VRTC-DCD3064
EA03-012

Investigation of Brake Line Failures on 1995-1997 Ford Crown Victoria, Lincoln Town Car, And Mercury Grand Marquis

VEHICLE RESEARCH AND TEST CENTER
EAST LIBERTY, OHIO 43319

FINAL REPORT
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16. Abstract

The objective of this program was to determine the condition of the rear brake lines in subject and peer vehicles by conducting an owner survey (questionnaire) and a subsequent vehicle inspection program for subject and peer vehicles.

Almost all of the subject vehicles inspected exhibited corrosion and abrasion on the rear brake lines that were not found on the General Motors peer vehicles or on the post-1997 Ford exemplar vehicles that were inspected. At least six of the subject vehicles also exhibited more severe corrosion than that found on the Chrysler peer vehicles that were inspected.

The change to the mastic patch on subject vehicles during March 1997 did not appear to reduce or eliminate the contact between the brake lines and the floor pan rib above them as compared to the shrink-wrap design. The mastic patch did appear to help reduce corrosion to the portion of the brake line within the mastic patch. Corrosion on subject vehicles appeared to be the result of contact between the brake line and surrounding dissimilar materials, including the mounting pads.

Exemplar Ford vehicles (post-1997) did not exhibit corrosion of the rear brake lines. The brake lines appeared to be either made of a different material or covered with a protective coating. These vehicles were also equipped with different routing and mounting methods that appeared to prevent abrasion against the floor pan.

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1.0 Introduction

This program was performed at the Vehicle Research and Test Center (VRTC) at the request of the Office of Defects Investigation (ODI) of the National Highway Traffic Safety Administration (NHTSA). ODI opened an Engineering Analysis (EA03-012) in response to complaints of alleged brake line failures in 1995 through 1997 Lincoln Town Car, Mercury Grand Marquis, and Ford Crown Victoria vehicles.

2.0 Background

ODI received complaints of rear brake line failures in subject vehicles and additional complaints and warranty claims from Ford. An analysis by ODI of data submitted by Ford showed a disproportionate number of failures in 1997 Crown Victoria and Grand Marquis models manufactured after March 1997. Some reports were related to abrasive failure caused by the brake line rubbing on a rib of the floor pan located in the area of the transmission-mount cross member (see Figure 3.1) while others suggested that corrosion may also be a major contributor to the failures. Subject vehicles produced prior to mid-March 1997 were equipped with a piece of shrink wrap on the brake line (see Figure 3.2) that was meant to prevent the abrasive rubbing and failure of the brake line in this area. Starting in mid-March 1997, a running change was instituted on Ford Crown Victoria and Mercury Grand Marquis vehicles that added a "mastic patch" to surround the brake line and other nearby lines in the area where shrink wrap had been used previously. This running change was not instituted on the subject Lincoln Town Cars.

A search of the ODI complaint database for peer vehicle complaints identified only one complaint involving General Motors (GM) peer vehicles (Caprice, Impala, Eighty-Eight, Ninety-Eight, and Regal) and only two complaints involving Chrysler LH peer vehicles.

3.0 Objective

The initial objective of this program was to determine the condition of the rear brake lines in subject and peer vehicles by conducting an owner survey (questionnaire) and a subsequent vehicle inspection program for subject and peer vehicles.

