VEHICLE FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

Chesterfield Twp, NJ

HWY-12-MH-007
(33 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C. 20594

VEHICLE FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

A. ACCIDENT

Type:	School Bus, Roll-Off Truck Intersection Related Accident
Date and Time:	February 16, 2012 8:15 AM. EST
Location:	Bordentown-Chesterfield Rd (Burlington County Route 528) and Old York, Rd (Burlington County Route 660) Chesterfield Township, Burlington County, New Jersey
Vehicle #1:	2012 IC Bus[1] 54-Passenger School Bus
Motor Carrier #1:	Garden State Transport, Inc.
Vehicle #2:	2004 Mack Granite Roll-Off Truck
Motor Carrier #2:	Herman's Trucking, Inc.
NTSB #:	HWY-12-MH-007

B. VEHICLE FACTORS GROUP

Steven L. Prouty, Vehicle Factors Engineer, Group Chairman
NTSB, Office of Highway Safety
624 Six Flags Drive, Suite 150, Arlington, TX 76011

John Stefani, Sergeant
Chesterfield Township Police Department
300 Bordentown-Chesterfield Road, Chesterfield, NJ 08515

Lawrence Higgins, Sergeant
New Jersey State Police, Motorcoach/Compliance Review Unit
P.O. Box 7068, West Trenton, NJ 08628

Richard Brunett, Detective Sergeant
New Jersey State Police, Fatal Accident Investigation Unit
P.O. Box 7068, West Trenton, NJ 08828

---

[1] IC Bus, LLC is a wholly owned subsidiary of Navistar, Inc.

Gino D'Addario, Trooper
New Jersey State Police
P.O. Box 7068, West Trenton, NJ 08828

Gaetano Frascella, Trooper
New Jersey State Police
P.O. Box 7068, West Trenton, NJ 08828

Roy S. Zeitlow, Sr. Product Integrity Engineer
Navistar, Inc.
2601 Navistar Drive, Lisle, IL 60532

Timothy LaFon, Director, Regulatory Affairs
Mack Trucks, Inc.
7900 National Service Road, Greensboro, NC 27409

Mac Bradley, Principal Engineer, Brake Systems & Vehicle Controls
Mack Trucks, Inc.
7900 National Service Road, Greensboro, NC 27409

James E. Szudy, Engineering Manager, Vehicle Systems
Bendix Commercial Vehicle Systems LLC
901 Cleveland Avenue, Elyria, OH 44035

John V. Ripley, Engineer, Systems Engineering
Bendix Commercial Vehicle Systems LLC
901 Cleveland Avenue, Elyria, OH 44035

Warren Kimble, General Manager
Palfinger – American Roll-Off[2]
572 Whitehead Road, Suite 301, Trenton, NJ 08619

C. ACCIDENT SUMMARY

For a summary of the accident, refer to the *Accident Summary* report which is available in the docket for this investigation.

D. DETAILS OF INVESTIGATION

This report is a collection of factual information obtained during the detailed inspection of the accident vehicles and subsequent review of records. Safety Board Staff inspected the 2012 IC

[2] At the time the accident truck was built, the final stage manufacturer was Automated Waste Equipment Co., Inc. In 2009, Palfinger – American Roll-Off purchased assets, including the "American Roll-Off" product line, from Automated Waste Equipment Co., Inc.

School Bus (bus) and the 2004 Mack Granite Roll-Off truck (truck) at Helmrich Towing and Recovery in Pennsauken, NJ, between February 18, and March 8, 2012.

All major mechanical systems were examined, including steering, braking, and suspension systems. Overall accident damage, along with any damage or anomalies within these systems, was documented. Supporting photographs, vehicle specifications, maintenance records, and prior annual inspection reports were collected and reviewed. Several brake system components were removed from the truck for additional examination.

E. VEHICLE INSPECTION

1. VEHICLE #1: 2012 IC BUS, PB10500, 54-PASSENGER SCHOOLBUS

1.1 GENERAL INFORMATION

VIN:[3]	4DRBUAAP7CB[redacted]
Model:	PB10500, 54-passenger
Manufactured:	September 17, 2010
Mileage:[4]	13,419
Curb Weight:[5]	15,374 lbs
GVWR:[6]	29,760 lbs
GAWR Front (Steer Axle):[7]	10,000 lbs
GAWR Rear (Drive Axle):	19,760 lbs
Engine:	International MaxxForce DT, 215 HP, Diesel, serial number – 2U3306097
Transmission:	Allison Automatic 2500 PTS5-SP, serial number – 6311013609
Steering Gear:	TRW model TAS-66, serial number – T4X486
Brake Type:	Meritor 4-wheel hydraulic ABS disc brakes

1.2 DAMAGE DESCRIPTION

The bus was removed from the scene the morning of the accident by Haine's Towing, and towed to their tow lot, located at 240 Route 130, in Bordentown, NJ.[8] On Saturday, February 18, 2012, the bus was moved to Helmrich Towing and Recovery, located at 4450 Marlton Pike, Pennsauken, NJ, for secure storage and inspection. The bus was initially inspected at this location

[3] Vehicle Identification Number (VIN), with the last 6 digits redacted.

[4] According to the odometer located on the dash of the bus.

[5] Curb weight is typically defined as the total weight of the vehicle with standard equipment, all necessary consumables (e.g., motor oil, coolant, etc.), and a full tank of fuel, while not loaded with passengers or cargo. The "curb" weight for this vehicle, however, is an approximation based on the sum of the incomplete chassis and incomplete bus body weights. Additional information is contained in *Vehicle Attachment 1 – 2012 IC School Bus – Technical Specifications*, which can be found in the docket for this investigation.

[6] 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.

[7] Gross Axle Weight Rating (GAWR) is the maximum distributed weight that a given axle is designed to support.

[8] The bus was placed on a "low-boy" semi-trailer to facilitate its transport from the scene.

between February 18, and February 24, 2012. A brief follow up inspection of the bus took place at this location on March 6, 2012.

The accident bus had two main areas of contact damage. For uniform description, "left" will refer to the driver's side, while "right" will refer to the boarding door side of the accident bus. The first area of contact damage was located on the left side of the vehicle behind the rear axle.[9] The damage began approximately 54-$^{1}/_{2}$ inches to the rear of the rear axle, and extended to approximately 128 inches to the rear of the rear axle. The damage extended vertically, from the bottom edge of the bus body, upward approximately 47 inches. Red paint transfer was located on the side of the bus near the rear extents of the contact damage area. Two areas of light yellow paint transfer, and greater penetration into the side of the bus, were located approximately 56 inches to the rear of the rear axle, and approximately 87 inches to the rear of the rear axle. An area of penetration into the interior of the bus was centered approximately 65 inches to the rear of the rear axle, and approximately 48 inches above ground level.[10] One lower glass window panel was broken out just forward of the contact damage area.

The second area of contact damage was located on the right side of the bus behind the rear axle.[11] The damage began approximately 24 inches to the rear of the rear axle, and extended to approximately 54 inches to the rear of the rear axle. The damage extended vertically from the bottom edge of the bus body to the roofline. The side of the bus body was crushed inward to a penetration depth of approximately 9 inches. One upper glass window panel and two lower glass window panels were broken out in the area of the contact damage.

Induced damage was present on the roof of the bus between the two areas of contact damage, bending the section of bus body behind the rear axle to the right. Induced damage was also present on the rear of the bus, bending the emergency exit door and door frame. The bus body was also displaced forward on the frame. The greatest forward displacement occurred near the right rear of the school bus, with the greatest displacement measuring approximately 3 inches.

All of the bus tires remained inflated. Electrical power was disconnected by emergency responders as a safety measure while the bus was on-scene.

1.3 WEIGHT AND MEASUREMENTS

The accident bus was weighed by the New Jersey State Police using certified portable scales on February 16, 2012.[12] The measured axle weights are shown in **Table 1**. Due to the post-crash condition of the bus, axle weights may not be distributed as they were at the time of the accident, and do not include the weights of the bus occupants.

---

[9] Refer to *Vehicle Photograph 1 – 2012 IC School Bus – Contact Damage to Rear Left Side*, which can be found in the docket for this investigation.

[10] Refer to *Vehicle Photograph 2 – 2012 IC School Bus – Penetrating Damage to Rear Left Rear Side,* which can be found in the docket for this investigation.

[11] Refer to *Vehicle Photograph 3 – 2012 IC School Bus – Contact Damage to Rear Right Side,* which can be found in the docket for this investigation.

[12] Additional information is contained in *Vehicle Attachment 2 – New Jersey State Police Portable Scale Certifications,* which can be found in the docket for this investigation.

Table 1: Accident Bus Axle Weights

Position	Weight (lbs)		Axle
	Left	Right	Total
Steer Axle	4,000	3,700	7,700
2nd Axle	5,150	5,500	10,650
Total	18,350		

According to records obtained from the manufacturer, pre-crash specifications for a PB10500 model school bus are listed in **Table 2**.[13] Also listed in **Table 2** are hand measurements of the accident bus taken by Safety Board investigators at the time of inspection.

Table 2: Pre and Post-Crash Measurements of Accident Bus

Dimension	Pre-Crash (inches)		Post-Crash (inches)	
Overall Length		438.9	Left	436.5
			Right	436.5
Overall Width		93.0	Front	92.0
			Rear	94.25
Wheelbase		253.9	Left	255.5
			Right	251.5
Track Width (Axle 1)		79.73	80.5	
Track Width (Axle 2)		72.53	74.5	
Front Overhang		40.0	Left	37.5
			Right	37.75
Rear Overhang		145.0	Left	143.75
			Right	147.0
Overall Height*	Front	119.0	Left Front	119.0
			Left Rear	118.5
	Rear	119.0	Right Front	119.0
			Right Rear	118.5

* Note: Pre-crash height measurements were taken from an exemplar vehicle. All other pre-crash measurements were supplied by the manufacturer.

