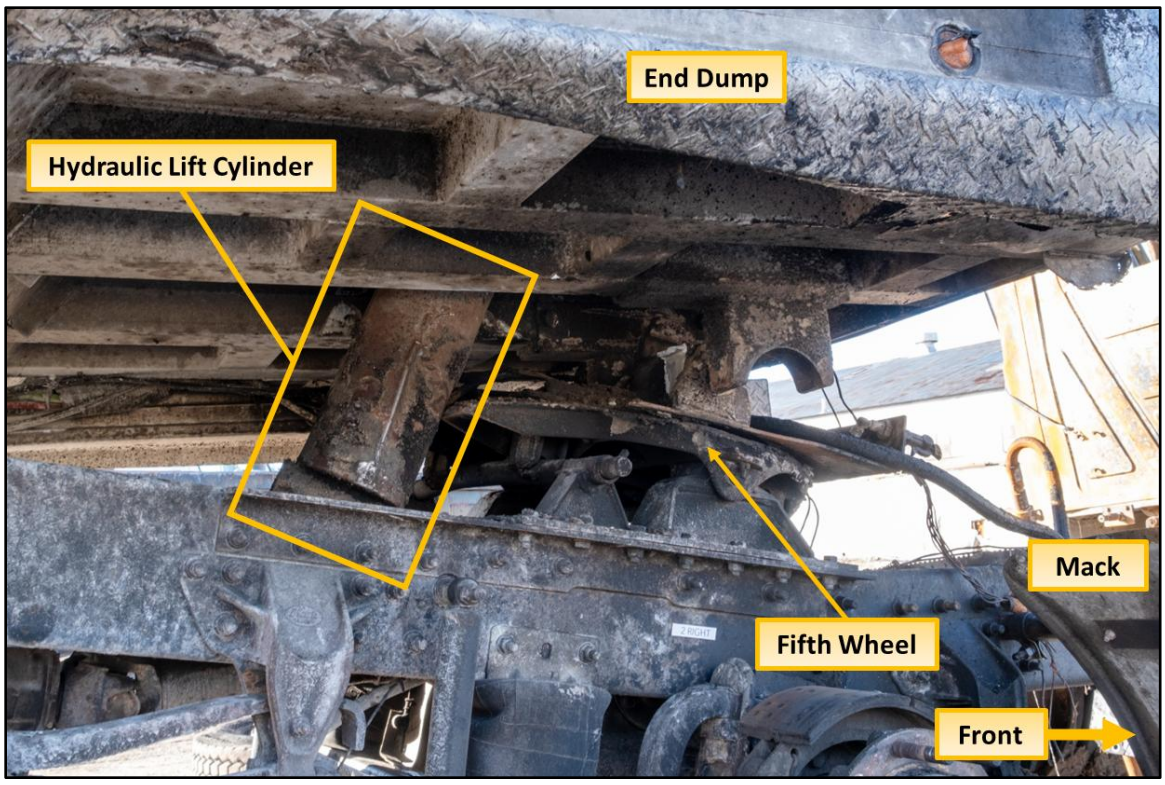

Figure 28. Hydraulic dump trailer ram and fifth wheel/kingpin coupling of the Mack combination.

3.3 Weights and Measurements

The Mack combination was weighed when the end-dump semitrailer was loaded at 10:45 a.m. on the morning of the crash. The loaded combination weighed 79,680 pounds.[34]

The crash-involved end-dump semitrailer and an exemplar Vantage T91-SS were scanned using a three-dimensional terrestrial laser scanner and point clouds were created for each vehicle. Refer to the docket for additional information regarding the three-dimensional laser scans. Vehicle dimensions were determined by measuring

[34] Vehicle Factors Attachment – Central Stone Company Ticket No: 55018264.

three-dimensional points in the point clouds using CloudCompare software (Figure 29).

