U.S. Department of Transportation

National Highway Traffic Safety Administration

ODI RESUME

OFFICE OF DEFECTS INVESTIGATION

NHTSA

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Investigation: EA 20-001
Prompted by:
Date Opened: 08/31/2020 **Date Closed:** 02/27/2023
Investigator: Roy Nelson **Reviewer:** Gregory Magno
Approver: Stephen Ridella
Subject: Loss of Brake Power Assist

MANUFACTURER & PRODUCT INFORMATION

Manufacturer: Land Rover
Products: 2012 - 2013 Range Rover Evoque
Population: 23,532

Problem Description: The brake vacuum pump may fail while driving, resulting in a loss of power assisted braking.

FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
Complaints:	9	39	48
Crashes/Fires:	0	0	0
Injury Incidents:	0	0	0
Fatality Incidents:	0	0	0
Other*:	0	208	208

***Description of Other:** Warranty claim data

ACTION / SUMMARY INFORMATION

Action: This Engineering Analysis is closed.

Summary:

On August 31, 2020, ODI upgraded PE18-014 to Engineering Analysis (EA)20-001 to continue its investigation of brake vacuum pump failures in model year (MY) 2012-2013 Range Rover Evoque vehicles and peer Jaguar Land Rover (JLR) products equipped with 2.0L GTDI engines fitted with Magna vacuum pumps. This investigative activity has focused on the cause, scope, and effect of inadequate vacuum supply at the vehicles brake booster with its attendant increases of brake pedal effort and diminished braking performance.

Following a detailed analysis of data collected, the alleged defect is progressive and reasonably detectable with adequate power braking assist available prior to complete pump failure; occurs at marginal failure rates, particularly where the vehicle age is considered; and the complaint trend dissipated to one occurrence per year over the last three calendar years.

Based on the analysis conducted, this investigation has been closed. The closing of this investigation does not foreclose the Agency from taking further action, if warranted, or the potential for a future finding that a safety-related defect exists, based upon additional information the Agency may receive.

For a detailed summary of the investigation see attached closing resume document.

The ODI reports cited above can be reviewed at:
http://www-odi.nhtsa.dot.gov/owners/SearchNHTSAID
using the following complaint identification numbers: 10986358, 11025409, 11083348, 11131896, 11149724, 11231234, 11343256, 11425440, 11485127.

EA20-001 Closing Report

Subject:

On December 1, 2018, the Office of Defects Investigation (ODI) opened Preliminary Evaluation (PE)18-014 to assess the scope, frequency, and safety consequences of brake vacuum pump failures reported to the agency in seven Vehicle Owner's Questionnaires (VOQs) that NHTSA had received at the time applicable to model year (MY) 2012 – 2014 Range Rover Evoque vehicles. Through PE18-014, ODI learned that the pump failures were attributed to poor engine oil conditions, identified the scope of vehicles equipped with this pump both with and without a supplementary engine vacuum source, and obtained available complaint data from Jaguar Land Rover (JLR). On August 31, 2020, ODI upgraded PE18-014 to Engineering Analysis (EA)20-001 to continue its investigation of brake vacuum pump failures in model year (MY) 2012-2013 Range Rover Evoque vehicles and peer Jaguar Land Rover (JLR) products equipped with 2.0L GTDI engines fitted with Magna vacuum pumps. This investigative activity has focused on the cause, scope, and effect of inadequate vacuum supply at the vehicles brake booster with its attendant increases of brake pedal effort and diminished braking performance.

In its responses to ODI Information Requests, JLR and subject brake vacuum pump supplier Magna International (Magna) assessed that the subject vacuum pump failures resulted from blockage of the pump's lubricating engine oil inlet orifice. JLR and Magna attributed this blockage to oil "sludge" resulting from failure to perform oil changes at the specified maintenance intervals.

Further analysis during PE18-014 found that the 2014 Evoque which also features an auxiliary vacuum source from the engine intake manifold demonstrated a tenth of the failure rate of MY 2012 -2013 Evoque vehicles which rely solely on the subject vacuum pump for brake booster vacuum. As a result, EA20-001 narrowed the investigation scope to MY 2012 – 2013 Evoque.

EA20-001 enlisted test services from NHTSA's Vehicle Research and Test Center (VRTC) to evaluate the effects of various pump deterioration levels on subject vehicle braking system performance and driver feedback.