In addition to the hand measurements, the accident bus was scanned using a 3-dimensional laser scanner that will allow for the creation of a 3-D model, from which additional scaled measurements can be taken.[14]

[13] Additional information is contained in *Vehicle Attachment 1 – 2012 IC School Bus – Technical Specifications*, which can be found in the docket for this investigation.

[14] Additional information is contained in the *Forensic Research and Evidence Documentation Factual Report (3D Laser Scanner)*, which can be found in the docket for this investigation.

1.4 DRIVER CONTROLS[15]

The driver's seat was intact and in place in the bus. The driver's lap/shoulder seatbelt was found unbuckled, retracted, and hanging from the upper attachment point to the left of the driver's seat location. To the left of the driver's seat was a long panel, which included a cup holder molded into the cover of a storage compartment, three dial controls for the heating system, numerous rocker switches, and controls for the two external rear-view mirrors. The interior temperature control dials included: a control allowing the driver to select the amount of air that came from being re-circulated vs. fresh air; a dial controlling the output location which could be adjusted between the driver's area and the passenger area in varying ratios; and the standard temperature selector (hot vs. cold). The numerous rocker switches, and their positions at the time of the inspection, include the following:

- Step-well Heater (on/off) – Off
- Driver Heater (on/off) - Off
- Rear Heater (on/off) – Off
- Defrost Fan (on/low/high) – Off
- Engine Coolant Boost Pump (on/off) – Off
- Heated Mirror (on/off) – Off
- Entry Door (close/neutral/open – self centering) – Neutral
- Front Air Conditioning (on/off) – Off
- Front Air Conditioning (low/medium/high) – High
- Rear Air Conditioning (on/off) – Off
- Rear Air Conditioning (low/medium/high) – High
- Dome Lights (on/off) – Off
- Driver Dome Light (on/off) – Off
- Master Flasher (on/off) – On
- Red Light Override (on/off) – Off
- Left Driver Area Fan (off/low/high) – Off
- Right Driver Area Fan (off/low/high) - Off

Located immediately in front of the driver's seat was a 17-¾ inch diameter steering wheel. The steering wheel was mounted on a steering column that was adjustable for both height and angle. The steering wheel contained two rocker style switches, one each on the left and right sides of the steering wheel. The left switch opened and closed the boarding door. The right switch activated the flashing yellow warning lights, as well as the red flashing lights, stop sign, and crossing gate. The turn signal stalk was located on the left side of the steering column, and included accessory functions such as high and low beam headlight selection, windshield wiper operation, and a button to dispense windshield washer fluid. The turn signal stalk was found in the centered position at the time of the examination, and the windshield wiper selector was in the off position. Also on the left side of the steering column was a lever allowing for the adjustment of steering wheel tilt and elevation. A "Hazard" flasher control button was located on the top steering column surface, and was found in the off position.

A button style switch, and two rocker style switches were located to the left of the steering column, and controlled various lighting functions. The button style switch initiated an exterior

[15] Refer to *Vehicle Photograph 4 – 2012 IC School Bus – Driver Control Area*, which can be found in the docket for this investigation.

lamp test sequence to aid in pre-trip inspections. A three position rocker switch controlled the headlight functions (off/parking/headlights), and was found in the “headlight on” position. The third switch was a self centering rocker switch which allowed for adjusting the brightness of the dash panel lights. A single, two position rocker switch was located to the right of the steering column. This switch activated the “transmission economy” feature, and was found in the off position.

Above the driver’s seating area, and to the left, was a two-way communication radio, which was found to be in the on position, with the volume selector slightly below half of full volume. Above the two-way radio was a lighting system status board that allowed the driver to determine which exterior school bus lights, such as flashers and the stop sign, were in operation or deployed at any given time.

The dash in front of the driver’s seat contained several gauges, indicator lights, and a digital information display. The gauges included: transmission temperature, water/coolant temperature, oil pressure, engine speed (RPMs), vehicle speed (mph & km/h), electrical system voltage, and fuel level. All of the gauge indicators were in their zero or “home” positions. Also present in the dash area was a stick style button to select and reset the trip odometer, trip timer, and other informational items.

The dash to the right of the driver contained a parking brake switch. The switch, while made to look like a traditional push/pull air parking brake knob, is a self centering electrical switch for the hydraulically released parking brake. When pulled, the parking brakes are actuated, and when pushed, the parking brakes are released. Below the parking brake switch is a three position keyed ignition switch (acc/off/run). The ignition was found in the off position. Also located in this area was the gear shift selection lever to operate the automatic transmission. Below the gear shift is a microphone and a two position toggle switch (INT/EXT), which was found in the “EXT” position. Four additional rocker switches are located to the right of the gear shift. These switches include:

- Cruise Control (off/neutral/on – self centering) – Neutral
- Set/Resume (set-coast/neutral/resume-accel – self centering) – Neutral
- Mud/Snow Traction Control (disabled/enabled) – disabled
- Emissions Regeneration (parked regen/neutral/on – self centering) – Neutral

Below the switches described above, is an in-vehicle stereo with CD player.

The vehicle’s accelerator pedal was 2-$^{1}/_{8}$ inches wide and 4-$^{1}/_{2}$ inches long. The brake pedal was 4-$^{1}/_{2}$ inches wide and 3 inches long. The accelerator and brake pedals were separated by a horizontal distance of 2-$^{3}/_{4}$ inches.

1.5 STEERING SYSTEM

The steering wheel was found to be concentric and was not deformed. With the front axle tires lifted off the ground, full rotation of the steering wheel from far left to right was possible without restriction or binding being felt at the wheel. With movement of the steering wheel, the front axle tires and wheels were observed to move outward and inward, from axle stop to axle stop, corresponding with the rotation of the steering wheel. When at full left and full right, both steer tires were rotated, and were found to be free of rubbing or binding on other vehicle components.

The steering column transcended through the firewall of the accident bus and connected via a universal joint to a straight steering shaft. The steering shaft connected to the input shaft of a TRW hydraulically assisted steering gear box through another universal joint. The output shaft from the steering gear was then connected to the pitman arm. The pitman arm was connected by means of a ball joint to the drag link. The drag link was connected to the left side of the steer axle through a steering arm using a ball joint connection. The left side of the steer axle was connected to the right side of the steer axle by means of a tie rod with ball joint connections on each end. No damage was noted to any of the steering system components. All connections were solid and free of wear or excessive play.

1.6 SUSPENSION

The accident bus was equipped with conventional leaf spring and shock absorber suspension system components. Each side of the steer axle was equipped with a set of leaf springs and a shock absorber. There were two main leaf springs on each side, all of which were free of any visible cracks, damage, or apparent defects. The shock absorbers were securely attached, and free of wear or excessive play.

Each side of the rear axle was equipped with a set of leaf springs and a shock absorber. The suspension on each side consisted of two full length leaf springs, and seven progressively shorter leaf springs. All of the leaf springs were free of any visible cracks, damage, or apparent defects. The shock absorbers were securely attached, and free of wear or excessive play. The right rear axle connection was found to be shifted forward from its original mounting position by approximately 1-$^{1}/_{8}$ inches.[16] Additionally, there was an approximate $^{3}/_{8}$ inch area of disturbed dust/dirt forward of the right axle connection.

1.7 TIRES AND WHEELS

The VIN/tire placard that was affixed to the vehicle by the manufacturer was cut away and destroyed during the installation of an aftermarket air conditioning unit. A copy of the information listed on the original placard was obtained from the manufacturer.[17] According to the information on the placard, the front axle of the bus was to be equipped with 265/75R22.5 tires mounted on 22.5 x 7.50 rims, with a cold inflation pressure of 110 pounds per square inch (psi). The rear axle was to be equipped with 10R22.5 tires mounted on 22.5 x 7.50 rims, with a cold inflation pressure of 105 psi.

Table 3 includes information on the condition of the bus tires as they were examined at the time of inspection. Also included in **Table 3** are the tire load ratings, in pounds, based on the tire manufacturer's recommended inflation pressures.[18] Tire tread depth measurements were taken in

---

[16] Refer to *Vehicle Photograph 5 – 2012 IC School Bus – Right Rear Axle Connection Shifted Forward*, which can be found in the docket for this investigation.
[17] Additional information is contained in *Vehicle Attachment 3 – 2012 IC School Bus – VIN Plate Information*, which can be found in the docket for this investigation.
[18] Additional information is contained in *Vehicle Attachment 4 – 2012 IC School Bus – Manufacturer Specifications for Firestone, Goodyear, and Hankook Tires*, which can be found in the docket for this investigation.

the major tread grooves of each tire. The smallest depth measured is displayed in the table, and represents a minimum tread depth value for that tire. The minimum tread depth regulation for commercial motor vehicle tires is $^{4}/_{32}$ of an inch on the steer axle, and $^{2}/_{32}$ of an inch for all other axles.[19] All of the tires on the accident bus had tread depths that were greater than required. The four tires on the rear axle were re-treaded tires.[20] All of the rims were inspected for cracks, welds, and elongated lug nut holes. None of these defects were found on any of the rims.

