



Vehicle Attachment 3 – RH Sheppard Steering Gear Inspection Report

**MULTIPLE VEHICLE ACCIDENT
Cranbury, NJ**

HWY14MH012

(6 pages)



Subject: Steering gear inspection removed from a 2011 Peterbilt vehicle involved in an accident.

Date: June 18, 2014

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: 2011 Peterbilt Cranbury NJ Accident
349,873 miles
M100PRZ31 10K03349

Attendees: Jennifer Morrison, Vehicle Factors Investigator, NTSB
Kenny Bragg, Vehicle Factors Investigator, NTSB

Background: Received a phone call/e-mail from Jennifer Morrison regarding the 2011 Peterbilt tractor and trailer. The vehicle was traveling on the New Jersey Turnpike when it failed to stop for traffic and struck the rear of a Mercedes Limo Bus resulting in injuries to several of the bus occupants and a fatality. The semi-tractor/trailer then went into the left lane and struck a Nissan Altima before coming to rest against a Jersey wall barrier. The incident resulted in a failure of the steering gear in which the bearing cap cover bolts were sheared allowing the rotary valve assembly to partially exit the bearing cap. Ms. Morrison requested a tear down and inspection of the steering gear to determine when the steering gear failed. The steering gear was hand delivered to the R. H. Sheppard Co. by Ms. Morrison and Mr. Bragg.

Steering Gear Inspection: The subject steering gear was placed on a clean work bench where disassembly was made. The gear was a Sheppard model M100PRZ31 (photo 8) with serial number 10K03349 (photo 7). Initial inspection showed the four bearing cap cover bolts had failed in tension allowing the rotary valve to partially exit out the bearing cap (photo 1 & 3). The pitman arm was first removed from the steering gear. The pitman arm retainer was still in its lock position and the tab locks on the retainer were the

original markings as the unit left the manufacturer (photo 4). The retainer was removed and the pitman arm was removed using a force load cell to determine the force required to remove the arm. The arm required 10,000 pounds of force to remove indicating the arm was still tight and secured to the sector shaft. The sector was then removed from the gear and inspection revealed the center tooth had a crack running completely down the entire length of the tooth (photos 14 & 15).

The piston and bearing cap assembly was removed next. Inspection of the piston showed rotary valve seal debris lying throughout the piston area (photo 9). The piston teeth were inspected for damage which none was present. The piston seal ring was in good operational condition (photos 9 & 10). 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 (photo 12 & 13). The heat code for the piston was N34 and heat treat code was 4DM9303 (photos 11 & 12). The bearing cap cover was removed from the bearing cap and inspection of the four bearing cap cover bolts showed the bolts had failed in tension resulting in the rotary valve partially exiting the bearing cap (photo 17). Inspection of the two upper thrust washers showed single steel needle roller indents on both washers (photos 19 & 20). Inspection of the lower washer showed several thrust bearing needle rollers missing (photo 18) but no roller needle indents. This results when the valve is moved from its normal operating position. Since the impact caused the bearing cap cover bolts to fail, the valve moved toward the outside of the bearing cap exposing these needle rollers with no support from the valve resulting in the needle rollers coming loose in the bearing. The needle rollers were found throughout the steering gear. The steering gear had the required 24 steel recirculating balls present and the ball tube retainer O-ring was in good operational condition (photo 23). Inspection of the rotary valve ball thread showed 15 steel ball indents on the shaft (photo 21). 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 3.500 inches (photo 22). 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 its center line is measured at 3.219 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 9 degrees forward into a left steer or 170 degrees to the left on the steering wheel based on an 18.9:1 steering gear ratio. The impact into the drag link/arm was driving the pitman arm toward the rear of the vehicle. Steel ball indents and the failure of the four bearing cap cover bolts occur when the steering gear assembly is subjected to impact load in excess of three times the output of the steering gear.

One final check was made to show the rotary valve and input shaft were operating correctly. The assembly was placed in a vise and the input shaft was turned left then right with no obstructions and sprang back in both directions (photos 24, 25, and 26). 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 170 degrees into left steer and the impact was driving the pitman arm toward the rear of the vehicle. All steering gear seals inspection shows the seals in good operational condition indicating the gear was operating properly at time of the accident.