Brake system description:

The subject vehicle power brake assist system utilizes a mechanical vacuum-actuated brake booster. Primary vacuum to the booster is supplied via an engine camshaft- driven single vane rotary pump (Figure 1). The pump is lubricated by pressurized crankcase engine oil which enters the pump through a fine screen filter (Figure 2). Certain vehicle build configurations within the PE18-014 subject vehicle population supplement the vacuum supplied by the subject pump with vacuum from a port connection at the engine intake manifold.

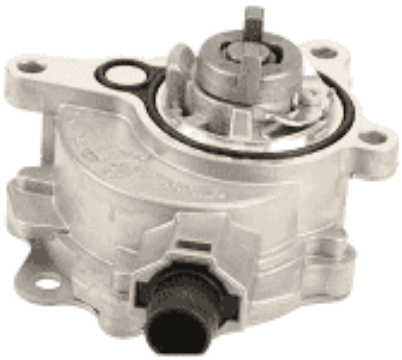


Figure 1 *2013 Range Rover Evoque vacuum pump*

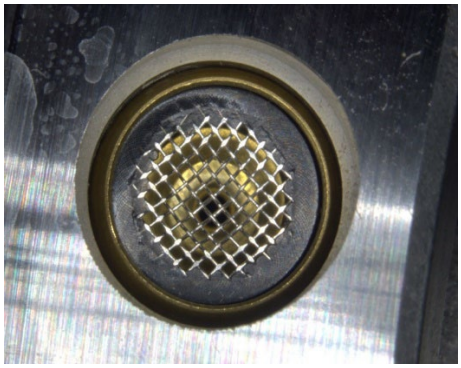


Figure 2 *Pump Orifice: 5.9mm with 400-micron mesh screen*

NHTSA Testing

VRTC furnished testing and evaluation of the alleged defect using an exemplar 2013 Land Rover Evoque obtained for this purpose and confirmed to contain a partially worn pump. In addition to the "as-received" vacuum pump on the test vehicle, two additional pumps were obtained. A new OEM pump was purchased from a Land Rover dealership to establish the baseline performance and a second complaint part was acquired from the filer of VOQ 11343256. VRTC simulated the supplemental engine vacuum source found in the MY 2014 and newer Evoque models and many peer models by retrofitting a modified 2014+ vacuum line to the NHTSA test vehicle. This line was connected to the vacuum pump and the valve cover through the existing port. Check valves in this line prevented pressurization of the brake booster due to the turbocharger.

Loss of vacuum assist in a vehicle can result in reduced braking performance and change of brake pedal feel. Tests were chosen to characterize the brake system performance in various stages of assisted and unassisted brake application. This varying level of brake assist helps quantify the impact of pump deterioration over time and wear before full seizure/failure occurs.

The brake booster on the 2012-2013 Evoque relied on a camshaft-driven vacuum pump. The reliance on a camshaft-driven pump results in brake booster vacuum recovery rates that are dependent on engine revolutions per minute (RPM). Vacuum recovery testing at idle and higher RPMs using OEM new, wearing (as received pump), and worn vacuum pumps revealed that the worn pump had a 7 percent reduction in maximum vacuum level and required nearly twice the time to recover maximum vacuum when compared to the other pumps at idle (Figure 3). At 2,000 RPM, the differences between pump performance greatly reduced with the worn pump having a 3.5 percent reduction in maximum vacuum levels and an approximately identical recovery time (Figure 4).

