VEHICLE GROUP CHAIRMAN'S FACTUAL REPORT

Gray Summit, MO

HWY-10-MH-018
(24 Pages)

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

VEHICLE GROUP CHAIRMAN'S FACTUAL REPORT

A. ACCIDENT

Type:	Truck Tractor, Pickup, School Bus Multivehicle Accident
Date and Time:	August 5, 2010, 10:11AM. CDT
Location:	Interstate 44 Eastbound West of Milepost 250.6 Gray Summit, Franklin County, Missouri
Vehicle #1:	2007 Volvo Truck Tractor
Motor Carrier:	Climate Express
Vehicle #2:	2007 GMC Sierra Pickup
Vehicle #3:	2003 Bluebird, 71-Passenger School Bus
Motor Carrier:	Copeland Bus Services, LLC
Vehicle #4:	2001 Bluebird, 72-Passenger School Bus
Motor Carrier:	Copeland Bus Services, LLC
Fatalities:	02
Injuries:	38

NTSB #: **HWY-10-MH-018**

B. VEHICLE GROUP

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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 THE INVESTIGATION

This Vehicle Group Chairman's Factual Report is a collection of factual information obtained during the detailed inspection of all four vehicles involved in this accident. All major mechanical systems were examined. Overall accident damage, along with any damage or anomalies within major vehicle mechanical systems is documented. Supporting photographs, vehicle specifications, maintenance records, and prior state inspections are referred to throughout this report, and are included as attachments in the docket for this investigation.

E. VEHICLE INSPECTIONS

1. VEHICLE #1: 2007 Volvo Truck Tractor

1.1 GENERAL INFORMATION

TRUCK TRACTOR:
Manufacturer: Volvo of North America
Model: VNL64T
VIN: 4V4NC9GHX7Nxxxxxx
Date of Manufacture: May 2006
DOT#: 648882
Odometer: 460,094 miles[1]
Gross vehicle weight rating (GVWR): 50,350 lbs
Gross axle weight rating (GAWR) Front: 12,350 lbs
GAWR Rear (each axle): 19,600 lbs
Engine: Volvo Engine, D12 - 465HP, serial number: D12*585174*D2*AH
Transmission: Eaton Fuller FRO-16210C, 10 speed manual, serial number: P0189735

1.2 DAMAGE DESCRIPTION

At the time of the accident the 2007 Volvo truck tractor was operating without being in combination with a trailer, also known as "bobtailing". The truck tractor was located at Chuck's Towing in Sullivan, MO, at the time of the inspection, and sustained damage at its rear, at the 3rd axle, and along the top of its rear frame rails to the area of the fifth wheel coupler. Both mud flaps and attachment arms were broken off the rear of the truck tractor. The top half of the sleeper berth was also damaged, with the fiberglass shell being broken open at the left top corner of the truck tractor cab.[2]

[1] According to data downloaded from the Volvo engine control module after the accident. According to most recent maintenance record, dated 8/4/2010, the day before the accident, the recorded mileage was 460, 085 miles.
[2] See Vehicle Photos 1 and 2 – 2007 Volvo Truck Tractor, Rear and Front

1.3 STEERING AND SUSPENSION

An examination of the steering system revealed no visible damage. The steering system remained functional, with movement of the steering wheel transcending through the steering column, steering gear box, and steering linkage to the wheels of the front axle. Staff noted that a frontal air bag was located in the steering wheel, and did not deploy as a result of the accident

The front axle leaf spring and shock absorbers, and the 2nd axle leaf springs, shock absorbers, and air suspension had no visible signs of damage, wear, or distortion. The 3rd axle suspension was pushed forward, causing the leaf spring U-bolts to shift forward approximately one inch on the top of both the left and right side leaf springs. The air suspension cushions were collapsed and pushed forward, detaching them from their bottom mounts on both the left and right sides of the 3rd axle. The left side air suspension cushion was also detached from the top mount on the left side of the 3rd axle. When the system was pressurized, air was allowed to escape from the pneumatic system through the damaged air cushions on the 3rd axle. In order to take push rod stroke measurements during the post-crash inspection, the air supply hoses to the 3rd axle air suspension were clamped off. Clamping off these hoses sealed the system, and allowed air pressure to be delivered to the brake chambers.

1.4 WEIGHT AND MEASUREMENTS

The Missouri State Highway Patrol weighed the truck tractor using certified portable scales on the day of the accident, and reported the individual axle weights as shown in **Table** . Due to the damage and weight shift as a result of the accident, these measurements may not represent the exact axle weights at the time of the accident.

Table 1: Vehicle 1 Post-crash Measured Axle Weights

	Weight	
	Left	Right
Steer Axle	5,250 lbs	5,300 lbs
2nd Axle	1,250 lbs	1,900 lbs
3rd Axle	1,950 lbs	2,250 lbs
Total	**17,900 lbs**	

According to manufacturer specifications, the original wheelbase (from the center of the front axle to the center between the two rear axles) for the truck tractor was 219 inches.[3] The same measurement was noted on the truck tractor post crash. The post crash 3rd axle wheelbase (from the center of the front axle to the center of 3rd axle) was found to be 244 inches on the right side of the truck tractor, and was 242.5 inches on the left side. The top of the integral cab/sleeper compartment (not including the fiberglass aerodynamic feature) was approximately 112 inches above the ground, and the top of the fifth wheel was approximately 44 inches above the ground. The height above the ground for the bottom of the front bumper was 15 inches; the middle of the tow hook was 23.5 inches; the top of the front bumper was 30 inches; and the most-forward edge of the engine hood cover was 65 inches above the ground. The rolling radius of the wheels was noted to be 19 inches for the steer axle, and 20 inches for both rear axles.

[3] See *Vehicle Attachment 1 – Manufacture Specifications for 2007 Volvo Truck Tractor*, which can be found in the docket for this investigation.

At the rear of the truck tractor, the lower edge of the rearmost cross member was pushed forward approximately 10.5 inches, and the upper edge was pushed forward about 10 inches. This cross member had three oval-shaped openings for the taillights and reverse light, which were no longer in position, due to the rear end damage.

1.5 TIRES AND WHEELS

Recommendations stamped on the placard on the inside of the driver's door suggest 295/75R22.5 load range G tires mounted on 22.5X8.25 rims, to be inflated to 110 pounds per square inch (psi) for all axles. A maximum inflation load of 110 psi for single wheel application, and 100 psi for dual wheel application was listed on the sidewalls of the tires. **Table** includes the tire and wheel information documented on the accident vehicle at the time of inspection. Tread depth measurements were taken in at least 3 locations in the tread grooves of a given tire, the lowest of which was entered in the table, and represents a minimum tread depth for each tire. The minimum tread depth regulation for commercial vehicle tires is 4/32 of an inch for the steer axle and 2/32 of an inch for all other axles.[4]

Table 2: Vehicle 1 Post-Crash Tire Information

	Left Steer Axle		**Right Steer Axle**	
Tire Make	Dunlop SP 384		Goodyear G395LHS	
Tire Size	295/75R22.5		295/75R22.5	
Load Rating	G		G	
Pressure	106 psi		86 psi	
Tread Depth	9/32 inch		7/32 inch	
2nd Axle	**Left**		**Right**	
Tire Make	Kelly KDA	Kelly KDA	Kelly KDA	Kelly KDA
Tire Size	295/75R22.5	295/75R22.5	295/75R22.5	295/75R22.5
Load Rating	G	G	G	G
Pressure	90 psi	84 psi	107 psi	80 psi
Tread Depth	18/32 inch	8/32 inch	12/32 inch	13/32 inch
3rd Axle	**Left**		**Right**	
Tire Make	Kelly KDA	Kelly KDA	Kelly KDA	Kelly KDA
Tire Size	295/75R22.5	295/75R22.5	295/75R22.5	295/75R22.5
Load Rating	G	G	G	G
Pressure	88 psi	96 psi	94 psi	85 psi
Tread Depth	10/32 inch	22/32 inch	11/32 inch	11/32 inch

1.6 LIGHTING

One red enclosed oval-shaped taillight was located at the accident scene, and another red enclosed oval-shaped taillight was located in the wreckage removed from the scene. These taillights matched the size and shape of the openings in the rear cross member of the truck tractor, and were taken to the NTSB Materials Lab for further examination[5]. Since the appearance of the two taillight assemblies is nearly identical, it is not possible to determine which was mounted on the left or right side on the rear of the truck tractor. Each taillight

[4] Measured in two adjacent tread grooves at any location on the tire, according to the Federal Motor Carrier Safety Regulations, Title 49 of the US Code of Federal Regulations, Part 393.75.