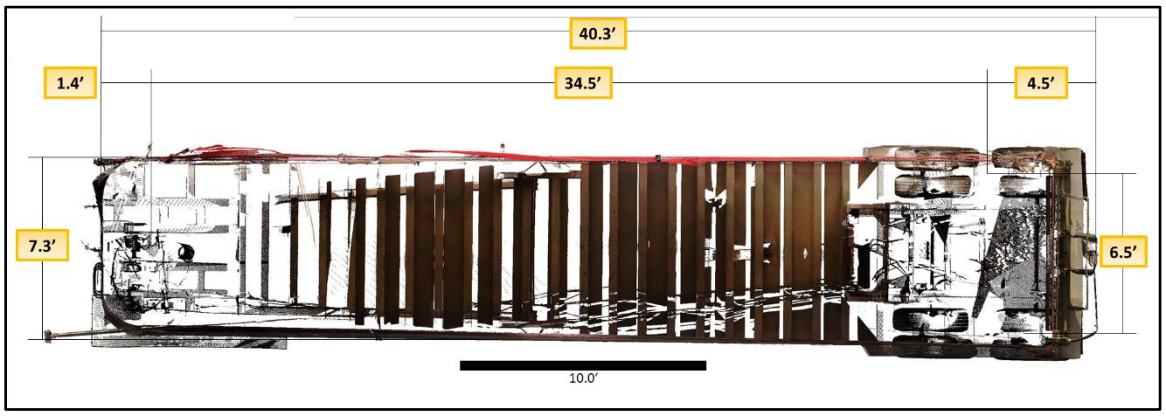

Figure 29. Three-dimensional laser scan of the end-dump semitrailer.

3.4 Suspension

Both axles were suspended by swing arms attached via bushings to mounts securely bolted to the underside of the frame structure. An airbag was in place between the trailing end of each control arm and the bottom of the frame. The airbags were supplemented with shock absorbers attached to the inboard side of each control arm, forward of the axles, and the control arm mounts.

3.5 Tires and Wheels

A manufacturer's specification label was affixed to the right side of the frame structure of the end-dump semitrailer. Per the specification label, the end-dump semitrailer was to be equipped with 11R22.5 tires, mounted on 22.5X8.25 rims at all positions. The tires were to be inflated to 100 pounds per square inch (psi) for all axles.

General information about each tire mounted on the end-dump semitrailer at the time of the inspection is documented in Table 13 and Table 14. All wheels were inspected for cracks, welds, and elongated lug nut holes. Tires at all positions were undamaged, but inflated below rated pressures for maximum load capacity.

Table 13. Axle 4 Tire and Wheel Information

Observation	Left Outside	Left Inside	Right Inside	Right Outside
Make	Ameristeel	Michelin	BF Goodrich	Ameristeel
Model	S360	XDN2	DR444	S360
Size	11R22.5	11R22.5	11R22.5	11R22.5
Pressure	96 PSI[a]	94 PSI[a]	84 PSI[a]	90 PSI[a]
Tread Depth[b]	16/32″, 15/32″, 15/32″, 16/32″	17/32″, 16/32″, 16/32″, 16/32″	13/32″, 12/32″, 12/32″, 13/32″	15/32″, 10/32″, 10/32″, 15/32″
DOT #	A33TKY7D4418	HJ3TA52X1516	HJ3TBUJX4816	A33TKY703319
Retread (Yes/No)	Yes	Yes	Yes	Yes
Retread #[c]	HYXC3021CIA, RYXC1123CIA	RYXL3920CIA, RYX3992CIA	RXYC3922CIA	RTXC172001IA
Tire Load Rating	6,005 lbs. at 120 PSI (dual)	5,840 lbs. at 105 PSI (dual)	5,840 lbs. at 105 PSI (dual)	6,005 lbs. at 120 PSI (dual)
Wheel Type	Alloy	Alloy	Alloy	Alloy
Wheel Size	22.5″ x 7.5″	22.5″ x 8.25″	22.5″ x 8.25″	22.5″ x 8.25″
Wheel Load Rating	Not found	7,300 lbs. at 120 PSI	7,300 lbs. at 120 PSI	7,400 lbs. at 130 PSI

Notes: [a]Measured using a high-pressure gauge by ISP investigators on March 12, 2024. [b]Minimum tread depth measured in 1/32″ increments (outboard to inboard). [c]Multiple retread numbers indicate the tire was retreaded more than once.

