ENGINEERING ANALYSIS CLOSING REPORT

SUBJECT: Brake pipe corrosion failures in model year (MY) 1999 through 2003 General Motors GMT800 series pickup trucks (Figure 1) and sport utility vehicles (Figure 2) in salt states.

Figure 1. 2003 Chevrolet Silverado 2500HD.

Figure 2. 2003 Chevrolet Suburban.

EA No.: EA11-001 **Date Opened:** 5-Jan-2011 **Date Closed:** 9-Apr-2015

BASIS: On March 2, 2010, the National Highway Traffic Safety Administration was petitioned by an owner of a MY 2003 Chevrolet Silverado 2500HD 4WD pickup truck to open a defect investigation into corrosion and failure of hydraulic brake pipes in Chevrolet pickup trucks. The letter references a complaint that had previously been submitted to the Office Defects Investigation (ODI) on January 21, 2010 (ODI No. 10301686).

On March 29, 2010, ODI opened Defect Petition DP10-003 to evaluate the petitioner's request for an investigation of brake pipe failures in MY 2003 Chevrolet Silverado 2500HD pickup trucks. The petition was granted on March 30, 2010, and Preliminary Evaluation PE10-010 was opened to investigate corrosion related brake pipe failure in MY 1999 through 2003 General Motors C/K pickup trucks and sport utility vehicles based on 110 complaints, including 3 alleged crashes. After PE10-010 was opened, the number of complaints received by ODI increased from less than 10 per month to 100 in April 2010 (Figures A1 and A2 in the Appendix).

ODI's analysis of consumer complaints and information provided by General Motors in response to the information request letter for PE10-010 showed that the field experience was concentrated in the region of the United States that NHTSA has viewed as salt states[1] for investigations of corrosion related issues.

[1] Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia and Wisconsin.

On January 5, 2011, the investigation was upgraded to an Engineering Analysis (EA11-001) covering MY 1999 through 2003 General Motors C/K pickup trucks and sport utility vehicles in salt states, where the highest complaint rates[2] had been observed in PE10-010.

Vehicle type	Vehicle series	Model/MY	MY 1999-2003		MY 2004-07		Grand total[3]
			Salt states (subject vehicles)	Non-salt states	Salt states	Non-salt states	
Pickup trucks	**1500**	1999-2007 Chevrolet Silverado	807,661	1,491,634	508,797	993,608	3,821,079
		1999-2007 GMC Sierra	234,773	444,560	162,210	322,656	1,170,257
		1500 Pickup Total	**1,042,434**	**1,936,194**	**671,007**	**1,316,264**	**4,991,336**
	2500	1999-2007 Chevrolet Silverado	257,671	362,100	240,655	432,632	1,304,363
		1999-2007 GMC Sierra	80,251	106,263	82,802	137,895	410,562
		2500 Pickup Total	**337,922**	**468,363**	**323,457**	**570,527**	**1,714,925**
	3500	1999-2007 Chevrolet Silverado	31,272	49,924	51,269	98,498	233,212
		1999-2007 GMC Sierra	10,902	13,672	19,617	27,189	72,183
		3500 Pickup Total	**42,174**	**63,596**	**70,886**	**125,687**	**305,395**
	Pickup Total		**1,422,530**	**2,468,153**	**1,065,350**	**2,012,478**	**7,011,656**
Utility Vehicles	**1500**	2002-2006 Cadillac Escalade	43,616	78,283	52,749	88,117	265,730
		2002-2006 Chevrolet Avalanche	81,531	121,970	57,563	123,990	388,248
		2000-2006 Chevrolet Suburban	138,128	357,892	76,240	162,825	742,204
		2000-2006 Chevrolet Tahoe	180,677	496,115	105,805	306,839	1,102,398
		2000-2006 GMC Yukon	151,146	337,993	100,064	234,369	830,046
		1500 Utility Total	**595,098**	**1,392,253**	**392,421**	**916,140**	**3,328,626**
	2500	2002-2006 Chevrolet Avalanche	3,606	4,402	1,272	1,478	10,940
		2000-2006 Chevrolet Suburban	12,655	26,053	5,485	10,523	57,366
		2000-2006 GMC Yukon	4,615	8,805	1,836	2,870	18,474
		2500 Utility Total	**20,876**	**39,260**	**8,593**	**14,871**	**86,780**
	Utility Total		**615,974**	**1,431,513**	**401,014**	**931,011**	**3,415,406**
Grand Total			**2,038,504**	**3,899,666**	**1,466,364**	**2,943,489**	**10,427,062**

Table 1. GMT800 production volume, by vehicle type, series, model, MY range and region.

SYSTEM DESCRIPTION: The subject vehicles have dual-circuit front-rear split hydraulic service brake systems. There are 66 different brake pipe routing configurations used in the subject vehicles, but all GMT800 vehicles share the same basic brake pipe configuration as shown in Figure A3 in the Appendix. The ABS modulator is located on the in-board side of the left frame rail beneath the driver's seating position. The pipes for the primary (front) and secondary (rear) circuits run from the master cylinder to the front face of the modulator and 3 pipes run from the upper front face of the modulator to the brakes, 2 routed forward to the left and right front brake calipers and 1 routed rearward along the left frame (Figure 3).

[2] Unless otherwise noted, all complaint rates are given in incidents per thousand vehicles (IPTV).
[3] Includes 79,039 vehicles with unknown sales state.

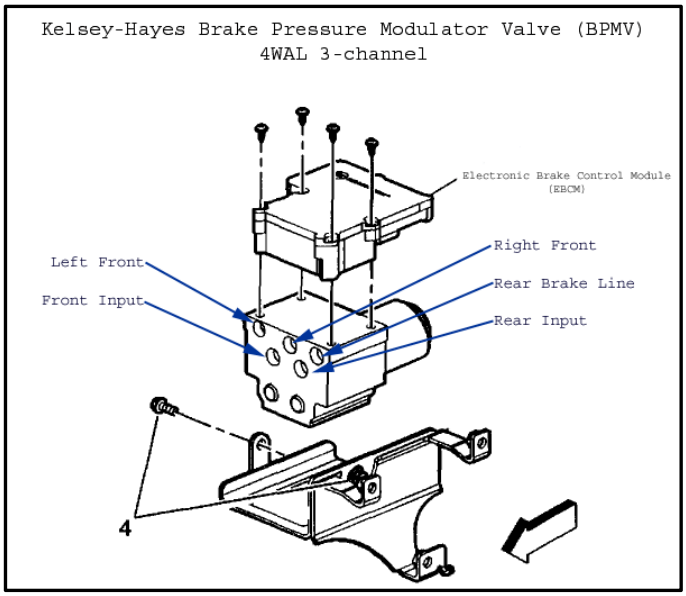

Figure 3. GMT800 ABS Modulator.

Brake Warning Telltale. Depending on the model and model year, the subject vehicles are equipped with a master cylinder reservoir fluid level sensor or a differential pressure switch that will illuminate the red BRAKE telltale in the instrument cluster when they are activated by a low fluid level or a pressure differential between the primary and secondary circuits. The differential pressure switch is used in subject vehicles that are equipped with a brake proportioning combination valve.

Speed (mph)	Stops, Each Mode	Average Stopping Distance (ft)		Percent Reduction in Distance
		Without Circuit Failure Signal	With Circuit Failure Signal	
30	4	131	117	11%
60	4	463	409	12%

Table 2. Effects of Circuit Failure Signal on Braking Performance in Rear Only Braking Condition (i.e., Front Circuit Failed).

When the system detects a partial system failure (i.e., the BRAKE telltale is illuminated), the ABS algorithm for the rear brakes changes to a more aggressive control logic prioritizing stopping performance over stability. Testing conducted by NHTSA's Vehicle Research and Test Center (VRTC) found that the change in rear braking strategy could improve braking performance with a loss of the primary (front) circuit by as much as 12 percent (Table 2).

Brake Pipe Construction/Coating. The brake pipes used in the subject vehicles are copper brazed, double-wall steel tubes (Bundy tubes) supplied by TI Automotive. Bundy tubes are manufactured from a low-carbon continuous strip of copper plated cold rolled steel, double wrapped through 720 degrees and brazed (Figure 4).