Table 3: Accident Bus Tire Information

Steer Axle	Left	Right
Make	Goodyear	Goodyear
Model	G661-HSA	G661-HSA
Size	10R22.5	10R22.5
Load Rating	F (5,205 lbs)	F (5,205 lbs)
Pressure	102 psi	102 psi
Tread Depth	15/32"	15/32"
Rolling Radius	19"	19"
DOT #	MC3NAL0W5009	MC3NAL0W5009

2nd Axle	Left		Right	
	Outside	Inside	Inside	Outside
Make	Goodyear	Hankook	Goodyear	Firestone
Model	G149-RSA	AH12	G149-RSA	FS 560
Size	10R22.5	10R22.5	10R22.5	10R22.5
Load Rating	F (4,940 lbs)	G (5,355 lbs)	G (5,355 lbs)	F (4,940 lbs)
Pressure	99	102	104	102
Tread Depth	14/32"	14/32"	13/32"	15/32"
Rolling Radius	19"	19"	19"	19"
Re-Tread Make	Bandag	Bandag	Bandag	Bandag
Re-Tread Size	200BDL	190BDL	200BDL	190BDL
DOT #	MC3N2H0W2306	T73PNEH1708	MC3NNROW3707	W13N3PA3708

During the tire examination, the tires were checked for obvious signs of collision related damage. The outer edge of the right rear tire tread had significant scuffing and abrasions along the portion of the tire in contact with the ground at the time of the inspection.[21] The circumferential length of this area of scuffing was approximately 28 inches long. The parking brake had remained engaged from

[19] According to the Federal Motor Carrier Safety Regulations (FMCSRs), Title 49 Code of Federal Regulations, Part 393.75 (49 CFR 393.75) tread depth shall be measured in a major tread groove at any location on the tire and not where tie bars, humps, or fillets are located.

[20] 49 CFR 393.75 prohibits the use of regrooved, recapped, or retreaded tires only on the steer axle wheels of busses. The use of regrooved, recapped, or retreaded tires on any other axle of a bus, and any axle of a truck, is not prohibited by the FMCSRs.

[21] Refer to *Vehicle Photograph 6 – 2012 IC School Bus – Scuffing to Outer Edge of Right Rear Tire Tread*, and *Vehicle Photograph 7 – 2012 IC School Bus – Close-up of Scuffing to Outer Edge of Right Rear Tire Tread*, which can be found in the docket for this investigation.

the time the vehicle was still at the accident scene until the time of the inspection, which did not allow the tire to rotate. The remaining tires were free of obvious signs of collision related damage.

1.8 BRAKING

The accident bus was equipped with Meritor hydraulic disc brakes on all four wheels. The disc brakes were controlled by a WABCO hydraulic anti-lock brake system (ABS). All of the visible brake components appeared to be in nearly new condition. The master cylinder was filled with brake fluid to the "Max Fill" line. No visible leaks were found in any of the brake system components, lines, or connections. ABS sensors were in place on all four of the wheels. The brakes were checked for basic function, and were found to be working with the brake pads firmly gripping the rotors. The wheels were removed from each axle end, and the disc brake components were examined and measured.[22] Measurements of the rotors and pads can be found in **Table 4**. All of the brake pads were found to be in excess of the $^1/_8$ inch minimum thickness requirement for disc type brakes.[23] The rotors were found to be smooth to the touch, and did not show any signs of heat checking or major cracks. Lateral run-out[24] measurements were performed with a dial indicator, the results of which can also be found in **Table 4**. Minimum usable rotor thickness is specified by the manufacturer in the maintenance manual for the accident bus as 1.320 inches.[25]

Table 4: Disc Brake Measurements

Location	Rotor Thickness (inches)	Lateral Run-out (inches)	Brake Pad Thickness Inner (inches)	Brake Pad Thickness Outer (inches)
Left Steer	1.5212	< 0.002	20/32	19/32
Right Steer	1.5145	< 0.001	20/32	19/32
Left 2nd Axle	1.5207	< 0.001	21/32	20/32
Right 2nd Axle	1.5210	< 0.001	21/32	21/32

The bus's emergency/parking brake was a hydraulically released drive shaft brake. By activating the parking brake switch on the dash, or in the case of a hydraulic pressure loss, the emergency/parking brake would be activated by a large spring. This would, by means of a cable connection, engage the drive shaft brake shoes against the drive shaft brake drum.

[22] Rotors were measured using a 1" – 2" micrometer, and brake pads were measured using a scientific ruler.
[23] According to 49 CFR 393.47(d)(1).
[24] Lateral run-out is measured using a dial indicator on a fixed rigid base, with the tip perpendicular to the face of the brake rotor, approximately ½ inch from the outside diameter of the disc. The difference between the minimum and maximum reading on the dial is called "lateral run-out"
[25] Additional information is contained in *Vehicle Attachment 5 – 2012 IC School Bus – Brake Rotor Machining Specifications*, which can be found in the docket for this investigation.

1.9 ELECTRICAL SYSTEM AND LIGHTING

As a safety measure while on scene, electrical power to the school bus was disconnected at the battery terminals by emergency responders. The battery cables remained disconnected from the terminals until they were re-connected by Safety Board investigators in order to inspect the integrity and function of the system. After re-connecting battery power, the electrical system was found to be functional, and all of the systems checked were found to be fully operational.

With the ignition in the "on" position, dash and indicator lights illuminated, and other electrically powered systems were functional. Some of the systems checked included, but were not limited to, fans, blowers, the emergency exit alarm, and the interior lighting. Also performed, were functional tests on all of the exterior school bus lighting, stop arms, and pedestrian gate. Additionally, the electrically operated emergency/parking brake was functional, as was the ignition system allowing the bus to be started.

With the ignition in both the "accessory" and "on" positions, functional tests of the electrically operated passenger boarding door were performed. The door was found to open and close smoothly using both the door operation switch mounted in the switch panel to the left of the driver's seat, as well as with the steering wheel mounted control switch. The electrically operated passenger boarding door did not operate with the ignition in the "off" position.[26] With the ignition in the "off" position, the boarding door could be opened and closed manually only after activating the emergency release handle.

Following the functional tests, the batteries maintained a charge while connected to the system for approximately 24 hours, after which the batteries were again disconnected for safety and storage.

1.10 MAINTENANCE HISTORY

Maintenance records for the accident bus were obtained from the motor carrier, Garden State Transport, Inc.[27] Records include the initial New Jersey State Vehicle Inspection Report, which recorded a passing result for both safety items, as well as emission standards. A single page form generated by Garden State Transport documented the preventative maintenance performed on the vehicle on November 26, 2011, January 18, 2012, and February 3, 2012. This form also documented that the quarterly State inspection was performed on February 3, 2012. One Garden State Transport maintenance request form was included in the records, and indicated that the check engine light and traction control lights were illuminated, and that the bus was out of fuel. Comments on the form indicate that the bus was sent back to the dealership, Wolfington Body Company, Inc., for repairs. These repairs are reflected in the warranty claim records provided by Navistar, Inc.[28]

---

[26] According to the school bus Operator's Manual, the passenger boarding door will only operate when the ignition is in the "accessory" or "on" positions. Additional information is contained in *Vehicle Attachment 6 – 2012 IC School Bus – Pages From Operator's Manual*, which can be found in the docket for this investigation.
[27] Additional information is contained in *Vehicle Attachment 7 – 2012 IC School Bus – Inspection and Maintenance Records*, which can be found in the docket for this investigation.
[28] Additional information is contained in *Vehicle Attachment 8 – 2012 IC School Bus – Warranty History*, which can be found in the docket for this investigation.

1.11 EVENT DATA

The International MaxxForce engine, of the accident school bus, was controlled by an Engine Control Module (ECM). The purpose of the ECM is to control engine timing and fuel injection based on various engine and sensor inputs. The ECM is also capable of diagnostics associated with engine and/or sensor faults, which may then illuminate warnings on the dash. The anti-lock braking system on the accident bus also had an electronic control module.

All of the batteries used to power the vehicle's 12 volt electrical system had been disconnected following the collision. Additionally, the three wiring harnesses connecting the ECM to the vehicle were unplugged by law enforcement in order to preserve any potential data being stored in the module prior to it being removed from the scene. The wiring harnesses were reconnected, and battery power was re-established to the bus by re-connecting the wires and cables that had been disconnected. The ECM and other vehicle modules were interrogated by an NTSB recorder specialist while still in the accident bus, however, none of the modules on the school bus had data recording capabilities.

1.12 DOCUMENTED RECALLS AND WARRANTY CLAIMS

A search of the safety recall database maintained by the National Highway Traffic Safety Administration (NHTSA) did not reveal any voluntary safety related recalls issued which would have pertained to the accident bus.[29] Additionally, records kept by Navistar, Inc., did not indicate there were any active or pending safety related recalls pertaining to the accident bus. A search of the defect investigation database, also maintained by NHTSA, did not reveal any active or inactive defect investigations which would have pertained to the accident bus.[30]

Navistar, Inc.'s warranty claim records indicated that 8 claims were filed for maintenance covered under the original vehicle warranty.[31] None of the warranty claims included any major engine, driveline, braking, steering, or suspension system components. One warranty claim filed in December of 2011, pertained to a bad accelerator pedal sensor. The bad sensor was causing the vehicle to stall or experience a low power situation when the accelerator was depressed to full throttle (100%). The accelerator pedal assembly was replaced. All of the covered warranty work was completed between July and December of 2011.

---

[29] The safety recall database was accessed via the NHTSA safety recall website, http://www-odi.nhtsa.dot.gov/recalls/recallsearch.cfm [accessed May 16, 2012].

[30] The defect investigation database was accessed via the NHTSA defect investigation website, http://www-odi.nhtsa.dot.gov/defects/index.cfm [accessed May 16, 2012].

[31] Additional information is contained in *Vehicle Attachment 8 – 2012 IC School Bus – Warranty History*, which can be found in the docket for this investigation.

