U.S. Department of Transportation

National Highway Traffic Safety Administration

ODI RESUME

OFFICE OF DEFECTS INVESTIGATION

NHTSA

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Investigation: EA 11-011
Prompted by: Fleet Complaint
Date Opened: 09/09/2011 **Date Closed:** 09/25/2013
Investigator: Nate Seymour **Reviewer:** Bruce York-B
Approver: Frank Borris
Subject: Haldex Spring Brake Failures

MANUFACTURER & PRODUCT INFORMATION

Manufacturer: Daimler Trucks North America, FREIGHTLINER LLC
Products: 2007 Sterling L-liner
Population: 487

Problem Description: Parking brake spring fracture resulting in unintentional partial application of a wheel-end brake, potentially resulting in a fire.

FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
Complaints:	1	4	4**
Crashes/Fires:	0	0	0
Injury Incidents:	2	1	2**
Number of Injuries:	2	1	2**
Fatality Incidents:	0	0	0
Other*:	0	9	9

***Description of Other:** Warranty Claims

** Total eliminates duplicates received by ODI and manufacturer.

ACTION / SUMMARY INFORMATION

Action: This Engineering Analysis is closed.

Summary:

ODI opened a Preliminary Evaluation (PE11-007) based on one fleet report alleging it had experienced multiple wheel-end fires involving the subject vehicles. The fleet believed the fires were due to a power spring fracturing and puncturing a brake chamber diaphragm resulting in a loss of compressed air to the brakes. The loss of air was believed to cause the brakes to drag and overheat.

ODI upgraded PE11-007 to this engineering analysis to further evaluate the cause of the wheel fires and assess the scope, frequency, and safety consequences of the alleged defect.

After a comprehensive review of the data related to brake chamber failures or replacements on the subject vehicles, ODI did not identify the existence of a safety related defect trend. Of the two vehicle fires initially reported, only one was subjected to a fire investigation. The fire investigator in that case could not identify the component responsible for the vehicle fire. Driver statements reviewed from one fleet which experienced two brake overheating events indicated that the vehicles had not been operating at normal air system pressure levels prior to the events. In addition, the failed or replaced chambers had been in service on average nearly 50 months.

ODI reviewed 477 warranty claims and fleet reports of brake chamber failure or replacement. From the data review, three (3) brake overheating incidents involving a subject size 24/30 failed brake chamber were identified. In reviewing the time in service for the overheating incidents, it was found that vehicles had an average of 50 months in service. This time in service represents a typical service life wear out.

The injuries reported in the opening resume for this investigation are no longer being considered as having resulted from the alleged defect in the subject brake chambers. In the case of the smoke inhalation originally reported, the fire was not determined to have been caused by a failed brake chamber. In the case of the injuries that resulted while replacing a subject brake chamber, it was found that these chambers have a limited service life and are subject to wear out. As a result, brake chambers are replaced frequently and standard safety precautions should be followed during this maintenance procedure that would prevent any chamber being replaced from experiencing an uncontrolled release of the compressed spring.

DTNA has informed NHTSA that it will take the following action to further reduce the likelihood of subject component failures. DTNA will offer owners of subject vehicles, equipped with the original size 211/212 chambers, a free replacement of the chambers. The chambers will be replaced with the more robust 003/004 sealed chambers.

In light of the low rate of wheel end fires resulting from a premature failure of the power spring in the subject vehicles, and DTNA's actions to reduce the likelihood of a failed brake chamber, further use of agency resources does not appear to be warranted. The closing of this investigation does not constitute a finding by NHTSA that no safety-related defect exists. The agency reserves the right to take further action if warranted by the circumstances.

For additional information, see the attached closing report.