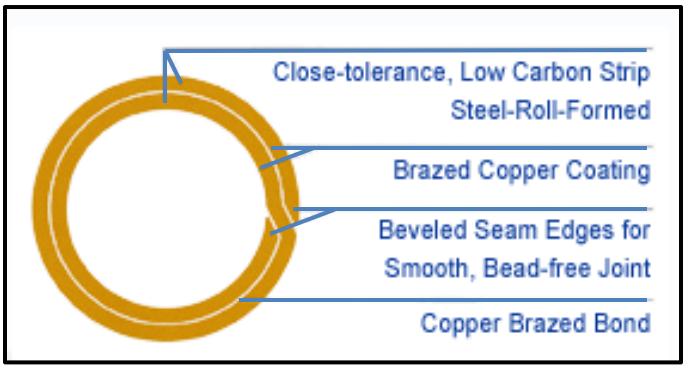

Figure 4. Double-Wall Brake Pipe (TI Automotive).

The steel-copper construction is vulnerable to galvanic corrosion if exposed to the environment. The subject brake pipes use an AlGal coating for protection against corrosion and abrasion. The AlGal coating system consists of a hot-dipped alloy inner sacrificial layer (95% zinc and 5% aluminum Galfan coating) and an aluminum rich paint outer barrier layer (Figure 5). General Motors changed to a NyGal coating system in the GMT900 series vehicles, which were launched in MY 2007. The NyGal coating uses an extruded nylon (PA12) coating for the outer barrier layer instead of the aluminum rich paint (Figure 6). The plastic coating is substantially (≈50x) thicker and provides a stronger barrier against damage from exposure to tire kick-up (e.g., stone pecking) than the aluminum paint used in the AlGal coating.

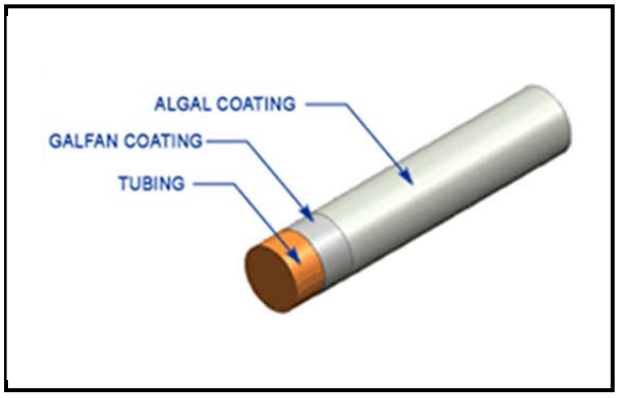

Figure 5. AlGal Coating (TI Automotive).

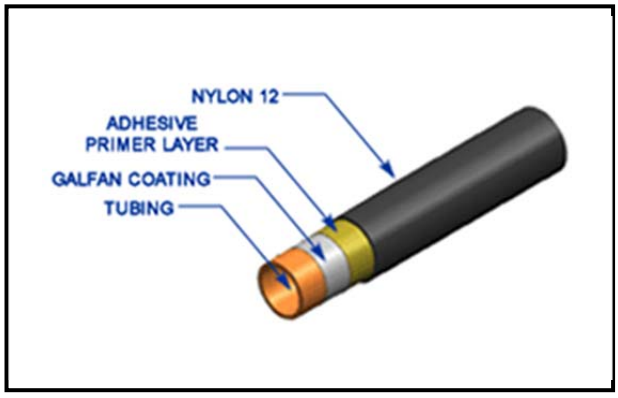

Figure 6. NyGal Coating (TI Automotive).

Safety Standards (Partial System Failure). Federal Motor Vehicle Safety Standard (FMVSS) 135, Light Vehicle Brake Systems, is the federal minimum braking standard for all pickup trucks, utility vehicles and vans (LTV's) with a GVWR of 3,500 kg (7,716 lbs) or less manufactured since September 1, 2002. FMVSS 105, Hydraulic and Electric Brake Systems, is the brake standard for light vehicles with GVWR's greater than 7,716 lbs. From December 1, 1997 to September 1, 2002, manufacturers had the option of testing LTV's with GVWR's of 7,716 lbs or less to either FMVSS 105 or 135.

Safety standard	Test Condition	Test Speed (mph)	Pedal Force (lbs)	Stopping distance requirement (ft)	Average deceleration (g's)	Subject Vehicle Applicability by Build Date	
						Before 9/1/2002	After 9/1/2002
105	LLVW	60.0	15 - 150	517	0.23	All	GVWR > 7,716 lbs[4]
	GVWR	60.0	15 - 150	517	0.23		
135	LLVW	62.1	15 - 112	551	0.23	Optional for GVWR ≤ 7,716 lbs	GVWR ≤ 7,716 lbs
	GVWR	62.1	15 - 112	551	0.23		

Table 4. Partial System Failure Test Conditions, Stopping Distance Requirements and Subject Vehicle Applicability, FMVSS 105 and 135.

The purpose of both safety standards is to ensure safe braking performance under normal and emergency conditions and both standards include requirements for stopping distance when hydraulic circuits #1 or #2 have failed (partial system failure). Table 4 summarizes the partial system failure test conditions and stopping distance requirements for FMVSS 105 and 135.

Prior to MY 2003, when FMVSS 135 became mandatory for GMT800 vehicles with GVWR of 7,716 lbs or less, GM tested the vehicles to the requirements of FMVSS 105. Figure A4 in the Appendix shows the FMVSS 105 full system and partial system failure stopping distance results for the subject vehicles and peers for both lightly loaded and fully loaded test conditions. Partial system failure results are given for both primary (front) circuit failures and secondary (rear) circuit failures.

Test condition	Lightly Loaded Vehicle Weight (LLVW)				Fully Loaded (GVWR)			
	Stopping distance (ft)	Average decel (g's)	Increase (ft)	% Increase	Stopping distance (ft)	Average decel (g's)	Increase (ft)	% Increase
Full system	151	0.80			179	0.67		
Front only	205	0.59	54	36%	250	0.48	71	40%
Rear only	473	0.25	322	213%	349	0.34	170	95%

Table 5. FMVSS 105 Test Results for MY 1999 Chevrolet Silverado 1500 4WD.

Table 5 summarizes the braking performance as measured in FMVSS 105 testing for a 1999 Chevrolet Silverado 1500 4WD pickup truck. For each of the subject and peer vehicles tested, the rear circuit failures when lightly loaded produced the smallest increases in stopping distance from the full/normal system performance. The worst case condition for each vehicle is front circuit failure (rear only braking) with light vehicle load. This is particularly true for unloaded pickup trucks, which have relatively large load differences between the front and rear axles. Low relative load on the rear axle results in lower relative braking capacity from the rear tires.

[4] In general, after September 1, 2002, FMVSS 105 applied to the heavy duty 2500 and 3500 series vehicles and FMVSS 135 applied to the light duty 1500 series vehicles.

PROBLEM EXPERIENCE: General Motors sold approximately 6 million MY 1999 through 2003 GMT800 series pickup trucks and utility vehicles in the United States, including about 2 million in salt states. Through December 2014, ODI identified 2,702 complaints alleging brake pipe leakage due to corrosion failures in the subject vehicles. Table 6 shows the complaint, crash and injury counts by region for MY 1999-2003 GMT800 vehicles through December 31, 2014.

Region	Population	Complaints		Crashes	Injuries
		Number	Rate (IPTV)		
Salt state[5]	2,038,504	2,702	1.33	88	20
Non-salt state	3,899,666	347	0.09	6	6
Total	**5,937,170**	**3,049**	**0.51**	**94**	**26**

Table 6. Problem Experience by Region, MY 1999-2003 GMT800 Vehicles.

Overall brake pipe leak complaint, crash and injury counts for the full production ranges of each GMT800 series model are shown in Table 7 (1500 series) and Table 8 (2500/3500 series).

Type	Models	MY's	Population	Complaints		Crashes	Injuries
				No.	Rate (IPTV)		
P/U's	Sierra	1999-2007	1,169,987	508	0.43	13	9
	Silverado	1999-2007	3,821,079	1,398	0.37	38	13
	Total, pickup trucks		**4,991,066**	**1,906**	**0.38**	**51**	**22**
Utility	Avalanche	2002-2006	388,248	145	0.37	2	0
	Escalade	2002-2006	265,730	31	0.12	0	0
	Suburban	2000-2006	742,204	224	0.30	7	7
	Tahoe	2000-2006	1,102,398	158	0.14	11	2
	Yukon	2000-2006	830,046	186	0.22	4	1
	Total, utility vehicles		**3,328,626**	**744**	**0.22**	**24**	**10**
Grand total			**8,319,692**	**2,650**	**0.32**	**75**	**32**

Table 7. Problem Experience, MY 1999-2007 GMT800 1500 Series Vehicles.