Figure 3.1
Routing of Brake, Fuel, and Vapor Return Lines

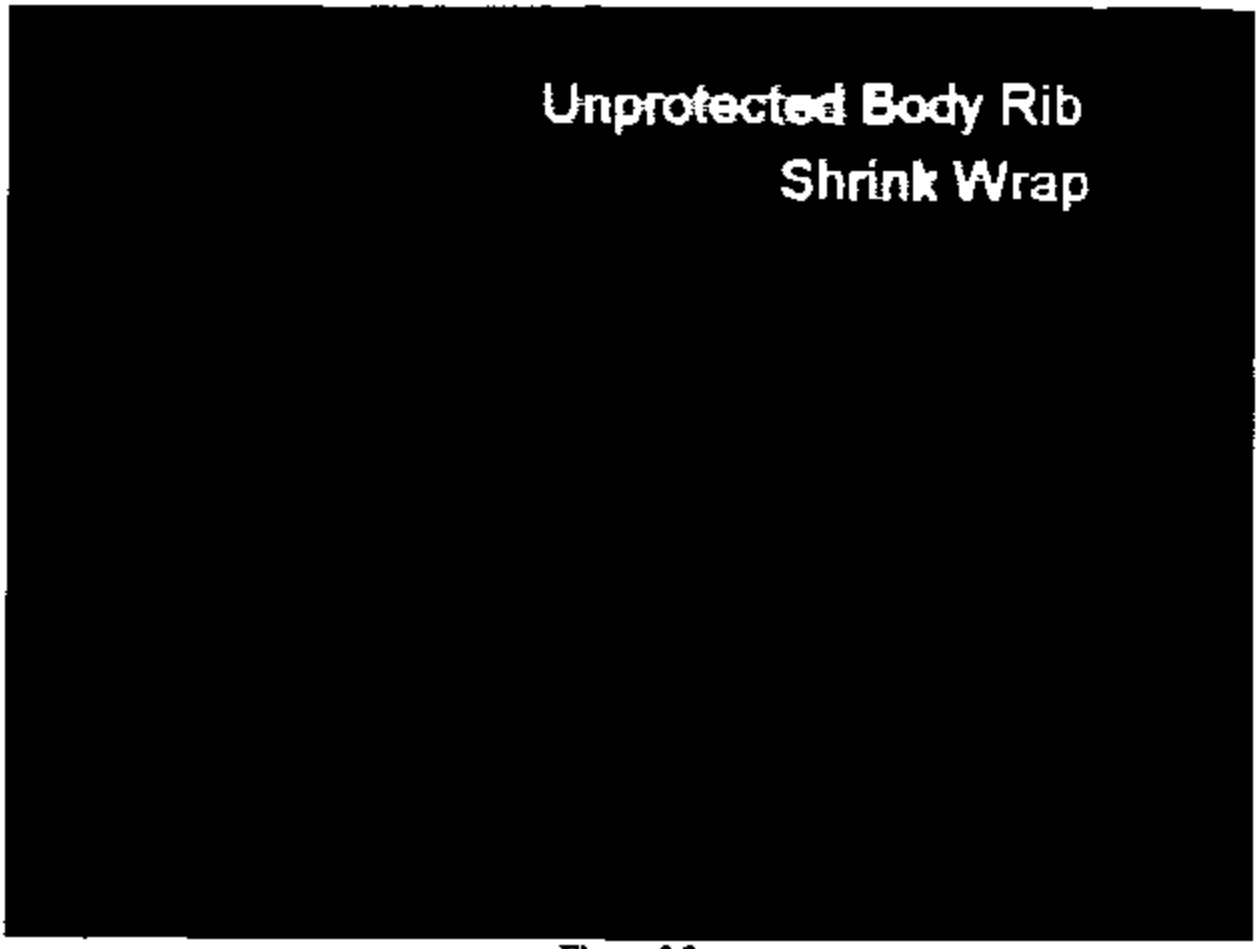


Figure 3.2
Shrink Wrap at Transmission Cross Member and Close Proximity at "Unprotected Area"

4.0 Procedure

The following activities were undertaken for this project:

1. Because VRTC is located in central Ohio, the Ohio Bureau of Motor Vehicles was requested to provide a list of owners of subject and peer vehicles within the state of Ohio. ODI identified the initial peer vehicles as 1995 – 1997 Chevrolet Caprice and Impala vehicles.

2. Questionnaires were mailed to 240 owners of subject vehicles and 40 owners of peer vehicles who resided within approximately 50 miles of VRTC. The questionnaires asked owners to provide the current odometer reading, the build date, and the owner's experience with brake line failure, if any, on their vehicle. A copy of the questionnaire is provided in Appendix 1.

3. Questionnaires that were returned from owners of subject vehicles were divided into three groups based on the build date of the vehicle. The three groups were: built before March 1997; built during March 1997; and built after March 1997. Each of these groups was then divided into two additional groups that were based on the owner's experience with the rear brake line. The two groups were: 1) rear brake line had not required repair and 2) rear brake line had already been repaired.

4. Attempts were made to contact owners who returned the completed questionnaires. When the owner was willing to participate, the vehicle was leased for a day and brought to VRTC. In a few cases, the vehicle was inspected at a dealership near the owner. The rear brake lines were inspected and photographed and certain clearances with body parts that were in close proximity to the brake lines were measured. On subject vehicles, special attention was given to the area where the brake line crossed over the stiffening rib at the transmission-mount cross member. The brake lines were replaced at a local Ford dealership in cases where the lines were deemed to be approaching failure.

5. In the case where the brake line was replaced as a result of the inspection, VRTC maintained possession of the removed brake line for subsequent microscopic examination and pressure testing. The pressure testing consisted of capping one end of the removed brake line and attaching the other end to a calibrated dead-weight tester and applying increasing pressure until a leak developed.

6. After the planned subject and peer (GM) vehicle inspections were complete, ODI requested that five additional peer vehicles, manufactured by Chrysler Corporation, be inspected. Peer vehicles from Chrysler were identified as 1995 – 1997 Chrysler LH vehicles. These included Chrysler Concorde, Dodge Intrepid, and Eagle Vision. Two of these peer vehicles were in the inventory of test vehicles at VRTC. The remaining three vehicles were found at local used vehicle dealerships.

7. After the subject and peer (Chrysler) vehicles were inspected, ODI requested that five exemplar (1998 or later) Ford Crown Victoria or Mercury Grand Marquis vehicles be inspected. The reason for this request was that Ford claimed that corrosion and abrasion of the rear brake line was not an issue with these vehicles after a design change starting with the 1998 model year. These vehicles were found at local used vehicle dealerships.

5.0 Results

The results of questionnaire responses, the visual inspections, and the pressure testing are presented below.

5.1 Subject Vehicles

The questionnaire to owners of subject Ford vehicles had a response rate of approximately 38%. A summary of the responses is shown in Table 1.

Table 1
Tabulation of Subject Vehicle Data

Subject Ford Vehicles	Numbers	Percentages	Build dates			
Total Questionnaires Sent:	240		1996/1996	1997		
Total Responses:	92	38%	All Months	pre-March	March	post-March
Has Not Required Repair:	73	79%	30	17	3	23
Has Already Been Repaired:	6	7%	4	0	0	2
No longer own:	7	8%				
Returned without answers:	6	7%				

5.1.1 Summary of Results for Subject Vehicle Inspections

A summary of the inspection results for the subject vehicles is shown in Table 2. Most of the columns in Table 2 are self-explanatory.

As noted earlier, subject vehicles manufactured prior to mid-March 1997 used a piece of shrink wrap on the brake line to protect the brake line from rubbing against the floor pan at the floor pan rib located above the transmission-mount cross member. Ford Crown Victoria and Mercury Grand Marquis subject vehicles manufactured after mid-March 1997 had a much larger mastic patch that surrounded the brake line and the other nearby lines in the area of the transmission-mount cross member. The column labeled "Protected Area, Type" refers to which method of brake line protection was utilized.

The column labeled "Protected Area, Contact or Clearance" refers to whether or not the shrink wrap on the brake line was found to be in contact with the floor pan stiffener. In most cases where there was no contact, the clearance is listed as measured with a feeler gauge. Vehicles equipped with the mastic patch all had contact between the mastic patch and the floor pan.

