U.S. Department of Transportation

National Highway Traffic Safety Administration

ODI RESUME

OFFICE OF DEFECTS INVESTIGATION

NHTSA

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Investigation: EA 09-009
Prompted by: PE-08-058 (COMPONENT SUPPLIERS)
Date Opened: 06/18/2009 **Date Closed:** 08/13/2010
Investigator: Tom Bowman **Reviewer:** Bruce York-B
Approver: Richard Boyd
Subject: AIR BRAKE SYSTEM CONTROL VALVES

MANUFACTURER & PRODUCT INFORMATION

Manufacturer: MACK TRUCKS, INC
Products: MY 2005-2009 MACK CTP, CV, CNX,CXU,GU,LE,MR
Population: 1,000

Problem Description: DIMINISHED VEHICLE BRAKING / EXTENDED STOPPING DISTANCE

FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
Complaints:	0	3	0
Crashes/Fires:	0	0	0
Injury Incidents:	0	0	0
Fatality Incidents:	0	0	0

ACTION / SUMMARY INFORMATION

Action: CLOSE THIS ENGINEERING ANALYSIS.

Summary:

INVESTIGATION HAS NOT IDENTIFIED A DEFECT. COMPLAINTS HAVE ABATED. SEE CLOSING REPORT FOR FURTHER DETAILS.

Closing Report – EA09-009

Air-Actuated Rear Brake Control Valves Manufactured by
Haldex Brake Products Corporation,
Distributed by Meritor WABCO Vehicle Control Systems,
And installed in
Vehicles Manufactured by Mack Trucks, Inc.