Jeff Neiderer

Technical Center Manager
R. H. Sheppard Co., Inc.
6/23/14



Walmart Peterbilt (1).JPG



Walmart Peterbilt (2).JPG



Walmart Peterbilt (3).JPG



Walmart Peterbilt (4).JPG



Walmart Peterbilt (5).JPG



Walmart Peterbilt (6).JPG



Walmart Peterbilt (7).JPG



Walmart Peterbilt (8).JPG



Walmart Peterbilt (9).JPG



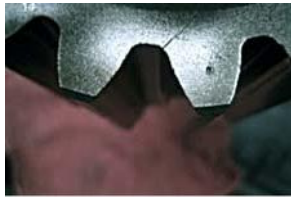
Walmart Peterbilt (10).JPG



Walmart Peterbilt (11).JPG



Walmart Peterbilt (12).JPG



Walmart Peterbilt (13).JPG



Walmart Peterbilt (14).JPG



Walmart Peterbilt (15).JPG



Walmart Peterbilt (16).JPG



Walmart Peterbilt (17).JPG



Walmart Peterbilt (18).JPG



Walmart Peterbilt (19).JPG



Walmart Peterbilt (20).JPG



Walmart Peterbilt (21).JPG



Walmart Peterbilt (22).JPG



Walmart Peterbilt (23).JPG



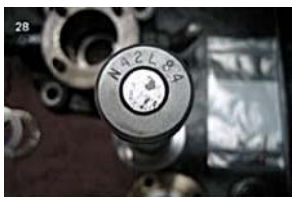
Walmart Peterbilt (24).JPG



Walmart Peterbilt (25).JPG



Walmart Peterbilt (26).JPG



Walmart Peterbilt (27).JPG

STEERING GEAR TEST SHEET
R. H. SHEPPARD CO., INC.

12/23/13
14:33:48

Serial #: 10K03349
Model #: M100PRZ31
Sheppard mfg #: M508180
Customer order #: C009843

Started: 2010/11/23 11:09:59
Skid #: 438767

Spec: 100N3HP
Oil: ES1
Pressure: 2350
Pass: Y

Customer: PETERBILT - DENTON

	<u>Piston</u>	<u>Gear/sector</u>	<u>Output shaft</u>	<u>Rotary valve</u>
Heat treat code:	P4DM9303		S2NV5356	VF6450
Steel heat #:	AN34		CN51	DN42

Date	Time	Stn	Data name	Rsn	Description	Value
2010/11/24	10:11:39	3.1B	BADGE		Badge number	5040.000
2010/11/24	10:11:39	3.1B	TESTED		Gear test	
2010/11/24	10:11:39	3.1B	01CSTOP		CHE stop pressure	125.000
2010/11/24	10:11:39	3.1B	02COUT		CHE output torque	4000.000
2010/11/24	10:11:39	3.1B	03CBRK		CHE center	1.000
2010/11/24	10:11:39	3.1B	04CLEAK		CHE leakage	.200
2010/11/24	10:11:39	3.1B	05CINPUT		CHE input @ 100PSI	45.000
2010/11/24	10:11:39	3.1B	07CREV		CHE reversability	50.000
2010/11/24	10:11:39	3.1B	08BSTOP		BCE stop pressure	125.000
2010/11/24	10:11:39	3.1B	09BOUT		BCE output torque	4000.000
2010/11/24	10:11:39	3.1B	10BBRK		BCE center	1.000
2010/11/24	10:11:39	3.1B	11BLEAK		BCE leakage	.200
2010/11/24	10:11:39	3.1B	12BINPUT		BCE input @ 100PSI	45.000
2010/11/24	10:11:39	3.1B	14BREV		BCE reversability	50.000
2010/11/24	10:11:39	3.1B	16TORQ-DIF		Torque differential	
2010/11/24	10:11:39	3.1B	17TCLEAR		Rack clearance	.001
2010/11/24	10:11:39	3.1B	21TLTOR		Total on 20" wheel	2.000
2010/11/24	10:11:39	3.1B	23TURNI		Dist. after 5 turns	312.500
2010/11/24	10:11:39	3.1B	24FPLEAK		Full pressure leak	1.000
2010/11/24	10:11:39	3.1B	25PPLEAK		PSI leak check	1.000
2010/11/24	10:11:39	3.1B	50STIMING		Sector timing check	1.000
2010/12/02	7:12:44	4.6A	BADGE		Badge number	5924.000
2010/12/02	7:12:44	4.6A	BADGE		Badge number	233.000
2010/12/02	7:12:44	4.6A	PITMAN		Torque value	352.200
2010/12/02	7:24:48	4.9	BADGE		Badge number	5090.000
2010/12/02	7:24:48	4.1	PAINT 4.9		Paint date: STN 4.9	