ENGINEERING ANALYSIS CLOSING REPORT

SUBJECT VEHICLES: 2007 STERLING L-LINER

EA No: 11-011 **Date Opened**: 9 September 2011 **Date Closed**: 20 June 2013

BASIS: ODI opened this investigation based on a report from a fleet alleging two vehicle fires. The fleet had a fire investigation conducted on the second fire which narrowed the origin to a single wheel-end. The fleet noticed that the Haldex 24/30 brake chamber pushrods were binding on other fleet vehicles and believed this to be the cause for the single wheel-end thermal events.

THE ALLEGED DEFECT: Parking brake spring fracture resulting in unintentional partial application of a wheel-end brake, potentially resulting in a fire.

VEHICLE POPULATION: Daimler Trucks North America (DTNA) sold a total of 14,407 Sterling L-liners equipped with Haldex brake chambers. Haldex was the standard chamber supplied by DTNA unless otherwise requested by the purchaser. Table 1 and 2 below present the production data for the subject vehicles. The subject vehicles operated by the fleet that submitted the incident report to NHTSA were configured as auto haulers.

Table 1: Subject Vehicle Production Data by Brake Chamber Size (Haldex Chambers)

Size	Population
24/30	927
30/30	13,415
30/36	3
36/36	62
Total	14,407

Table 2: 24/30 and 30/30 Haldex Brake Chambers by Option Level

Size	P/N	Description	Population
24/30	211/212	Standard	487
	003/004	Sealed	440
30/30	214/215	Standard	13,360
	312/313	Sealed	55

DESCRIPTION OF COMPONENTS: The subject component of this investigation is the air brake chamber (pictured in Figure 1.) The subject vehicles are typically equipped with a total of four (4) subject components mounted on two rear drive axles (pictured in Figure 2). The subject component converts pressurized air to linear motion in order to actuate the vehicle brakes.

The air brake chamber is a dual chamber design. One half actuates the service brake and the other applies the parking (emergency) brake. The parking brake side consists of a power spring, diaphragm, and pressure plate. Both halves utilize a common pushrod to actuate the vehicle brakes. The pressure plate is an aluminum disk used to capture one end of the power spring. At the center of the plate is a caging bolt fitting. This caging bolt is used to manually release the parking brakes in the event of total system air loss so that the vehicle may be moved. The diaphragm is made of durable rubber. It creates an airtight compartment between the push rod and pressure plate. When the diaphragm is pressurized, it expands and compresses the power spring, releasing the parking brake. In a situation when vehicle system air pressure is lost, the power spring applies the parking brake.

The subject vehicle operates at a maximum air pressure of 125 psi with a compressor cut-on pressure of 100 psi. A low air warning light and buzzer are set to alert the driver when the system air pressure drops below 60 psi. If the air pressure continues to drop, the diaphragm will contract and the power spring will apply the parking (emergency) brake. NHTSA's Vehicle Research and Test Center (VRTC) confirmed that spring brake application would begin at an air system pressure of 60 psi and that full application occurs at 25 psi.



Figure 1: Subject Component



Figure 2: Brake Chambers Installed (1 on each wheel-end)

PROBLEM EXPERIENCE:

ODI was alerted to this issue through a fleet network contact. The fleet reported multiple failures of the subject component with limited mileage and time in service. Additionally, two (2) vehicles fires were suspected to have been caused by a failure of the subject component which resulted in a dragging wheel-end.

This same fleet also experienced two (2) overheated wheel-end events during the course of the investigation. In both cases the drivers stated that they were first alerted to a problem when they heard a tire blow out. Upon immediately stopping and exiting the vehicle, the drivers detected smoke at the wheel-end, and used a fire extinguisher on the heated wheel. Both vehicles were fixed and returned to service. Each vehicle required a new tire and brake chamber.

Of the two vehicle fires initially reported only one was subjected to a fire investigation. In that case, the fire investigator could not conclusively identity the component responsible for the vehicle fire. The vehicle that was investigated had 12 months in service.

WARRANTY DATA:

The warranty data submitted by DTNA in its response to the ODI Information Request (IR) letter, dated 11 May 2011, did not give a complete account of the subject component failures. The subject component is a consumable item. Many owners did not submit warranty claims when they experienced a failure because the time and cost to do so would have been greater than their part cost. Therefore ODI sent Information Request letters to several fleets to gain a better understanding of the failure frequency. ODI received responses including replacement data from six (6) fleets.