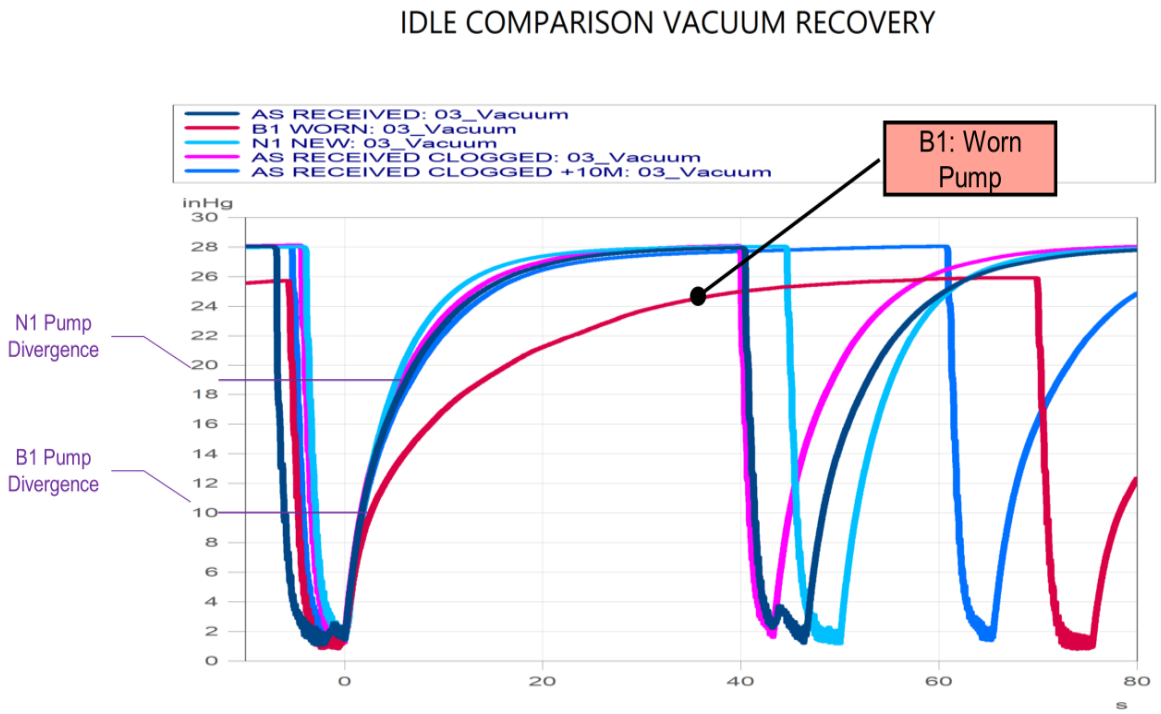


Figure 1 – Vacuum Recovery Curve at Idle

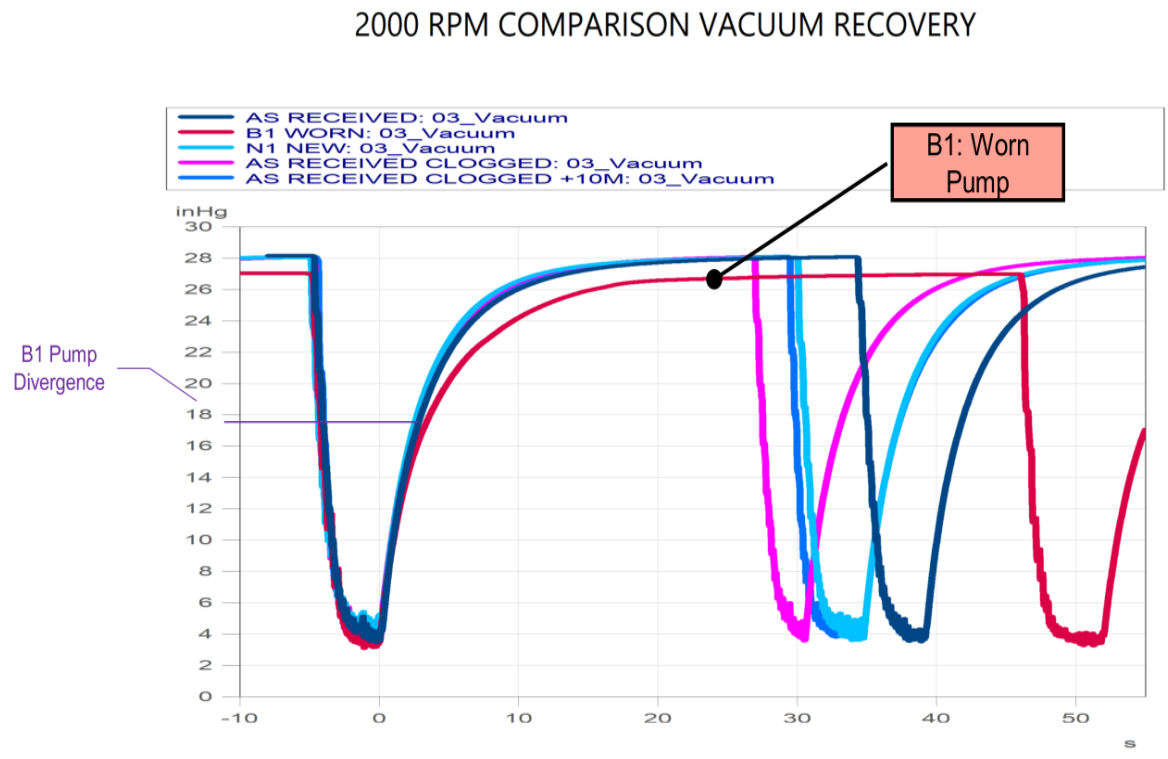


Figure 2- Vacuum Recovery Curve @ 2000 RPM

Vacuum recovery tests performed with the worn pump, and the second vacuum source added led to greater system performance at idle and higher RPM than the single source system OEM new pump, both in terms of recovery time and maximum vacuum produced. The B1 dual source pump had a 35 percent increase in maximum vacuum over the pump alone at idle and a 37 percent increase in maximum vacuum at 2,000 RPM (Figure 5).