Type	Models	MY's	Population	Complaints		Crashes	Injuries
				No.	Rate (IPTV)		
P/U's	Sierra	1999-2007	482,745	232	0.48	10	5
	Silverado	1999-2007	1,537,575	701	0.46	21	3
	Total, pickup trucks		**2,020,320**	**933**	**0.46**	**31**	**8**
Utility	Avalanche	2002-2006	10,940	17	1.55	0	0
	Suburban	2000-2006	57,366	35	0.61	1	0
	Yukon	2000-2006	18,474	10	0.54	0	0
	Total, utility vehicles		**86,780**	**62**	**0.71**	**1**	**0**
Grand total			**2,107,100**	**995**	**0.47**	**32**	**8**

Table 8. Problem Experience, MY 1999-2007 GMT800 2500/3500 Series Vehicles.

[5] Incident vehicle owner address, or vehicle originally sold, in a salt state.

Overall analysis of the complaint rate by vehicle age for salt states and non-salt states shows failure experience begins to develop in the salt states after approximately 7 years in service as shown in Figure A5 in the Appendix. By the 12th year of service, the complaint rates have exceeded 1.0 IPTV for both the subject pickup trucks and utility vehicles.

Pennsylvania Inspection Data: The state of Pennsylvania through the Pennsylvania Department of Transporation (PennDOT) requires annual inspections to ensure that vehicles are maintained for safe operation. After a pilot study in 2007, PennDOT began electronically collecting and storing safety inspection data from a small subset of its inspection stations (e-SAFETY program). ODI requested e-SAFETY inspection data from PennDOT for the years 2008 through mid-2014 to assess the rate and trends of brake pipe inspection failures in the subject vehicles and certain peer vehicles. PennDOT inspection guidelines indicate that brake pipes that are leaking or corroded/damaged severly enough to be classified as unsafe should result in an inspection failure.

ODI's analysis of the PennDOT e-SAFETY data by vehicle age for GM, Ford and Chrysler full-size pickup trucks is shown in Figure A6 in the Appendix. The chart shows the cumulative risk of experiencing a brake pipe related inspection failure by the number of years the vehicle had been in service. Similar to the complaint rate analysis by vehicle age shown in Figure A5, the PennDot data shows that the GM risk for inspection failure is low for the first 7 years of service. After 10 years in service the GM vehicles have about a 1.8 percent chance of having failed an annual inspection. In comparison, the inspection failure rates at 10 years in service were 1.4 percent for the Ford peer trucks and 0.5 perent for the Chrysler peer trucks. The inspection failure rates increase for all three manufacturers after 10 years in service, with all three having more than a 2 percent chance of experiencing an inspection failure by 12 years in service and more than a 3 percent chance by 13 years in service.

VRTC Survey: The PennDOT e-SAFETY data is not a complete measure of the brake pipe failure risk. Many brake pipes would likely be repaired each year prior to inspection, some pipes failed by inspection due to excessive corrosion may have survived another year before failure[6], and pipes passed by inspection may sometimes be at risk of failure before the next inspection occurs. Reliable service history information for vehicles outside of warranty coverage is difficult to obtain, as ownership changes, service records may not be retained and owners may not accurately remember full service histories. VRTC mailed 7,977 questionnaires to owners of MY 1999 through 2003 subject and peer vehicles registered in Ohio to gather information related to brake pipe leakage and repair experience.

[6] As noted by GM, brake pipes with excessive flaking corrosion can only be fully evaluated, including estimations of remaining service life, by removing them from the vehicle, cleaning the corrosion from the pipes and sectioning the pipes to assess remaining wall thickness.

	GM		Ford		Chrysler	
	Count	Percent	Count	Percent	Count	Percent
Questionaires mailed	3,960		2,841		1,088	
Usable responses	999	100%	794	100%	167	100%
Brake pipe repair	210	21%	170	21%	29	17%
Brake fluid leakage	186	19%	136	17%	23	14%

Table 9. Summary of VRTC Survey Results.

Table 9 summarizes the results the results of the survey. The overall survey responses showed similar results for GM and Ford, slightly lower rates for brake pipe repair and leakage for Chrysler.

ODI conducted an additional analysis to account for vehicle age as a factor in the survey results. The analysis showed similar rates for each manufacturer for vehicles with 10 years or less of service and higher rates for each manufacturer for vehicle more than 10 years old (Figure A7). These results indicate substantially higher rates of pipe failure/repair through 10 years of service (10 to 23 percent) than the subject vehicle complaints (less than 0.1 percent) or PennDOT e-SAFETY data (1 percent).

Vehicle Inspections: During PE10-010 and EA11-001, NHTSA and GM engineers inspected brake pipes in 71 randomly selected MY 1999 through 2003 subject and peer vehicles (Ford and Chrysler full-size pickup trucks) located in salt states with high use of road salts for deicing, including the Boston and Buffalo metropolitan areas and various locations in Maryland and Ohio. Some of the inspections were conducted independently and some jointly. The vehicles ranged from 8 to 12 years in age and from 49,859 to 248,619 miles of use. The average mileage was 123,582 miles and the median mileage was 120,729 miles. The combined results of all such inspections are summarized in Figure A8 in the Appendix.

The brake pipes were inspected to determine if there had been a prior repair and the areas of most severe brake pipe corrosion were ranked on a scale from 1 to 10. Vehicles with no visible brake pipe corrosion were given the highest ranking (10) and vehicles with at least one brake pipe leaking or previously repaired/replaced were given the lowest ranking (1). Vehicles with scaling/flaking corrosion indicating onset of metal loss were given the second lowest ranking (2). The inspections found similar results for each manufacturer, with vehicle age a significant factor in the likelihood of having a prior brake pipe repair and for exhibiting severe flaking corrosion of some section of brake pipes.

For all of the subject vehicles that were inspected, special attention was given to examining the vehicle for: (1) evidence of brake pipe abrasion, (2) other routing concerns; and (3) areas showing unusual/unique patterns of severe corrosion, such as at retention clips or in areas of greatest exposure to stone pecking. The inspections did not identify any specific locations where corrosion was visually more severe in any of the inspected vehicles nor were any patterns evident between vehicles. In general, when corrosion was noted in the vicinity of the ABS module or at retention clips, similar levels of brake pipe corrosion were observed in multiple other locations for that

vehicle. In addition, analysis of incident vehicle service records also indicates that repairs are not isolated to a specific location or brake pipe.

Brake Pipe Coating. The coating system used for the outer barrier layer appears to be the most significant design factor affecting the corrosion resistance of the brake pipes. The AlGal coating used by GM for the brake pipes in the subject vehicles was the most common in use for full-size pickup trucks and utility vehicles in the United States when the MY 1999 GMT800 platform was designed and launched. By MY 2002 peer manufacturers were all using improved brake pipe coatings in underbody sections and by MY 2006 the peer vehicles had completely changed to the improved brake pipe coatings.

GM began a phased implementation of NyGal coating for brake pipes in passenger cars, light trucks, utility vehicles and vans, starting with the S/T utility vehicle platform change in MY 2002. Plastic coating systems were fully implemented in GM full-size pickup trucks and utility vehicles when the brake pipes were redesigned for the GMT900 platform, which was launched in MY2007. Similar phased implementation schedules for plastic coated brake pipes were followed by peer manufacturers reviewed by ODI during EA11-001.

Comparison with peer manufacturers of full-size trucks and utility vehicles, information reviewed by ODI shows that each company (GM, Ford and Chrysler)[7] phased in 100% plastic coated brake lines over a period of about 10-12 years starting in the late 1990's. By the 2012 model year, plastic coated brakes lines were fully implemented in all light vehicles by all three companies. The full-sized pick-ups were in the middle of the phase-in for each company. Each company implemented the changeovers to plastic coated lines with either a new platform launch or a new brake line release (e.g., GM's rear brake line change in MY05 to accommodate change from rear disc to rear drum brakes).

Field Data Analysis by Region. Failure rates by state are shown for subject vehicles in Figure A9 in the Appendix. The analysis shows a significant difference between Northeastern and North Central salt states, with many of the latter experiencing rates comparable to non-salt states. Most of the Northeastern states require safety inspections every one or two years. The states without inspection programs (Connecticut, Maryland and New Jersey) had the highest rates, indicating that inspections may be partially helpful in reducing the risk of brake pipe failure. The highest rates for non-Salt states were observed in states bordering the salt states (e.g., Virginia, Kentucky) or coastal states (e.g., Hawaii).

Analysis of failure rates by vehicle age and region is provided in Figure A10 in the Appendix. This analysis shows the differences between regions as a function of vehicle age. As noted above, the highest rates are observed in Northeastern states with no mandatory safety inspection programs, followed by Northeastern states with inspection programs.