After the first two vehicles had been inspected, an additional area to inspect was noted approximately 4 inches to the rear of the area protected by shrink-wrap. The clearance between the unprotected brake line and the floor pan stiffening in this secondary area was minimal or there was contact. The column labeled "Unprotected Area Contact or Clearance" refers to whether or not this condition existed. In cases where there was no contact in this secondary area, the clearance is listed. This area will be referred to as the "unprotected area" in this report.

Table 2 - Summary of Results of Inspections of Subject Vehicles

Insp. No.	Model Year	Vehicle	VIN	Mfg. Date	Odometer Reading	No. of Brake Lines	Corrosion on Brake Lines		Repaired	Protected Area		Unprotected Area Contact or Clearance (in.)
							Locations	Severity		Type	Contact or Clearance (in.)	
1	1995	Town Car	1LNLM83W8SY[redacted]	Jan-95	140,120	2	All	Heavy	By Owner	SW	No Contact	Not Inspected
2	1995	Crown Vic	2FALP73W8SX[redacted]	Dec-94	52,533	1	Isolated	Light	No	SW	Contact	Not Inspected
3	1995	Town Car	1LNLM82W8SY[redacted]	Aug-94	78,391	2	Most	Moderate	No	SW	No Contact	-1/4
4	1996	Crown Vic	2FALP74W6TX[redacted]	Nov-95	123,242	1	Front Half	Moderate	No	SW	No Contact	Probable Contact
5	1996	Crown Vic	2FALP74W2TX[redacted]	Nov-95	77,850	1	Front	Very Light	No	SW	No Contact	Contact
6	1997	Town Car	1LNLM81W2VY[redacted]	Oct-96	140,989	2	Cross mbr & body mt.	Light	No	SW	Contact	0.025
7	1995	Crown Vic	2FALP74W8SX[redacted]	Apr-95	89,880	1	At Cross Member	Light	No	SW	Contact	-1/4
8	1996	Crown Vic	2FALP74W2TX[redacted]	Mar-96	52,429	1	Front Half	Moderate	No	SW	Contact	0.015
9	1997	Town Car	1LNLM82W8VY[redacted]	Aug-97	32,888	2	Slight under rear door	Very Light	No	SW	Contact	-1/4
10	1997	Crown Vic	2FALP74W8VX[redacted]	Apr-97	40,950	1	None	None	No	MP	Contact	0.045
11	1996	Crown Vic	2FALP73W3TX[redacted]	Jul-96	116,511	1	Middle area	Moderate	Maybe	SW	Contact	0.015
12	1997	Crown Vic	2FALP74W6VX[redacted]	Jun-97	112,894	2	Cross mbr & body mt.	Moderate	No	MP	Contact	0.115
13	1997	Town Car	1LNLM81W5VY[redacted]	Sep-97	98,675	2	Behind Body Mt.	Very Light	No	SW	1/4	-1/4
14	1997	Town Car	1LNLM82W2VY[redacted]	May-97	39,850	2	Isolated, Random	Moderate	No	SW	Contact	-1/8
15	1997	Crown Vic	2FALP74W7VX[redacted]	Jul-97	71,541	2	Isolated	Lt. To Heavy	No	MP	Contact	-1/2
16	1997	Crown Vic	2FALP72W6VX[redacted]	Aug-96	85,712	1	All except rear	Moderate	No	SW	Contact	0.035
17	1997	Town Car	1LNLM83W2VY[redacted]	Dec-96	116,702	2	All	Heavy	No	SW	0.035	-1/4
18	1997	Crown Vic	2FALP74W3VX[redacted]	Sep-96	145,755	1	All	Moderate	No	SW	Contact	Contact
19	1997	Crown Vic	2FALP74W4VX[redacted]	Oct-97	40,257	1	At mounting clips	Light	No	MP	Contact	-1/4
20	1995	Crown Vic	2FALP74W3SX[redacted]	Jan-95	174,590	1	At Cross Member	Heavy	No	SW	0.060	0.15
21	1997	Crown Vic	2FALP73W2VX[redacted]	Oct-96	51,188	1	Ahead of Cross Mbr.	Heavy	By VRTC	SW	0.017	0.03
22	1994	Town Car	1LNLM83W8SY[redacted]	Dec-94	60,530	2	All	Heavy	By Owner	SW	N/A	N/A

SW = Shrink Wrap
MP = Mastic Patch

5.1.2 Descriptions of Subject Vehicle Inspections

Results of each of the 22 subject vehicle inspections are discussed below. Selected photos from the subject vehicle inspections are provided in Appendix 2.

5.1.2.1 1995 Lincoln Town Car, VIN: 1LNLM82W8SY[redacted]

The odometer reading on this vehicle was 140,120 miles. This vehicle was equipped with ABS and dual rear brake lines. Both brake lines had been repaired prior to this inspection. The repair consisted of inserting two new sections of brake line, each measuring approximately 54 in. long, in the original brake lines using flare union fittings. The front union was directly under the front of the left front door. The rear union was approximately 6 inches to the rear of the front of the left rear door. The remainder of the original brake lines was extremely corroded. According to the owner's questionnaire, the new sections of brake line had been in place less than six months but were already somewhat corroded. The new brake lines had been bent so that they did not contact the transmission-mount cross member.

5.1.2.2 1995 Crown Victoria, VIN: 2FALP73W9SX[redacted]

The odometer reading on this vehicle was 52,533 miles. This vehicle had one brake line to the rear axle that was in very good condition with only isolated areas of light corrosion. Shrink-wrap was attached to the brake line where the line was routed between the floor pan and the transmission-mount cross member. The shrink-wrap was in contact with the floor pan rib. The brake line was also in contact with the "unprotected area."

5.1.2.3 1995 Town Car, VIN: 1LNLM82W8SY[redacted]

The odometer reading on this vehicle was 78,391 miles. This vehicle was equipped with ABS and dual rear brake lines. Both lines were moderately corroded. The brake line closest to the body was protected by shrink-wrap in the area of the body rib. The shrink-wrap was not in contact with the body rib. There was approximately ¼ inch of clearance at the "unprotected area."