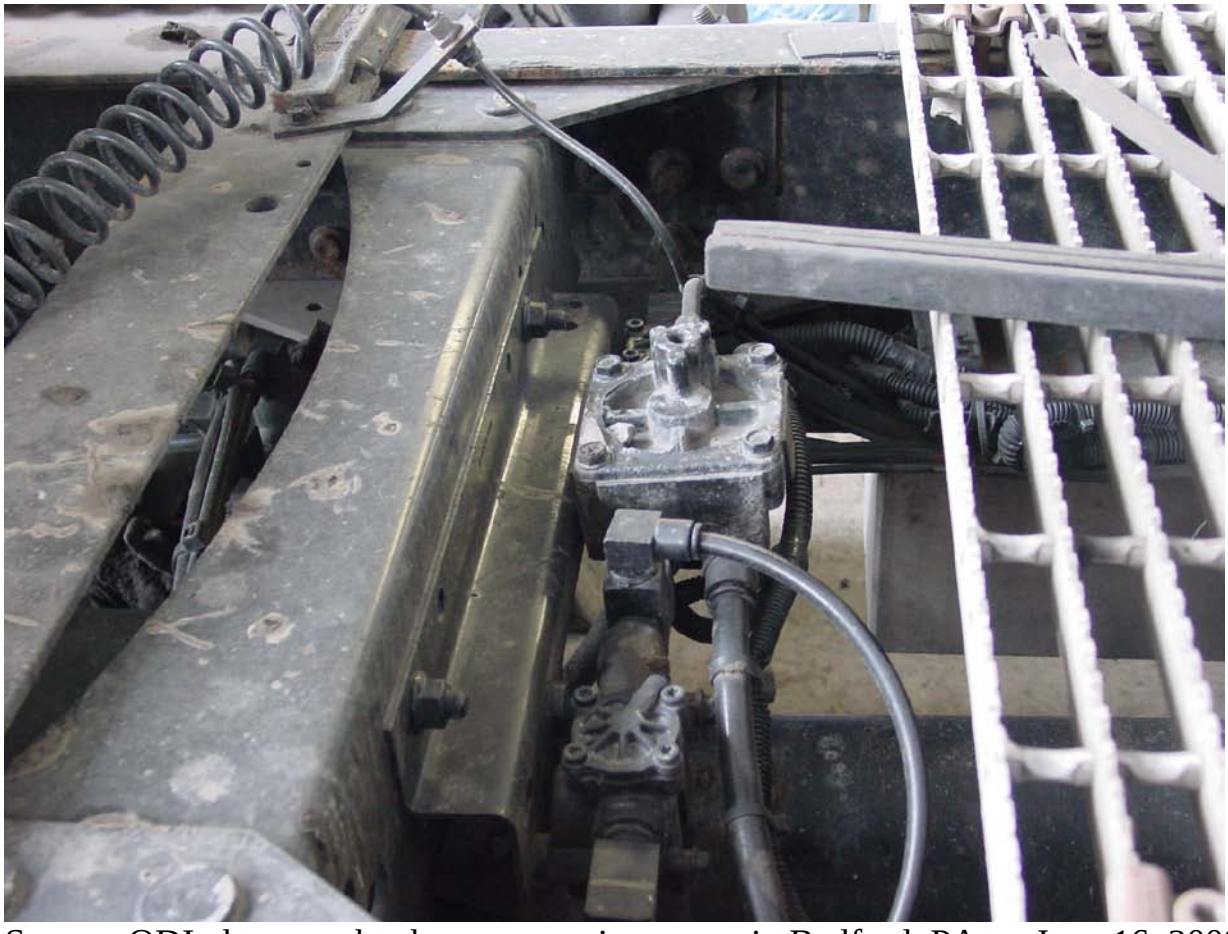
CONTENTS

(1) Subject Components -

This report summarizes the Office of Defects Investigation's (ODI's) investigation of air-actuated rear brake control valves manufactured by Haldex, distributed by Meritor WABCO, and purchased and installed in certain vehicles manufactured by Mack Trucks, Inc.

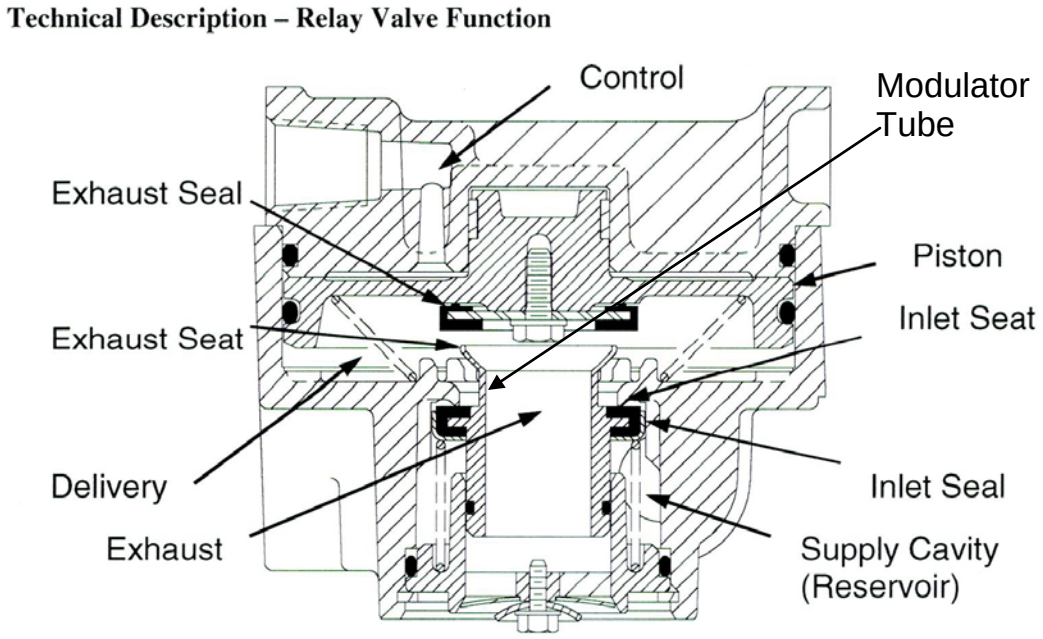
Photograph 1 (below) depicts a representative rear brake control valve mounted on the cross-member of a 2004 model year Mack model CXN 613 tractor.

Photograph 1 – Rear brake control valve as installed on Mack CXN613 tractor frame cross-member.



Source: ODI photograph taken at a service center in Bedford, PA on June 16, 2009.

Engineering Assembly Drawing No. 1 below depicts a cross section view of a representative control valve.