[5] Additional information is contained in the Materials Laboratory Factual Report (#10-103), which can be found in the docket for this investigation.

assembly contained a single, dual-filament light bulb. According to the Materials Laboratory Factual Report, none of the filaments showed evidence of hot stretching.

1.7 BRAKING

The truck tractor was equipped with pneumatic drum brakes and a Bendix anti-lock brake system (ABS) with automatic traction control. During the post-crash inspection, the primary tank on the left side of the truck tractor was pressurized and regulated to 92 psi, using an auxiliary air compressor. A foot pedal application was applied, and push rod stroke measurements were taken at each axle. The parking brakes were first released when taking the measurements on the 2nd axle. **Table 1** contains the push rod stroke measurements that were obtained, along with the adjustment limits.

Table 1: Vehicle 1 Post-Crash Brake Adjustment

	Brake Type	Slack Adjusters	Push Rod Stoke (inches)	Adjustment Limit [6] (inches)
L Steer Axle	20	5 ½ inch Auto	7/8	1 ¾
R Steer Axle	20	5 ½ inch Auto	1	1 ¾
L 2nd Axle	30/30	5 ½ inch Auto	1 ¼	2
R 2nd Axle	30/30	5 ½ inch Auto	1 3/8	2
L 3rd Axle	30	5 ½ inch Auto	1 3/8	2
R 3rd Axle	30	5 ½ inch Auto	1 ½	2

1.8 TRANSMISSION

According to the driver of the truck tractor, he had engaged the transmission into 3rd gear with one foot on the brake and one foot on the clutch at the time of the accident.[7] At the time of inspection the transmission gear shift appeared to be in neutral. Due to the gear shift being in neutral and the lack of direct impact damage to the transmission, and internal inspection of the transmission gears was not conducted. The truck tractor was equipped with an Eaton Fuller FRO-16210C, 10 speed manual transmission, and a Volvo D12 – 465 HP diesel engine. The Volvo engine had a governed engine speed of 1900 revolutions per minute (RPM). The rear drive axle ratio was 3.42:1. The drive tires had a rolling radius of 20 inches, and would rotate at a rate of 504 revolutions per mile. Knowing these values, vehicle speed can be calculated for each forward and reverse transmission gear ratio using **Equation 1**.

$$S = \frac{60\frac{min}{hr} \times Engine_{speed}}{Ratio_{Axle} \times Ratio_{Trans} \times Tire_{Speed}} \quad \textbf{(1)}$$

S	=	Vehicle speed (in miles per hour)
$Engine_{Speed}$	=	Engine Speed (in revolutions per minute)
$Ratio_{Axle}$	=	Drive Axle Ratio
$Ratio_{Trans}$	=	Transmission Gear Ratio
$Tire_{Speed}$	=	Tire Speed (in revolutions per mile)

[6] According to April 1, 2010 Commercial Vehicle Safety Alliance North American Standard Out of Service Criteria for clamp type pneumatic brakes.
[7] See Human Performance Factual Report Attachment 1, pages 2 and 3.

The calculated speeds for the accident vehicle with the configuration listed above are shown in **Table 2**. The results in the table are based on the operating engine speed range of 900 to 1900 RPM. Third gear, the gear that the driver reported he was in while stopped at the time of the accident, would have provided a speed range of approximately 4 to 9 mph.

Table 2: Vehicle 1 Transmission Gear Speed Calculations

Gear	Engine RPM Range		Tire	Transmission	Minimum Speed	Maximum Speed
	min	max	$^{rev}/_{mi}$	Gear Ratio	(mph)	(mph)
1	900	1,900	504.2	12.69	2.5	5.2
2	900	1,900	504.2	9.29	3.4	7.1
3	900	1,900	504.2	6.75	4.6	9.8
4	900	1,900	504.2	4.90	6.4	13.5
5	900	1,900	504.2	3.62	8.7	18.3
6	900	1,900	504.2	2.64	11.9	25.0
7	900	1,900	504.2	1.90	16.5	34.8
8	900	1,900	504.2	1.38	22.7	47.9
9	900	1,900	504.2	1.00	31.3	66.1
10	900	1,900	504.2	0.74	42.3	89.3
R_{Low}	900	1,900	504.2	13.75	2.3	4.8
R_{High}	900	1,900	504.2	2.80	11.2	23.6

1.9 MAINTENANCE HISTORY

Maintenance files for the truck tractor were obtained from Climate Express for all regularly scheduled and as-needed repairs that were made to the truck tractor in the year 2010. The most recent file was dated August 4, 2010, the day before the accident, at a vehicle mileage of 460,085 miles, and indicated that the truck tractor underwent service to correct a slipping generator belt and an inoperative air conditioning fan.

1.10 EVENT DATA

The 2007 Volvo truck tractor was equipped with an Engine Control Module (ECM), an ABS control module, an Airbag Control Module, and a Xata mobile communications system. The capability of these systems to record vehicle operation, and accident data, surrounding the collision event was examined. Details of the system capabilities and recorded event data are included in the Event Data Recorder Group Chairman Factual Report, which can be found in the docket for this investigation. According to document contained in the Event Data Factual Report Attachments, there were no active fault or trouble codes found in either the engine ECM, or the ABS module.

2. VEHICLE #2: 2007 GMC Sierra Pickup Truck

2.1 GENERAL INFORMATION

Manufacturer: General Motors
Model: Sierra 1500 Extended Cab 4x4
VIN: 1GTEK19Z67Zxxxxxx
Date of Manufacture: 06/13/2006
Odometer: 29,574[8]

[8] Mileage noted on recent Missouri State Vehicle Inspection, see footnote 13.

GVWR: 6,408 lbs
Engine: Vortec 5.3L V8 Flex Fuel (E85/Gasoline)
Transmission: 4-speed Automatic with Overdrive

2.2 DAMAGE DESCRIPTION

At the time of inspection the 2007 GMC pickup truck was located at I-44 Towing in St. Clair, MO. During the inspection, the pick-up truck was resting on its roof. The vehicle sustained severe damage to all areas, which affected all major mechanical systems of the pickup truck. [9] The frame of the vehicle was folded into an upside down "U" shape during the collision sequence.[10] The degree and nature of the collision damage limited the extent to which the vehicle could be inspected following the accident.