It is important to note that fleets utilize varying strategies regarding brake chamber replacements. Strategies range from replace as needed after a failure, to replacing all chambers on the vehicle after a single chamber failure. Additionally, some fleets will replace chambers based on time or mileage without having experienced a failure.

The standard warranty coverage for the subject brake chambers is four (4) years with unlimited mileage provided by Haldex. However the warranty information submitted by DTNA was limited to one (1) year which coincides with the vehicle warranty.

Table 4 shows the claim rate by brake chamber size for the warranty data submitted by DTNA.[1]

Table 4: Failure rates based on DTNA Warranty Data

Chamber Size	Subject Vehicle Population	Claims	Rate
24/30	927	9	0.97%
30/30	13,415	106	0.79%

Further sub-categorization of the focus chambers by size and type is shown in Table 5.

Table 5: Failure rates based on DTNA warranty data, for select chambers

Chamber Size	Chamber Type	Subject Vehicle Population	Claims	Rate
24/30	211/212 (Std.)	487	9	1.85%
24/30	003/004 (Sealed)	440	0	0.00%
30/30	214/215 (Std.)	13,415	106	0.79%
30/30	312/313 (Sealed)	55	0	0.00%

Of particular interest is the difference between 211/212 and 003/004 chamber types for the 24/30 chamber size. The 211/212 chambers are standard chambers vented and open to the atmosphere. The 003/004 chambers are sealed chambers and internally vented. Sealed chambers are a premium product as they prevent corrosive elements, which accelerate power spring failure, from entering the chamber. The 214/215 chambers are also standard chambers vented to the atmosphere. As the 003/004 and 312/313 chambers are sealed and considered a premium product, ODI would expect that the failure replacement rates on these chambers would be lower.

As noted earlier, the subject component is a relatively inexpensive item that wears out over time. Many fleets did not take the time to submit warranty claims when the part needed replacing. Table 6 presents the number of chamber failures/replacements reported by the six (6) responding fleets in addition to the number of warranty claims reported by DTNA. All six of the responding fleets purchased only 24/30 chambers and therefore could only report failures on this subset.

[1] A small number of subject vehicles are equipped with 30/36 or 36/36 chambers. However, since the vast majority of subject vehicles are equipped with either 30/30 or 24/30 chambers, ODI focused on 30/30 and 24/30 chambers.

Table 6: Warranty Data Combined with Fleet Replacement Data

Chamber Size	Chamber Type	Subject Vehicle Population	Replacements	Rate
24/30	211/212 (Std.)	487	205	42%
24/30	003/004 (Sealed)	440	0	0.00%

When reviewing the warranty data for the standard 24/30 chamber with the fleet data included, it can be seen that the replacement/failure rate for the standard chamber is relatively high at 42%. ODI noticed this high rate of replacement and conducted additional analysis to determine if it was an indication that the 24/30 chambers contained a defect. This analysis is discussed later in the report. This data also supports ODI's belief that fleets do not submit chamber replacement warranty claims to the manufacture and instead cover the cost on their own.

In order to determine if the subject auto hauler vehicle configuration was associated with the replacement/failure rate of the subject brake chambers, ODI collected and analyzed warranty and replacement data for Freightliner trucks equipped with the same 211/212 Haldex brake chambers. The peer Freightliner trucks were not configured as auto haulers. Component replacement information gathered from the responding fleets combined with DTNA warranty data for the subject and peer vehicles are shown in Table 7.