Engineering Assembly Drawing No.1 - Source: Attachment D, Meritor WABCO response to ODI's request for Information, dated November 21, 2008.

According to Meritor WABCO [The following description was provided as part of the Attachment D information cited under the Engineering Assembly Drawing No. 1 depicted above.], "Service relay valves receive a pneumatic control signal from the vehicle foot pedal valve. The valve is used to speed up the application and release of the primary circuit service brakes which are typically the rear brakes on trucks, tractors and buses. [Pressurized] Control air on top of the piston forces the piston down until the exhaust seal engages [contacts] the exhaust seat and closes the exhaust passage. Further travel will cause the inlet seal to separate [unseat] from the inlet seat and allow supply air to pass into the delivery cavity and to the brake chambers.

When the exhaust seal or inlet seal is degraded, "the opening of the inlet seal may be reduced. The reduced valve travel may restrict the rate at which air passes through the inlet opening" [resulting in slower application of the affected brakes].

(2) Failure Mode -

In the present investigation, evidence from field returned valves generally indicate a softening and/or cutting of the exhaust valve set as depicted in Photograph 2 (below).

Photograph 2 – Example of a severely (not intended to indicate representative or typical) damaged (softened and cut) exhaust seal. The black probe indicates a circumferential cut on the face of the exhaust port seal.

Source: Excerpt from Meritor WABCO Briefing Information --- December, 2009. The depicted seal had been removed from a vehicle inspected during the field visit conducted August 5- 8, 2009

(3) Characteristics and Issues -

Inspections of components collected during fieldwork that were conducted at Meritor WABCO during the course of this investigation detected evidence of n-Butyl Benzene Sulfonamide (BBSA) on the surfaces of the affected field-returned

air valve seals. BBSA is a “plasticizer” that is used to “soften” elastomeric materials.

BBSA does not constitute any portion of the chemical make-up of the internal seals nor any other element of the control valve. This suggests that the BBSA has been transferred onto the seals from another upstream source. A significant amount of investigation activity among the various affected manufacturers has been to determine the source of the BBSA and assess its effect.

While considerations have been given to engine oils and additives, biodiesel fuels (B5, B10, etc.), and upstream components of the air system, evidence indicates that the plastic (nylon) air brake lines are the most likely source of the transferred BBSA. The nylon air lines (manufactured by Eaton) require a plasticizer (softener) so that the otherwise rigid tubing is flexible for handling and installation. According to the brake line supplier and supported by laboratory data, brake line tubing gradually loses BBSA over time and the rate of loss is accelerated by exposure to higher temperatures. Once the brake lines have been installed and anchored at the appropriate positions in the vehicle, there is little need for the air line to retain its flexibility characteristics and the loss of BBSA is of little significance to the integrity and/or function of the air line. However, it appears that BBSA that has been displaced from the inside surface of the brake tubing may be transferred downstream and deposited on downstream brake components such as the subject air control valve seals. (Though inconsequential to this investigation, BBSA is also released from the brake tubing to atmosphere from the outside surface of the brake tubing.)

According to the manufacturer of the brake tubing, the composition of the brake line tubing has remained relatively unchanged for years. Similarly, Haldex, the manufacturer of the control valve, maintains that the composition of the affected control valve seals has also remained relatively unchanged for years.

In light of these findings/ positions, investigation focused on the whether there have been any significant changes in the air brake system and/ or vehicle environment and/or duty cycle that might be casual or contributory factors. This area of the investigation has tentatively concluded that vehicle demand for compressed air are likely higher suggesting that compressor run cycles (volume and temperatures) are likely higher than in the past --- and that lubricants, fuels and their additives have also evolved creating many difficult to assess contributing factors and combinations of factors.

Air valves are “wear-out” components which are likely to require replacement as a normal maintenance requirement after some period of field use. The affected manufacturers have generally estimated that an air control valve replacement is would be expected to require replacement after “5 years.”

> [ODI note: ODI interprets this estimate as meaning that owners are not particularly surprised to replace a valve at or around the 5-year of service. It is unlikely that this estimate indicates that all or even half of the population might require replacement. Hence the rough estimate of a “5-year service life” may logically be construed as somewhere in the B5 to B10 failure rate range (i.e. a 5-10% failure rate at 5 years of service).]