5.1.2.4 1996 Crown Victoria, VIN: 2FALP74W6TX[redacted]

The odometer reading on this vehicle was 123,242 miles. This vehicle had one brake line to the rear axle. The line was moderately corroded toward the front of the vehicle and mostly free of corrosion toward the rear of the vehicle. Shrink-wrap was attached to the brake line where the line was routed between the floor pan and the transmission-mount cross member. There was a very small gap between the shrink-wrap and the floor pan. There appeared to be contact between the brake line and the floor pan at the "unprotected area." This contact could not be confirmed since access to this area was restricted and bending the brake line would have been necessary to take a measurement.

5.1.2.5 1996 Crown Victoria, VIN: 2FALP74W2TX[redacted]

The odometer reading on this vehicle was 77,650 miles. This vehicle had one brake line to the rear axle. The line was very lightly corroded. It appeared that the brake line had been previously pulled downward in front of the transmission-mount cross member so that the shrink-wrapped area did not contact the floor pan. There was a light-colored powdery residue on the brake line from rubbing contact with the floor pan at the "unprotected area." The rest of the brake line was unremarkable. The brake line was bent slightly before returning the vehicle to the owner to prevent continued rubbing.

5.1.2.6 1997 Town Car, VIN: 1LNLM81W2VY[redacted]

The odometer reading on this vehicle was 140,989 miles. This vehicle was equipped with ABS and dual rear brake lines. The area over the cross member had shrink wrap on one brake line but not on the other. The shrink-wrap was in contact with the floor pan; the clearance on the other brake line was measured at 0.025 inch. Both brake lines were lightly corroded near the transmission-mount cross member and near the body mount. The remainder of the brake lines was not corroded. The brake lines and all the lines parallel to them were wrapped with a single piece of rubber or shrink-wrap where the lines pass between the body mount and the floor pan, under the left rear door. The wrap had a longitudinal split that faced inboard on the car. This "rubber" wrap was not noted on vehicles inspected previously.

5.1.2.7 1995 Crown Victoria, VIN: 2FALP74W0SX[redacted]

The odometer reading on this vehicle was 99,690 miles. This vehicle had one brake line to the rear axle. The vehicle had been undercoated and, except for a small area of light corrosion ahead of the transmission-mount cross member, the line was unremarkable. The shrink-wrap was in contact with the floor pan. The clearance at the "unprotected area" was approximately 0.025 inch.

5.1.2.8 1996 Crown Victoria, VIN: 2FALP74W2TX[redacted]

The odometer reading on this vehicle was 52,429 miles. This vehicle had one brake line to the rear axle. Moderate corrosion was present starting at the front of the brake line, and extended to approximately 1 foot behind the transmission-mount cross member. There was also minimal corrosion to the rear of the body mount located under the left rear door. The shrink-wrap was in contact with the floor pan. The clearance at the "unprotected area" was 0.015 inch.

5.1.2.9 1997 Town Car, VIN: 1LNLM82W6VY[redacted]

The odometer reading on this vehicle was 32,668 miles. This vehicle was equipped with ABS and dual rear brake lines. The brake lines had only a very light amount of corrosion. The only visible corrosion was at the small rubber damper near the body mount beneath the left rear door. The shrink-wrap appeared to be slightly thicker than on other vehicles and was in contact with the floor pan. The clearance at the "unprotected area" was approximately ¼ inch.

5.1.2.10 1997 Crown Victoria, VIN: 2FALP74W8VX[redacted]

The odometer reading on this vehicle was 40,950 miles and the build date was after March 1997. This vehicle had one brake line to the rear axle. This was the first vehicle to be inspected that was equipped with a mastic patch. The patch surrounded all the lines at the cross member area where previous models had only shrink-wrap on the brake line. The mastic patch had a soft, rubbery consistency and was in contact with the floor pan. The clearance at the "unprotected area" was 0.045 inch. The brake line exhibited no visible corrosion.

5.1.2.11 1996 Crown Victoria, VIN: 2FALP73W3TX[redacted]

The odometer reading on this vehicle was 118,511 miles. This vehicle had one brake line to the rear axle. The owner questionnaire described this vehicle as having had the brake line repaired

but there was no evidence of any new brake line. There was moderate corrosion on the middle area of brake line, between the front area and the body mount beneath the left rear door. The brake line was protected by shrink-wrap that was in contact with the floor pan. The clearance at the "unprotected area" was 0.015 inch.

5.1.2.12 1997 Crown Victoria, VIN: 2FALP74W8VX[redacted]

The odometer reading on this vehicle was 112,694 miles and the build date was after March 1997. This vehicle was equipped with ABS and dual rear brake lines. There was moderate corrosion on both lines, both at the transmission-mount cross member and to the rear of the body mount under the left rear door. There were also portions of both brake lines that were free of corrosion. A mastic patch surrounded the brake lines and all of the parallel lines nearby at the transmission-mount cross member. The patch was in contact with the floor pan. The clearance at the "unprotected area" was 0.115 inch.

5.1.2.13 1997 Town Car, VIN: 1LNLM81W5VY[redacted]

The odometer reading on this vehicle was 98,675 miles. This vehicle was equipped with ABS and dual rear brake lines. There was very light corrosion on the brake lines, starting at the body mount under the left rear door and extending rearward for about 1 foot. There was shrink-wrap on only one brake line. There was at least 1/4" clearance at the "unprotected area." There was what appeared to be a "rubber" patch in the area of the body mount, similar to that described in Section 5.1.2.6.