2.3 MAJOR VEHICLE SYSTEMS

The pickup truck was equipped with an anti-locking braking system (ABS), front disc brakes, rear drum brakes, and four wheel drive. Following the collision, the major components of the vehicle's powertrain remained within the wreckage. The main driveshaft between the transmission and the rear differential, however, was broken off at its universal joints, and was displaced from the vehicle. A functional inspection of the steering system was not possible based on the extent of the damage. The front suspension remained relatively intact during the collision. The rear suspension sustained severe damage during the collision sequence. The forward halves of the rear leaf springs were bent and ungrouped. The left rear shock was bent, and the right rear shock was bent and broken away from its top mounting. The fuel system was also compromised during the collision, releasing fuel from the fuel tank. The rear fuel tank mounting strap was torn loose, and a small tear to the tank itself was present on the bottom rear section of the tank. The driver's controls were not inspected or documented due to the damage and space limitations within the wreckage.

2.4 WEIGHT AND MEASUREMENTS

The overall post crash weight of the pickup truck was measured by the Missouri State Highway Patrol to be 4,810 pounds. Several hand measurements were taken to illustrate the extent of the damage. According to manufacturer specifications the pickup had an original wheelbase of 143 ½ inches.[11] The original wheelbase was reduced to a length of 113 inches on the left side, and 107 inches on the right side. The original rear overhang of 47 inches was reduced to 17 inches on the left, and 0 inches on the right. The original front overhang of 39 inches was reduced to 7 inches on the left, and 0 inches on the right. The original pickup truck bed length of approximately 77 ¾ inches was reduced to 32 inches.

2.5 TIRES AND WHEELS

According to the tire and loading placard mounted to the inside of the driver's door, the pickup truck was to be equipped with size 265/70R17 tires, inflated to 35 psi. The tires on the pickup truck were all Bridgestone Dueler A/T size 265/70R17 tires. The tread depth ranged

[9] See Vehicle Photo 3 – 2007 GMC Sierra Pickup Truck , Driver Side (Inverted)
[10] See Vehicle Photo 4 – 2007 GMC Sierra Pickup Truck – Rear Driver Side Corner (Inverted)
[11] See *Vehicle Attachment 2 – Manufacturer Specifications for 2007 GMC Sierra Pickup*, which can be found in the docket for this investigation.

from 5/32 to 6/32 of an inch for all tires.[12] All but the right front tire were flat. The right front tire held 12 psi at the time of inspection. A spare tire for the pickup truck was located at the accident scene. The spare tire was a Goodyear Wrangler size 265/70R17, was damaged at the sidewall and wheel rim, and was flat.

2.6 MAINTENANCE HISTORY

On the morning of the accident, August 5, 2010, the pickup truck underwent an annual safety and emissions inspection as mandated under Missouri State law. The vehicle was inspected in the condition in which it was presented, and no repairs were made or recommended during the inspection. This inspection was completed approximately 25 minutes prior to the collision. The results of both the safety and emissions portions of the inspection were reported as being a "Pass".[13] The Missouri State safety inspection program requires that vehicles be inspected for vehicle components and systems that include, but are not limited to, the following: brake performance, brake components, lighting equipment and signals, steering mechanisms, suspension components, tires and wheels, exhaust system, glass, fuel system, and seatbelts.[14]

2.7 EVENT DATA

The 2007 GMC pickup truck was equipped with an Airbag Control Module (ACM) which had the capability of recording, in an electronic format, data surrounding a collision event. The data contained in the ACM was downloaded by members of the Missouri State Highway Patrol, and was forwarded to the Event Data Recorder Group Chairman. Details of the ACM recording capability and recorded event data are included in the Event Data Recorder Group Chairman Factual Report, which can be found in the docket for this investigation.

3. VEHICLE #3: 2003 Bluebird School Bus

3.1 GENERAL INFORMATION

Manufacturer: Blue Bird Corporation
VIN: 1BABJCPH63Fxxxxxx
Model Number: A3 FE 7200
Body Number: L054128
Date of Manufacture: 06/02
Model year: 2003
Odometer: 87,043 miles[15]

GVWR:	32,200 lbs
GAWR Front:	13,200 lbs
GAWR Rear:	19,000 lbs

Engine: Cummins ISB Diesel – 205HP, serial number 46212531
Transmission: Allison 2000, automatic, serial number 6310212712

[12] According to the Missouri Motor Vehicle Inspection Regulations, a vehicle is not rejected for worn tires unless there is no tread (0/32 of an inch) across the middle half of the tire.
[13] See *Vehicle Attachment 3 – GMC Sierra Vehicle Inspection Report for 08-05-2010*, which can be found in the docket for this investigation.
[14] Additional information is contained in pages 19 through 50 of *Vehicle Attachment 8 – Missouri Motor Vehicle Inspection Regulations*, which can be found in the docket for this investigation.
[15] According to data downloaded from the engine control module after the accident.

3.2 DAMAGE DESCRIPTION

At the time of inspection the 2003 Bluebird school bus was located at Miles and Sons Towing in Cuba, MO. The bus was a transit-style (flat front) design with a front diesel engine, accessible through a panel inside the center front console of the bus, between the entrance steps and the driver's seat.

The bus sustained moderate front end damage, resulting in the driver's side portion of the front windshield being broken out and the boarding door side portion of the front windshield being cracked and hanging only by the remaining windshield seal.[16] The front body panels and bumper were bent and pushed inward. At the front of the bus several lights including three of the four headlights were broken out.

The bus sustained substantial rear end damage at the right rear corner.[17] The damage overrode the rear bumper and intruded into the seating compartment at the right rear of the bus. Several lights including the tail, brake, reverse, and turn signal lights on the right rear of the bus were broken out.

The bus also sustained undercarriage damage at its center and left front side.[18] In these areas there was damage to the electrical fuse box located behind the left side of the front bumper, as well as the engine oil pan, engine exhaust system, and drive shaft, all located in the center of the bus, and the battery box, located on the left side of the bus, behind the front axle.

3.3 INTERIOR DASH DOCUMENTATION

The driver's dash and interior switches and gauges were examined during the vehicle inspection. Initially no power was available to the bus due to the fuse box damage. The speedometer needle was noted to have been stopped at approximately 47 mph upon initial inspection.[19] Correspondingly, the tachometer needle was found stopped at approximately 1500 rpm.

The automatic transmission gear selector was found in the 'overdrive' position. The cruise control on/off switch was in the 'off' position. The high idle on/off switch was in the 'on' position. The stalk on the left side of the steering wheel, for hazard and bright light control, was found in its neutral position and bent downward. One of two fan switches located on the panel to left of the driver's seat was on 'high' and the other was 'off'. The bus was equipped with air conditioning; however dials for the air conditioning, also located on the panel to left of the driver's seat, appeared to be off at the time of inspection. The heat dials located at the center of the dash, to the right of the driver's seat were all found 'off'. For details associated with the driver's seat, passenger seats, and restraints, refer to the Survival Factors Group Chairman's Factual Report.

After a fusible link was replaced inside the damaged fuse box, power was restored to the bus, and the engine could be started. With power on and the engine running, and with neither the parking nor service braking applied, none of the brake system indicator lights were illuminated.

[16] See Vehicle Photo 5 – 2003 Blue Bird School Bus, Right Front Corner
[17] See Vehicle Photo 6 – 2003 Blue Bird School Bus, Right Rear Corner
[18] See Vehicle Photo 7 – 2003 Blue Bird School Bus, Center Undercarriage Damage
[19] See Vehicle Photo 8 – 2003 Blue Bird School Bus, Speedometer at time of Inspection

Four available brake system indicator lights were located in the center of the dash, in the indicator light panel.[20] The brake system indicator lights consisted of; a red service brake application indicator, an amber ABS warning indicator, a red parking brake application indicator, and a red brake system warning indicator.[21]

The service brake and parking brake application indicators illuminated, as intended, when the service and parking brakes were applied. The ABS warning light indicator illuminates when there is a fault in the anti-lock brake system. The brake system warning indicator illuminates when the hydraulic brake pressure is below safe limits. Neither the ABS warning light indicator nor the brake system warning indicator illuminated when the bus was running, or when it was driven and tested as described in **Section 5** below.