Table 14. Axle 5 Tire and Wheel Information

Observation	Left Outside	Left Inside	Right Inside	Right Outside
Make	Cooper	Cooper	Ameristeel	Ameristeel
Model	Work Series RHA	Work Series RHA	S360	S360
Size	11R22.5	11R22.5	11R22.5	11R22.5
Pressure	94 PSI[a]	96 PSI[a]	92 PSI[a]	96 PSI[a]
Tread Depth[b]	13/32″, 14/32″, 14/32″	13/32″, 14/32″, 12/32″	18/32″, 18/32″, 18/32″	18/32″, 18/32″, 18/32″
DOT #	1CR3TLWN10221	1CR3TLWP13720	A33TKYD3423	A33TK7D3423
Retread (Yes/No)	No	No	No	No
Retread #	N/A	N/A	N/A	N/A
Tire Load Rating	5,840 lbs. at 105 PSI (dual)	6,005 lbs. at 120 PSI (dual)	6,005 lbs. at 120 PSI (dual)	6,005 lbs. at 120 PSI (dual)
Wheel Type	Alloy	Alloy	Alloy	Alloy
Wheel Size	22.5″ x 8.25″	Not found	22.5″ x 8.25″	22.5″
Wheel Load Rating	7,300 lbs. at 120 PSI	Not found	7,400 lbs. at 130 PSI	7,400 lbs. at 130 PSI

Notes: [a]Measured using a high-pressure gauge by ISP investigators on March 12, 2024. [b]Minimum tread depth measured in 1/32″ increments (outboard to inboard).

3.1 Brake System

The end-dump semitrailer was equipped with air-actuated, S-cam brakes on both axles. Service and supply air pressure was routed from the Mack through air lines to a reservoir tank securely mounted laterally between the frame rails, forward of axle 4, and on to a series of valves at various locations around the vehicle and individual brake chambers. The end-dump semitrailer had originally been equipped with ABS, as required by 49 *CFR* Part 393.55 (c)(2); however, brake drums at both axles lacked wheel speed sensors. Wheel speed wiring had been cut, with loose ends fastened to air lines to brake chambers on axle 5 (Figure 30). Missing ABS components on the end-dump semitrailer was a violation of 49 *CFR* Part 396.1 (l)(6), which was not an out-of-service condition.

Chafing, which caused fraying of the reinforcing ply and a reduction of hose diameter was identified where air hoses contacted other vehicle components. Locations of the observed abrasions included a) a hose to the right brake chamber on axle 5 at the crossmember for axle 4, b) a hose to the right brake on axle 4 at the crossmember for axle 4, and c) a hose to the left brake on axle 4 at the crossmember for axle 4 (Figure 31). In addition to the chafing, there was a cut in the hose to the right brake on axle 5 that affected the reinforcing ply (Figure 32). The pre-existing conditions were out-of-service violations of 49 *CFR* Part 393.45 (b) (Commercial Vehicle Safety Alliance, 2023).