[7] ODI also reviewed information from Toyota, which also sold full-size pickup trucks in MY's 1999-2003. Toyota implemented plastic coating for brake lines in all of its light vehicles earlier in the 1990's.

GM Brake Pipe Kits. On June 28, 2013, GM released 66 new part numbers for servicing brake pipes in 1999 through 2007 GMT800 pickup trucks and utility vehicles. The kits include a complete set of pre-formed and pre-flared hydraulic brake pipes for virtually every design configuration of the subject vehicles. The kits are intended for use any time replacement of the entire brake pipe assembly is required. GM recommends replacing the entire set of pipes whenever any pipe is leaking or exhibits corrosion severe enough to require replacement.

Analysis of repair records submitted with some complaints indicates that consumers often elect to repair only the failed circuit. Partial system repairs were also noted in vehicle inspection and survey results. This may be based on repair cost, as complete brake pipe replacement before the brake pipe kits were released by GM often cost consumers well over $1,000, mostly from the labor time required to form and flare the replacement tubing to fit the vehicle. The base time estimate for performing this work is approximately 8.5 hours. The GM brake pipe kits reduce the labor time for complete pipe replacement, as no forming/bending or flaring is required.

GM issued Technical Service Bulletin (TSB) 13-05-22-001, "Pre-Formed and Pre-Flared Hydraulic Brake Pipe Kits Now Available for Service", in November 2013 to inform dealers of an improved service strategy to aid in the replacement of hydraulic brake pipes utilizing brake pipe kits including the newly developed Brake Line Kit Installation service procedure. The TSB was reissued three times, with the most recent version in October 2014 including a labor time guideline for the procedure (4.5 to 6.0 hours, depending on the vehicle's configuration). Through November 2014, GM reported sales of 50,912 kits (Table 10). Figures A11 and A12 in the Appendix show estimated cumulative sales percentage curves by sales region. Consistent with complaint data, the Northeast states have had the highest sales rates and volume, accounting for nearly 60 percent of total kit sales.

Vehicle Type	Kits	GM Sales Region					Grand Total
		Northeast	North Central	Southeast	South Central	Western	
Pickup	55	23,856	11,097	4,675	1,016	243	40,887
SUV	11	6,483	2,185	1,097	207	53	10,025
Total	66	30,339	13,282	5,772	1,223	296	50,912

Table 10. GM Brake Pipe Kit Sales Through November 2014, by Vehicle Type and Region.

DISCUSSION: Brake pipe leakage that results in brake circuit failure without warning is generally considered an unreasonable risk to motor vehicle safety when it is caused by a defect condition, such as improper routing or retention of the pipes. ODI's analysis of the failure, inspection and survey data did not identify any specific defect conditions in the routing or retention of the brake pipes that resulted in any unique or unusual patterns of brake pipe corrosion or failures in the subject vehicles. The corrosion observed in incident vehicles was general corrosion affecting most of the pipe assembly, as well as other underbody components on the vehicle, and not localized corrosion indicative of a design or manufacturing problem in the routing or retention of the pipes. In addition, analysis of inspection and survey data did not indicate a significant difference between

the subject and peer vehicles using AlGal coated brake pipes in the likelihood of finding prior brake pipe repair or significant brake pipe corrosion adjusted for vehicle age.

ODI reviewed design, testing and field data regarding the approximately 10.4 million MY 1999 through 2007 GMT800 vehicles sold in the United States. The analysis identified 3,645 complaints of brake pipe corrosion failures in these vehicles, including 107 alleging crashes. Analysis of the complaints showed strong correlations to vehicle age and geographic region. The highest rates were observed in the salt states, particularly in the Northeast corner of the United States. The complaint rate in the salt states reached 1.0 IPTV after the 12th year of service for the subject pickup trucks and utility vehicles. In the Northeast region, where the highest complaint rates were observed, the subject pickup truck complaint rate reaches 1.0 IPTV in the 9th year in states with no mandatory safety inspection requirements and the 10th year in states with safety inspections required. No significant differences in failure rates between body types, brake pipe configurations or build range were identified in ODI's analysis.

REASONS FOR CLOSING: ODI's investigation did not identify any specific defect conditions related to pipe retention or routing that were causing or contributing to the brake pipe failures. Nor did the analysis isolate the problem to any specific brake pipe locations on the vehicle or subject vehicle subpopulations when analyzed by vehicle type or production range. The investigation found that vehicles experiencing brake pipe corrosion failures were likely to have general patterns of excessive corrosion on the majority of the brake pipe assembly and appear to be occurring due to expected wear out for the brake pipe coating material used in the subject vehicles and the environmental conditions in severe corrosion states. The coating was the most common in industry for full-size pickups and utilities when the subject vehicles were design and launched in the late 1990's and analysis of inspection and survey data did not indicate a significant difference between the subject and peer vehicles using AlGal coated brake pipes in the likelihood of finding prior brake pipe repair or significant brake pipe corrosion adjusted for vehicle age. GM changed to improved coating material when the pipes were redesigned for the GMT900 platform.

A safety-related defect has not been identified at this time and further use of agency resources does not appear to be warranted. 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 monitor this issue and reserves the right to take further action if warranted by the circumstances.

APPENDIX

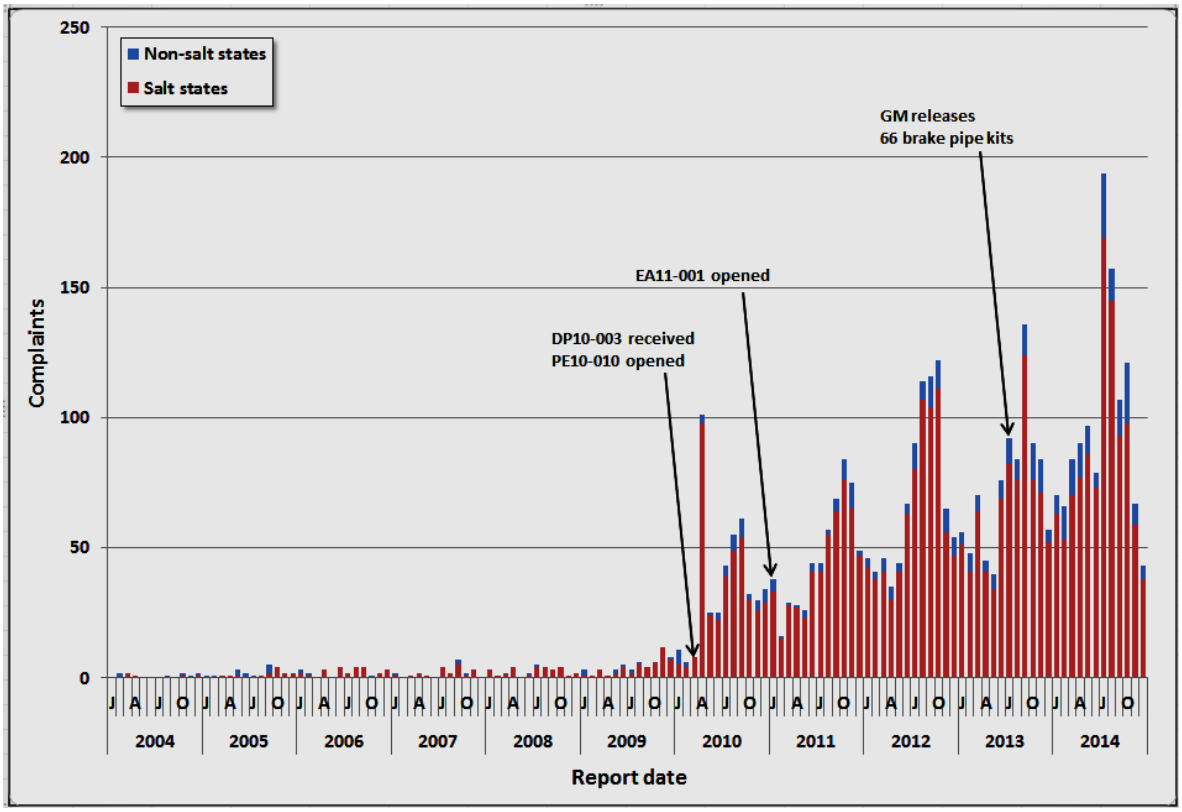

Figure A1. ODI Complaint Trend, GMT800 Brake Lines.