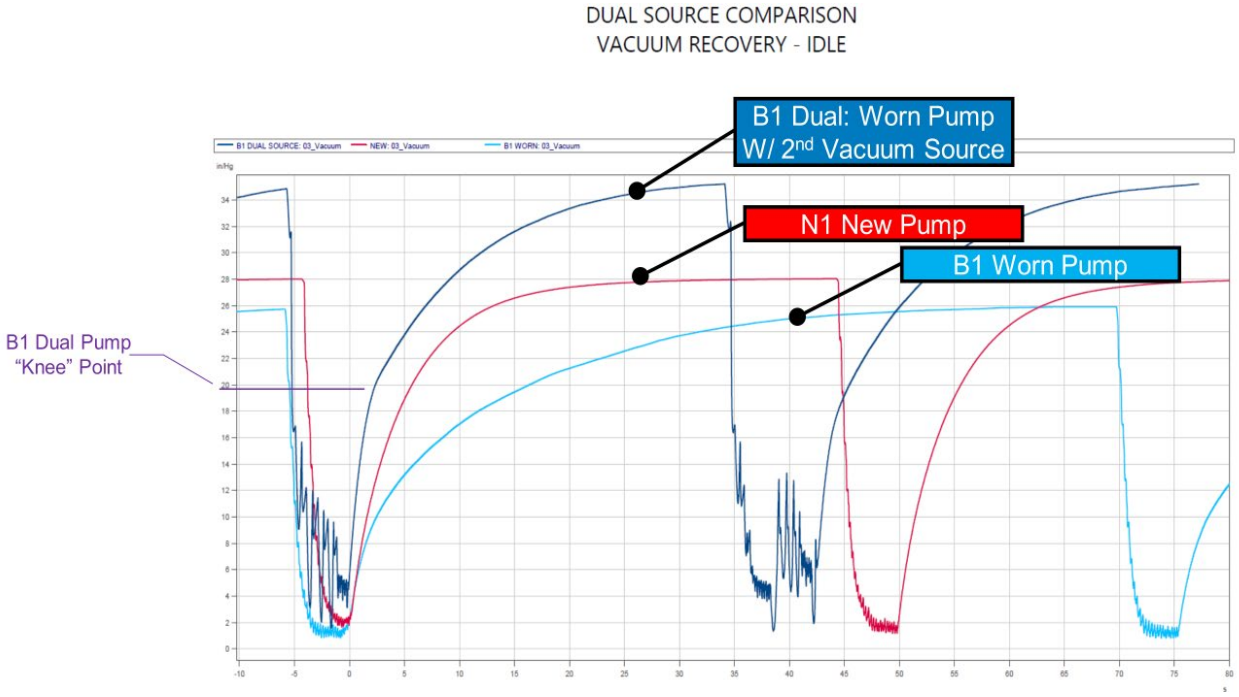


Figure 3 - Dual-source Vacuum Recovery at Idle

All new vehicles must meet federal motor vehicle safety standards (FMVSS) for braking in FMVSS 135.[1] The Test vehicle was subjected to FMVSS 135 S7.5 and S7.11 in varying configurations of vacuum pump operating states. The S7.5 cold effectiveness test requires the vehicle to stop within 230 feet when tested at 62 miles-per-hour (MPH). The S7.11 test requires the vehicle to stop within 551 feet when tested at 62 MPH with the primary source of power for the brake power assist unit disconnected.