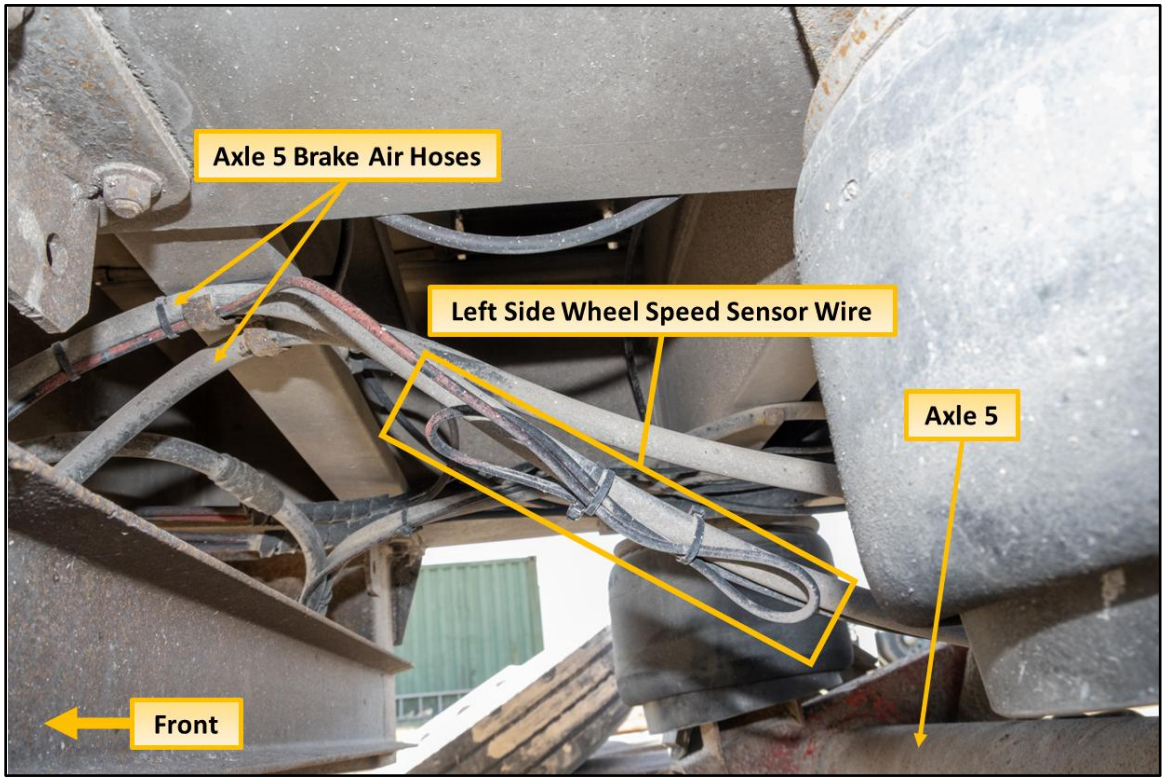

Figure 30. Left side wheel speed sensor wire cut and secured to an axle 5 brake air hose.

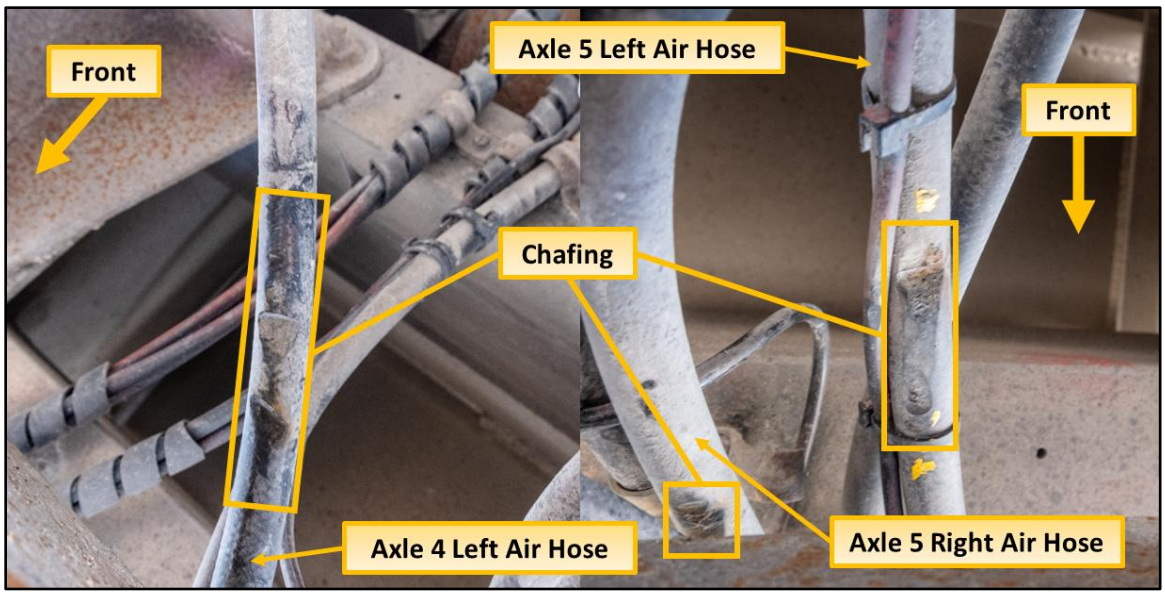

Figure 31. Chafing of air hoses to air hoses to axle 4 and axle 5.

