



**VEHICLE FACTORS GROUP CHAIRMAN'S
FACTUAL REPORT**

Vehicle Attachment 1 - 2015 IC school bus RH Sheppard Steering Gear Examination Report

Baltimore, MD

HWY17MH007

(7 pages)



Subject: Steering gear inspection removed from a 2015 Navistar CE school bus involved in an accident.

Date: December 9 , 2016

Customer: National Transportation Safety Board
490 L'Enfant Plaza SW
Washington, DC 20594

Location: R. H. Sheppard Co., Inc.
Technical Center
Hanover, PA 17331

Subject Vehicle: 2015 Navistar CE Bus Accident
M100PMT3 13J14475

Attendees: Jennifer Morrison, Investigator-in-Charge, NTSB
David Pereira, Vehicle Factors Investigator, NTSB

Thomas Bender, Detective, City of Baltimore PD

Background: Received a phone call/e-mail from David Pereira regarding the 2015 Navistar CE Bus involved in an accident with multiple fatalities.

Tuesday, November 1, 2016, a 2015 IC 64-passenger school bus was traveling east in the 4000 block of Frederick Avenue in Baltimore, Maryland. The school bus was occupied by a 67-year-old driver and an adult teacher aide. No student passengers were on the bus at the time. After the school bus had traveled through the intersection of Frederick Avenue and Loudon Street, it struck the rear of a 2012 Ford Mustang passenger car, which was also traveling east on Frederick Avenue. The Ford Mustang then struck the south curb of Frederick Avenue and collided with a brick wall and a metal fence before coming to rest in the eastbound lane.

After striking the Ford Mustang, the school bus continued traveling east on Frederick Avenue, departed the eastbound travel lane, crossed through the center turn lane, and entered the westbound travel lane, where it collided with the left side of a 2005 New Flyer transit bus operated by the Maryland Transit Administration (MTA). The extent of the school bus's impact ran along the left side of the transit bus and terminated near its rear axle. A full investigation report can be found at the NTSB website.

The incident resulted in a failure of the steering gear in which the sector was sheared between the pitman arm and the gear. Mr. Pereira requested a tear down and inspection of the steering gear to determine when the steering gear failed and the position of the wheels at impact. The steering gear was hand delivered to the R. H. Sheppard Co. by Ms. Morrison and Mr. Pereira. Photographs and documentation of the teardown inspection were collected by Ms. Morrison , Mr. Pereira and Mr. Bender.(Photo 2)The following is a report based on my observations and inspection of the parts.

Steering Gear Inspection: The subject steering gear was placed on a clean work bench where disassembly was made. The gear was a Sheppard model M100PMT3 with serial number 13J14475. Initial inspection showed the sector was sheared between the pitman arm and the sector cover. (Photos 3,6 and 7)The pitman arm remained attached to the broken end of the sector shaft. The pitman arm retainer was still in its lock position and the tab locks on the retainer were marked with seal lock such as the unit left the manufacturer. The remaining part of the fractured sector shaft was removed from the steering gear and examined. The sector teeth were in good condition with no signs of damage from the impact. The heat codes from the sector were recorded and verified with the original build records.(Photo 5)

The piston and bearing cap assembly was removed next. The piston teeth were inspected for damage which none was present. The heat code from the piston was recorded and verified with the original build sheet. The piston seal ring was in good operational condition (Photo 4). The rotary valve assembly was then removed from the piston. Inspection of the internal ball thread of the piston showed steel recirculating ball imprints on the thread. The bearing cap cover was removed from the bearing cap and inspected.

Inspection of the thrust washers showed single steel needle roller indents on both washers. This results when the rotary valve receives a single impact load. The steering gear had the required 24 steel recirculating balls present and the ball tube retainer O-ring was in good operational condition. Inspection of the rotary valve ball thread showed 15 steel ball indents on the shaft. The 15 ball indents were marked and the center of the ball indents was also marked. A measurement from the bottom of the rotary valve where the thrust bearing is located to the center line of the steel ball indents was measured at 3.53125 inches. This measurement provides the position of the pitman arm at the time the steering gear failed. Ball indentation of this type only occurs when the steering gear is subjected to an impact load in excess of three times the output torque of the steering gear. When the steering gear is in its center of travel (straight ahead) the distance from the bottom of the rotary center to it center line is measured at 3.220 inches. The piston/pitman arm moves .0315 inches per degree of travel. With these numbers, the position of the pitman arm at time of impact to the steering gear occurred approximately 10 degrees forward into a left steer or .31125 to the left on the steering wheel based on an 18.9:1 steering gear ratio. (Photo 1) The impact into the drag link/arm was driving the pitman arm toward the rear of the vehicle.