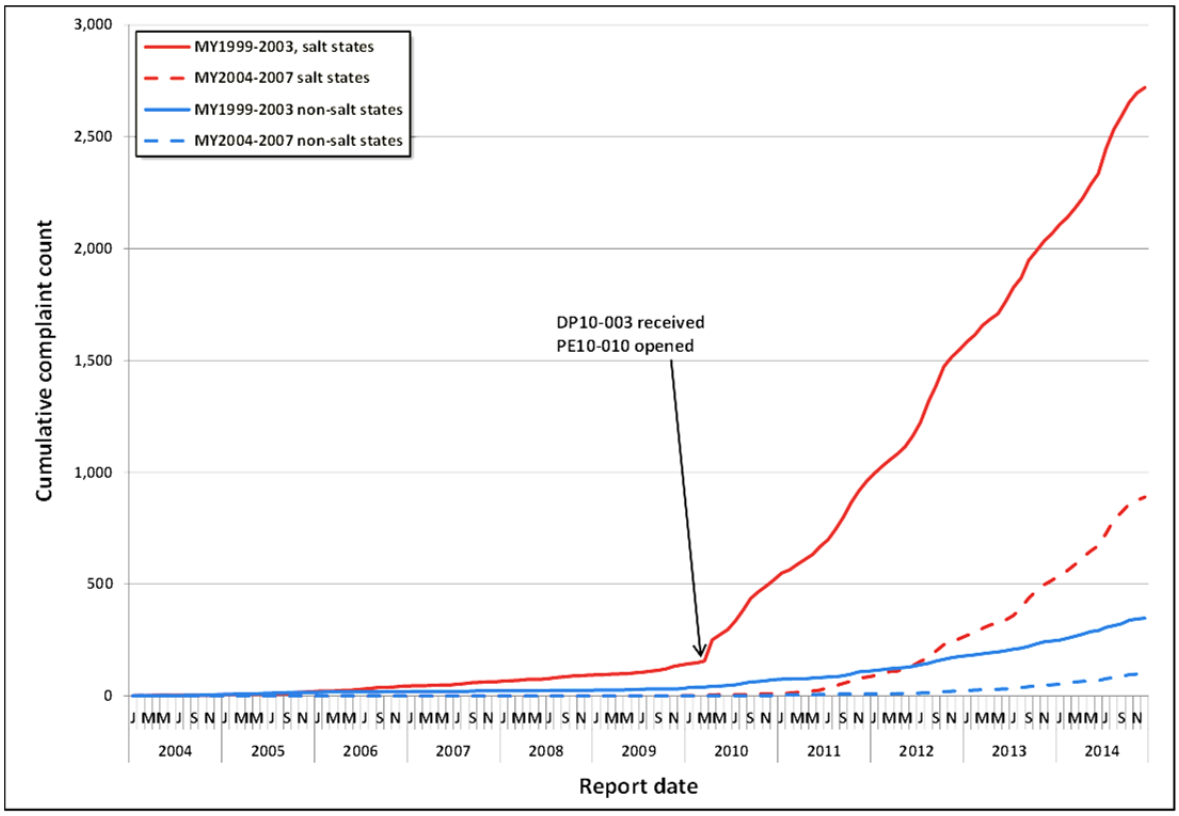

Figure A2. GMT800 Cumulative Failure Rate by Vehicle Age and Region.

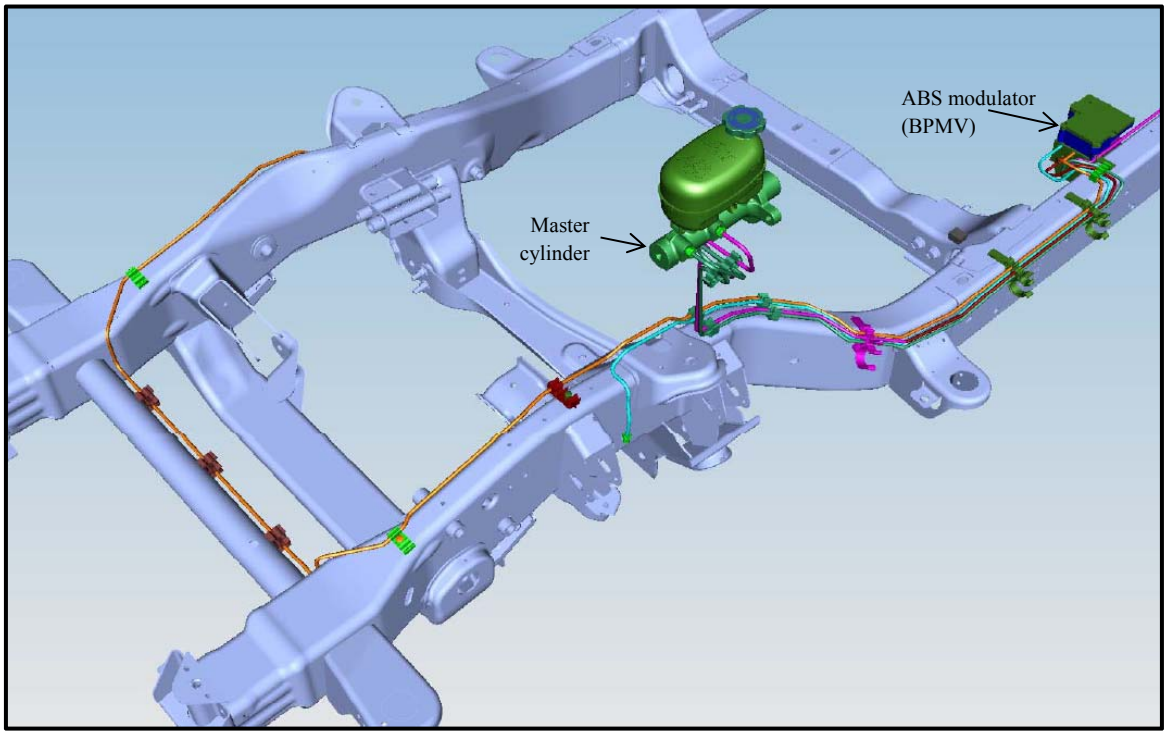

Figure A3. GMT800 Brake Pipe Configuration.

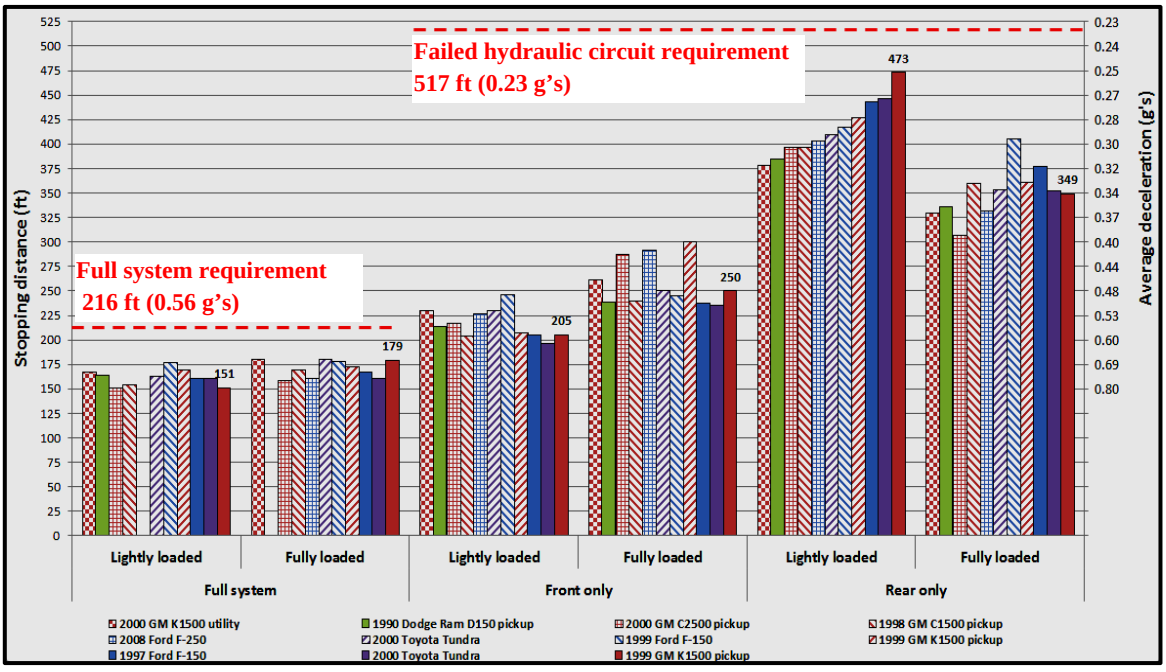

Figure A4. FMVSS 105 Test Results for Full-Size Pickup Trucks and Utility Vehicles.