Based on discussions with manufacturers and fleet maintenance personnel, ODI conjectures that worn valves and valve seals (and other components in the vehicle air brake system) are most frequently detected by audible air leaks. In most cases, the wear and associated air loss leak are likely initially imperceptible but gradually worsen with exposure during which time the audible indication of the air leak becomes more and more obvious.

Since the compressor is continually providing the vehicle air system with pressurized air during its “run” cycle, modest air losses are unlikely to pose a significant degradation in brake performance before detection and replacement of the leaking air systems components.

(4) Chronology -

This investigation has consisted of several joint meetings and field and laboratory inspections. A summary of the major activities is listed below in Table 1.

ODI participated in a series of 25 conference calls conducted among the various manufacturers between July 6, 2009, (Initial investigation coordination / planning meeting held in Troy, MI) and August, 2010 (ODI closing of EA09-009). These conference calls addressed numerous technically complex issues by means of investigation assignments, some of which were by supported by manufacturers such as Bendix (treadle and parking brake control valves) and Eaton (brake line tubing) who provided voluntary assistance though their products were not the primary focus of investigation inquiries. This series of investigation conference calls resulted in

59 completed tasks / sub-tasks. Approximately 30 tasks / sub-tasks are suspended, remain in-process, or are being monitored.

Table 1 – Summary of Principle Investigation Activity Milestones

Date	Location	Event
June 16, 2009	Bedford, PA	Inspect complaint vehicle; remove vale for lab inspection
June 18, 2009	---	EA09-009 opened – preceded by PE09-009 and PE08-058. EA09-009 was based 3 complaints and that reported / implied degradation in vehicle braking. The 35 warranty claims cited, as typical of warranty claim information, provides limited, obscure and/or incomplete technical information.
July 6, 2009	Troy, Michigan	Reviewed field performance status; orientation to inspection lab capabilities and evaluation procedures; planned field inspection program e.g. site selections, methods [inspections and component removal was conducted in August followed by the inspection and analysis of the returned parts by each of their respective suppliers.
August 5-8, 2009	Philadelphia & Reading, PA – Mack fleet visits	Inspect and remove pertinent components from selected air brake systems in candidate vehicles. Removed oil samples and components were returned to their respective suppliers for analysis and findings report. Reports were consolidated and summarized in a December 17, 2009 review.
December 17, 2009	ODI Offices, Washington	Mack – Meritor WABCO review of the consolidated field investigation findings
March 2, 2010	---	Mack provides an updated complaint summary

(5) Manufacturers' Actions -

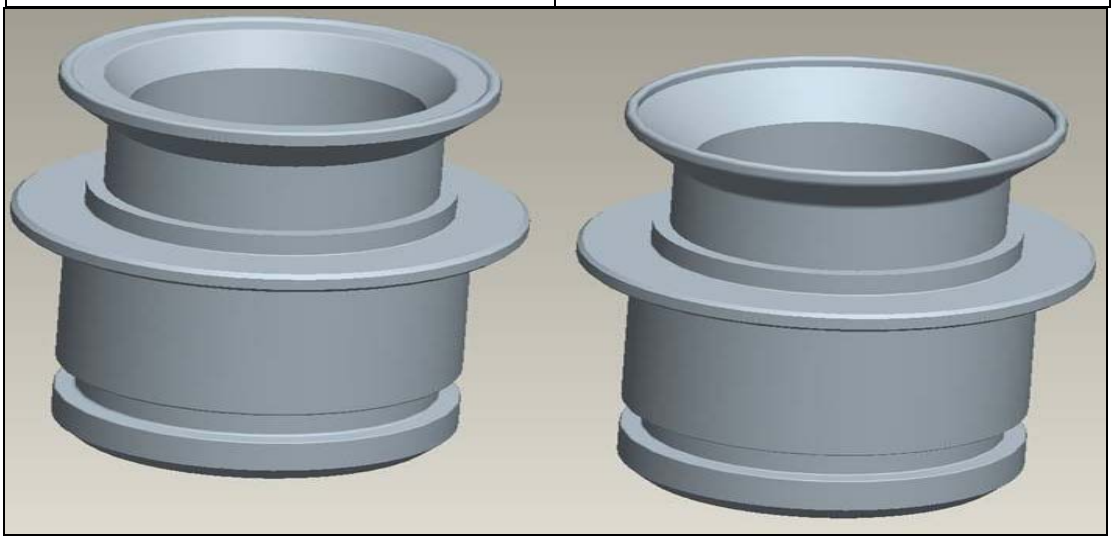
In addition to leading the joint investigation activities, during the course of this investigation the affected manufacturers have taken various actions to improve the