5.1.2.14 1997 Town Car, VIN: 1LNLM82W2VY[redacted]

The odometer reading on this vehicle was 39,950 miles. This vehicle was equipped with ABS and dual rear brake lines. There was moderate corrosion randomly located at various locations on both brake lines. The shrink-wrap area was in very light contact with the floor pan. A 0.001-inch feeler gage could almost be inserted between the shrink-wrap and the floor pan rib. The clearance at the "unprotected area" was approximately 1/8 inch.

5.1.2.15 1997 Crown Victoria, VIN: 2FALP74W7VX[redacted]

The odometer reading on this vehicle was 71,641 miles and the build date was after March 1997. This vehicle was equipped with ABS and dual rear brake lines. The car was equipped

with a mastic patch that was in contact with the floor pan. There was a hole in the patch that exposed the lines but the lines did not appear to have been contacting the floor pan. There was light to heavy corrosion on both lines in all areas except inside the patch and above the body mount beneath the left rear door. The portions of brake line within the mastic patch were much less corroded that the areas outside the patch. The clearance at the "unprotected area" was approximately 0.050 inch. The mastic patch could not be completely removed from the vehicle so photographically documenting the hole in the mastic patch was limited. The patch was rotated before returning the vehicle to its owner so that an unworn area of the patch was aligned between the brake lines and the floor pan.

5.1.2.16 1997 Crown Victoria, VIN: 2FALP72W6VX[redacted]

The odometer reading on this vehicle was 85,712 miles and the build date was prior to March 1997. This vehicle was equipped with a single rear brake line. The brake line was covered with moderate corrosion along all but the rearmost portion. The shrink-wrap was in light contact with the floor pan and there was no visible wear. The clearance at the "unprotected area" was approximately 0.035 inch.

5.1.2.17 1997 Town Car, VIN: 1LNLM83W2VY[redacted]

The odometer reading on this vehicle was 118,702 miles. This vehicle was equipped with ABS and dual rear brake lines. Both brake lines were heavily corroded along their entire length. The clearance at the shrink-wrap was 0.095 inch. The clearance at the "unprotected area" was approximately ¼ inch.

5.1.2.18 1997 Crown Victoria, VIN: 2FALP74W3VX[redacted]

The odometer reading on this vehicle was 145,756 miles and the build date was prior to March 1997. This vehicle was equipped with a single rear brake line. The brake line was moderately corroded along its entire length. It had shrink-wrap protection that was making light contact with the floor pan. There was no discernable wear on the shrink-wrap. The brake line was discolored in the "unprotected area." Although there was light contact in this area, there was no discernable abrasion to this area of the line.

5.1.2.19 1997 Crown Victoria, VIN: 2FALP74W4VX[redacted]

The odometer reading on this vehicle was 40,257 miles and the build date was after March 1997. This vehicle was equipped with a single rear brake line. The brake line exhibited minimal corrosion, mostly near the plastic clips that held it in place. The mastic patch was removed during the inspection and was found to have a triangular hole in it that was apparently caused by rubbing on the floor pan. The portion of brake line within the patch area exhibited no corrosion. In the "unprotected area," a soft and spongy rubber-like material was attached to the brake line. This material was approximately ¼ inch thick. It was in contact with the floor pan and protected the brake line from rubbing against the floor pan rib.

5.1.2.20 1995 Crown Victoria, VIN: 2FALP74W3SX[redacted]

The odometer reading on this vehicle was 174,590 miles. This vehicle was equipped with a single rear brake line. The brake line was completely free of corrosion in some places but was severely corroded, to the point of flaking, near the shrink-wrapped area. The clearance at the shrink-wrapped area was 0.060 inch. The clearance at the "unprotected area" was 0.150 inch. The least corrosion was next to the catalytic converter. Rearward of the shrink-wrapped area, the corrosion was mostly light.

5.1.2.21 1997 Crown Victoria, VIN: 2FALP73W2VX[redacted]

The odometer reading on this vehicle was 51,188 miles and the build date was prior to March 1997. This vehicle was equipped with a single rear brake line. The brake line was extremely corroded ahead of the transmission-mount cross member, to the point of extensive flaking. The corrosion was deemed severe enough that the vehicle was sent to a local Ford dealer to have the brake line replaced before the vehicle was returned to the owner. The clearance at the shrink-wrap was 0.017 inch. The clearance at the "unprotected area" was 0.030 inch. After the brake line was removed, it was pressure tested. A small leak developed at 2,500 psi.

5.1.2.22 1994 Town Car, VIN: 1LNLM83W8SY[redacted]

The odometer reading on this vehicle was 80,630 miles. This vehicle was equipped with ABS and dual rear brake lines. Sections of both rear brake lines had been replaced by the owner prior to this inspection. The replaced old sections were left in place and the new sections were added in a parallel fashion. Instead of being properly installed in the original mounting clips, the new

sections of the brake lines were held in place by friction against the body and each other and by one tie-wrap. Each new section had only one splice visible underneath the car.

The new sections of line were grayish in color and had some light corrosion where one of them contacted the steel transmission-mount cross member. There was no corrosion where the two new sections made contact with each other.

The original replaced sections of brake line were most corroded where they were in contact with the other lines in the area. It appeared that the corrosion was an electro-chemical reaction between dissimilar metals, possibly exacerbated by road salt. The corrosion did not appear to be initiated by abrasion or stone chips.

Portions of the original replaced sections of the brake line were removed from this vehicle and sectioned so that the wall thickness could be measured. A relatively non-corroded section of this original brake line (see Figure 5.1) was determined to have a wall thickness of 745 micrometers (0.029 inch). One corroded section of the brake line (see Figure 5.2) was determined to have an area where the wall thickness was 376 micrometers (0.015 inch). Another corroded section (see Figure 5.3) was determined to have an area where the wall thickness was 183 micrometers (0.007 inch). Microscopic examination of the sections of brake line showed that the corrosion was limited to the outside wall of the brake line.