VRTC tested configurations ranged from a disconnected brake booster vacuum line (simulating a failed pump), two varying levels of worn pumps, and new OEM pump. The test vehicle was found to satisfy the requirements found in FMVSS 135 S7.5 and S7.11 (Figures 6 and 7). Variations in maximum pedal force application rate and retention were found to be the largest cause of braking distance variation.

[1] 49 CFR § 571. - No. 135; Light vehicle brake systems.

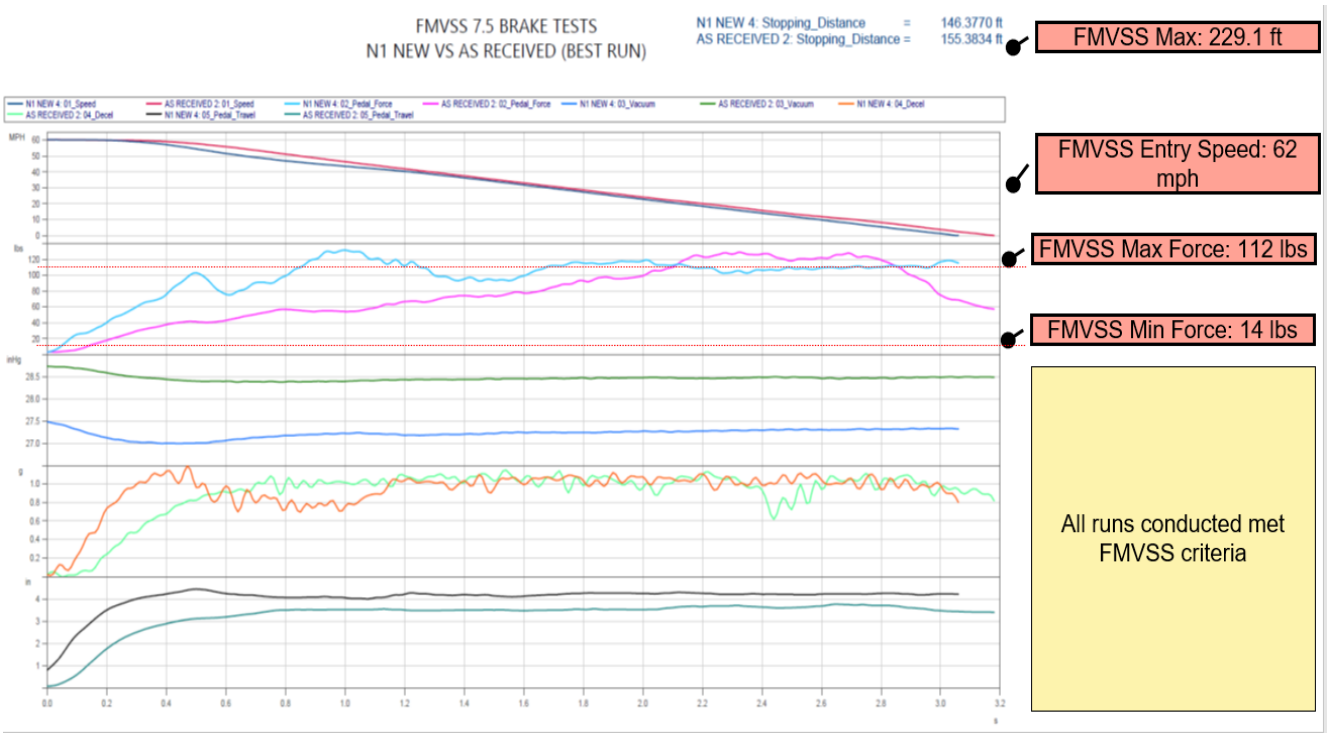


Figure 6 - FMVSS 135 S7.5

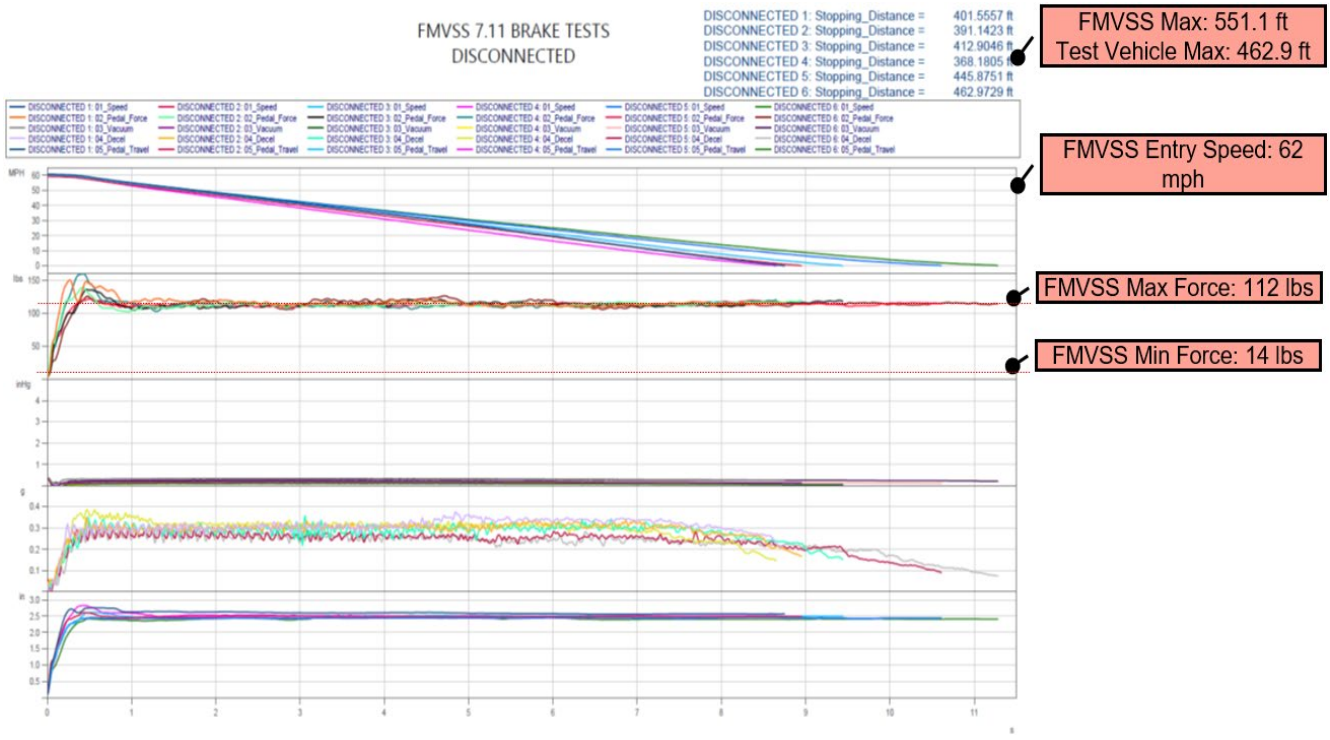


Figure 7 - FMVSS 135 S7.11

Additional testing to identify variables in pump condition included target decelerations of 0.5g and 1.0g braking, coast test, and heavy stop and go traffic scenarios. A large change in either of the pedal-related variables can result in loss of confidence from the driver or a hesitancy for the driver to apply full braking capability due to unexpected changes in brake pedal feel and system performance. The most notable changes in both variables were only observed during full vacuum pump disconnect scenarios, with variations between new and worn pumps being minimal.

All dynamic tests were re-conducted with the test vehicle modified with the secondary vacuum source line retrofit. Tests conducted to characterize pedal effort vs deceleration rates determined brake pedal force and brake pedal travel had minimal change or improvement. A larger vacuum reserve depletion was noted, but the drop was relatively small and resulted in no characteristic change (Figure 8).