Each steering gear manufactured by the R. H. Sheppard Co., Inc. is tested after the steering gear is assembled for hydraulic and mechanical functions. A copy of this test is also attached. The steering gear component parts were then wrapped up and preserved. All parts were taken back to Washington via the NTSB personnel.

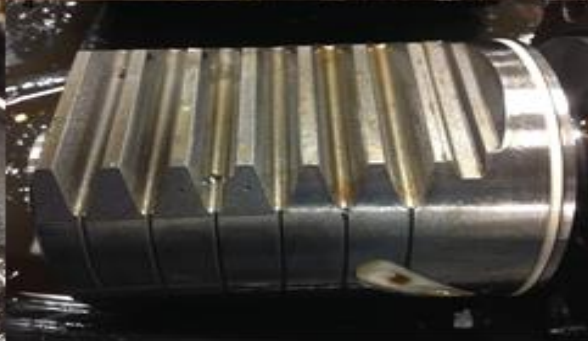
Conclusion: Based on the inspection of the steering gear assembly, results show that the steering gear was subjected to an impact load in excess of three times the steering gear output torque. Impact failure occurred when the steering wheel was approximately 10 degrees into left steer position and the impact was driving the pitman arm toward the rear of the vehicle. All steering gear seals inspected showed the seals in good operational condition indicating the gear was operating properly at time of the accident.

Sincerely Yours,

Mike Long

Field Service and Warranty
Manager

R. H. Sheppard Co., Inc.



Serial: 13J14475 Piston Gear Shaft Valve F1 Quit
RHS #: M100PMT3 P5DM3938 S2DN6371 VF7677 F2 Date
Mfg order: M985790 AQ95 CR11 DR06
Passed: Skid: 550079

Stn	Name	Description	Value	Error
1.11E	BADGE	Badge number	5326.000	
1.11E	PANGLE	Piston plug angle	50.000	
1.11E	PTORQUE	Piston plug torque	180.700	
1.11E	BADGE	Badge number	5326.000	
1.11E	PANGLE	Piston plug angle	71.000	
1.11E	PTORQUE	Piston plug torque	180.300	
1.11E	BADGE	Badge number	5792.000	
1.11E	PANGLE	Piston plug angle	19.000	
1.11E	PTORQUE	Piston plug torque	70.400	
1.11E	PZPART	01227341		

2.1A	BADGE	Badge number	5974.000	
2.2A	BADGE	Badge number	5496.000	
2.2A	KLVDT	Kurt LVDT (x.001)	.820-	
2.2A	KOFFSET	Kurt offset (x.001)	.070-	
2.2A	KSIZE	Kurt gage size	80.000	
2.3A	RZPART	0166684		
2.3A	BADGE	Badge number	1375.000	

2.3A	BALL	Ball insertion		
2.3A	BADGE	Badge number	1375.000	
2.3A	RETAINER	Retainer check	32.000	
3.1E	TESTED	Gear test	Y	
3.1E	01CSTOP	CHE stop pressure	100.000	
3.1E	02COUT	CHE output torque	4100.000	
3.1E	03CBRK	CHE center	Y	1.000
3.1E	04CLEAK	CHE leakage	.150	
3.1E	05CINPUT	CHE input @ 100PSI	45.000	
3.1E	07CREV	CHE reversability	30.000	
3.1E	08BSTOP	BCE stop pressure	120.000	
3.1E	09BOUT	BCE output torque	4100.000	
3.1E	10BBRK	BCE center	Y	1.000
3.1E	11BLEAK	BCE leakage	.150	
3.1E	12BINPUT	BCE input @ 100PSI	45.000	
3.1E	14BREV	BCE reversability	40.000	
3.1E	16TORQ-DIF	Torque differential		
3.1E	17TCLEAR	Rack clearance	.001	
3.1E	21TLTOR	Total on 20" wheel	2.140	
3.1E	23TURNI	Dist. after 5 turns	312.730	
3.1E	24FPLEAK	Full pressure leak	Y	1.000
3.1E	25PPLEAK	PSI leak check	Y	1.000
3.1E	50STIMING	Sector timing check	Y	1.000