3.4 STEERING AND SUSPENSION

The steering wheel of the school bus remained concentric, and was not deformed or damaged. The steering wheel remained attached to the steering column, which extended down and through the floorboard of the bus. Just beyond the floorboard the steering column connected to a TRW, Inc. 90-degree steering transition box with a universal joint. The transition box was mounted with an L-shaped bracket to the back of the front bumper. The transition box was then connected through another set of universal joints to the steering input shaft into a TRW, Inc. Ross hydraulically powered steering gear box.

The joints all appeared to be solidly connected and undamaged, however, due to the front bumper damage, the transition box, mounting bracket, and linkage on either side, were pushed both rearward and towards the center of the bus. Although this damage altered the alignment of the steering components, it did not prevent movement from the steering wheel from reaching the lower steering linkage.

On the outboard side of the steering gear box, the pitman arm was connected through the drag link to the lower steering linkage at the front axle of the bus. The tie rods and steering knuckles appeared to be solidly connected during the inspection. The center link, connecting the left and right sides of the front axle steering, was damaged and bent upward into a portion of the exhaust system on the right side of the link. This damage deformed the center link however movement of the steering wheel was able to reach both sides of the axle, and articulation of both the left and right front wheels was achieved by rotating the steering wheel.[22]

The front axle suspension of the bus consisted of double taper leaf springs and shock absorbers on either side of the axle. The rear axle suspension consisted of larger multi-layer leaf springs and shock absorbers on either side of the axle, as well as a rear axle sway, or stabilizer, bar. No damage was observed to any of the suspension system components.

[20] See Vehicle Attachment 4a - 2002 Operators Manual for All American Bluebird School Buses, item 16 on page 9.
[21] See Vehicle Attachment 4a, items 2, 3, 4, and 5 on page 10.
[22] With the front axle lifted off the ground, since at the time of the steering system inspection power was not available to the bus, so there was no power steering, making it difficult to turn the wheel.

3.5 WEIGHT AND MEASUREMENTS

The Missouri State Highway Patrol weighed the bus using certified portable scales on the day of the accident, and reported an empty post crash weight of 17,550 lbs. According to manufacturer specifications the 2003 school bus had an original overall length of 427 inches, an overall width of 94 inches, and a wheel base of 210 inches.[23] Post crash measurements of the bus included a right side wheelbase of 210 inches and a left side wheel base of 211 ½ inches. The overall height of the bus was also measured and found to be 112 inches. For a detailed account of measurements taken to document the crash damage and rear intrusion into the passenger compartment refer to the Survival Factors Group Chairman's Factual Report.

3.6 TIRES AND WHEELS

According to the tire choice placard located on the inside of the bus, 11R22.5 load range H tires mounted on 22.5X8.25 rims, to be inflated to 115 psi, are recommended for both front and rear axles. A maximum inflation load of 120 psi for both single and dual wheel application was listed on the sidewalls of the tires. **Table** includes the tire and wheel information documented on the accident vehicle at the time of inspection. Tread depth measurements were taken in at least 3 locations in the tread grooves of a given tire, the lowest of which was entered in the table, and represents a minimum tread depth for each tire. The minimum tread depth regulation for commercial vehicle tires is 4/32 of an inch for the steer axle and 2/32 of an inch for all other axles.[24]

There was no damage to the tires or wheels. As the bus sat at the inspection site for several days during the post crash inspection, a slow leak in the left front tire was noted.

Table 5: Vehicle 3 Post-Crash Tire Information

	Left Steer Axle		**Right Steer Axle**	
Tire Make	Michelin XZE		Michelin XZE	
Tire Size	11R22.5		11R22.5	
Load Rating	H		H	
Pressure	72 psi		72 psi	
Tread Depth	18/32 inch		18/32 inch	
2nd Axle	**Left**		**Right**	
Tire Make	Michelin XDE M/S	Michelin XDE M/S	Michelin XDE M/S	Michelin XDE M/S
Tire Size	11R22.5	11R22.5	11R22.5	11R22.5
Load Rating	H	H	H	H
Pressure	72 psi	74 psi	84 psi	82 psi
Tread Depth	23/32 inch	23/32 inch	25/32 inch	23/32 inch

[23] See *Vehicle Attachment 4 – Manufacturer Specifications for 2003 Blue Bird School Bus*, which can be found in the docket for this investigation.

[24] Measured in two adjacent tread grooves at any location on the tire, according to the Federal Motor Carrier Safety Regulations, Title 49 of the US Code of Federal Regulations, Part 393.75.

3.7 BRAKING

The bus was equipped with four wheel hydraulic disc brakes and an anti-lock braking system (ABS). Hydraulic power boost was supplied in combination with the bus's power steering pump and hydraulic power brake booster pump through an integral flow switch. A reserve electric motor pump also provided a redundant source of hydraulic power boost. In the absence of power, and with the engine off, the brakes would function with manual hydraulic force only.

The brake pedal was mechanically linked through the floorboard of the bus to the master cylinder. Due to the front bumper damage the alignment of the mechanical linkage was slightly deformed, but movement was not restricted. The master cylinder was wet in appearance, showing hydraulic fluid seepage over the body of the unit.[25] There was also a wet spot behind the left side of the front axle, adjacent to the brake lines that ran from the master cylinder back to the hydraulic ABS unit.[26] These brake lines appeared to be rusted, corroded, and leaking, with concentrated areas of corrosion where the lines were clamped to the left side frame rail.[27] The paint on the frame rail next to, and below, the wet area was bubbled up and had begun to peel away from the metal.[28]

The brake line that ran from the ABS unit to the left front wheel also appeared to be rusted, causing it to look corroded and orange in color; however it was dry and did not appear to be leaking. The hydraulic brake lines that ran from the ABS unit to the right and rear wheels of the bus had a few areas where rust and corrosion had begun to build, however they were overall metallic gray in appearance, and dry, and no other leaks were found. ABS sensors were found connected and undamaged at all four wheel locations.

The reservoir for the hydraulic brake fluid was located inside the bus, under the driver's seat. Upon initial inspection the brake fluid reservoir was full, having 3 ¾ inch depth of fluid in both chambers. However, after the brake pedal was depressed multiple times during and after brake deceleration testing that occurred on August 10, 2010, (See **Section 5** of this report) the fluid level dropped to just over 1 ½ inch. At that time an obvious leak in one or both of the brake lines that ran from the master cylinder back to the ABS unit was observed. When the brake pedal was depressed, the movement of the pedal was soft and spongy, and fluid could be seen squirting out of the brake line(s) at this location.

Leaking hydraulic brake lines are considered to be an out-of-service item according to the Commercial Vehicle Safety Alliance (CVSA) Out-of-Service Criteria.[29] A leak in a hydraulic brake line would also cause a vehicle to be rejected during a vehicle inspection using the Missouri Motor Vehicle Inspection Regulations (MMVIRs).[30]

[25] See Vehicle Photo 9 – 2003 Blue Bird School Bus, Master Cylinder
[26] Wet spot can be seen on the left side of Vehicle Photo 7 – 2003 Blue Bird School Bus, Center Undercarriage Damage
[27] See Vehicle Photo 10 – 2003 Blue Bird School Bus, Leaking Hydraulic Brake Lines, View 1
[28] See Vehicle Photo 11 – 2003 Blue Bird School Bus, Leaking Hydraulic Brake Lines, View 2
[29] Out-of-service item 1.n(8), based on Title 49 of the US Code of Federal Regulations, Part 393.45
[30] Rejection item "N" listed on page 21.