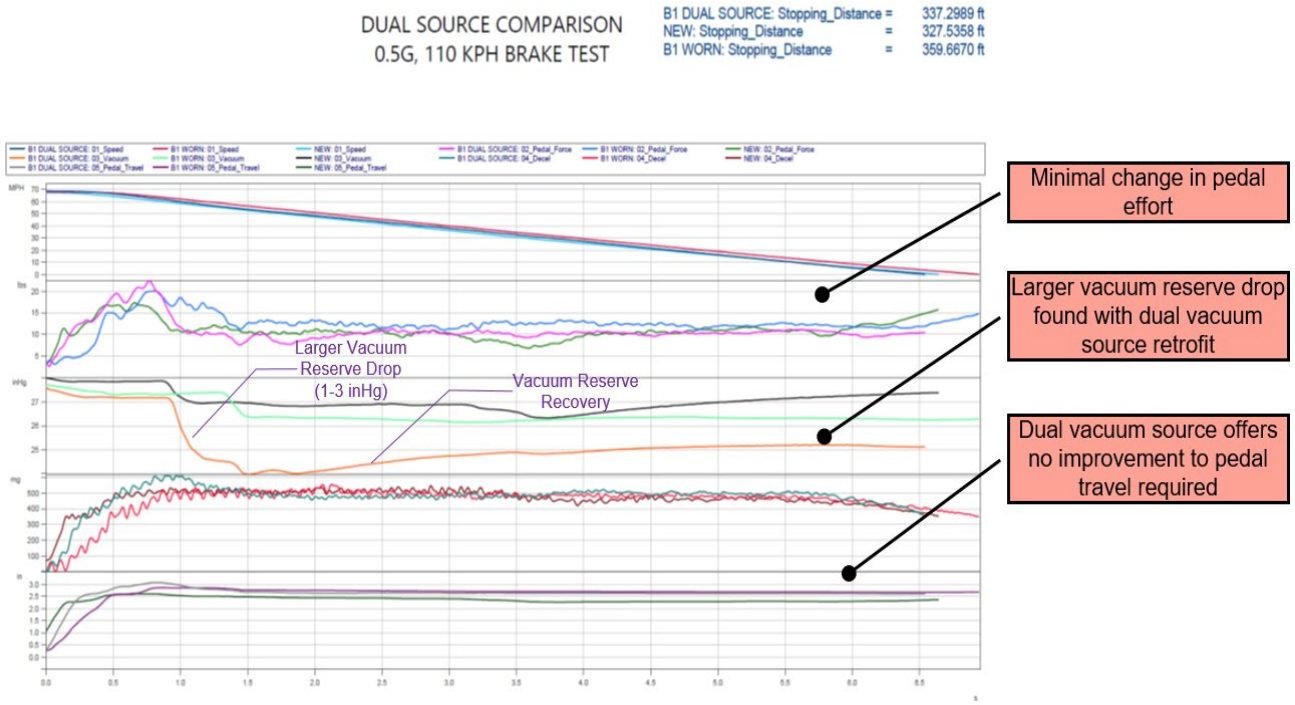


Figure 8- Dual Source Vacuum 0.5 g, 110 km/h Brake Test

ODI concluded that comparative testing revealed that vacuum pumps in a worn state had not resulted in a significant reduction in brake pedal required force or brake booster available vacuum. Results of the .5g braking test (Figure 9) identified an egregious change in brake pedal effort necessary to meet FMVSS required stopping distance of vehicles where a pump ceased to pull measurable vacuum *and* brake booster vacuum is provided solely by the mechanical vacuum pump (single source). The test vehicle modified to a build configuration supplementing pump vacuum with a connection at the intake port (dual source) was found to adequately compensate for a vacuum pump failure and braking characteristics were not noticeably affected.

FMVSS 135 0.5G, 110 KPH Braking Test					
Vacuum Source	Pump State	Brake Pedal Force (MAX Force: 112 lbs)	Brake Pedal Travel	Booster Vacuum	Stopping Distance (FMVSS Max: 551.1 ft)
Single (pump)	New	12 lbs.	2.4"	27 inHg	327.53
Single (pump)	Worn	13 lbs.	2.7"	26 inHg	359.66
Single (pump)	Inoperable	>150 lbs.	3.0"	0 inHg	384.27
Dual (Pump/ Manifold)	Worn	12 lbs.	2.5"	26 inHg	365.28
Dual (Pump/ Manifold)	Inoperable	12lbs.	1.8"	18 inHg	374.41

Figure 9- Single vs. Dual Source Vacuum 0.5 g, 110 km/h Brake Test

Jaguar Land Rover Assessment

"The conclusions provided in Jaguar Land Rover's PE18-014 response remain unchanged in terms of the reasons for failure. These conclusions being that blocking the vacuum pump oil filter screen leads to progressively reduced pump lubrication and ultimately overheating the brake vacuum pump causing seizure due to absence of lubrication. This is a consequence of the engine oil not being changed in accordance with the published routine service intervals. Failure to maintain vehicles by adhering to the published service intervals will reduce service life through wear of parts and systems for which adequate lubrication is essential."

Jaguar Land Rover stated that "although there is an absence of direct warning of failure, there are reports related to other vehicle conditions which are attributed, at time of dealer diagnosis, to the cause of vacuum pump failure."