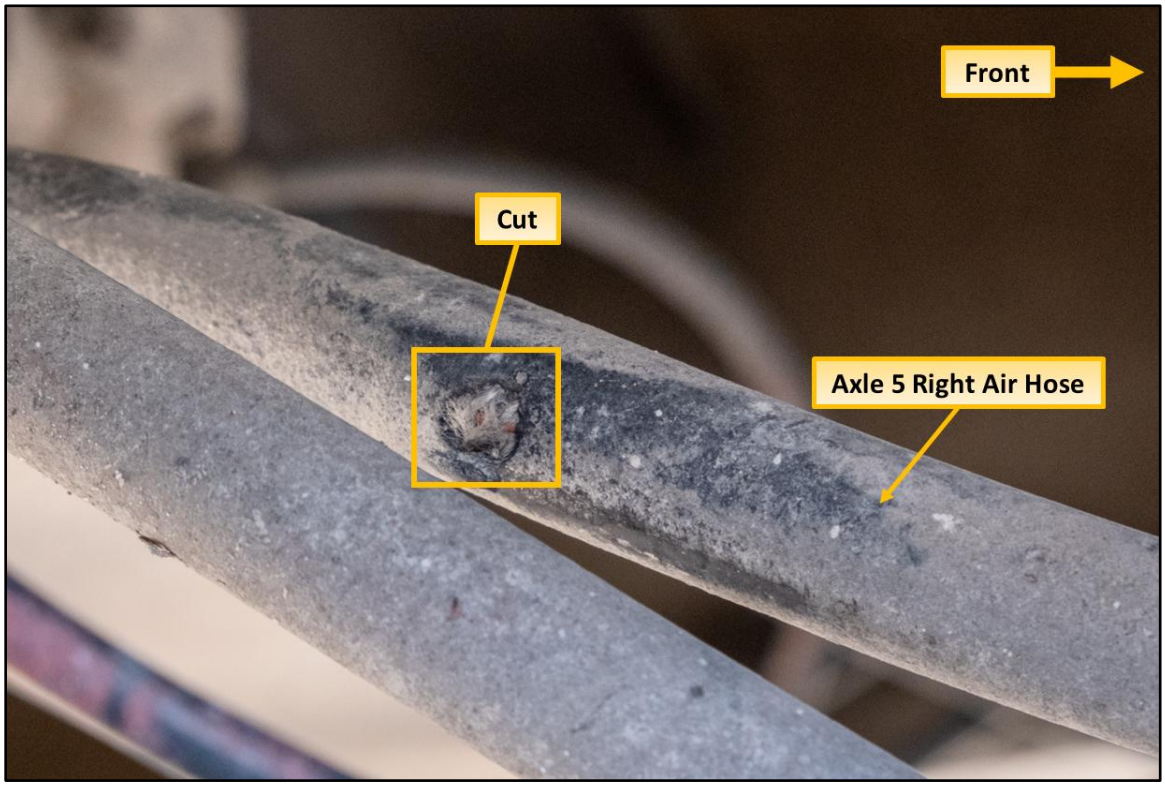

Figure 32. Cut into the reinforcing ply in the air hose to the right brake chamber on axle 5.

Testing of the brakes by ISP investigators on March 12, 2024, was conducted by applying 135 PSI of shop air to individual brake chambers through their respective hoses.[35] Pushrod travel measured during testing of the brakes was within adjustment limits for all positions. Wheels and brake drums were removed at each position to inspect brake shoes and drum friction surfaces. Cam rollers were in contact with brake cams, and return springs were in place at all positions.

There were discernable ridges on the friction surfaces on the drums on left side of axle 4 and right side of axle 5. There was heat checking on the friction surfaces of both drums on axle 4. Measured drum diameters were less than the maximum diameter identified by markings embossed on the external surfaces of the drums.

Brake linings were securely attached to all shoes. Minimum brake lining thicknesses were above inspection limits specified in 49 *CFR* Part 396.47 (d)(2). Pushrod travel, brake lining thickness, and drum diameter measurements taken by ISP and NTSB investigators are presented in Table 15, and Table 16.

Table 15. Axle 4 Brake Component Information

Observation	Left	Right
Brake Type	S-Cam Drum	S-Cam Drum
ABS	No	No
Upper Brake Lining Thickness[a]	14/32″, 19/32″, 22/32″	10/32″, 14/32″, 13/32″
Lower Brake Lining Thickness[a]	15/32″, 26/32″, 22/32″	9/32″, 16/32″, 14/32″
Measured Drum Diameter[b]	16.5″	16.5″
Maximum Drum Diameter	16.62″	16.62″
Brake Chamber Type	30/30C	30/30C
Measured Pushrod Travel	1 1/2″	1 1/8″
Adjustment Limit[c]	2″	2″
Slack Adjuster Length	6″	6″
Slack Adjuster Type	Automatic	Automatic

Notes: [a]Brake lining thickness measured to the nearest 1/32 inch at leading edge, middle, and trailing edge. [b]Inside drum diameters were measured using a brake drum gauge to the nearest 1/8 (0.125) inch. [c] (Commercial Vehicle Safety Alliance, 2023).