A return trip to conduct further documentation of the hydraulic brake system occurred on October 19, 2010. The bus was kept at the inspection site between the time of the accident and the return trip. When inspecting the bus upon return, it was noted that the hydraulic brake fluid reservoir was dry down to the fluid intakes at the bottom of both chambers. Due to the lack of fluid, no braking force was available to the bus. This was noted by lifting the front and rear axles off the ground, rotating the wheels, depressing the brake pedal, and getting no resistance from brakes, allowing the wheels to continue spinning. A brake fluid sample was taken by depressing the brake pedal and collecting the fluid that dripped out of the leaking brake line(s) that ran from the master cylinder back to the ABS unit.

During the return trip staff was accompanied by mechanics from Central States Bus, the service and repair company that Bluebird uses for school buses in the accident area. The mechanics removed and replaced the two lines that ran from the master cylinder back to the ABS unit. The brake lines were then shipped to the NTSB Materials Lab for further examination.[31] Once the lines were removed, another brake fluid sample was taken from one of the open fittings on the master cylinder. Two additional fluid samples were also taken for comparison; one from the reservoir of the 2001 school bus that was also involved in this accident, and a clean sample of new fluid that was used to refill the hydraulic brake system of the bus once the new brake lines were in place. All four fluid samples were shipped to the NTSB Materials Lab for further examination.[32]

After the brake lines were replaced, deceleration testing of the bus was again conducted (See **Section 5** of this report). After the deceleration testing, the wheels of the bus were removed for closer inspection of the brake pads and rotors. With the hydraulic brake system repaired, the brake calipers could be seen actuating, with the pads gripping the rotors at each wheel location. The brake rotors were measured for thickness using a micrometer and the brake pads were measured to the nearest 32nd of an inch using a scientific ruler, measurements are shown in **Table 6** below.

Table 6: Vehicle 3 Post-Crash Brake Component Measurements

	Left	**Right**
Front		
Rotor Thickness	1.522 inch	1.521 inch
Pad Thickness	10/32 inch	8/32 inch
Rear		
Rotor Thickness	1.505 inch	1.509 inch
Pad Thickness	11/32 inch	12/32 inch

All of the brake rotors were smooth and showed even wear, and were within the manufacturer minimum thickness specification of 1.420 inch. All brake pads were found to be with the minimum thickness limit of 1/16 (or 2/32) inch.[33] However, the front brake pads were observed to have sections where small cracks could be seen at the outer edge of the pads. The rear brake pads both had small sections of missing pad lining at the outer edges.[34]

[31] Additional information is contained in the Materials Laboratory Factual Report (#11-006), which can be found in the docket for this investigation.
[32] Additional information is contained in the Materials Laboratory Factual Report (#11-003), which can be found in the docket for this investigation.
[33] Title 49 of the US Code of Federal Regulations, Part 393.47(d – lining and pads)
[34] See Vehicle Photo 12 – 2003 Blue Bird School Bus, Left Rear Brake Showing Missing Lining

Cracked and missing sections of brake pads are considered to be an out-of-service item according to the CVSA Out-of-Service Criteria,[35] and would cause a vehicle to be rejected during a vehicle inspection using the MMVIRs.[36]

3.8 MAINTENANCE HISTORY

See **Section 6** of this report, Copeland Bus Services, which addresses the maintenance of both school buses involved in this accident.

3.9 EVENT DATA

The 2003 Bluebird school bus was equipped with an Engine Control Module, and an ABS control module. The capability of these systems to record vehicle operation, and accident data, surrounding the collision event was examined. Details of the system capabilities and recorded event data are included in the Event Data Recorder Group Chairman Factual Report, which can be found in the docket for this investigation.

4. VEHICLE #4: 2001 Bluebird School Bus

4.1 GENERAL INFORMATION

Manufacturer: Blue Bird Corporation
VIN: 1BABHCPH11Fxxxxxx
Model Number: A3 FE 7200
Body Number: F129674
Date of Manufacture: 07/00
Model year: 2001
Odometer: 105,092 miles[37]

GVWR:	32,200 lbs
GAWR Front:	13,200 lbs
GAWR Rear:	19,000 lbs

Engine: Cummins ISB Diesel – 190HP, serial number 45968926
Transmission: Allison 2000, automatic, serial number P6310016489

4.2 DAMAGE DESCRIPION

The 2001 Bluebird school bus was initially located at I-44 Towing in St. Clair, MO. On Tuesday August 9, 2010 the bus was moved to Miles and Sons Towing in Cuba, MO so that both buses could be inspected at the same location. The 2001 school bus was of the same front engine transit-style as the 2003 school bus involved in this accident, just 2 model years older. The 2001 bus sustained more substantial front end damage than the 2003 bus. The left front corner was pushed inward, damaging the left front bumper and upper exterior warning light area, and also buckling the left front lower body panel. [38] The driver's side of the front windshield was broken

[35] Out-of-service item 1.a(6) and 1.b(3), based on Title 49 of the US Code of Federal Regulations, Part 393.47
[36] Rejection item "I" listed on page 21.
[37] According to data downloaded from the engine control module after the accident.
[38] See Vehicle Photo 13 – 2001 Blue Bird School Bus, Left Front Corner

out and the boarding door side detached and hanging from the windshield seal. The rear of the school bus was undamaged.[39] Power remained available to the electrical system.

4.3 INTERIOR DASH DOCUMENTATION

The driver's dash and interior switches and gauges were examined during the vehicle inspection. There was damage to the dash and instrument panels, with 3 of the 5 gauges located directly forward of the steering wheel being broken out due to the frontal damage sustained by the bus. At the time of inspection the speedometer needle was resting at 0 mph and the tachometer, oil pressure, and water temperature gauges had been broken out of the dash. The automatic transmission gear selector was found in the 'N' (neutral) position. Although there was damage to the dash in the area of the cruise control on/off switch, it appeared to be in the 'off' position. The high idle on/off switch also appeared to be in the 'off' position. The stalk on the left side of the steering wheel, for hazard and bright light control, was found in its neutral position. The bus was not equipped with air conditioning. The heat dials located at the center of the dash, to the right of the driver's seat were all found 'off'. For details associated with the driver's seat, passenger seats, and restraints, refer to the Survival Factors Group Chairman's Factual Report.

With power on and the engine running, it could not be determined if any of the three available brake indicator lights were illuminated since they were not functional due to the damage to the center of the dash display area.

4.4 STEERING AND SUSPENSION

The steering wheel of the bus sustained deformation damage and was no longer completely concentric. The steering wheel remained attached to the steering column, which extended down and through the floorboard of the bus. Just beyond the floorboard, the steering column connected to a TRW, Inc. 90-degree steering transition box with a universal joint. The transition box was mounted with an L-shaped bracket to the back of the front bumper. The transition box was then connected through another set of universal joints to the steering input shaft into a TRW, Inc. Ross hydraulically powered steering gear box. The joints all appeared to be solidly connected and undamaged; however, due to the front bumper damage the transition box, mounting bracket, and linkage on either side, were all pushed rearward. Although this damage altered the alignment of the steering components, it did not prevent movement from the steering wheel from reaching the lower steering linkage.