operating environment and/or the robustness of the control valve. Following is a summary of the significant actions these manufacturers have taken.

Design Change – Control Valve Modulator Tube

In January 2009, Haldex / Meritor WABCO changed the profile of the circumferential lip of the exhaust seal seat face of the modulator tube. This change reduces the risk of the modulator valve seat deforming and/or cutting the surface of exhaust seal face (when actuated) by distributing the actuation forces over a larger contact area.

Current Design (since January, 2009)	Former Design (prior to January, 2009)
The current modulator tube is designed with a wide "upper" (as shown in the orientation of the photograph) contact face below to reduce the contact pressures and deflections on the rubber face of the mating exhaust valve seal thereby reducing the risk of premature deformation and/or cuts in the seal face.	The former modulator tube is designed with a narrow "upper" (as shown in the orientation of the photograph) contact face which could impose increased contact pressures and deflections in the rubber face of the mating exhaust valve seal facilitating premature deformation and/or cuts on the seal face.



Source: Meritor WABCO Review at ODI December 17, 2009.

Introduction and Availability of Coalescent Air Dryer Filter Cartridges

"Standard" vehicle air dryers are equipped with cartridges that are partially filled with desiccant beads intended to filter and dry the compressed air that passes through the air dryer filter. Coalescent air filters provide an additional (improved) filtration element intended to collect "aerosols" suspended in the compressed system air. "Aerosols" are small airborne oil droplets which are created when small quantities of engine or air compressor lubricating oil pass through the air compressor and are atomized into the vehicle compressed air system flow. "Aerosols" that are not filtered (removed) from the vehicle system air can be deposited on downstream air system components and adversely affect the durability and/or the performance of these components.

On September 16, 2009, Mack Trucks issued Technical Service Bulletin PSM2009-261, announcing that Mack Trucks was introducing coalescent air dryer filters as standard equipment on their (new) vehicles. (See Appendix A.)

On December 1, 2009, Meritor WABCO announced the availability of desiccant air dryer cartridges that incorporate a coalescing filter which are "backward compatible" meaning they are interchangeable replacements for earlier model air dryers. This product offering provides owners of older vehicles the opportunity to upgrade the serviceable-by-replacement air dryer filters installed in their vehicles. (See Appendix B.)

Alternative Seal Materials Evaluation

Haldex / Meritor have manufactured a limited quantity of (prototype) valves that incorporate exhaust and inlet seals made of materials more resistant to degradation when exposed to BBSA than the currently-specified seal materials. Since there may be trade-offs with other aspects of the materials performance, these companies are selectively deploying these prototypes incorporating the alternative (improved) seal materials into vehicles for evaluation in actual vehicle environments.

(6) Investigation Activities and Findings -

Safety Assessment Statistics -

ODI's analysis of warranty data submitted by Mack in response to ODI's information request under PE09-010 proved to be inconclusive. The warranty claim data encompassed a wide array of parameters[1] but they lacked technical specificity needed to develop reliable conclusions.

To further its investigation, in a letter dated April 10, 2009 (under PE09-010 and extended into the current investigation, EA09-009), ODI requested Mack to advise ODI of incidents pertaining to diminished vehicle brake performance promptly after they were reported to Mack. This would allow ODI to inspect and evaluate complaint vehicles prior to repair and to enable ODI to retrieve the suspect components for inspection, testing or other purposes before the parts are lost or discarded.

Between April 10, 2009 and August 2009, Mack reported to ODI the following three "freshly-reported" incidents.