Table 7: Subject Vehicles vs. Peer Vehicles: 211/212 Chambers

Chamber Size/Type	Vehicle	Vehicle Population	Replacements	Rate
24/30 – 211/212	Sterling (auto hauler)	487	205	42%
24/30 – 211/212	Freightliner	349	156	44%

The data in Table 7 shows that the auto hauler configuration does not appear to have an impact on the replacement/failure rate of the 24/30 chambers. The data identifies a high chamber replacement rate for both the subject and peer vehicles. As mentioned earlier, ODI conducted additional analysis to determine if the high replacement rate represented a potential safety defect and is discussed later in the report in the ODI Analysis section.

ODI also requested and reviewed failure data on a peer brake chambers installed on DTNA vehicles. DTNA manufactured some subject vehicles with peer brake chambers when they were specified by the buyer. Table 8 presents warranty claim data for DTNA vehicles equipped with peer and Haldex 24/30 chambers.

Table 8: DTNA Warranty Data for Subject Haldex Chambers vs. Peer 24/30 Chambers

Chamber Brand	Chamber Type	Vehicle Population	Claims	Rate
Haldex	Std.	487	9	1.85%
Haldex	Sealed	440	0	0.00%
Peer	Std.	55	0	0.00%
Peer	Sealed	462	0	0.00%

TESTING:

At the request of ODI, the Vehicle Research and Test Center (VRTC) conducted testing of the subject brake chambers. In addition to the tests listed below, two independent laboratories were contracted to provide additional expertise on materials analysis.

1) Inspection and function tests of twelve (12) subject components collected from the field;

2) Diaphragm durability testing;

3) Chemical analysis of brake chamber internal debris;

4) Effects on the power spring while driving and loading/unloading cargo;

5) Under-vehicle air/smoke turbulence analysis;

6) Single wheel-end brake drag detectability;

7) Effects of a system air leak;

8) Material analysis of failed power springs.

Testing was also conducted by Interteck APTECH who provided a material analysis of the power spring failure. They concluded that the power springs failed due to torsional fatigue. The paint had de-bonded from the spring surface in several areas. Coil clash caused mechanical abrasion to remove paint, exposing the bare metal to the environment, leading to pitting corrosion. The pits on the outer diameter acted as stress concentrators and initiation points for a torsional fatigue and ultimate failure of the power spring. This finding was supported by the analysis of the debris found in the chambers of failed power springs by VRTC.

Torsional fatigue is a normal failure mode for a coil spring. However coil clash is also known to damage anti-corrosion coatings. VRTC and Interteck conducted spring compression testing on the intact spring and determined that the spring coils do indeed clash during normal intended operation of the spring. The contact occurs both between the coils of the springs and with the housing end wall and pressure plate of the brake chamber.

For testing details see the complete VRTC and Interteck final reports located in the public file for this investigation at www.SaferCar.gov.

FAILURE MODE:

The failure mode of the power springs inspected by Intertek APTECH was torsional fatigue. This type of fatigue is a common cause of coil spring failure.

WARNING SYMPTOMS:

If the diaphragm is ruptured as a result of a fractured spring puncturing it, an audible air leak would likely exist outside the driver cab. A professional driver should also notice the air compressor cycling more frequently and/or the vehicle not maintaining maximum air pressure. However, if the exact

component or location of the air leak cannot be determined, the vehicle is allowed to proceed per the North American Out of Service Criteria if it passes the Air Loss Rate Test.

DTNA'S EVALUATION OF THE ALLEDGED DEFECT:

DTNA stated the following: "Daimler Trucks North America has found no evidence indicating a defect exists in the subject component on the subject vehicles. The subject component is a consumable commodity with varying serviceable life depending on duty cycle, service environment, and vehicle maintenance. The defect alleged in ODI's opening resume is a typical progressive failure which can normally occur at the end of the subject component's service life regardless of the manufacturer of this commodity. The failure begins with a fatigue fracture of the power spring, potentially accelerated by corrosion, which may lead to abrasion of the diaphragm. If the diaphragm abrades, an air leak may develop and gradually increase over time. If the operator fails to heed the warning signs, and neglects his/her duties by continuing to operate the vehicle with insufficient air pressure, the leak can result in brake drag and overheating of the wheel-end. Continued operation with an unacceptable air leak and brake drag may result in overheating of the wheel-end.