2. VEHICLE #2: 2004 MACK, CV713 GRANITE, ROLL-OFF TRUCK

2.1 GENERAL INFORMATION

This vehicle was manufactured in two stages. It was originally ordered on September 29, 2003. The first stage build of the Mack truck cab and chassis, known in the industry as an incomplete vehicle, or commercial cutaway, was completed in November 2003. The final stage build consisted of configuring the truck with a roll-off container and an additional axle, which was completed in December of 2003 by Automated Waste Equipment Co., Inc. The completed vehicle was delivered to O'Shea Truck Center in Trenton, NJ, and was purchased by Herman's Trucking, Inc. The vehicle was first placed into service on February 26, 2004. At the time of the accident, the truck's front end was equipped with a snowplow mount.[32]

Mack Truck, Cab, and Chassis:

VIN:	1M2AG11C54M[redacted]
Model:	CV713 Granite Truck – Originally Manufactured as a Chassis Only
Manufactured:	November 2003
Mileage[33]:	246,843.8
Hours[34]:	12,959.7
GVWR:	87,360 lbs
GAWR – Axle #1:	18,000 lbs
GAWR – Axle #2:	20,000 lbs
GAWR – Axle #3:	24,680 lbs
GAWR – Axle #4:	24,680 lbs
Engine:	Mack AI-400 ASET, 400 HP, Serial Number: E3V0786
Transmission:	Mack Maxi Torque ES T310, 10-Speed Manual , Serial Number: T3V0435
Steering Gear:	R.H. Sheppard, 492S
Brake Type:	"S"-cam drum brakes on all axles

Roll-Off Equipment:

Manufacturer:	Automated Waste Equipment Co., Inc.
Model:	ARO-75-22-XT
Manufactured:	December 2003
Serial Number:	L-1-4175

2.2 DAMAGE DESCRIPTION

The truck was removed from the scene the morning of the accident and towed by Haine's Towing to their tow lot, located at 240 Route 130, in Bordentown, NJ. On Saturday, February 18, 2012, the truck was moved to Helmrich Towing and Recovery for secure storage and inspection facilities located at 4450 Marlton Pike, Pennsauken, NJ. The truck was inspected at this location

[32] At the time of the accident, the truck was equipped with the snowplow mounting bracket only, and was not equipped with a snowplow.
[33] According to the odometer located in the truck's digital information display.
[34] According to the hour meter located in the truck's digital information display.

between February 18, and February 24, 2012. A follow-up inspection of the truck took place between March 6, and March 8, 2012.

The accident truck had contact damage concentrated in the area of the front right corner.[35] Contact damage was observed on the snowplow mount, front steel bumper, and the front right corner of the fiberglass hood. "School Bus Yellow" paint transfer was observed on the snowplow mount, as well as on the front right corner of the hood. The snowplow mount was displaced rearward, inducing a rearward crush to the center portion of the steel bumper.[36] The right upright of the snowplow mount was displaced rearward a greater distance than the left upright, causing a twisting of the mount. The lower mounting pin for the hydraulic ram used to raise and lower a snowplow as well as the pin attachments, were bent. The lower mounting hole on the hydraulic ram was elongated. The upper mounting pin for the hydraulic ram appeared straight and undamaged where it connected to the lifting plate. The rear of the lifting plate, however, was bent and displaced from its original location. The left and right steel plates that hold the ends of the pin for the rear of the lifting plate were bent outward. The pin itself had broken free on the right end, and allowed the lifting plate to become detached from the plow mount, and only remained connected to the vehicle through the hydraulic ram. The outer edges of the vertical uprights of the snowplow mount are approximately 25 inches apart. The rear mounts for the lifting plate were located approximately 48 inches above ground level. The vehicle's radiator was pushed rearward on the right side approximately 5 inches. The right end of the truck's steel bumper was displaced rearward, with the upper edge being pushed back farther to the rear than the lower edge.

The right front corner of the fiberglass hood sustained numerous large cracks. A portion of the hood from the area of the right headlight opening was displaced from the vehicle, and was located amongst the debris collected from the scene. The hood also showed signs of induced damage to the right front portion of the cab. There were red paint transfer and scuff marks on the windshield of the truck near the right end.[37] The right rear portion of the fiberglass hood was also cracked near its top edge. The right hood latch was broken off from the vehicle's body in front of the passenger door.

The remainder of the vehicle remained undamaged from the collision. All of the truck's tires remained inflated at the scene[38]. Electrical power was disconnected by emergency responders as a safety measure while the truck was at the crash scene.

[35] Refer to *Vehicle Photograph 8 – 2004 Mack Truck – Contact Damage to Front*, which can be found in the docket for this investigation.
[36] Refer to *Vehicle Photograph 9 – 2004 Mack Truck – Rearward Displacement of Steel Front Bumper*, which can be found in the docket for this investigation.
[37] Refer to *Vehicle Photograph 10 – 2004 Mack Truck – Right Rear of Truck's Hood and Paint Transfer/Scuff Marks to Windshield*, which can be found in the docket for this investigation.
[38] At the time of the Safety Board's inspection of the vehicle, the inner tire on the left end of axle #3 was flat. According to the New Jersey State Police, however, at the time of their inspection at the crash scene, that tire was holding approximately 100 psi of pressure.

2.3 WEIGHT AND MEASUREMENTS

The accident truck was weighed by the New Jersey State Police using certified portable scales on February 16, 2012.[39] The resultant axle weights are shown in **Table 5**. Due to the post-crash condition of the truck, axle weights may not be distributed as they were at the time of the accident, and do not include the weight of the truck driver.

Table 5: Accident Truck Axle Weights

Position	Weight (lbs)		Axle
	Left	Right	Total
Steer Axle	7,700	7,400	15,100
2nd Axle	6,300	6,500	12,800
3rd Axle	14,300	14,700	29,000
4th Axle	14,250	13,800	28,050
Total	84,950		

According to records obtained from Mack Trucks, Inc., pre-crash specifications for a CV713 Granite chassis are listed in **Table 6**.[40] Also listed in **Table 6** are hand measurements taken by Safety Board investigators of the accident truck at the time of inspection. Internal and external dimensions of the roll-off container are listed in **Table 7**.

~ This Space Intentionally Left Blank ~

[39] Additional information is contained in *Vehicle Attachment 2 – New Jersey State Police Portable Scale Certifications*, which can be found in the docket for this investigation.
[40] Additional information is contained in *Vehicle Attachment 9 – 2004 Mack Truck - Technical Specifications (Chassis Only)*, as well as *Vehicle Attachment 10 – 2004 Mack Truck – Pages from Body Installer's Guide for Mack Class 8 Chassis*, which can be found in the docket for this investigation.

Table 6: Pre and Post Crash Measurements of Accident Truck

Dimension	Pre-Crash (inches)	Post-Crash (inches)	
Overall Length	393.0*	Left	421.5
		Right	422.0
Overall Width	100.5*	Front	102.0
		Rear	97.0
Wheelbase (Axle 1 - center of drive axles)	265.0	Left	265.5
		Right	265.5
Axle Spacing (Axles 1-2)	N/A**	Left	189.0
		Right	189.0
Axle Spacing (Axles 1-3)	238	Left	238.5
		Right	238.5
Axle Spacing (Axles 1-4)	292.0	Left	293.0
		Right	293.0
Axle Spacing (Axles 3-4)	54.0	Left	54.5
		Right	54.5
Track Width (Steer)	83.96	83.75	
Track Width (Axle 2)	N/A**	60.5	
Track Width (Axle 3)	74.134	73.5	
Track Width (Axle 4)	74.134	73.5	
Front Overhang	49.2*	Left	39.5
		Right	37.0
Rear Overhang	74.0*	Left	92.0
		Right	92.0
Overall Height	109.1*	Front Left	104.75
		Front Right	104.75
		Rear Left	98.5
		Rear Right	99.0

* Pre-Crash Measurements are based on the incomplete vehicle.

** No measurement available, as the lift axle was not part of the incomplete vehicle.

Table 7: Post-Crash Roll-Off Container Dimensions

Dimension	External (inches)	Internal (inches)
Length	267.25	262.0
Width	97.0	87.0
Height	45.0	41.75

In addition to the hand measurements, the accident truck was scanned using a 3-dimensional laser scanner that will allow for the creation of a 3-D model, from which additional scaled measurements can be taken.[41]

2.4 DRIVER CONTROLS[42]

The driver's seat was intact and in place in the truck. The driver's lap/shoulder seatbelt was found unbuckled, retracted, and hanging from the upper attachment point to the left of the driver's seat location. Located immediately in front of the driver's seat was an 18 inch diameter steering wheel. The steering wheel was mounted on a steering column that was adjustable for both height and angle. The steering wheel contained a large button at its center to activate the standard electric horn. The turn signal stalk was located on the left side of the steering column, and included accessory functions such as high and low beam headlight selection, a slide switch for courtesy flashing of high beam headlights, and a button at the end of the stalk for courtesy flashing of the vehicle's marker lights. The turn signal stalk was found in the centered position at the time of the examination. Directly below, and in contact with the turn signal stalk, was the "hazard" flasher lever, which would activate the lights when pulled, and was found in the off position. Also on the left side of the steering column was a lever allowing for the adjustment of steering wheel tilt and elevation. The vehicle's keyed ignition switch was located on the right side of the steering column.

The dash in front of the driver's seat contained several gauges, indicator lights, and a digital information display. The gauges included: electrical system voltage, exhaust temperature, coolant temperature, engine oil pressure, engine oil temperature, engine speed (RPMs), vehicle speed (mph & km/h), air pressure (primary and secondary), fuel level, and transmission temperature. All of the gauge indicators were in their zero or "home" positions. Also present in the dash area were two small black buttons used to operate the digital information display.