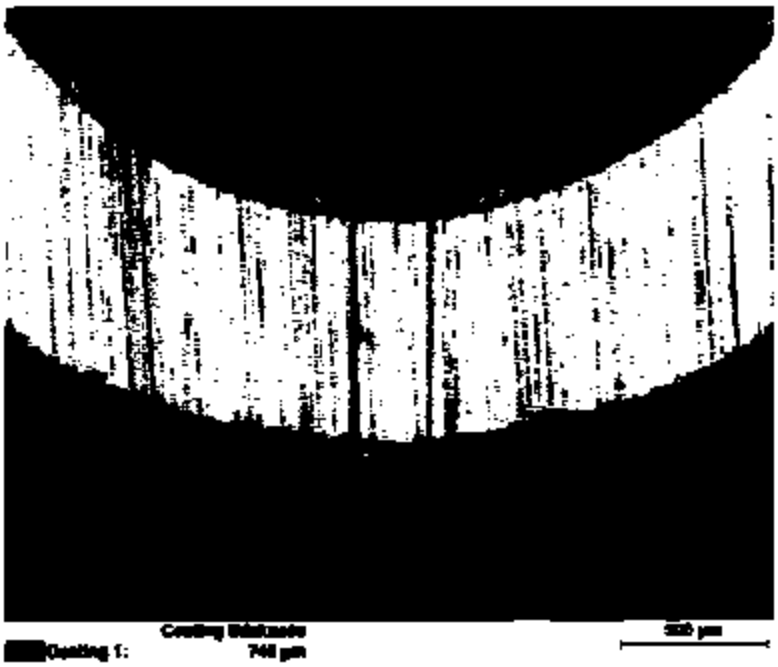


Figure 5.1
Relatively Non-Corroded Brake Line - 745 µm Cross Section

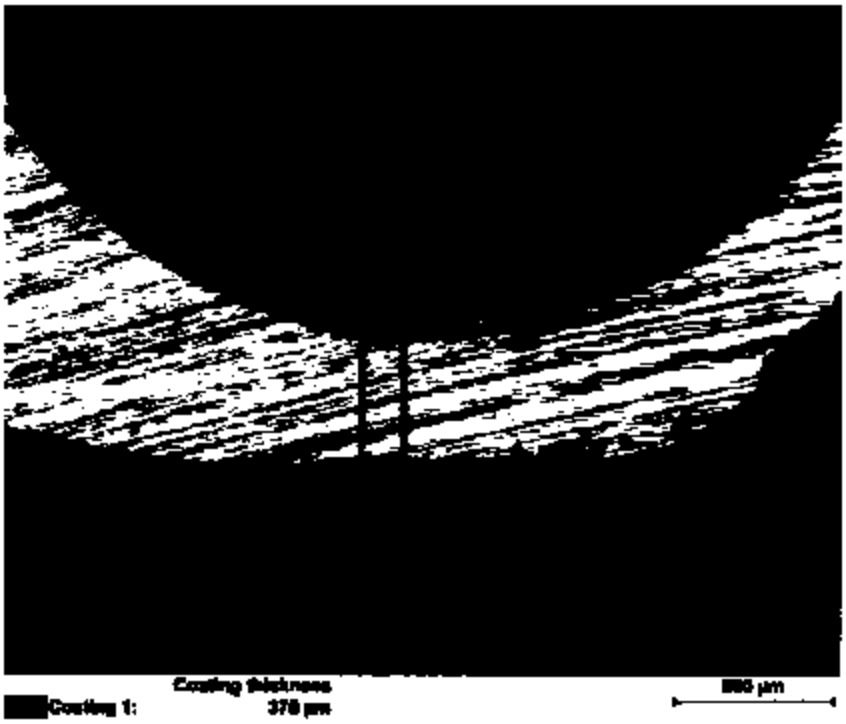


Figure 5.2
Corroded Section of Brake Line - 376 µm Cross Section

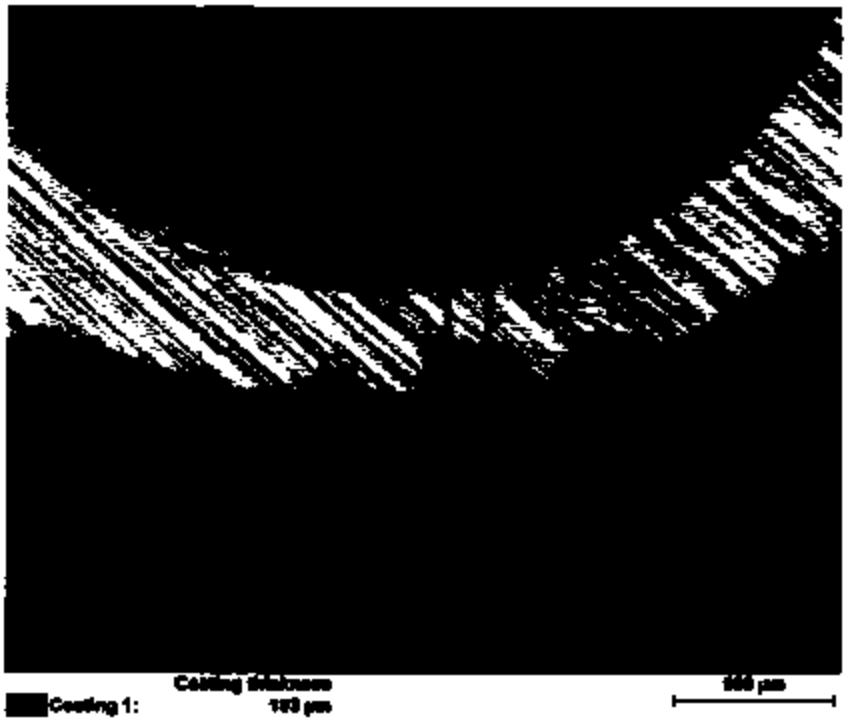


Figure 5.3
Corroded Section of Brake Line - 183 µm Cross Section

5.2 General Motors Peer Vehicles

The results of the GM peer vehicle inspections are discussed below.