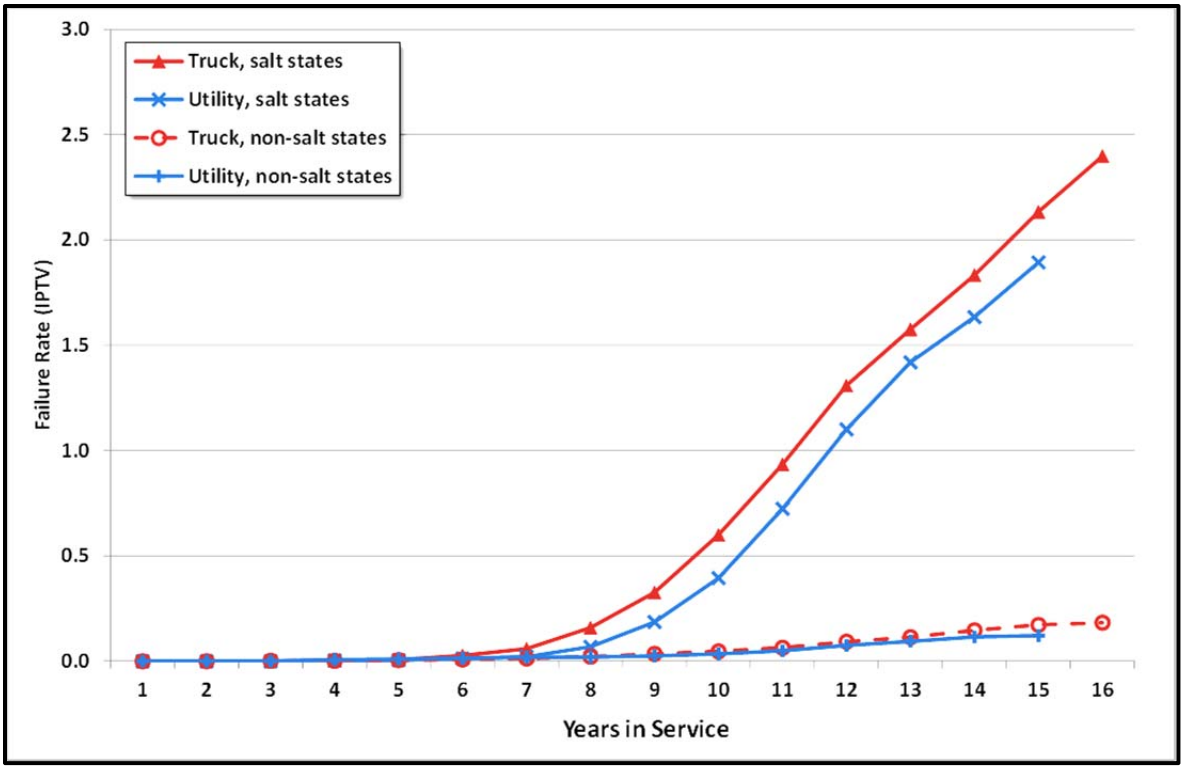

Figure A5. Cumulative Hazard Plot Of Brake Pipe Leak Complaints by Vehicle Type, Region and Years in Service (MY 1999-2003 GMT800 Vehicles).

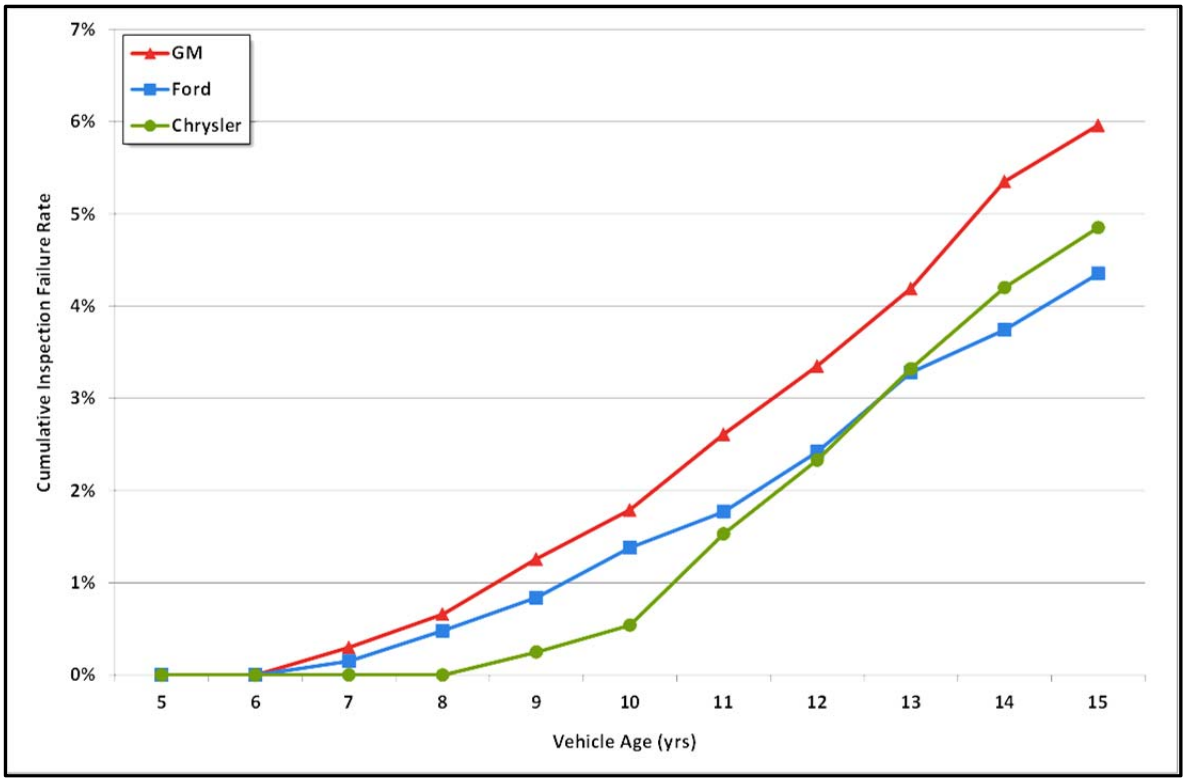

Figure A6. Cumulative Brake Pipe Inspection Failure Risk by Vehicle Age for MY 1999-2003 Full-Size Pickup Trucks, PennDOT E-SAFETY Data from CY 2008-2014 Inspections.

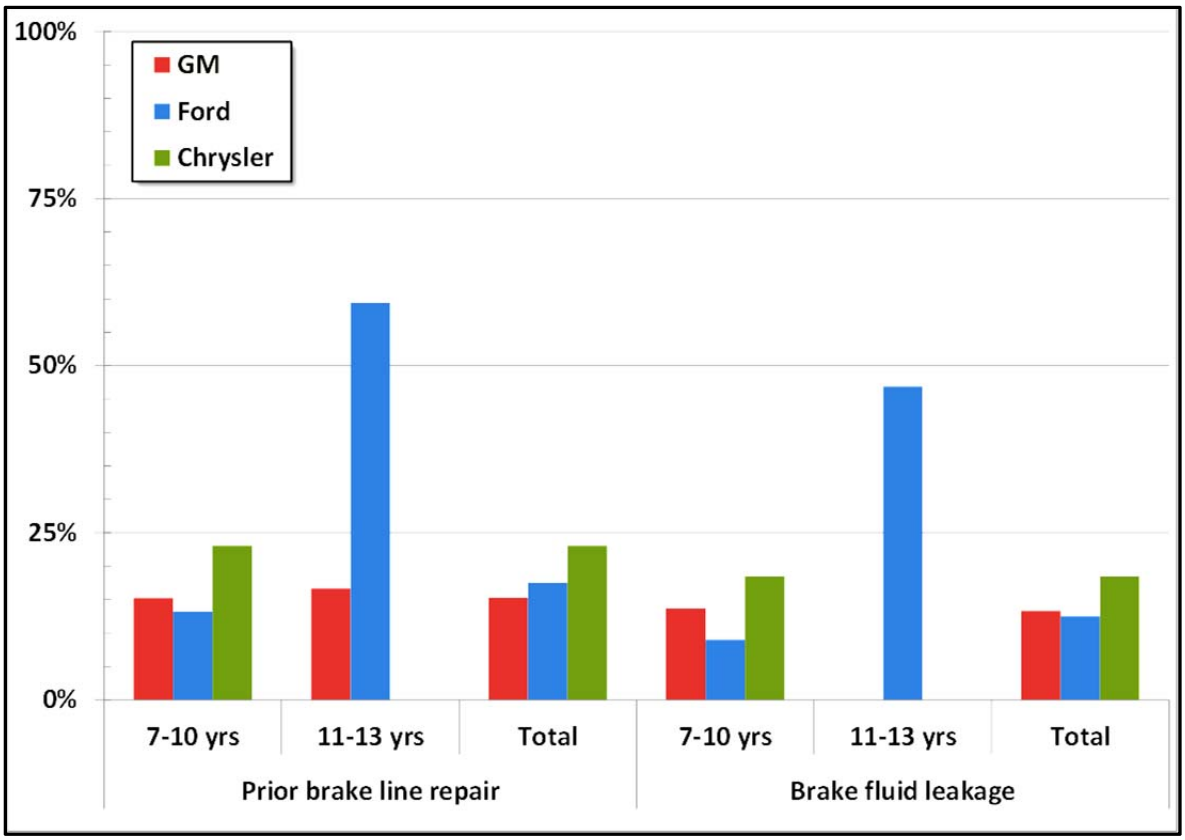

Figure A7. VRTC survey results by vehicle age, MY 1999-2003 full-size pickup trucks.