Located to the right of the gauge panel was a hand lever for applying the truck's rear brakes, which was labeled "not for parking". To the right of the hand lever were numerous switches. The switches and their positions at the time of the inspection include the following:

- Headlights (off/parking/headlights) – Off
- Dash Panel Brightness (dimmer/neutral/brighter – self centering) – Neutral
- Rotating Amber Beacon (off/on – lighted when on) – On
- Speed Control (off/on) – Off
- Speed Control (set-decel/neutral/resume-accel – self centering) – Neutral
- Mirror Heat (neutral/on-off – self returning) – Neutral
- Engine Shutdown Override (neutral/override – self returning) – Neutral
- Windshield Wipers (9 position stick) – Off
- Engine Brake (low/off/high) – Off
- Inter-axle Power Divider Lockout (off/on) - Off

[41] Additional information is contained in the *Forensic Research and Evidence Documentation Factual Report (3D Laser Scanner)*, which can be found in the docket for this investigation.
[42] Refer to *Vehicle Photograph 11 – 2004 Mack Truck – Driver Control Area*, which can be found in the docket for this investigation.

To the right of the switches was an in-vehicle stereo with CD player. Below the above described switches is a diamond shaped yellow air parking brake valve control. The parking brakes are applied when the valve is out, and released when the valve is in. The valve was found in the out or applied position. It should be noted, however, that all air was drained from the system following the towing process, and that the valve will automatically move to the out, or applied position, when there is low air pressure. The lower center portion of the dash contained standard dial controls for the heat and air conditioning system.

Located between the driver and passenger seat were several additional controls. A silver colored hand valve for operating the lift axle was located in this area, and included an air pressure gauge which was indicating a pressure of 20 psi at the time of the inspection[43]. Also located between the seats were control levers for the operation of the roll-off container winch and hoist, or bed tilt, as well as a lever to engage and disengage the Power-Take-Off (PTO) needed to run the hydraulic system for the roll-off container equipment. A two-way communication radio was also located in the area between the seats. The on/off/volume control for the communication radio was in the off position at the time of the inspection.

The vehicle's accelerator pedal was 3 inches wide and 9-$^{1}/_{4}$ inches long. The brake pedal was 4 inches wide and 3-$^{1}/_{4}$ inches long. The clutch pedal was 4 inches wide and 2-$^{1}/_{2}$ inches long. The accelerator and brake pedals were separated by a horizontal distance of 3-$^{1}/_{4}$ inches. The brake and clutch pedals were separated by a horizontal distance of 3 inches.

The vehicle was equipped with left and right side windows that were manually operated by hand cranks.

2.5 STEERING SYSTEM

The 18 inch steering wheel was found to be concentric and was not deformed. With the engine off, and the front axle tires lifted off the ground, full rotation of the steering wheel from far left to right was possible without restriction or binding being felt at the wheel. With movement of the steering wheel, the front axle tires and wheels were observed to move outward and inward, from axle stop to axle stop, corresponding with the rotation of the steering wheel. When at full left and full right, both steer tires were rotated, and were found to be free of rubbing or binding on other vehicle components. Steering wheel lash[44] of approximately 3-$^{1}/_{4}$ inches was present in the system.[45]

The steering column transcended through the firewall of the accident truck and connected to a steering shaft by means of a universal joint. The shaft connected with another universal joint to a 45° transfer joint. The universal joint into the 45° transfer joint was observed to have excessive play when moving the steering wheel from side to side. The 45° transfer joint was connected to the

[43] The New Jersey State Police reported a pressure reading of 60 psi in the lift axle suspension system at the crash scene.

[44] According to 49 CFR 393.5, steering wheel lash is defined as: The condition in which the steering wheel may be turned through some part of a revolution without associated movement of the front wheels.

[45] According to 49 CFR 393.209, steering wheel lash for a power steering system with an 18 inch steering wheel must not exceed 4-$^{3}/_{4}$ inches, and according to Appendix G item 7(a), must be measured with the engine running. Due to collision damage, the engine of the accident truck was not able to be started, thereby not allowing for the steering wheel lash measurement to be taken under the specified conditions.

top of the R.H. Sheppard hydraulically assisted steering gear box via another universal joint. The output shaft from the steering gear was then connected to the pitman arm and drag link. The pitman arm was connected by means of a ball joint to the drag link. The drag link was connected to the left side of the steer axle through a steering arm using a ball joint connection. The left side of the steer axle was connected to the right side of the steer axle by means of a tie rod with ball joint connections on each end. No damage was noted to any of the steering system components. With the exception of the aforementioned play in the universal joint connecting the steering shaft to the 45° transfer joint, all other connections were solid and free of wear or excessive play.

2.6 SUSPENSION SYSTEM

The accident truck was equipped with both air and conventional suspension system components. Each side of the steer axle was equipped with a set of leaf springs and a conventional shock absorber. The suspension on each side consisted of two full length leaf springs and seven progressively shorter leaf springs. All of the leaf springs were free of any visible cracks, damage, or apparent defects. The shock absorbers were securely attached, and free of wear or excessive play.

The lift axle suspension consisted of two air suspension cushions. Air pressure in these cushions was used for suspension purposes, as well as to push the axle down from a raised position. Two horizontal spring assemblies served to raise the axle when there was little or no air pressure in the suspension cushions. Adjusting the air pressure in the suspension cushions would also adjust the amount of weight being supported by the lift axle.

The drive axles were equipped with a Mack "camelback" spring suspension system.[46] The suspension on each side consisted of two full length camelback springs, and eight progressively shorter camelback springs. All of the springs were free of any visible cracks, damage, or apparent defects.

2.7 TIRES AND WHEELS

The VIN, tire, and weight rating placard mounted inside the door frame of the truck was faded and not legible. A copy of the original placard was obtained from Palfinger – American Roll-Off, the current owner of the final stage product line.[47] According to the placard, the truck was to be equipped with 385/65R22.5 tires mounted on 22.5 x 12.25 rims for the steer axle, and 11R24.5 tires mounted on 24.5 x 8.25 rims in a dual tire configuration for the lift and drive axles. Recommended tire pressure was listed as 120 psi for the steer axle tires, and 110 psi for the lift and drive axle tires.

---

[46] The Mack camelback suspension system utilizes a series of upward arching leaf springs which resemble a camel's hump. This suspension system was designed to assist with heavy vehicle steering and stability while cornering.

[47] Limited paper records from Automated Waste Equipment Co., Inc., the original final stage manufacturer that finished the vehicle by mounting the roll-off equipment onto the chassis, were available to the current owner of the product line, Palfinger – American Roll-Off. Additional information is contained in *Vehicle Attachment 11 – 2004 Mack Truck – American Roll-Off VIN Plate Information and Mack Trucks, Inc., Incomplete Vehicle Document*, which can be found in the docket for this investigation.

Table 8 includes information on the condition of the truck tires as they were at the time of inspection. Also included in **Table 8** are the tire load ratings, in pounds, based on the tire manufacturer's recommended inflation pressures.[48] Tire tread depth measurements were taken in the major tread grooves of each tire. The smallest depth measured is displayed in the table, and represents a minimum tread depth value for that tire. The minimum tread depth regulation for commercial motor vehicle tires is $^{4}/_{32}$ of an inch on the steer axle, and $^{2}/_{32}$ of an inch for all other axles.[49] The inside tire on the left side of axle #3 did not meet the tread depth requirement. All of the other tires on the truck had tread depths that were greater than required. All of the rims were inspected for cracks, welds, and elongated lug nut holes. None of these defects were found on any of the rims. No collision related damage was observed on the tires at the time of the inspection. For all sets of dual tires on the truck, the tire surfaces to the inside of each dual pair were checked for visible signs of rubbing and/or chaffing. None of these signs were present.

Table 8: Accident Truck Tire Information

Steer Axle	Left	Right
Make	Goodyear	Goodyear
Model	G296 MSA	G296MSA
Size	385/65R22.5	385/65R22.5
Load Rating	J (9,370 lbs)	J (9,370 lbs)
Pressure	118 psi	104 psi
Tread Depth	9/32"	13/32"
Rolling Radius	19.5"	19.0"
DOT #	MC79JJEW2810	MC79JJEW2810

2nd Axle	Left	Right
Make	Goodyear	Goodyear
Model	G286	G286
Size	385/65R22.5	385/65R22.5
Load Rating	J (9,370 lbs)	J (9,370 lbs)
Pressure	132 psi	132 psi
Tread Depth	3/32"	6/32"
Rolling Radius	20.0"	20.0"
Re-Tread Make	Bandag	Recamic
Re-Tread Size	15WBR290	XZA290B
DOT #	MC79IREW1206	MC79IREW1606

3rd Axle	Left		Right	
	Outside	Inside	Inside	Outside
Make	Goodyear	Goodyear	Yokohama	Yokohama
Model	G362	G182	TY517	RY023
Size	11R24.5	11R24.5	11R24.5	11R24.5

[48] Additional information is contained in *Vehicle Attachment 12 – 2004 Mack Truck – Manufacturer Specifications for Goodyear and Yokohama Tires*, which can be found in the docket for this investigation.
[49] According to 49 CFR 393.75, tread depth shall be measured in a major tread groove at any location on the tire and not where tie bars, humps, or fillets are located..