5.2.1 Tabulation of Questionnaire Response Data

The questionnaire to owners of GM peer vehicles had a response rate of 28%. A summary of the responses is shown in Table 3.

Table 3
Tabulation of GM Peer Vehicle Data

GM Peer Vehicles:	Numbers	Percentages
Total Questionnaires Sent:	40	
Total Responses:	11	28%
Has Not Required Repair:	9	82%
Has Already Been Repaired:	0	0%
Currently Needs Repair:*	1	9%
No longer own:	1	9%

Note: * Not available for inspection

5.2.2 Summary of Vehicle Inspection Results

A summary of the inspection results for the GM peer vehicles is shown in Table 4. Only one owner replying to the questionnaire was able to provide his vehicle (1996 Caprice) during this test program. The other four GM vehicles were found at local used vehicle dealerships.

Table 4
Summary of GM Peer Vehicle Inspections

Insp. No.	Model Year	Vehicle	VIN	Mfg. Date	Mileage	Corrosion
1	1996	Caprice	1G1BL52W4TR[redacted]	Feb-96	79,028	None
2	1996	Impala SS	1G1BL52P8TR[redacted]	Jun-96	77,954	None
3	1996	Impala SS	1G1BL52W4TR[redacted]	Jun-96	81,181	None
4	1995	Impala SS	1G1BL52P3SR[redacted]	Mar-95	92,313	None
5	1996	Impala SS	1G1BL52P4TR[redacted]	Unknown	66,405	None

The date of manufacture of the fifth GM peer vehicle was unknown because the certification label was not present. An analysis of the VIN indicated the vehicle was manufactured prior to February 1996.

5.2.3 Results of Vehicle Inspections

Each of the five GM peer vehicles inspected had a single rear brake line. The line was routed along the inside of the left frame rail, similar to the location used by Ford. Unlike Ford, the GM peer vehicles did not have any other lines in the vicinity of the brake line. None of the vehicles exhibited any visible corrosion on the brake line. There was no evidence that any of these vehicles had a previous brake line replacement. Selected photos of GM peer vehicle inspections are provided in Appendix 3.

5.3 Chrysler Corporation Peer Vehicles

The results of the Chrysler peer vehicle inspections are discussed below.

5.3.1 Summary of Vehicle Inspection Results

A summary of the inspection results for the Chrysler peer vehicles is shown in Table 5.

Table 5
Summary of Chrysler Corporation Peer Vehicle Inspections

Insp. No.	Model Year	Vehicle	VIN	Mfg. Date	Mileage	Corrosion	
						Location	Amount
1	1996	Concorde	1C3HD56F9TF[redacted]	Feb-96	54,088	Isolated	Lt to mod.
2	1996	Concorde	1C3HD56F6TF[redacted]	Feb-96	47,594	Isolated	Lt to mod.
3	1997	Intrepid	(Not documented)	Oct-96	~78,000	None	None
4	1995	Intrepid	2C3HD56F5S[redacted]	Dec-94	91,596	Isolated	Lt to mod.
5	1995	Concorde	2C3EL56F0P[redacted]	May-93	113,275	Isolated	Lt to mod.

5.3.2 Descriptions of Vehicle Inspections

Each of the five Chrysler peer vehicles was equipped with dual rear brake lines. The brake lines were routed with three other lines along the lower surface of the floor pan and located approximately halfway between the longitudinal centerline of the vehicle and the right edge of the vehicle. All five lines were attached to the vehicle using four shared plastic mounting clips. There was no evidence that the brake lines had been replaced on any of these vehicles. Results of each inspection are discussed below. Selected photos from the Chrysler peer inspections are provided in Appendix 4.

5.3.2.1 1996 Concorde, VIN: 1C3HD56F9T[redacted]

The odometer reading on this vehicle was 54,088 miles. Very light corrosion was found on both brake lines near each of the four mounting clips. Moderate corrosion was found on both brake lines in the area of the fuel pump. Otherwise, the brake lines were free of corrosion.

5.3.2.2 1996 Concorde, VIN: 1C3HD56F6TF[redacted]

The odometer reading on this vehicle was 47,594 miles. Light corrosion was found on both brake lines near each of the four mounting clips. Light to moderate corrosion was found on both brake lines in the area of the fuel pump. Otherwise, the brake lines were free of corrosion.

5.3.2.3 1997 Intrepid, VIN: (not recorded)

The odometer reading on this vehicle was approximately 78,000 miles. No corrosion was found on either brake line of this vehicle.

5.3.2.4 1995 Intrepid, VIN: 2C3HD56F5SH[redacted]

The odometer reading on this vehicle was 91,596 miles. Light corrosion was found on both brake lines in four areas: at the mounting clip at the center of the vehicle, in the area of the fuel pump, next to the fuel tank, and over the right rear suspension area. Both brake lines were found to be somewhat discolored just rearward of where they came down from the engine compartment. Because there was dampness from a fluid leak in this area, including dampness in the surrounding body area, it was unclear whether this discoloration was the beginning of some corrosion or if it was caused by a fluid leak. The brake lines were otherwise free of corrosion.

5.3.2.5 1993 Concord, VIN: 2C3EL56F0PH[redacted]

The odometer reading on this vehicle was 113,275 miles. Minimal corrosion was found on both brake lines near three of the four mounting clips. Both lines were free of corrosion at the rearmost mounting clip. Moderate corrosion was found on both brake lines in the area of the fuel pump. Clear liquid that appeared to be water, possibly from the air conditioner condenser, was also found on the brake lines at the front clip. The brake lines were otherwise free of corrosion.

5.4 Ford Exemplar Vehicles

The results of the 1998 - 1999 Ford exemplar vehicle inspections are discussed below.