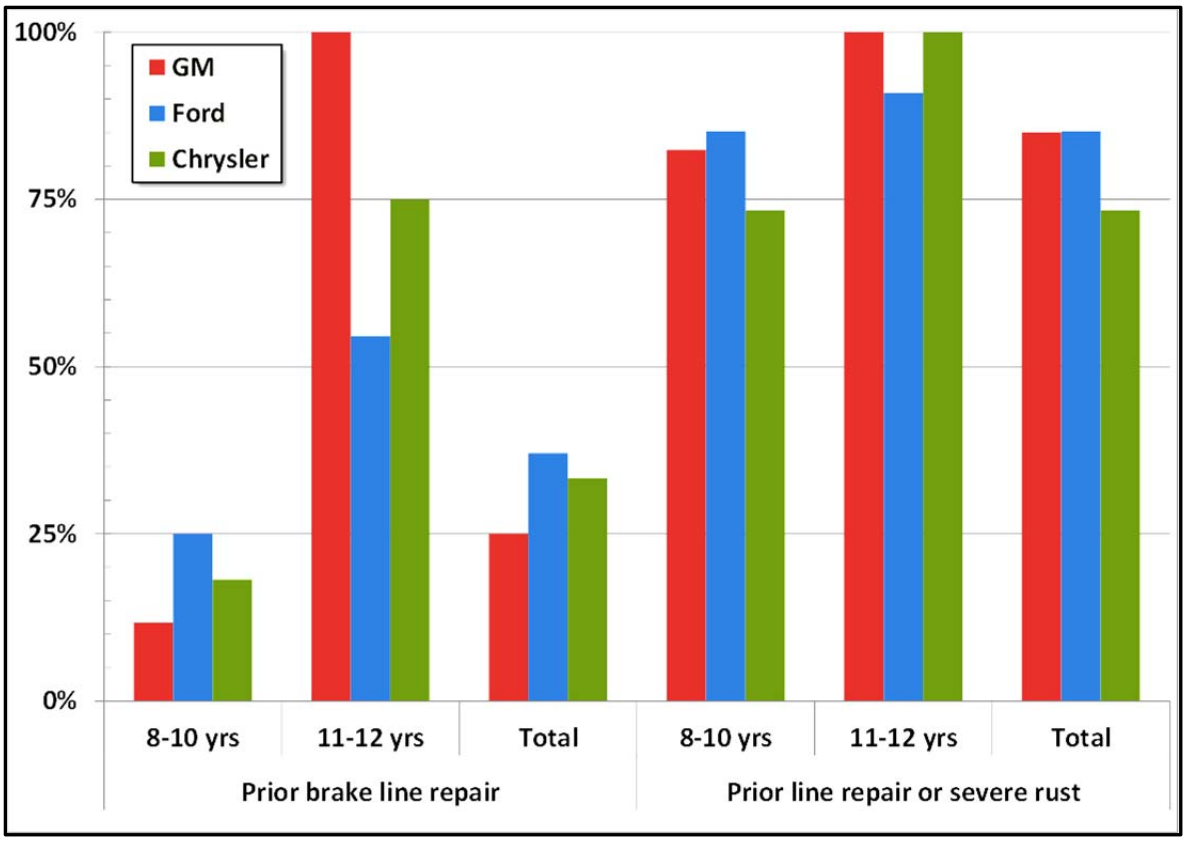

Figure A8. Combined Inspection Results by Vehicle Age, MY 1999-2003 Full-Size Pickup Trucks.

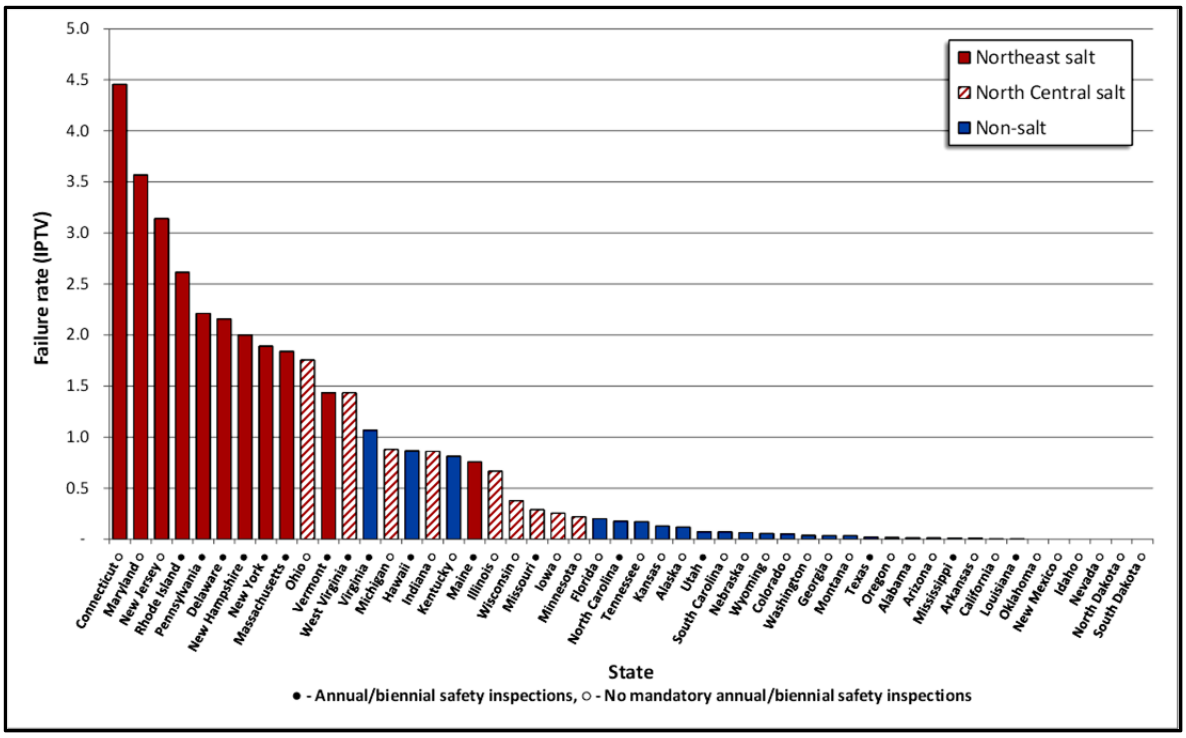

Figure A9. Failure Rate by State, MY 1999-2003 GMT800 Vehicles.