Load Rating	G (6,005 lbs)	H (6,610 lbs)	H (6,610 lbs)	H (6,610 lbs)
Pressure	114 psi	0 psi*	123 psi	112 psi
Tread Depth	9/32"	1/32"	5/32"	4/32"
Rolling Radius	20.0"	20.0"	20.5"	20.5"
Re-Tread Make	Bandag	Bandag	Bandag	Bandag
Re-Tread Size	8.5D4310211	9-219D1310	220BTL	--**
DOT #	MC4FR70W0507	MC4F76BW2007	6B4F1TN2810	FB4FUHA5104

4th Axle	Left		Right	
	Outside	Inside	Inside	Outside
Make	Goodyear	Goodyear	Goodyear	Goodyear
Model	G362	G362	G362	G362
Size	11R24.5	11R24.5	11R24.5	11R24.5
Load Rating	G (6,005 lbs)	G (6,005 lbs)	G (6,005 lbs)	G (6,005 lbs)
Pressure	108 psi	110 psi	106	104 psi
Tread Depth	14/32"	12/32"	12/32"	11/32"
Rolling Radius	20.0"	20.0"	20.5"	20.5"
Re-Tread Make	Bandag	Bandag	Bandag	Bandag
Re-Tread Size	8.5D4310	8.5-211D4310	8.5-211D1310	8.5-211D1310
DOT #	MC4FR70W0908	MC4FR70W2909	MC4FR70W2909	MC4FR70W2605

* - The New Jersey State Police reported a pressure reading of 100 psi in the lift inside tire of Axle #3 at the crash scene.

** - Re-tread size information was worn off and not able to be determined.

2.8 AIR AND BRAKING SYSTEMS

Air for the accident truck's pneumatic system, which operated the brakes as well as the lift axle, was compressed and supplied by a 318cc WABCO air compressor, which was connected directly to the Mack AI-400 ASET engine. The air compressor was removed from the truck and shipped to the WABCO Compressor manufacturing facility in Charleston, SC, for examination and testing by WABCO engineers and NTSB staff. Testing of the components occurred on May 9, 2012. Testing revealed that the compressor was operating according to specifications, and met the air delivery requirements of a new compressor.[50]

Other major air system components included a governor, air dryer, supply reservoir or "wet tank", primary air system reservoir, secondary air system reservoir, and an expansion air reservoir. The expansion air reservoir had been installed by the final stage manufacturer at the time the air operated lift axle and the associated air suspension and brake components were installed.[51] The

[50] Additional information is contained in *Vehicle Attachment 13 – 2004 Mack Truck – Pages from Air Compressor Performance Testing Summary Report from WABCO Compressor Mfg. Co.*, which can be found in the docket for this investigation.

[51] Additional information is contained in *Vehicle Attachment 14 – 2004 Mack Truck – American Roll-Off Installation Documentation*. Also, detailed guidance and recommended practices for the installation of air and brake system components can be found in *Vehicle Attachment 10 – 2004 Mack Truck – Pages from Body Installer's Guide for Mack Class 8 Chassis*, and *Vehicle Attachment 10A – 2004 Mack Truck – National Truck Equipment Association Technical*

four air reservoir volumes are shown in **Table 9**. Air lines connected the primary air system reservoir directly to the expansion air reservoir. A pressure protection valve separated the expansion air reservoir from the lift axle and power take off air supply lines. The expansion air reservoir served two functions. Because there was no "one-way" or single check valve between the primary and expansion air reservoirs, it served to increase the effective reservoir volume of the primary air system. Additionally, the expansion air reservoir supplied the air required to operate the lift axle and power take off system which was used to operate the roll-off hoist and winch for loading and unloading a container. When in use, the lift axle would be lowered to the ground by air pressure in the air spring/suspension cushions that would overcome the force of mechanical springs located on the axle assembly which were used to raise the axle. When the lift axle was not in use, the mechanical springs would return the axle to a raised position. Also present on the vehicle, were numerous brake valves and eight brake chambers. A schematic showing the layout of the accident truck's air system as well as its braking and ABS components is shown in **Figure 1**.[52]

Table 9: Accident Truck Air Reservoir Volumes

Reservoir	Volume (in^3)	Volume (L)
Supply	830	13.6
Primary	3,637	59.6
Secondary	1,452	23.8
Expansion	2,850	46.7

~ This Space Intentionally Left Blank ~

Report (T97-2): Mack Truck Issues Liftable Axle Installation Guidelines, all three of which can be found in the docket for this investigation

[52] Additional information is contained in *Vehicle Attachment 15 – 2004 Mack Truck – Detailed Air System Schematic for Incomplete Vehicle Only*, which can be found in the docket for this investigation.

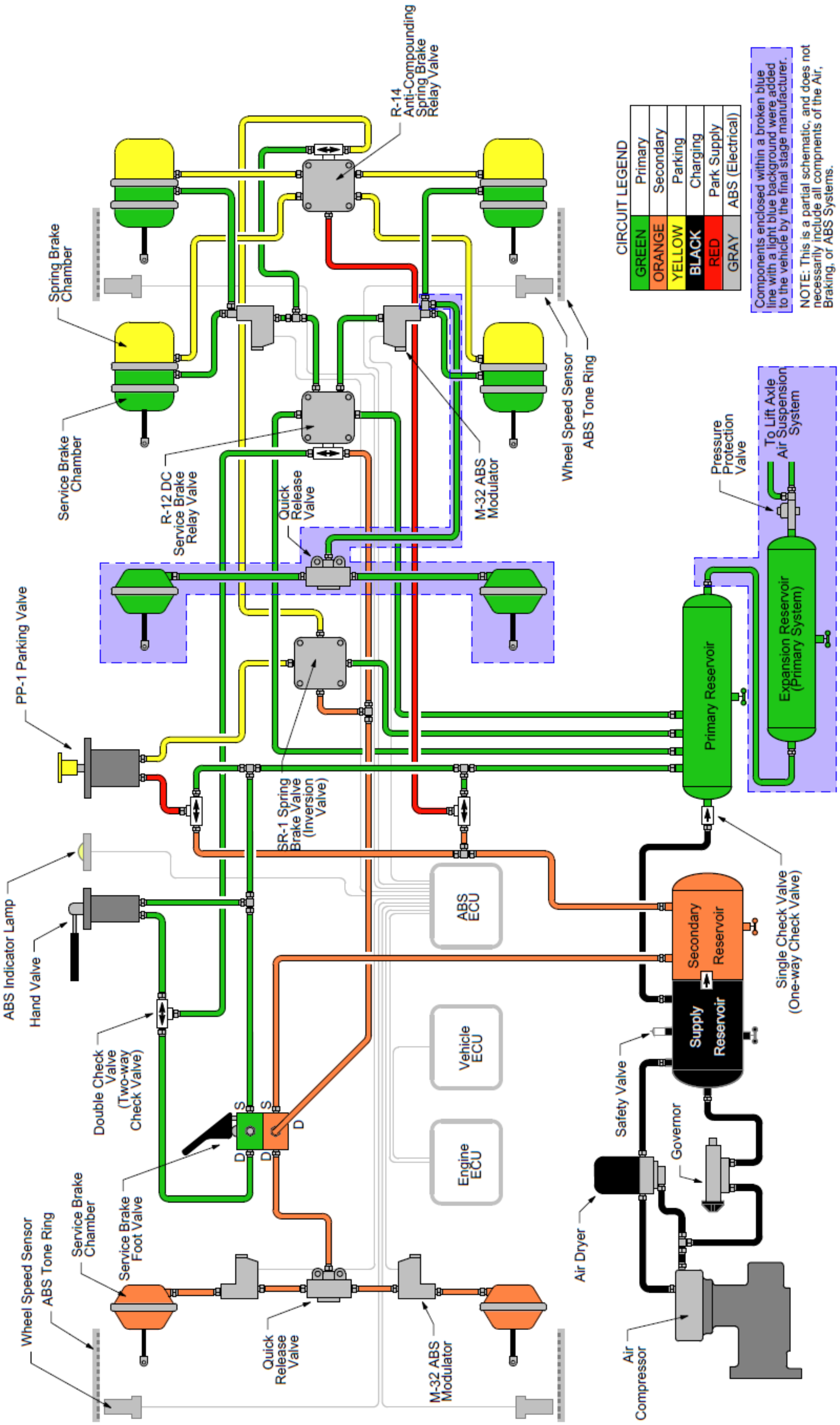

Figure 1: Accident Truck Air System Schematic

The low air pressure warning sensors for both the primary and secondary systems were checked. With air pressure supplied to both systems, the pressure in each system was drained until the low air pressure warning device activated. The low air pressure warning activated when the primary system dropped to approximately 70 psi. The low air pressure warning device also activated when the secondary system dropped to approximately 68 psi. The parking brake valve was automatically applied when the entire air system dropped to approximately 40 psi. During the testing of the low air pressure warning sensors, an added result of draining the individual service systems is a check of the isolation systems. The draining of either the primary or secondary system did not result in the depletion of the other system. The function of the accident truck's spring brake valve was also tested. With a lack of air pressure in the primary air system, operation of the brake treadle valve resulted in an application of the truck's spring brakes.

A pressure protection valve was present between the expansion air reservoir and the lift axle and power take off air supply lines. The purpose of a pressure protection valve is to maintain sufficient air pressure for brake system operation in the case of a failure or pressure loss in one of the accessory systems.[53] A test of the pressure protection valve was performed by simulating a failure or leak in the air suspension system. With both the primary and secondary systems pressurized to 120 psi, an air leak was induced in the system at the supply port to the left air spring/suspension cushion. The secondary system pressure held, while the primary system pressure drained to 0 psi.

The accident truck was equipped with s-cam drum brakes on all of the wheels. The incomplete vehicle was equipped with two Type 24 long stroke brake chambers on the steer axle (axle #1), and four Type 30/30 service/spring brake chambers on the two drive axles (axles #3 and #4). Along with the installation of the lift axle, two additional Type 24 long stroke brake chambers were installed to actuate the brakes on that axle (axle #2). The air supply lines for both of these brake chambers were connected to the delivery port of the left side ABS modulator valve for the drive axles, as shown in **Figure 1**.