[35] Brake adjustment inspections should be conducted at 90 to 100 PSI (Commercial Vehicle Safety Alliance, 2023)

Table 16. Axle 5 Brake Component Information

Observation	Left	Right
Brake Type	S-Cam Drum	S-Cam Drum
ABS	No	No
Upper Brake Lining Thickness[a]	15/32″, 25/32″, 20/32″	14/32″, 23/32″, 20/32″
Lower Brake Lining Thickness[a]	15/32″, 25/32″, 22/32″	13/32″, 26/32″, 21/32″
Measured Drum Diameter[b]	16.5″	16.5″
Maximum Drum Diameter	16.62″	16.62″
Brake Chamber Type	30/30C	30/30C
Measured Pushrod Travel	1 3/4″	2″
Adjustment Limit[c]	2″	2″
Slack Adjuster Length	5.5″	5.5″
Slack Adjuster Type	Automatic	Automatic

Notes: [a]Brake lining thickness measured to the nearest 1/32 inch at leading edge, middle, and trailing edge. [b]Inside drum diameters were measured using a brake drum gauge to the nearest 1/8 (0.125) inch. [c] (Commercial Vehicle Safety Alliance, 2023).

3.1 Frame

At the right swing arm mount for axle 5, vertically aligned cracks were observed in the bottom flanges of the outboard side of the frame rail and rear of the crossmember (Figure 33). There were also cracks through welds at metal shims between the axle 5 right-side swing arm mount and above the axle 5 right-side air bag mount (Figure 33 and Figure 34). The pre-existing cracks on the frame rail and crossmember at the right-side axle 5 swing arm adversely affected the support of functional suspension components; an out-of-service violation of 49 *CFR* Part 393.201 (a).

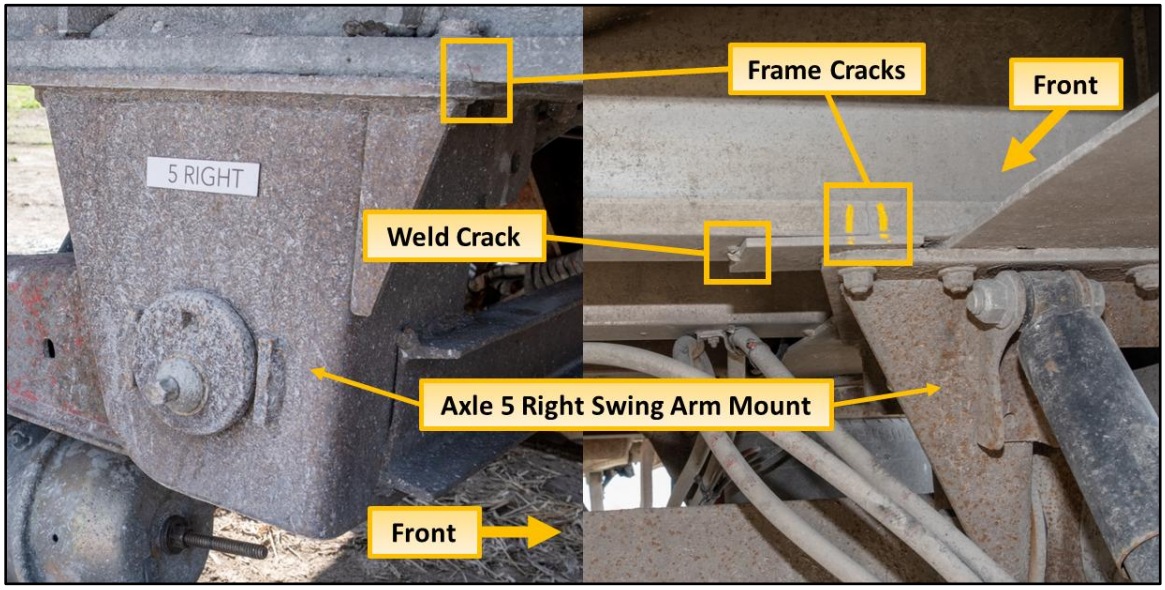

Figure 33. Cracks in the right frame rail and crossmember at the axle 5 swing arm mount.