Jaguar Land Rover further stated that "the lack of accident reports is a clear indication that a vacuum pump failure is a controllable event. Indeed, Federal Motor Vehicle Safety Standard (FMVSS) 135 - Light Vehicle Brake Systems includes specific brake system performance requirements in the event of brake assistance failure. These vehicles comply fully with the performance requirements provided in FMVSS 135. When considered within the context of the regulation, along with a lack of accidents, Jaguar Land Rover believes this issue is not considered an unreasonable risk to safety."

Jaguar Land Rover asserted that "failures caused by inadequate maintenance, schedules for which are clearly published and provided to vehicle owners by way of the owner literature, should not be considered a manufacturing defect. The onus sits with the vehicle owner to undertake reasonable actions to maintain the condition of their vehicle and is outside of the control of the manufacturer."

Field Data

Review of warranty claim data provided by Jaguar Land Rover revealed a contrast in symptoms described by consumers concurrent with a failed pump diagnosis. Pump failures in single vacuum source vehicles let to reports of hard or firm pedal, or hard to reduce vehicle speed while dual vacuum source complaints outlined one or more of the following: oil leak, check engine light, engine performance, and slightly different pedal feel. As a result, ODI's risk assessment narrowed the concentration of its investigation to subject and peer vehicles without build configurations to supplement pump vacuum

with a connection at the intake port. This narrowed scope included MY2012-13 Range Rover Evoque, MY2013 Land Rover LR2, and MY2013-15 Jaguar XF vehicles.

ODI conducted complaint data analysis of it narrowed focus of single vacuum source vehicles. Pump failures within the scoped population revealed slightly less than a 1% failure rate in Land Rover vehicles and less than 0.1% failure rate in Jaguar vehicles. Notwithstanding vehicle vacuum system design that does not provide a direct audible or visual warning such as an error message or warning lamp, pump wear was confirmed to be progressive and does produce detectable symptoms through brake pedal haptics as the vacuum pump degrades. Within the narrowed scope of single vacuum source vehicles, ODI has received 9 total VOQ submissions (Figure 10) relating to brake concerns attributable to vacuum pump failures in the subject vehicles. To date, none of the submissions include allegation of a crash or injury. Similarly, a data refresh from JLR showed that they had received no newly responsive consumer complaints or warranty claims from January 2021 to May 2022.

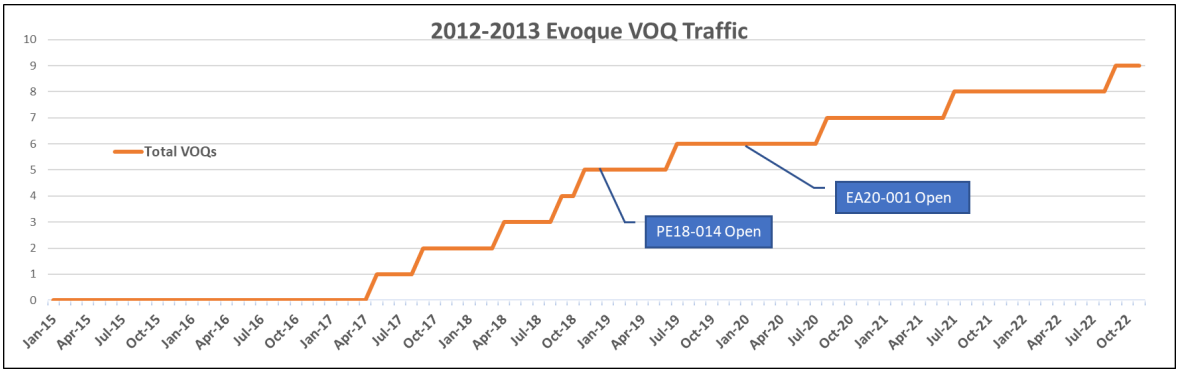


Figure 10- Vehicle Owner's Questionnaire Complaints

ODI Conclusion

Based on ODI's investigation, the alleged defect is: progressive and reasonably detectable with adequate power braking assist available prior to complete pump failure; remains FMVSS 135 compliant; occurs at marginal failure rates, particularly where the vehicle age is considered; and the VOQ trend dissipated to one occurrence per year over the last three calendar years.

Based on the analysis conducted, this investigation has been closed. The closing of this investigation does not foreclose the Agency from taking further action, if warranted, or the potential for a future finding that a safety-related defect exists, based upon additional information the Agency may receive.