In evaluating the brake system, push rod stroke measurements were taken for all of the brakes, as seen in **Table 10**, along with the adjustment limits.[54] In order to obtain the push rod stroke measurements, shop air was used. The shop air was connected to the output line from the air dryer, was regulated to approximately 105 psi, and then was disconnected from the vehicle. To assist in evaluating the integrity and effectiveness of the air brake system, engineers from Bendix Commercial Vehicle Systems, LLC, assisted in the inspection of the accident truck's brake system. The Bendix engineers also performed a series of brake timing and balance tests. Because only a limited number of pressure sensors could be connected to the test equipment at any one time, the brake timing tests were performed in two stages, with three test runs per stage. Axle #1 and axle #2 were tested together in the first stage, while axle #3 and axle #4 were tested together in the second stage. The average results of the test runs for each of the axle ends is reproduced in **Table 11**.[55] In

[53] According to 49 CFR 393.207(f), "The air pressure regulator valve shall not allow air into the suspension system until at least 55 psi is in the braking system." This valve, also known as a pressure protection valve, should also cause a pressure of at least 55 psi to be maintained in the braking system in the event of a downstream air leak.
[54] According to April 1, 2011 Commercial Vehicle Safety Alliance North American Standard Out of Service Criteria for clamp type pneumatic brakes.
[55] Complete test results are contained in *Vehicle Attachment 16 – 2004 Mack Truck – Brake System Timing, ABS Module, and Brake Valve Testing Summary Report from Bendix Commercial Vehicle Systems, LLC. – Including Supplemental Report*, which can be found in the docket for this investigation.

2003, Federal Motor Vehicle Safety Standard (FMVSS) 121 required, for new vehicles, that the air pressure in each brake chamber be able to reach 60 psi within 0.45 seconds.[56] FMVSS 121 also required that the air pressure within each brake chamber be able to drop from 95 psi to 5 psi within 0.55 seconds.[57]

Table 10: Accident Truck Brake Measurements

Position	Brake Chamber Type	Brake Chamber Manufacturer	Slack Adjuster Length (inches)	Slack Adjuster Manufacturer	Push Rod Stoke (inches)	Adjustment Limit (inches)
L Steer Axle	24-L (2.5" RS)	MGM	5 1/2	Haldex	1 1/2	2
R Steer Axle	24-L (2.5" RS)	MGM	5 1/2	Haldex	1 1/4	2
L 2nd Axle	24-L (2.5" RS)	MGM	5	Gunite	7/8	2
R 2nd Axle	24-L (2.5" RS)	MGM	5	Gunite	1	2
L 3rd Axle	30/30	MGM	6	Haldex	1 7/8	2
R 3rd Axle	30/30	Bendix	6	Haldex	2	2
L 4th Axle	30/30	MGM	6	Haldex	2 1/4	2
R 4th Axle	30/30	MGM	6	Haldex	2	2

Table 11: Average Accident Truck Brake Timing Results

Channel	Average Apply Time (seconds)	Average Release Time (seconds)
Primary Control	0.094	0.303
Axle 1 Left	0.324	0.383
Axle 1 Right	0.322	0.377
Axle 2 Left	0.613	0.699
Axle 2 Right	0.627	0.725
Primary Control	0.094	0.302
Axle 3 Left	0.583	0.619
Axle 3 Right	0.440	0.560
Axle 4 Left	0.580	0.621
Axle 4 Right	0.433	0.562

The wheels were removed from each axle end, and a detailed examination of the brake system components was conducted. The steer, lift, and drive axle drum brake components were examined and measured. Measurement of the drums and brake shoes can be found in **Table 12**. The truck's brake shoes were found to be at or above the $^{1}/_{4}$ inch minimum thickness requirement for drum type brakes.[58] Where possible, ABS sensor gap measurements were taken between the

[56] According to 49 CFR 571.121 (FMVSS 121) S5.3.3.1(a)
[57] According to 49 CFR 571.121 (FMVSS 121) S5.3.4.1(a)
[58] According to 49 CFR 393.47(d)(2).

sensors and the tone ring, and can also be found in **Table 12**. According to records provided by Mack Trucks, Inc., the accident truck drive axle brakes were originally built with R403 brake linings, which have a "GG" friction code. According to the maintenance manager at Herman's Trucking, the brakes being used on the accident truck at the time of the accident had R301 brake linings, which have a "FF" friction code.

Table 12: Brake Drum, Brake Shoe, and ABS Gap Measurements

Axle	Side	Drum Diameter (inches) ⦶	Drum Diameter (inches) ⊖	Brake Shoe Thickness (inches)	ABS Sensor Gap (inches)
Steer Axle	Left	16.618	16.615	3/8	0.007
Steer Axle	Right	16.598	16.596	3/8	0.008
2nd Axle	Left	16.568	16.561	3/8	N/A*
2nd Axle	Right	16.602	16.598	5/16	N/A*
3rd Axle	Left	18.047	18.033	1/4	N/A*
3rd Axle	Right	18.041	18.044	1/2	N/A*
4th Axle	Left	18.064	18.062	1/2	---**
4th Axle	Right	18.048	18.052	5/16	---**

* By design, ABS sensors were only located on the steer axle wheels, and the rearmost drive axle wheels.

** The ABS tone rings remain attached to the drums when they are removed, and as a result, are separated from the ABS sensor, making it impossible to measure the ABS sensor gaps on the rear drive axle wheels.

Several observations were made during the detailed brake component examination, and include the following:

- Grooves were present in the left steer axle brake drum, with the drum diameter in the deepest groove measuring 16.788 inches;
- Shallow grooves were present in the right steer axle brake drum;
- Cracks were present in the lower rear brake pad on the left side of axle #2,[59] including:
    - A main crack which measured approximately 5-$^{1}/_{2}$ inches long, $^{1}/_{8}$ inch wide, and $^{1}/_{8}$ inch deep;
    - A shorter intersecting crack which measured approximately 3-$^{1}/_{4}$ inches long; and
    - A third crack which intersected the shorter of the first two cracks and extended through two rivet holes to the edge of the pad, creating a void in the edge of the pad material that measured in excess of $^{1}/_{8}$ inch;[60] this would be considered a defective lining condition, resulting in the left side of axle #2 to be considered a defective brake according to the CVSA Out-of-Service Criteria;[61]

[59] Refer to *Vehicle Photograph 12 – 2004 Mack Truck – Cracks in Lower Rear Brake Pad on Left Side of Axle #2*, which can be found in the docket for this investigation.

[60] Refer to *Vehicle Photograph 13 – 2004 Mack Truck – Crack Extending Through Two Rivet Holes to the Edge of Brake Pad, Creating a Void in the Brake Pad Material on the Left Side of Axle #2*, which can be found in the docket for this investigation.

[61] According to April 1, 2011 Commercial Vehicle Safety Alliance (CVSA) North American Standard Out-of-Service Criteria for Drum (Cam-Type and Wedge) Air Brakes.

- Surface cracks were present in the lower rear pad on the right side of axle #2 which measured approximately 5 inches in total length, but did not extend to the edges of the pad;[62]
- Brake dust buildup was present on the inner approximate 2-$^{1}/_{2}$ inches of brake pads on the right side of axle #2, with the corresponding approximate 2-$^{1}/_{2}$ inches of brake drum inner surface being rusted;
- Grooves were present in the left side axle #3 brake drum, with the drum diameter in the deepest groove measuring 18.077 inches;
- The lower rear brake pad lining on the right side of axle #3 was found to be loose, and was able to be moved approximately $^{1}/_{8}$ inch in the longitudinal direction, as well as approximately $^{1}/_{8}$ inch in the lateral direction;[63] this would be considered a defective lining condition, resulting in the right side of axle #3 to be considered a defective brake according to the CVSA Out-of-Service Criteria;
- The brake pads on the left side of axle #4 were approximately $^{1}/_{2}$ inch thick, and showed little signs of wear;
- The cam rollers on the left side of axle #4 were shiny and silver in color, and also showed little signs of wear;
- The brake components on the right side of axle #4 were contaminated with grease and/or oil;[64] and
- The brake pads on the right side of axle #4 appeared to be saturated with grease and/or oil, and had a partially glazed area that appeared to be heated and dried grease and/or oil;[65] the friction surface of the brake drum on the right side of axle #4was also coated with grease and/or oil, and had a similar partially glazed area also appearing to be heated and dried grease and/or oil;[66] this would be considered a defective lining condition, resulting in the right side of axle #4 to be considered a defective brake according to the CVSA Out-of-Service Criteria.

Following the vehicle inspection, Safety Board investigators removed several of the brake system components for additional testing. These components included the Antilock Brake System Electronic Control Unit (ABS ECU), air compressor governor, rear axle service relay valve, lift axle quick release valve, and the left and right rear axle ABS modulator valves. Once removed from the accident truck, the components were shipped to the Bendix Commercial Vehicle Systems facility in Elyria, OH, for examination and testing by Bendix engineers and NTSB staff.[67] Testing of the components occurred on April 17, 2012. The Bendix ABS ECU was electronically interrogated and checked for active and inactive diagnostic trouble codes, none of which were found. A function test

[62] Refer to *Vehicle Photograph 14 – 2004 Mack Truck – Crack in Lower Rear Brake Pad on Right Side of Axle #2*, which can be found in the docket for this investigation.
[63] Refer to *Vehicle Photograph 15 – 2004 Mack Truck – Gap Between Brake Shoe and Loose Friction Material of Lower Rear Brake Pad on Right Side of Axle #3*, which can be found in the docket for this investigation.
[64] Refer to *Vehicle Photograph 16 – 2004 Mack Truck – Grease/Oil Contamination of Brake Components on Right Side of Axle #4*, which can be found in the docket for this investigation.
[65] Refer to *Vehicle Photograph 17 – 2004 Mack Truck – Grease/Oil Saturated and Glazed Brake Pads on Right Side of Axle #4*, which can be found in the docket for this investigation.
[66] Refer to *Vehicle Photograph 18 – 2004 Mack Truck – Grease/Oil Saturated and Glazed Inside Friction Surface of Brake Drum on Right Side of Axle #4*, which can be found in the docket for this investigation.
[67] Additional information is contained in *Vehicle Attachment 16 – 2004 Mack Truck – Brake System Timing, ABS Module, and Brake Valve Testing Summary Report from Bendix Commercial Vehicle Systems, LLC. – Including Supplemental Report*, which can be found in the docket for this investigation.

was also performed on the ABS ECU, and the module was found to be operating correctly. The service relay valve, air compressor governor, and both ABS modulator valves, all of which were manufactured by Bendix, were tested. All of the Bendix valves were found to meet the Bendix test requirements for new valves, and were operating properly. Upon the request of a Safety Board investigator, the lift axle quick release valve, which was manufactured in Taiwan and marked with a Tremac logo, was also tested. When a test application pressure was applied, the quick release valve delivered the full pressure and exhausted to 0 psi upon release of the test pressure.