On the outboard side of the steering gear box the pitman arm was connected through the drag link to the lower steering linkage at the front axle of the bus. The tie rods and steering knuckles appeared to be solidly connected during the inspection.

The front axle suspension of the bus consisted of double taper leaf springs and shock absorbers on either side of the axle. The rear axle suspension consisted of larger multi-layer leaf springs and shock absorbers on either side of the axle, as well as a rear axle sway, or stabilizer, bar. No damage was observed to any of the suspension system components.

[39] See Vehicle Photo 14 – 2001 Blue Bird School Bus, Right Rear Corner

4.5 WEIGHT AND MEASUREMENTS

The Missouri State Highway Patrol weighed the bus using certified portable scales on the day of the accident, and reported an empty post crash weight of 16,250 lbs. According to manufacturer specifications, the 2001 school bus had an original overall length of 420 inches, an overall width of 94 inches, and a wheel base of 190 inches.[40] Post crash measurements of the bus included a right side wheelbase of 190 ¼ inches and a left side wheel base of 189 ½ inches. The overall height of the bus was also measured and found to be 112 inches. For a detailed account of measurements taken to document the passenger compartment refer to the Survival Factors Group Chairman's Factual Report.

4.6 TIRES AND WHEELS

According to the tire choice placard on the inside of the bus, 11R22.5 load range H tires mounted on 22.5X8.25 rims, to be inflated to 115 psi, are recommended for both front and rear axles. **Table** includes the tire and wheel information documented on the accident vehicle at the time of inspection. Tread depth measurements were taken in at least 3 locations in the tread grooves of a given tire, the lowest of which was entered in the table, and represents a minimum tread depth for each tire. The minimum tread depth regulation for commercial vehicle tires is 4/32 of an inch for the steer axle and 2/32 of an inch for all other axles.[41] There was no damage to the tires or wheels of the bus.

Table 7: Vehicle 4 Post-Crash Tire Information

	Left Steer Axle		**Right Steer Axle**	
Tire Make	Michelin XZE		Michelin XZE	
Tire Size	11R22.5		11R22.5	
Load Rating	H		H	
Pressure	80 psi		88 psi	
Tread Depth	19/32 inch		19/32 inch	
2nd Axle	**Left**		**Right**	
Tire Make	Bridgestone MZX 711	Bridgestone MZX 711	Bridgestone MZX 711	Bridgestone MZX 711
Tire Size	11R22.5	11R22.5	11R22.5	11R22.5
Load Rating	H	H	G	G
Pressure	80 psi	84 psi	86 psi	62 psi
Tread Depth	9/32 inch	11/32 inch	9/32 inch	10/32 inch

4.7 BRAKING

This school bus, similar to the 2003 school bus that was involved in this accident, was equipped with a four wheel hydraulic disc brake system with anti-lock braking. The hydraulic power boost system was also configured similarly to the 2003 school bus. The brake pedal was mechanically linked through the floorboard of the bus to the master cylinder. Due to the front bumper damage, the alignment of the mechanical linkage was pushed inward and deformed, but movement of the linkage could still be achieved with firm pressure.

[40] See *Vehicle Attachment 5 – Manufacturer Specifications for 2001 Blue Bird School Bus*, which can be found in the docket for this investigation.

[41] Measured in two adjacent tread grooves at any location on the tire, according to the Federal Motor Carrier Safety Regulations, Title 49 of the US Code of Federal Regulations, Part 393.75.

A non-standard spring assembly was found mounted between the housing of the 90-degree steering transition box and the front of the brake push rod that goes into the master cylinder.[42] When Copeland Bus Services was asked about the spring assembly, they indicated that they added it to help return the brake pushrod from a braking actuation to its non-braking position. This was done in attempt to keep the service brake application indicator light from staying on in the dash.

The brake lines that lead from the master cylinder back to the ABS unit appeared to be newer than the surrounding lines, and in much better condition than the same lines on the 2003 school bus that was involved in this accident. The brake lines coming from the master cylinder and going to all for wheels were inspected. There were a few locations where rust and corrosion were evident, however all of the lines were dry and no hydraulic fluid leaks were detected.[43] The level of hydraulic brake fluid in the reservoir, located under the driver's seat, remained full, at 3 ¾ inches deep in both chambers before and after deceleration tests. When the brake pedal was depressed, the pedal movement was more firm and reactive than that of the 2003 school bus.

The right rear ABS wheel speed sensor was found out of its placement hole in the wheel end, and dangling from its wire at the time of the inspection. The sensor appeared to have been heat damaged, having a bubbled surface at the end of the sensor.[44] The wheels were not removed, so no measurements were taken of the brake rotors or pads.

4.8 MAINTENANCE HISTORY

See **Section 6** of this report, Copeland Bus Services, which addresses the maintenance of both school buses involved in this accident.

4.9 EVENT DATA

The 2001 Bluebird school bus was equipped with an Engine Control Module, and an ABS control module. The capability of these systems to record vehicle operation, and accident data, surrounding the collision event was examined. Details of the system capabilities and recorded event data are included in the Event Data Recorder Group Chairman Factual Report, which can be found in the docket for this investigation.

5. SCHOOL BUS DECELERATION TESTS

To assess the deceleration capabilities of the two school buses involved in this accident, as well as an exemplar school bus from the same bus fleet, a series of tests were conducted by skidding the buses on a roadway with a similar coefficient of friction as the accident location.[45] A Vericom VC4000 brake accelerometer, supplied by the Missouri State Highway Patrol, was mounted to the right of the driver's seating area for each test and was utilized to quantify the braking performance of the school buses. All of the deceleration tests were conducted on a level section of 2-lane undivided asphalt road located approximately four miles north of Miles & Sons Towing in Cuba, MO. Five of the six tests (Runs 1-5 shown in **Table 8**) were conducted on

[42] See Vehicle Photo 15 – 2001 Blue Bird School Bus, Non-standard Spring Assembly
[43] See Vehicle Photo 16 – 2001 Blue Bird School Bus, Hydraulic Brake Line for Left Front Wheel
[44] See Vehicle Photo 17 – 2001 Blue Bird School Bus, Right Rear Wheel Speed Sensor
[45] Using a common police vehicle and the same Vericom VC4000 as used in the deceleration tests, the test surface was measured to have a drag factor of 0.795, and the surface at the accident location was measured to have a drag factor of 0.797.

August 10, 2010. The final test (Run 6) was conducted on October 19, 2010 during the return trip to remove and replace the leaking hydraulic brake lines of the 2003 bus.

Both the exemplar bus and the 2001 bus could be started and driven.[46] The 2003 bus could not be driven due to the drive shaft damage, however after the a fusible link was replaced inside the fuse box on the left front underside of the bus, which also sustained damage, the engine was able to be started. With the engines running on all of the buses during testing, hydraulic power assist was available for both braking and steering.

Two tests (Runs 1 and 5) were conducted by driving the exemplar and 2001 bus to a constant speed of approximately 20 mph before the service brakes were fully applied to mimic an emergency brake application. The same procedure was repeated to conduct a second test with the exemplar bus at approximately 30 mph (Run 2). Since the 2003 bus could not be driven, a tow truck was utilized to push the bus to approximately 20 mph and 25 mph before the service brakes were fully applied (Runs 3 and 4).[47]

The road was dry when the tests were conducted with the exemplar and 2003 school buses. Light rain, however, began to fall which made the road surface damp but not rain-soaked when the single test with the 2001 school bus was conducted.