VIN	Vehicle Location	Model	Date of Vehicle Manufacture	Date in Service	Date Reported	Time in service (yrs)	Vehicle Mileage
1M2AG11C56MXXXXXX	Texas	CV713	12/9/05	7/6/06	4/23/09	2.80	107,786
1M1AK06YX6NXXXXXX	Bedford, PA	CXN613	4/1/05	7/1/05	6/15/09	3.96	348,000
?	New Jersey	?	?	?	8/5/09	?	?

[1] The warranty data variables included parameters such as vehicle manufacturer (information inquiries were sent to numerous manufacturers under PE08-058), vehicle models (indicative of vocation), model years, engine types, engine models, compressor types, compressor manufacturers, and air dryer manufacturers, models, and vintages, treadle valve manufacturers, models, and vintages, vehicle mileages, duty cycles, air system maintenance practices, etc.

The control valve removed from the Texas complaint vehicle (1st report listed) was retrieved and subsequently inspected. ODI visited the Bedford vehicle (2nd report listed) on June 16, 2009 with Mack personnel; valves were removed and returned for examination. The information regarding the New Jersey vehicle (3rd report listed) lacked actionable information and was not pursued.

ODI—along with representatives from Mack, Meritor WABCO and Haldex—conducted site visits to inspect complaint vehicles reported by Mack in its PE09-010 IR response. During the site visits, ODI performed a comprehensive inspection of the vehicle brake systems including brake timing and adjustment, inspected vehicles' service records, and removed various vehicle components, typically including the control valve, air dryer and filter, treadle valve, parking brake control valve, portions (sections) of the brake tubing, and samples of engine oil and samples of oil contamination found deposited in various parts of the air system, for later laboratory tests.

From the information obtained during the site visit, ODI reached the interim conclusion that contamination was evident in the air system--including contamination of the control valves--and that internal seals of the control valve had been softened. However, the valve function, including actuation timing, appeared to be within the expected range for used, similarly aged valves.

Vehicle Brake System Air Leaks -

Vehicle brake system air leaks typically become an issue when (1) there is a significant rate of air loss (a greater rate of air loss than the on-board air compressor can replenish)(*); and/or (2) there is no apparent audible indication that would prompt a driver or mechanic to investigate, identify and correct the leak.

(*) Section 5.1.5 of FMVSS No. 121; Air brake systems requires all air braked vehicle sold in the United States to be equipped with a low pressure warning system intended to alert the operator is the air pressure in the service reservior is less than 60 psi. (49 CFR § 121 S5.1.5.) In ODI's experience, even at this low pressure condition, the vehicle (if fully charged prior to the leak) should retain sufficient compressed air in the brake reservoir(s) to provide an adequate volume of pressurized air to make several vehicle stops without a need for air replenishment. [(ODI Note: The exact number of these "emergency" stop

capability varies depending on several factors, including, among others, vehicle brake system and adjustment, vehicle condition and loading, operating grade, pedal stroke application and duration.]

Comparison to Federal Safety Standard Requirements –

Meritor WABCO labs inspected and tested all of the valves returned from field service during and pursuant to this investigation; all valves were found to conform to the brake actuation timing requirement of FMVSS No. 121; Air brake systems. (49 CFR § 121 S.5.3.3.1(a).) Each valves exhibited an actuation time within the range of approximately 0.11- to 0.25 seconds—under the maximum allowable actuation time of 0.45 seconds under the standard. In short, the suspect field units tested in the "used" condition under laboratory condition conformed to the minimum timing requirements applicable to new vehicle brake systems as required by federal motor vehicle safety standards.

On April 10, 2009 (request letter issued under PE09-010 and extended into the current investigation, EA09-009), ODI requested Mack to advise ODI of all newly-reported incidents pertaining to diminished vehicle brake performance. The purpose of obtaining immediate (timely) information is to provide ODI with the opportunity to inspect and/or evaluate complaint vehicles in the reported condition prior to repair and to enable ODI to retrieve the suspect components for inspection, testing or other purposes before the parts are lost or discarded.

(7) ODI Findings and Assessments -

ODI is closing this investigation for the following reasons

(1) There have been few new reported complaints since this investigation was initiated in June, 2009 (14 months).