2.9 LIGHTING

Several of the lamps located on the front end of the accident truck, in or near the area of collision damage, were removed from the vehicle and forwarded to the NTSB Materials Laboratory for examination. These lamps included the left headlamp, left clearance/turn signal lamp, left corner marker lamp, right clearance/turn signal lamp, and right corner marker lamp. The glass envelope of the right clearance/turn signal lamp was found to be broken, and most of the lamp's filament was missing upon the first examination of the vehicle by Safety Board investigators. The right headlamp was missing upon Staff's examination of the vehicle, and was unable to be located in the associated wreckage. The NTSB Materials Laboratory reported that the right front corner marker lamp was found to have stretching of the filament.[68] No signs of filament stretching were found in the other lamps that were examined.

2.10 MAINTENANCE HISTORY

Maintenance records for the accident truck were obtained from the motor carrier, Herman's Trucking, Inc.[69] Records include the last three annual vehicle inspection reports, over three months of Driver's Vehicle Inspection Reports, and over three years of maintenance records.

The annual vehicle inspection report dated February 25, 2009, indicated that the service brakes needed to be repaired. The report also indicated that those repairs were completed on the same date as the inspection. No defects were noted on either the February 25, 2010, inspection report, or the February 16, 2011, vehicle inspection report. The truck was due to have its next annual vehicle inspection performed by the end of February 2012, the month in which this accident occurred.

The Driver Vehicle Inspection Reports contained reports for 39 days of use between October 31, 2011, and February 10, 2012. No defects were noted by the drivers on any of the reports.

A summary of notable maintenance actions performed on the accident truck and contained in the maintenance records is as follows:

- 4/3/2009 – Replaced slack adjuster on left side of axle #4;
- 4/4/2009 – Replaced brake shoes and wheel seal on the right side of axle #4;

[68] Additional information is contained in the *Materials Lab – Group Chairman Factual Report 12-036,* which can be found in the docket for this investigation.

[69] Additional information is contained in *Vehicle Attachment 17 – 2004 Mack Truck – Inspection and Maintenance Records*, which can be found in the docket for this investigation.

- 7/15/2009 – Adjusted clutch and replaced "fuel pedal" assembly;
- 7/29/2009 – Replaced two tires with re-treaded tires on left side of axle #4, replaced the drive axle wheel bearings, races, wheel seal, and two studs on left side of axle #4, reversed the left steer tire due to wear, and replaced the tire on the right side of axle #2 with a re-treaded tire.
- 9/10/2009 – Repaired the left inside tire on axle #3, which was flat;
- 10/30/2009 – Replaced the tire and wheel on the left side of the steer axle with new parts;
- 6/2/2010 – Replace tire on the left side of axle #2;
- 7/8/2010 – Replaced the brakes, drum, and wheel seal on the right side of axle #3;
- 7/10/2010 – Replaced brakes and drums on the left sides of both axle #3 and axle #4;
- 7/19/2010 – Replaced brake shoes, drum, wheel seal, and one stud on right side of axle #4;
- 9/2/2010 – A note was made about low air pressure on the left inside tire on axle #3;
- 10/8/2010 – Replaced inside tire on right side of axle #4;
- 1/19/2011 – Adjusted clutch;
- 9/26/2011 – Replaced both tires on the left side of axle #4 with re-treaded tires;
- 9/29/2011 – Replaced slack adjuster on left side of axle #2; and
- 2/2/2012 – Replaced "elephant pads" on right side leaf spring assembly.

2.11 EVENT DATA

The Mack AI-400 ASET engine of the accident truck was controlled by an Engine Electronic Control Unit (EECU), which communicated with a Vehicle Electronic Control Unit (VECU). The purpose of these modules is to control engine timing and fuel injection based on various engine and sensor inputs. These modules are also capable of diagnostics associated with engine and/or sensor faults, which may then illuminate warnings on the dash. At the request of an NTSB Recorder Specialist, the EECU was removed from its mounting on the left side of the engine, and the VECU was removed from its mounting behind the passenger side kick panel in the vehicle's interior. After being removed from the vehicle, both modules were turned over to the Recorder Specialist in order to attempt to retrieve any stored data. The data recovered from the modules was determined to be unrelated to the accident.[70]

[70] Additional information is contained in the *Electronic Control Modules – Specialist's Factual Report*, which can be found in the docket for this investigation.

2.12 DOCUMENTED RECALLS AND WARRANTY CLAIMS

A search of the safety recall database maintained by the National Highway Traffic Safety Administration (NHTSA) indicated there was one voluntary safety related recall issued which would have affected the accident truck.[71] The recall pertained to the potential for cracks to develop in affected axle beams, which could lead to axle beam failure, and a potential for a resultant crash. According to records kept by Mack Trucks, Inc., this voluntary safety recall was satisfied on October 7, 2009, by replacing the affected axle beam.[72] A search of the defect investigation database, also maintained by NHTSA, did not reveal any active or inactive defect investigations which would have pertained to the accident truck.[73]

Mack Trucks, Inc.'s warranty claim records indicated that seven claims were filed for maintenance covered under the original and extended coverage warranties on the vehicle.[74] None of the warranty claims required the replacement of any major engine, driveline, braking, steering, or suspension system components. These warranty repairs were completed between January 2005, and June 2007.

F. ACCIDENT DOCKET MATERIAL

The following items are included in the docket to this investigation:

LIST OF ATTACHMENTS

Vehicle Attachment 1 – 2012 IC School Bus – Technical Specifications

Vehicle Attachment 2 – New Jersey State Police Portable Scale Certifications

Vehicle Attachment 3 – 2012 IC School Bus – VIN Plate Information

Vehicle Attachment 4 – 2012 IC School Bus – Manufacturer Specifications for Firestone, Goodyear, and Hankook Tires

Vehicle Attachment 5 – 2012 IC School Bus – Brake Rotor Machining Specifications

Vehicle Attachment 6 – 2012 IC School Bus – Pages From Operator's Manual

Vehicle Attachment 7 – 2012 IC School Bus – Inspection and Maintenance Records

Vehicle Attachment 8 – 2012 IC School Bus – Warranty History

[71] The safety recall database was accessed via the NHTSA safety recall website. http://www-odi.nhtsa.dot.gov/recalls/reacallsearch.cfm [accessed August 10, 2012].
[72] Additional information is contained in *Vehicle Attachment 18 – 2004 Mack Truck – NHTSA Recall Campaigns, Warranty Claims, and Recall Repairs*, which can be found in the docket for this investigation.
[73] The defect investigation database was accessed via the NHTSA defect investigation website. http://www-odi.nhtsa.dot.gov/defects/index.cfm [accessed August 10, 2012].
[74] Additional information is contained in *Vehicle Attachment 18 – 2004 Mack Truck – NHTSA Recall Campaigns, Warranty Claims, and Recall Repairs*, which can be found in the docket for this investigation.

LIST OF PHOTOGRAPHS

Vehicle Photograph 7 –	2012 IC School Bus – Close-up of Scuffing to Outer Edge of Right Rear Tire Tread
Vehicle Photograph 8 –	2004 Mack Truck – Contact Damage to Front
Vehicle Photograph 9 –	2004 Mack Truck – Rearward Displacement of Steel Front Bumper
Vehicle Photograph 10 –	2004 Mack Truck – Right Rear of Truck's Hood and Paint Transfer/Scuff Marks to Windshield
Vehicle Photograph 11 –	2004 Mack Truck – Driver Control Area
Vehicle Photograph 12 –	2004 Mack Truck – Cracks in Lower Rear Brake Pad on Left Side of Axle #2
Vehicle Photograph 13 –	2004 Mack Truck – Crack Extending Through Two Rivet Holes to the Edge of Brake Pad, Creating a Void in the Brake Pad Material on the Left Side of Axle #2
Vehicle Photograph 14 –	2004 Mack Truck – Crack in Lower Rear Brake Pad on Right Side of Axle #2
Vehicle Photograph 15 –	2004 Mack Truck – Gap Between Brake Shoe and Loose Friction Material of Lower Rear Brake Pad on Right Side of Axle #3
Vehicle Photograph 16 –	2004 Mack Truck – Grease/Oil Contamination of Brake Components on Right Side of Axle #4
Vehicle Photograph 17 –	2004 Mack Truck – Grease/Oil Saturated and Glazed Brake Pads on Right Side of Axle #4
Vehicle Photograph 18 –	2004 Mack Truck – Grease/Oil Saturated and Glazed Inside Friction Surface of Brake Drum on Right Side of Axle #4

END OF REPORT

Steven L. Prouty
Vehicle Factors Engineer