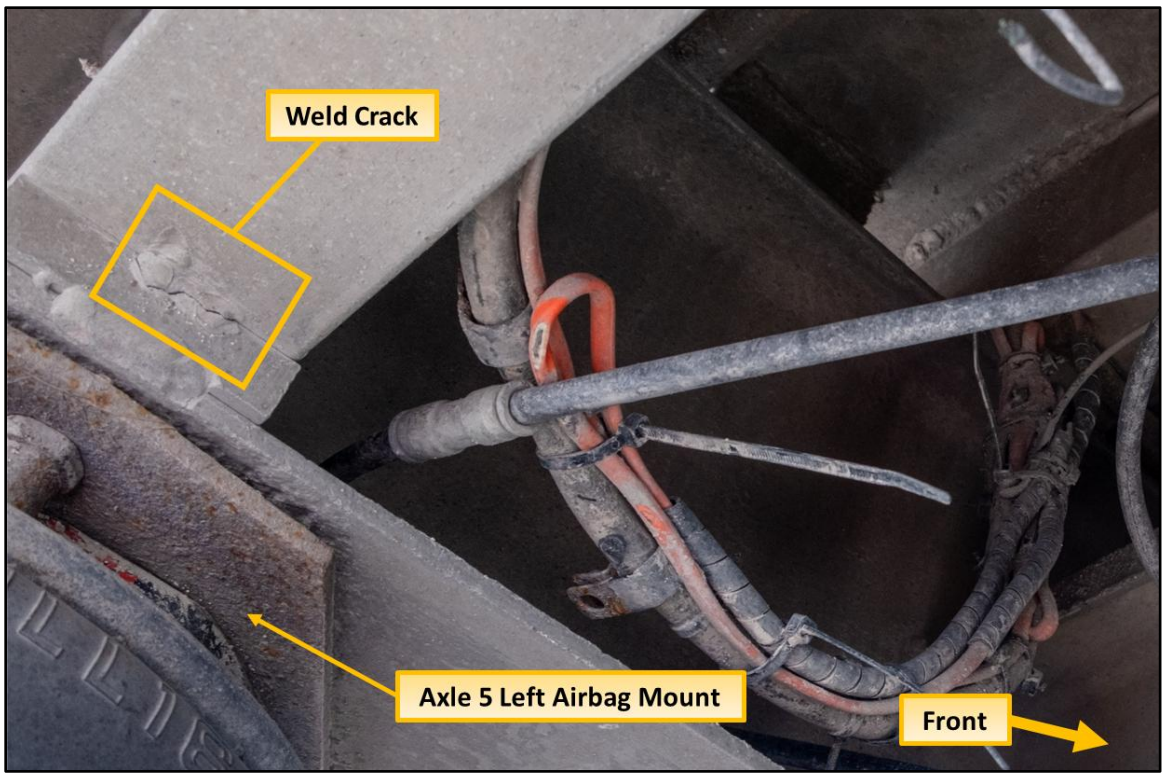

Figure 34. Weld crack at the left-side axle 5 airbag mount.

3.2 Maintenance and Inspection History

Maintenance and inspection records were obtained by the Motor Carrier Group Chairman from Beaird Transport. The latest annual inspection was completed in March 2023.[36] The annual inspection report indicated ABS on the end-dump semitrailer was functional at the time of the last inspection and no other deficiencies were noted. An annual inspection decal was not found on the vehicle. A log of maintenance performed on the end-dump semitrailer documented routine maintenance and repairs performed on the vehicle between June 2023 and March 2024.[37] Documented changes to the brakes on the end-dump semitrailer after the March 2023 annual inspection were limited to:

- New components and a new S-cam bushing were installed and the slack adjuster was repaired on the right side of axle 4 on July 18, 2023.
- The slack adjuster on the right side of axle 4 was replaced on November 23, 2023.

[36] a) Vehicle Factors Attachment – End-Dump Semitrailer Annual Inspection Report. b) Only 3-23 noted for inspection date.
[37] Vehicle Factors Attachment – End-Dump Semitrailer Maintenance Log.

- New brakes and drum were installed on the left side of axle 5 on December 21, 2023

The lack of required ABS components and cracks in the right frame rail and crossmember at the right-side swing arm mount for axle 5 were deficiencies that should have resulted in failure of the annual inspection.

The post-crash inspection of the Mack combination by ISP investigators was documented in Driver/Vehicle Inspection Report IL3998291753.[38] Ten violations were noted for the end-dump semitrailer, with six of the violations coded as out-of-service (Table 17).

Table 17. Violations Documented by ISP Investigators for the End-Dump Semitrailer.