This investigation was initiated in response to (a) the affected manufacturers alerting ODI of their concern that regarding the reported brake complaints coupled with (b) the initial review of complaint and warranty claims indicating concern that heavy vehicle braking might have been, or could be, compromised(*). To date, these concerns have not materialized.

(*) In the majority of instances in which the control valve and/or rear brakes are not fully responsive, it is likely that the vehicle operator will compensate for the corresponding reduction in vehicle braking performance by instinctively applying additional brake pedal force until the vehicle slows and/or stops in a manner that is consistent with the vehicle operator's needs or expectations. In these cases, the effect of a modest component degradation on overall vehicle stopping distance would be negligible.

In a small number of driving situations, the operator may require maximum or close-to-maximum slowing or stopping performance. Such situations might occur when there is a high likelihood of an imminent vehicle crash.

Under slowing or stopping conditions requiring a maximum or close-to-maximum brake application, the operator of a vehicle equipped with one or more degraded vehicle braking system components might be unable to provide any additional compensating actuation air to the slower responding brakes valves and/or brakes which could result in an increase in the vehicle stopping distance.

(2) This investigation has substantiated the opinion expressed by Meritor WABCO and Haldex in the pre- and early stages of this investigation that BBSA may be found on downstream brake component s and that the nylon brake tubing material is most likely source of this contaminant. Eaton, the manufacturer of the nylon brake tubing for Mack vehicles, has confirmed that nylon tubing will "shed" BBSA and that exposure (time) and temperature accelerate the rate at which this material is lost from the brake tubing. The loss of BBSA will cause the tubing to become less flexible, but this is of little concern since there is no need for the tube to be pliant once the tubing has been installed in a fixed location on the vehicle. Since nylon tubing has been installed as brake tubing for many years (estimated at 30 years) without significant changes to the material, the presence of BBSA has likely been a factor in the air brake system environment for a significant period of time. Whether the effects of BBSA were not previously known, whether valves were replaced due to other interceding failure mechanisms, or whether the application, use and/or operating environment has changed remain unanswered questions.

(3) The air control valves and air system valves in general are subject to wear and require eventual replacement. During discussions with manufacturers during the course of this investigation, the manufacturers have opined that replacing an air control valve after 5 years of service (for whatever reason) is not unusual. It appears from the reported complaints, that the presence of BBSA has effected a modest to marginal reduction in the affected valve's normal wear-out life expectancy.

Of greater concern is that a handful of owner complaints indicated that the vehicle operator had detected and reported a concern about the vehicle braking system based on their perception that the vehicle was exhibiting diminished braking response rather than being alerted by an evident, audible air leak which would indicate a need to service the vehicle air system. This suggests that a deteriorating air control valve may not be detected promptly in all cases.

Less-than-ideal attention to air system maintenance is a further contributing factor to reduced service life and a complication to this investigation. Inspected vehicle air dryers evidenced oil contamination at or exceeding acceptable limits indicating the filters were generally past due for replacement. Whether a desiccant filter or a coalescing filter air dryer is, or will be, effective at reducing BBSA is not clear.

(4) “Degraded” valves that were tested conform to Federal Safety Standards applicable to air actuated brake systems installed in new vehicles.

(5) To date, there is scant data indicating that there is an unreasonable risk to motor vehicle safety. There have been no reported crashes, fatalities, injuries, or “close-call” incidents associated with the air control valve in the Mack vehicles.

(6) Recent investigation progress has been slowing. Further, the investigation issue appears to be more related to a long-term assessment and response to evolutionary changes in the product environment rather than indicative of an overt product defect.

(8) ODI Recommendations -

Given the forgoing assessment, ODI recommends closing this investigation.

Appendix A –
Mack Trucks Bulletin PSM2009-261

PARTS Sales and Marketing

To:	Parts Managers	**Bulletin:**	PSM2009-261
		Issue Date:	September 16, 2009
From:	Dan Bambrick Product Marketing Manager Phone: (336) 393-3719 e-mail: dan.bambrick@volvo.com		
Subject:	**Coalescent Air Dryers and Cartridges**		

Mack GENUINE PARTS

Coalescent air dryers were introduced as standard equipment on all Mack® Trucks just about a year ago. These specially-designed dryers contain coalescing filter media that provides additional filtration for the air brake system, resulting in cleaner, dryer air.