Table 8: Deceleration Tests[48]

Run #	**Test vehicle** (school bus)	**Pre-braking Speed** (mph)	**Time** (secs)	**Distance** (ft)	**Acceleration** (G-force)
1	Exemplar	19.25	1.410	21.232	**-0.622**
2	Exemplar	29.50	2.350	49.361	**-0.572**
3	2003	19.65	4.040	58.188	**-0.222**
4	2003	24.38	4.470	79.877	**-0.249**
5	2001	18.71	1.330	20.576	**-0.641**
Run #6 – after leaking braking lines were replaced on the 2003 school bus					
6	2003	25.75	1.860	36.245	**-0.631**

6. COPELAND BUS SERVICES

Copeland Bus Services (Copeland) is owned and operated by Mr. Ron Copeland, who is also one of the two mechanics that perform routine maintenance and as-needed repairs on the fleet of school buses. The business has two separate roles; one being the purchase, repair, and sales of used school buses, and the other being the sole school bus operator for the St. James School District.

At the time of the accident there were a total of 23 school buses in the St. James transportation fleet. Eighteen of them were transit-style school buses; three were conventional school buses; and two were mini school buses. Nineteen buses were manufactured by Blue Bird Corporation; two manufactured by Thomas Built Buses, Inc.; and the two mini buses were

[46] After the accident the engine of the 2001 bus could be started, however prior to being able to drive it, a rear section of drive shaft, which had been removed for towing after the accident, had to be been replaced.

[47] Prior to starting the engine of the 2003 bus for the deceleration tests a hole at the bottom of the engine oil pan was patched and oil was added to the engine. The left front tire, which had a slow leak, was also filled with air. A rear section of drive shaft that had been removed for towing after the accident was left removed so that the bus could be pushed.

[48] Detailed data from each of the deceleration tests can be found in *Vehicle Attachment 6 – Deceleration Test Data*, which can be found in the docket for this investigation.

manufactured by General Motors Corporation. All of the buses were outfitted with hydraulic (and not air) brake systems. Mr. Copeland stated that he only operated hydraulically braked buses so that his CDL drivers would not be required to have air brake endorsements.

The 2003 school bus involved in this accident was the newest in the fleet. All buses were purchased by Copeland as pre-owned and operated by other school districts in the surrounding states and counties. NTSB staff toured Copeland's fleet and facilities and observed that there did not appear to be any set maintenance schedule for the buses or any established form of maintenance records retention. Also, there was no apparent organization of service manuals or reference materials. The entire set of maintenance records for the fleet of school buses were contained in a small spiral bound notebook, where each bus had less than one page of notes on maintenance preformed while at Copeland. Mr. Copeland and the one other mechanic that he had on his staff indicated that many small repairs or service checks (such as topping off fluid and checking tire pressure) are not typically written in the notebook. Neither Mr. Copeland nor his one mechanic had any formal training in the service or maintenance of passenger or heavy vehicles. Since Copeland is an intra-state carrier, and is not authorized for interstate operations, they are not subject to the Federal Motor Carrier Safety Regulations (FMCSRs). Part 396 of the FMCSRs addresses the inspection, repair, and maintenance (including retention of maintenance records) of commercial motor vehicles; however, as stated above, Copeland Bus Services was not subject to these regulations.

According to maintenance notes, the 2003 bus was purchased by Copeland in November 2005, at a mileage of 43,502 miles, and the 2001 bus was purchased by Copeland in October 2005, at a mileage of 72,810 miles.[49] The notes contained multiple mentions of preventative maintenance items such as 'lube' and 'full service', as well as notes when new tires were put on the buses. The last note made about the 2003 bus was on April 29, 2010, for a 'full service' that included a tailpipe and rear brake check. Other notable items in the 2003 bus notes were a transmission computer service in April 2008, and a speedometer replacement in December 2008. The last note made about the 2001 bus was on March 31, 2010, for a 'full service' that included tailpipe and clamp replacements to the driveline and/or exhaust system. Other notable items in the 2001 bus notes were a 'repaired 2 brake lines' note in September 2009, and speedometer replacements in both October 2006, and March 2007.

6.1 MISSOURI STATE VEHICLE INSPECTIONS

Although the school buses were not subject to inspection for "Parts and Accessories Necessary for Safe Operation" as set forth by FMCSR Part 393, the State of Missouri required that the buses be inspected twice a year, once by the State Highway Patrol, and once by a state certified inspection location, to comply with the guidelines contained in the MMVIRs.[50] The MMVIRs also sets forth requirements for state certified inspection stations and for the licensing of inspectors and mechanics.

[49] See *Vehicle Attachment 7 – School Bus Maintenance and Inspection Records*, which can be found in the docket for this investigation, and contain typed versions of the notes from the spiral bound notebook that Copeland provided to NTSB staff. Inspection records for the last 3 inspections on both buses are also contained in this attachment.

[50] See *Vehicle Attachment 8 – Missouri Motor Vehicle Inspection Regulations*, which can be found in the docket for this investigation

Certified inspection stations are required to have the appropriate space and tools to conduct the State inspections, depending on the classification of the station, defined by Classes A through D. Class A stations are certified to inspect all vehicles. Class B stations are certified to inspect full size domestic passenger vehicles and motorcycles, and not commercial motor vehicles. Commercial motor vehicles are defined in the MMVIRs as "motor vehicles designated or regularly used for carrying freight and merchandise, or more than eight passengers." Class C stations are certified to inspect motorcycles only. Class D stations are certified to inspect commercial motor vehicles only. The price of state inspections in Missouri is set to $12 for all vehicles, and $10 for motorcycles.

The licensing of inspectors and mechanics requires that each individual be at least 17 years old, have at least one year of practical experience or vocational instruction as an automotive mechanic, complete an application, and pass a written exam on the contents of the MMVIRs by getting 80 percent or more of the answers correct. Licenses (referred to as permits) are valid for 3 years, after which they can be renewed without reexamination within 60 days of the expiration date, if they are not revoked during that time. If the permit is revoked or lapses the 60 day grace period, a reexamination is required.

Both the inspection stations that are operated by the Missouri State Highway Patrol, as well as the inspectors from the Missouri State Highway Patrol, are subject to the same certification, licensing, and permit regulations as the private stations and inspectors.

The MMVIRs contains sections on "Brake Performance" and "Brake Components" under "Passenger Car and Truck Inspection"; however there are no brake sections under "School Bus Inspection". There is a single line of text under "School Bus Inspection" that states "In addition, the items listed in this rule will be inspected on all school buses." According to the Missouri State Highway Patrol, this means that school buses are then also subject to all of the inspection criteria within "Passenger Car and Truck Inspection", including the section pertaining to brakes.

According to the brake performance section under "Passenger Car and Truck Inspection", on pages 17-18 of the MMVIRs, a single unit vehicle with a GVWR over 10,000 lbs (such as the accident buses) is required to develop deceleration equal to or greater than 14 ft/sec, equivalent to a G-force deceleration factor of 0.43. However, according to the Missouri State Highway Patrol, these quantitative brake performance tests are not preformed on school buses during the state inspections. Rather, a "Drive and Stop" test, also listed in the brake performance section, is typically done at a speed of 5 to 20 mph to observe the bus's stopping ability.

According to the section on hydraulic brake system components, on pages 19-21 of the MMVIRs, the vehicle is to fail inspection if brake pedal movement exhibits signs that there is a fluid leak, if the master cylinder is leaking, or if worn, broken, or loose brake components are found. This section advises that, in the absence of brake performance testing, one front or one rear wheel must be removed for the inspection of brake components on passenger vehicles and pick-up trucks or similar vehicles not equipped with dual rear wheels. According to the Missouri State Highway Patrol, a wheel is not required to be removed from a school bus for the inspections of brake components; however, many of the listed brake inspection items would not be visible without removal of the wheel.