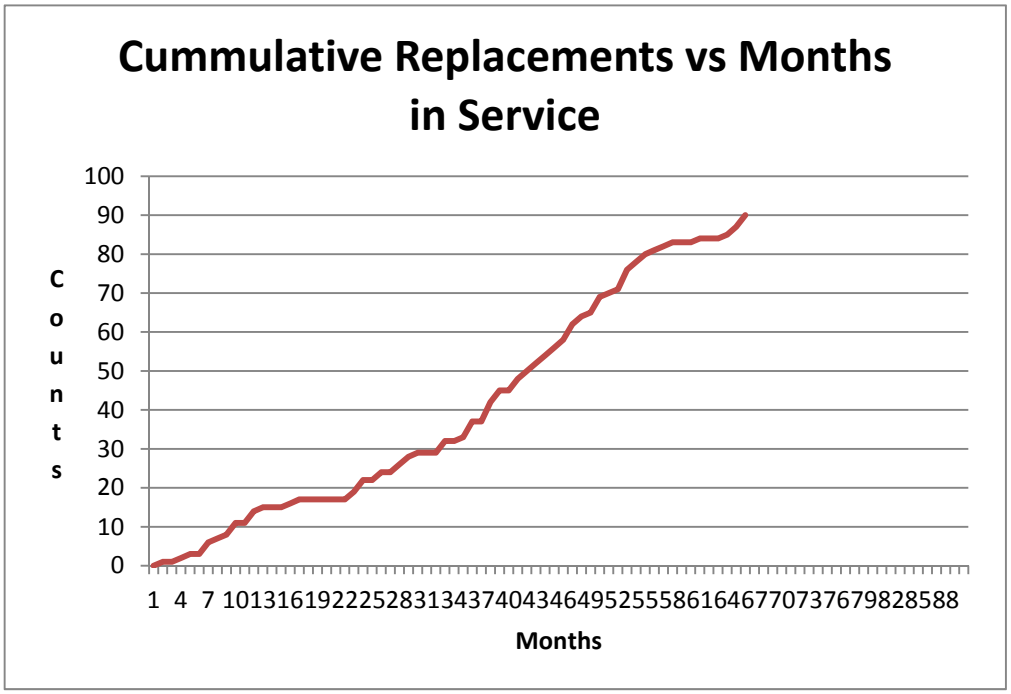
The vehicle operator receives a series of warnings as this failure progresses, and has ample opportunity to take the unit out of service prior to wheel-end overheating. During his/her periodic check of the vehicles air pressure gauge, as instructed by both the vehicle operators manual and many CDL handbooks, the first indication the operator will have is an air loss of more than the three psi per minute specified in CDL handbooks. Over time, as the failure progresses, and the leak rate increases to well over the three psi per minute allowable, the air gauge will continually sweep between approximately 100 and 135 psi. Eventually, if the driver continues to operate the vehicle in this unsafe condition, and the rate of the air leak grows, the air gauge stops sweeping as maximum air pressure can no longer be obtained. Finally, after the operator has ignored all warnings, the leak rate reaches a point where the air compressor can no longer maintain the minimum required pressure of 100 psi, and the brakes may begin to drag.

Of the 14,407 subject vehicle, 99 reported 125 claims for the subject component within the vehicles' warranty period, while no subject component failures were reported on the remaining 14, 308 subject vehicles. Complaints and reports of property damage and overheated wheel-ends allegedly related to the subject component are isolated to one customer. This customer indicated they experience similar failure with spring brake chambers supplied by other manufacturers. During a visit to this customer it was observed that the customer installed body on these vehicles made the rear brake chambers more susceptible to road spray than other vehicles utilizing the subject component, and that the tethered dust plugs intended to prevent road spray and corrosive material from entering the chambers were not always put in place.