Coalescent filter cartridges are engineered to trap and collect the finest of oil droplets, called aerosols, and remove more moisture and contaminants than standard air dryer cartridges. What's best is that these cartridges are backwards compatible with standard style dryers and should be used any time your air brake system dryer requires a cartridge replacement.

We recommend using Coalescent Air Dryers and Cartridges on every Mack® Truck or any other heavy-duty vehicle.

Below is a list of components currently available from two major suppliers (Bendix and Meritor WABCO) either from your Mack PDC or via our vendor direct ship program.

Coalescent Dryers		Model Number	Coalescent Cartridges	
PDC Part #	VDSP #		PDC Part #	VDSP #
21255206	8235-S4324210480	Meritor WABCO SS1200P w/turbo cut-off valve	85110799	8235-R950068
20935355	8235-S4324210330	Meritor WABCO SS1200UP	85110799	8235-R950068
21255207	8235-S4324210540	Meritor WABCO SS1800P w/turbo cut-off valve	85115361	8235-R950069
21255208	8235-S4324210520	Meritor WABCO SS1800UP	85115361	8235-R950069
21255209	8235-S4324310280	Meritor WABCO SS1200P Twin	85110799	8235-R950068
21245706	745-K028157	Bendix AD-IP w/turbo cut-off valve	85115876	745-5020369
21245716	745-K028798	Bendix AD-9 w/turbo cut-off valve	85115878	745-K028830

For questions on this or any other program, please contact your district parts manager or the product manager noted above.

Appendix B –
Meritor WABCO Product Information Letter # 512

PRODUCT INFORMATION LETTER

Meritor WABCO
Vehicle Control Systems
2135 West Maple Road
Troy, MI 48084-7121

MERITOR WABCO

PRODUCT INFORMATION LETTER #512

DATE: **December 1, 2009**

SUBJECT: **Air Dryers with Coalescing Cartridges**

MODELS: **All Meritor WABCO System Saver Air Dryers**

Meritor WABCO System Saver Air Dryers are now available with desiccant cartridges that incorporate a coalescing filter. Coalescing filter technology is proven to increase filter efficiency which results in cleaner, drier air in the air brake and auxiliary systems.

Volvo and Mack Trucks made air dryers with the coalescing filter/cartridge standard equipment in 2008 and are encouraging fleets to use the coalescing cartridge when servicing all Volvo and Mack Truck vehicles regardless of age.

The coaelescing filter traps and collects small diameter oil droplets (aerosols) present in the vehicle's air system and forms them into a more compact liquid, which optimizes their separation from the circulating air. While non-coalescing filters provide satisfactory performance; they cannot provide the level of efficiency of a coalescing filter which results in oil and other containments entering the desiccant bed leading to lower dryer performance and service life.

The Meritor WABCO coalescing cartridges are backwards compatible with pre-2008 System Saver 1200 and 1800 air dryer housings. Meritor WABCO along with VTNA recommend using Coalescing Air Dryers and Cartridges on every Volvo/Mack Truck or any other heavy-duty vehicle.

The following is a list of available Meritor WABCO air dryers with coalescing cartridges.

Volvo Trucks

Coalescing Dryers		Model	Coalescing Cartridges	
PDC Part #	VDSP #		PDC Part #	VDSP #
21255206	TDAS4324210480	Meritor WABCO SS1200P w/turbo cut-off valve	85110799	TDAR950068
20935355	TDAS4324210330	Meritor WABCO SS1200UP	85110799	TDAR950068
21255207	TDAS4324210540	Meritor WABCO SS1800P w/turbo cut-off valve	85115361	TDAR950069
21255208	TDAS4324210520	Meritor WABCO SS1800UP	85115361	TDAR950069
21255209	TDAS4324310280	Meritor WABCO SS1200P Twin	85110799	TDAR950068

Paul Johnston
Sr. Director Compression and Braking
Compression and Braking

PRODUCT INFORMATION LETTER

PRODUCT INFORMATION LETTER

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