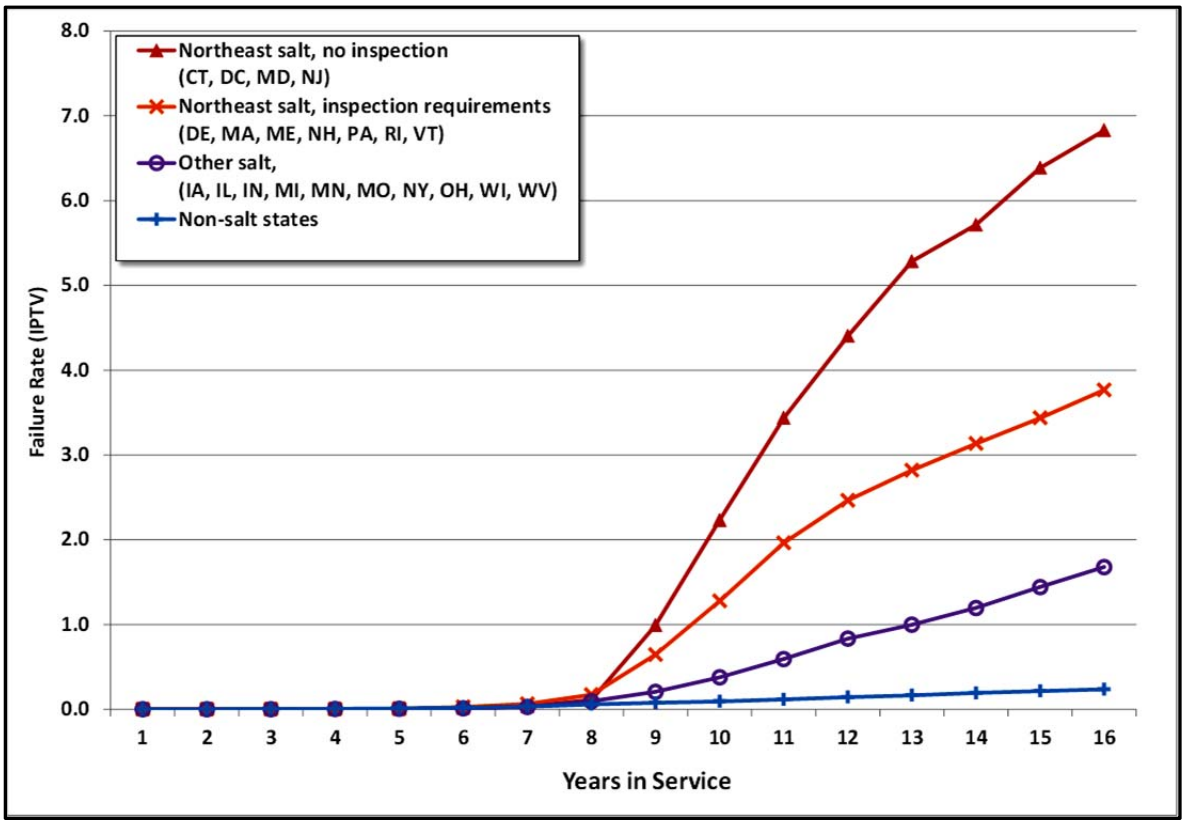

Figure A10. Cumulative Failure Rate by Vehicle Age and Region, MY 1999-2003 GMT800.

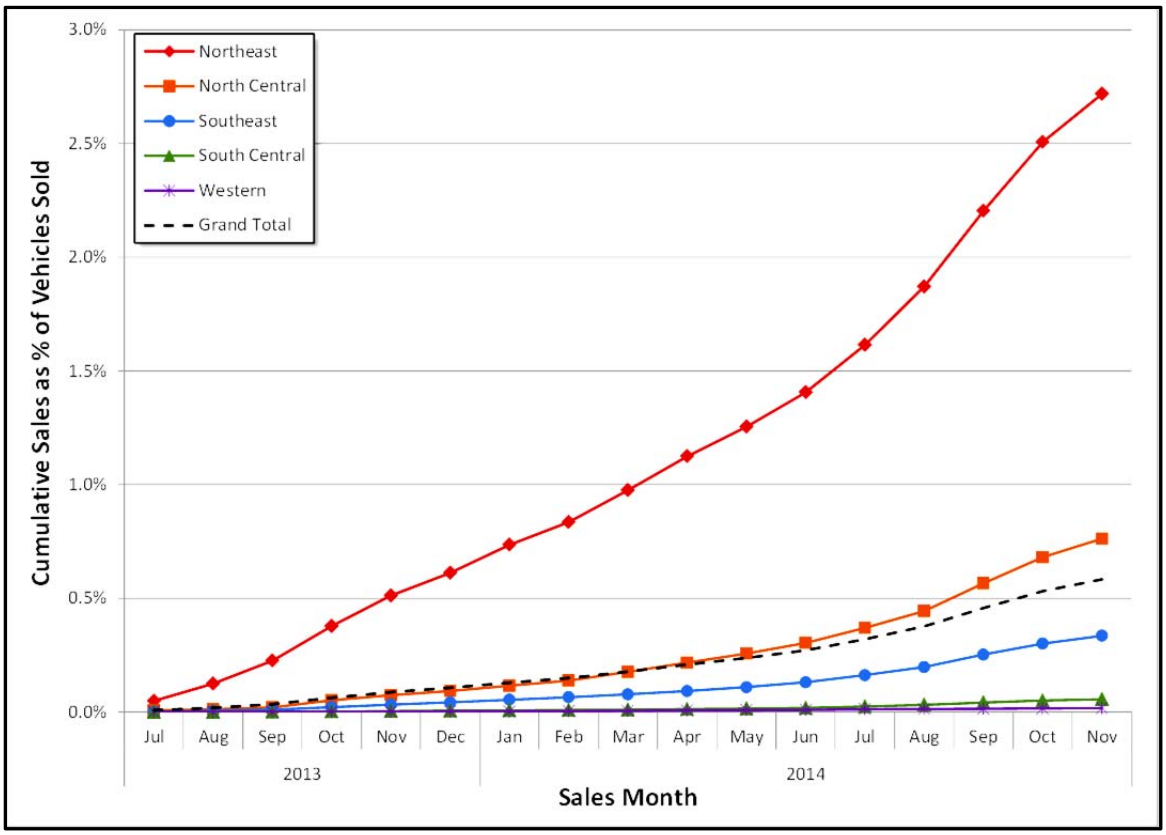

Figure A11. Combined GM Brake Pipe Kit Sales for Pickup Trucks by Region, as Approximate % of Vehicles Sold.

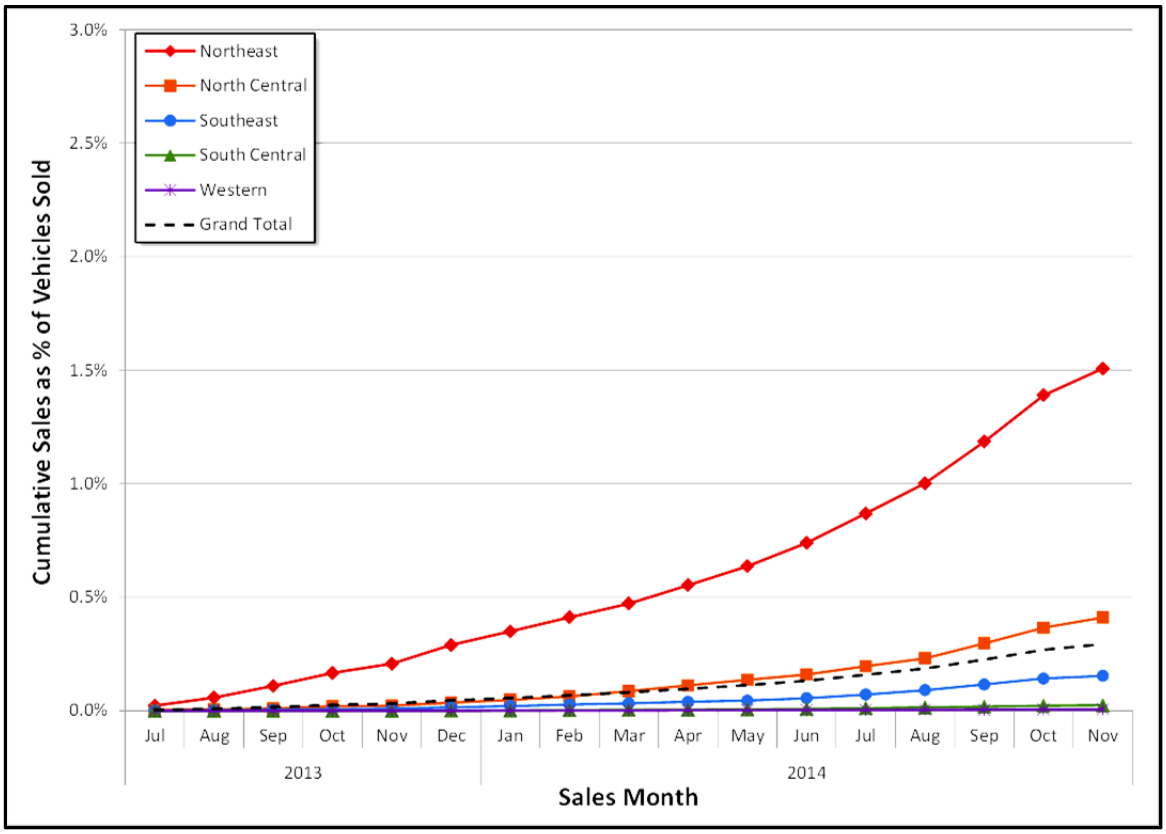

Figure A12. Combined GM Brake Pipe Kit Sales for Utility Vehicles by Region, as Approximate % of Vehicles Sold.