Daimler Trucks North America believes the observed failures of the subject component are typical end of life failures for this commodity, and that the low failure rate and lack of complaints for the subject component, a consumable commodity which is not expected or intended to last the life of the vehicle, indicate a defect does not exist in the subject component."

ODI ANALYSIS:

ODI reviewed information related to the two vehicle fires suspected to have been caused by a failure of the subject brake chamber. In both cases, the brake chambers could not be identified as the cause of the fire. ODI also reviewed 477 warranty claims and fleet reports of brake chamber failure or replacement. From the warranty data review, three (3) brake overheating incidents involving a subject 24/30 failed brake chamber were identified. In reviewing the time in service for the overheating incidents, it was found that vehicles had an average of 50 months in service. This time in service represents a typical service life wear out.



Graph 1.

Graph 1 shows the cumulative replacement of standard 211/212 chambers on subject Sterling vehicles over time. The data includes both DTNA and fleet reports and represents what appears to be a normal wear out service life.

The warranty data presented in tables 4 and 5 do not provide a comprehensive summary of the failure rate for the subject brake chambers because they include only DTNA warranty claims and many fleets do not file warranty claims for brake chamber replacements. Table 6 shows that the standard 211/212 fails or is replaced more often than the sealed 003/004 chamber. This difference in failure rate is to be expected as the sealed chamber is more expensive and designed to last longer and be more durable than the standard chamber. With regard to the elevated rate presented in Table 6, ODI feels that the high rate is the result of the subject vehicles having been in service for a long period of time and the subject components are wear out items that are being replaced as expected. Table 7 presents chamber failure/replacement data for the subject brake chamber on two different model vehicles. In this case, the data suggest that the chamber failures are not unique to the auto hauler configuration and in fact the non-auto hauler configured vehicles show a similar wear out service life as the auto haulers. The data represented by Table 8 compares the closest peer chamber to the subject chamber. The warranty

and replacement data collected on events that did not involve fire or overheating showed that the average time in service for the chambers at the time they were replaced was 40 months. This includes chambers that may not have failed but were replaced as a result of the fleet replacement strategies mentioned earlier.

Through analysis, component testing, and fleet interviews ODI found that in the case of the 2 fire incidents, the chambers could not be identified as the cause of the fires and in the case of the 3 brake overheating events, the vehicle brake chambers were at or near the end of their expected service life. An analysis of the warranty / replacement data also shows that the chambers are failing or wearing out at their expected service life. Additionally, various company replacement and warranty claim policies concealed or inflated failure rates. Some fleets adopted various replacement policies ranging from replace as needed to replace all chambers on the vehicle when just one failed. Brake chamber failures are typically discovered when there is an air leak.

Although testing conducted on the subject brake chamber power spring showed that coil clash can occur and caused the failure of some springs, these failures have been found to occur at or after their expected life. Only 5 potential fire or overheating incidents have been identified representing a 1% failure rate over 5 service years while approximately 205 or 42% were replaced as wear-out items as expected and without an overheating or fire incident.

REASON FOR CLOSING:

After a comprehensive review of the data related to brake chamber failures or replacements on the subject vehicles, ODI has not identified the existence of a safety related defect trend. Of the two vehicle fires initially reported, only one was subjected to a fire investigation. The fire investigator in that case could not identify the component responsible for the vehicle fire. Driver statements reviewed from one fleet which experienced two of the brake overheating events indicated that the vehicles had not been operating at normal air system pressure levels prior to the events. In addition, the failed or replaced chambers had been in service on average nearly 50 months.

DTNA has informed NHTSA that it will take the following action to further reduce the likelihood of subject component failures. DTNA will offer owners of subject vehicles, equipped with the original 211/212 chambers, a free replacement of the chambers. The chambers will be replaced with the more robust 003/004 sealed chambers.

Accordingly, this investigation is closed. The closing of this investigation does not constitute a finding by NHTSA that a safety-related defect does not exist. The agency will continue to monitor complaints and other information relating to the alleged defect in the subject vehicles and take further action in the future if warranted.