The accident buses were last inspected at Ray's Tire, a Class A state certified inspection location, on July 27, 2010, and by the Missouri State Highway Patrol on March 25, 2010.[51] The July 27, 2010, approval notices from Ray's Tire noted that each of the school bus inspections took approximately 20 minutes and no defects were listed. A section for 'brake inspected' with 4 check boxes (one for each of the brakes) had none of the boxes checked. Both of the buses were also inspected by Ray's Tire in July 2009, and those records showed the same 20 minute inspection times, with no defects found, and none of the brake inspection boxes checked.

On March 25, 2010, during a pre-arranged inspection with Copeland, the Missouri State Highway Patrol inspected all 23 buses at Copeland Bus Services. All 23 buses passed with no re-inspections needed. The inspection certificates from the Missouri State Highway Patrol do not note the time the inspections started or ended, nor do they have an area for brake inspection check boxes. For the accident buses, both certificates have an 'approved' box checked and no defects listed. As a result of this fleet inspection Copeland Bus Services (recognized as St. James R-1) was given a Total Fleet Excellence Award by the Missouri State Highway Patrol, for having a 90% or greater approval rating.[52]

After the accident, and after NTSB staff found the leaking master cylinder and hydraulic brake lines on the 2003 bus, and the out of place ABS sensor on the 2001 bus, the Missouri State Highway Patrol returned to Copeland Bus Services for un-planned spot fleet inspection on August 11, 2010. At that time a total of 20 buses were inspected, eight of which were rejected, resulting in an approval rating of 60%.[53] Five of the eight rejected buses were considered to be "out-of-service".[54] Six of the eight rejected buses were re-inspected after repairs were made on the same day and then passed inspection, with two out-of-service buses remaining out-of service.

All of the rejected buses had recently been inspected by Ray's Tire in July 2010. As a result of the defects found during the August 11, 2010 fleet inspection, the Missouri State Highway Patrol revoked both the inspection station certification for Ray's Tire, as well as the lead mechanic's inspector permit, for the maximum term of one year each. The inspection station certification, and inspector permit, were both revoked on August 24, 2010.

For the August 11, 2010 fleet inspection, Copeland's fleet of 23 buses was reduced to 20 buses due to the two accident buses that were in NTSB's possession at the time, and one additional bus that was not available for the fleet inspection due to it being involved in an accident in the parking lot of St. Johns Mercy Hospital in Washington, Missouri, on the same day of this accident (August 5, 2010). The bus involved in the hospital parking lot accident was sent there, by Copeland, to be available in case any uninjured students involved in this accident needed transportation back to St. James, Missouri.

[51] See *Vehicle Attachment 7 – School Bus Maintenance and Inspection Records*, which can be found in the docket for this investigation.
[52] See *Vehicle Attachment 9 – Total Fleet Excellence Award given to Copeland Bus Services*, which can be found in the docket for this investigation.
[53] See *Vehicle Attachment 10 – Post Accident Copeland Bus Services Fleet Inspection*, which can be found in the docket for this investigation.
[54] The five out-of-service rejections were for: 1) an inoperative rear overhead warning light, 2) no brake pedal pressure, 3) a worn right front tire, 4) a right rear brake line leaking and master cylinder fluid low, and 5) a split in a left rear tire sidewall.

The bus involved in the hospital parking lot accident was a 2000 Blue Bird transit-style front diesel engine school bus, with hydraulic disc brakes, similar to the two school buses involved in this accident. According to the police report, the driver of the school experienced a loss of braking in the parking lot, and struck three parked cars before coming to rest against a small garage at the end of the lot. [55]

A trail of fluid was found along the path of the bus in the parking lot, and brake fluid was observed to be leaking from the left front undercarriage of the school bus. This bus also passed a 20 minute state inspection at Ray's Tire on July 19, 2010, with no defects found, and none of the brake inspection boxes checked.[56]

Since hydraulic brake line failures were discovered on three similar buses during the course of this investigation, The Office of Defects Investigations (ODI) within the National Highway Traffic Safety Administration (NHTSA) was contacted. A query of ODI databases revealed no brake line recalls, service bulletins, or complaints applicable to the failures that were found on the Copeland school buses.

LIST OF ATTACHMENTS

Vehicle Attachment 1 – Manufacture Specifications for 2007 Volvo Truck Tractor
Vehicle Attachment 2 – Manufacturer Specifications for 2007 GMC Sierra Pickup
Vehicle Attachment 3 – GMC Sierra Vehicle Inspection Report for 08-05-2010
Vehicle Attachment 4 – Manufacturer Specifications for 2003 Blue Bird School Bus
Vehicle Attachment 4a – 2002 Operators Manual for All American Bluebird School Buses
Vehicle Attachment 5 – Manufacturer Specifications for 2001 Blue Bird School Bus
Vehicle Attachment 6 – Deceleration Test Data
Vehicle Attachment 7 – School Bus Maintenance and Inspection Records
Vehicle Attachment 8 – Missouri Motor Vehicle Inspection Regulations
Vehicle Attachment 9 – Total Fleet Excellence Award given to Copeland Bus Services
Vehicle Attachment 10 – Post Accident Copeland Bus Services Fleet Inspection
Vehicle Attachment 11 – Police Report and Photos of Hospital Parking Lot Accident
Vehicle Attachment 12 – Prior State Inspection of Bus Involved in Hospital Parking Lot Accident

LIST OF PHOTOGRAPHS

Vehicle Photo 1 – 2007 Volvo Truck Tractor, Rear
Vehicle Photo 2 – 2007 Volvo Truck Tractor, Front
Vehicle Photo 3 – 2007 GMC Sierra Pickup Truck, Driver Side (Inverted)
Vehicle Photo 4 – 2007 GMC Sierra Pickup Truck, Rear Driver Side Corner (Inverted)
Vehicle Photo 5 – 2003 Blue Bird School Bus, Right Front Corner
Vehicle Photo 6 – 2003 Blue Bird School Bus, Right Rear Corner
Vehicle Photo 7 – 2003 Blue Bird School Bus, Center Undercarriage Damage
Vehicle Photo 8 – 2003 Blue Bird School Bus, Speedometer at time of Inspection
Vehicle Photo 9 – 2003 Blue Bird School Bus, Master Cylinder
Vehicle Photo 10 – 2003 Blue Bird School Bus, Leaking Hydraulic Brake Lines, View 1
Vehicle Photo 11 – 2003 Blue Bird School Bus, Leaking Hydraulic Brake Lines, View 2

[55] See *Vehicle Attachment 11 – Police Report and Photos of Hospital Parking Lot Accident*, which can be found in the docket for this investigation.
[56] See *Vehicle Attachment 12 –Prior State Inspection of Bus Involved in Hospital Parking Lot Accident*, which can be found in the docket for this investigation.

Vehicle Photo 12 – 2003 Blue Bird School Bus, Left Rear Brake Showing Missing Lining
Vehicle Photo 13 – 2001 Blue Bird School Bus, Left Front Corner
Vehicle Photo 14 – 2001 Blue Bird School Bus, Right Rear Corner
Vehicle Photo 15 – 2001 Blue Bird School Bus, Non-standard Spring Assembly
Vehicle Photo 16 – 2001 Blue Bird School Bus, Hydraulic Brake Line for Left Front Wheel
Vehicle Photo 17 – 2001 Blue Bird School Bus, Right Rear Wheel Speed Sensor

END OF REPORT

Jennifer L. Morrison
Vehicle Factors Engineer