Violation [49 *CFR*]	Description	Out of Service [Yes/No]
393.45	Brake tubing and hose adequacy; axle 5 p/side brake chamber hose near axle 4 frame any damage extending through outer reinf	Yes
393.45	Brake tubing and hose adequacy; axle 4 d/side brake chamber hose any damage extending through outer reinforcement ply	Yes
393.45	Brake tubing and hose adequacy; axle 4 p/side brake chamber hose any damage extending through outer reinforcment ply	Yes
393.45	Brake tubing and hose adequacy; axle 4 d/side brake chamber hose any damage extending through ouer reinforcement ply	Yes
393.13D2	Improper lower rear area trailer reflex reflectors mfg <12/93; bumper reflective tape needs replaced old/worn/missing/damaged	No
393.11S	Side retroreflect sht/reflx reflect mfg>12/93; side reflective tape needs to be replaced old/faded/worn	No
393.207A	Axle positioning parts defective/missing; axle 5 d/side air bag suspension support broken/cracked rusted (old) crack	Yes
393.47A	Inadequate brakes for safe stopping - brake lining condition; axle 2 brake linings cracked	No
393.207A	Axle positioning parts defective/missing; trailer frame/axle support crack	Yes
393.55C1	ABS all tractors mfg>2/97 air brake system; cut wires on trailer	No

[38] Vehicle Factors Attachment – Mack Driver/Vehicle Inspection Report.

3.3 Documented Recalls and Warranty Claims

No recall information was found using the NHTSA vehicle search tool for the end-dump semitrailer (2024).[39]

Warranty claim information was not available for the end-dump semitrailer.

3.4 Event Data Recorders

The end-dump semitrailer was not equipped with components with event data recorder (EDR) capability.

3.5 Collision Mitigation Technologies

The end-dump semitrailer was not equipped with collision mitigation technology.

3.6 References

Commercial Vehicle Safety Alliance. (2023). *North American Standard Out-Of-Service Criteria*.

CVSA. (2024). *CVSA*. Retrieved August 14, 2024, from About CVSA: https://www.cvsa.org/about-cvsa/

Ford Motor Company. (2024). *Tire Finder*. Retrieved 2024, from Ford.com: https://www.ford.com/support/service-maintenance/tire-finder/search-results.html#/Results/Vehicle?year=2020&make=Ford&model=Transit&trim=T-350%20HD%20Cutaway%20DRW&searchType=vehicle&size=195%2F75R16C&loadRange=D&load=107&loadDual=105&speed=R&breadcrumbs=

Mack Trucks North America. (2024, March 13). *Lookup Safety Recalls*. Retrieved 2024, from https://www.macktrucks.com/recalls/

National Highway Traffic Safety Administration. (2024). *Safety Issues and Recalls*. Retrieved March 13, 2024, from https://www.nhtsa.gov/recalls

[39] A safety recall is issued when a manufacturer or NHTSA determines that a vehicle, equipment, car seat, or tire creates an unreasonable safety risk or fails to meet minimum safety standards. Most decisions to conduct a safety recall and remedy a safety defect are made voluntarily by the manufacturers prior to involvement by NHTSA.

3.7 Docket Material

The following attachments are in the docket for this investigation:

Vehicle Factors Attachment – Micro Bird Configuration Diagram

Vehicle Factors Attachment – Micro Bird Specifications

Vehicle Factors Attachment – 2020 Ford Transit Specifications

Vehicle Factors Attachment – Micro Bird Inspection Report

Vehicle Factors Attachment – Micro Bird Maintenance Log

Vehicle Factors Attachment – Micro Bird Driver/Vehicle Inspection Report

Vehicle Factors Attachment – 2020 Ford Transit Owner's Manual – Lane Keeping System

Vehicle Factors Attachment – 2020 Ford Transit Owner's Manual – Pre-Collision Assist

Vehicle Factors Attachment – Central Stone Company Ticket No: 55018264

Vehicle Factors Attachment – Mack Invoice and Vehicle Specifications

Vehicle Factors Attachment – Mack Annual Inspection Report

Vehicle Factors Attachment – Mack Maintenance Log

Vehicle Factors Attachment – Mack Driver/Vehicle Inspection Report

Vehicle Factors Attachment – End-Dump Semitrailer Annual Inspection Report

Vehicle Factors Attachment – End-Dump Semitrailer Maintenance Log

Submitted by:

Justin Snider
Senior Highway Accident Investigator