5.4.1 Summary of Vehicle Inspection Results

A summary of the inspection results for the Ford exemplar vehicles is shown in Table 6.

Table 6
Summary of Ford Exemplar Vehicle Inspections

Insp. No.	Model Year	Vehicle	VIN	Mfg. Date	Mileage	Corrosion
1	1999	Grand Marquis	2MEFM75W9X[redacted]	Oct-98	Not recorded	None
2	1998	Crown Victoria	2FAFP74W9WX[redacted]	Dec-97	120,941	None
3	1999	Crown Victoria	2FAFP73W6XX[redacted]	Nov-98	46,844	None
4	1999	Crown Victoria	2FAFP74W7XX[redacted]	Mar-99	69,868	None
5	1998	Crown Victoria	2FAFP74W2WX[redacted]	Mar-98	101,617	None

5.4.2 Results of Vehicle Inspections

Four of the five Ford exemplar vehicles inspected had a single rear brake line. The remaining exemplar vehicle (Inspection No. 5) had dual rear brake lines and ABS. The brake lines on these vehicles were black rather than the silver/gray found on the subject vehicles. None of the brake lines on these vehicles exhibited any visible corrosion. There was no evidence that the brake lines had been replaced on any of these vehicles. These vehicles utilized a method of mounting the brake lines that held the line approximately ¼ inch away from the vehicle frame. The brake lines on these vehicles were routed in a manner that appeared to eliminate the possibility of abrasion due to contact with the floor pan in the area of the transmission-mount cross member. Selected photos of the Ford exemplar inspections are provided in Appendix 5.

6.0 Discussion

Abrasion from contact with the floor pan was exhibited on the brake line of several subject vehicles. In addition, all except one of the 22 subject vehicles inspected had some amount of corrosion of the rear brake lines. The corrosion of the brake line was judged to be heavy on six of the subject vehicles, including three "repaired" vehicles where replacement of the brake lines appeared to be necessary. Two of the "repaired" subject vehicles had already had the rear brake lines replaced prior to the inspection by VRTC. This would suggest that the brake lines had failed at some point or the corrosion on the lines was significant enough to merit replacing the

lines as preventative maintenance. Inspection of the repaired brake lines on these two vehicles showed that corrosion had already begun on the new sections of brake line. The corrosion appeared to originate where the brake line contacted dissimilar metals, such as body structures and other lines running parallel to the brake lines, and near the plastic clips used to hold the brake lines in place on the vehicle. One of the "repaired" subject vehicles exhibited corrosion to the extent that VRTC used a local Ford dealership to have the brake line replaced prior to returning the vehicle (1997 Crown Victoria) to the owner. Testing showed that the section of brake line removed from this vehicle generated a leak when pressurized to 2,500 psi. (Brake line pressure does not normally exceed 2,000 PSI)

Metallurgical sectioning and analysis of sections of a "replaced" brake line removed from one "repaired" subject vehicle (1994 Town Car) showed that corrosion had significantly reduced the wall thickness in two areas identified as having heavy corrosion.

None of the GM peer vehicles exhibited any visible corrosion of the rear brake line or abrasion due to contact with any portion of the vehicle. Four of the five Chrysler peer vehicles exhibited isolated light-to-moderate corrosion of both brake lines. None of these peer vehicles exhibited abrasion of either brake line due to contact with any portion of the vehicle. None of the Ford exemplar vehicles exhibited any visible corrosion of the rear brake line or abrasion due to contact with any portion of the vehicle.

7.0 Conclusions

1. Almost all of the subject vehicles inspected exhibited corrosion and abrasion on the rear brake lines that were not found on the GM peer vehicles or on the post-1997 Ford exemplar vehicles that were inspected. At least six of the subject vehicles also exhibited more severe corrosion than that found on the Chrysler peer vehicles that were inspected.

2. Corrosion appeared to be a more significant problem than abrasion on three of the subject vehicles, to the point that replacement of the brake lines appeared to be necessary.

3. In the limited number of subject vehicles that were examined during this program that contained the mastic patch, the mastic patch did not appear to reduce or eliminate the contact

between the brake lines and the floor pan rib above them as compared to the shrink wrap design. The mastic patch did appear to help reduce corrosion to the portion of the brake line within the mastic patch. However, the mastic patch did not prevent corrosion over the remainder of the brake line.

4. Corrosion on the subject vehicles appeared to be the result of contact between the brake line and surrounding dissimilar materials, including the mounting pads.

5. Exemplar Ford vehicles (post-1997) did not exhibit corrosion of the brake line. The brake line appeared to be either made of a different material or covered with a protective coating. These vehicles were also equipped with different routing and mounting methods that appeared to prevent abrasion against the floor pan.

Appendix I

Owner Questionnaire

Consumer's Name
Address

Date

Dear _____

You are being asked by the United States Department of Transportation to take part in an informal questionnaire regarding the rear brakes on your <MY Make, Model>. By participating in this questionnaire, you will be assisting in determining if a safety related defect exists on your model vehicle. This questionnaire will only take you about 10 minutes to complete. Your help is very much appreciated. If you no longer own this vehicle, please check the box to the right and return this form in the enclosed envelope.

NO LONGER OWN: ☐

To conduct and complete the questionnaire:

- **First,** review the "QUESTIONNAIRE INSTRUCTIONS" printed on the back of this form.
- **Second**, Review the three possible responses to the questionnaire.
- **Third,** complete the "QUESTIONNAIRE RESPONSE" section of this form.
- **Fourth,** mail your completed questionnaire to us. No postage is necessary to return the questionnaire response form.

Please be advised that we may need to contact you concerning your questionnaire response and or provide a copy of it (possibly including your name and contact information) on request to your vehicle's manufacturer. If you do not wish to be contacted by us, or do not want your response provided on request to your vehicle's manufacturer, please so indicate on the questionnaire form.

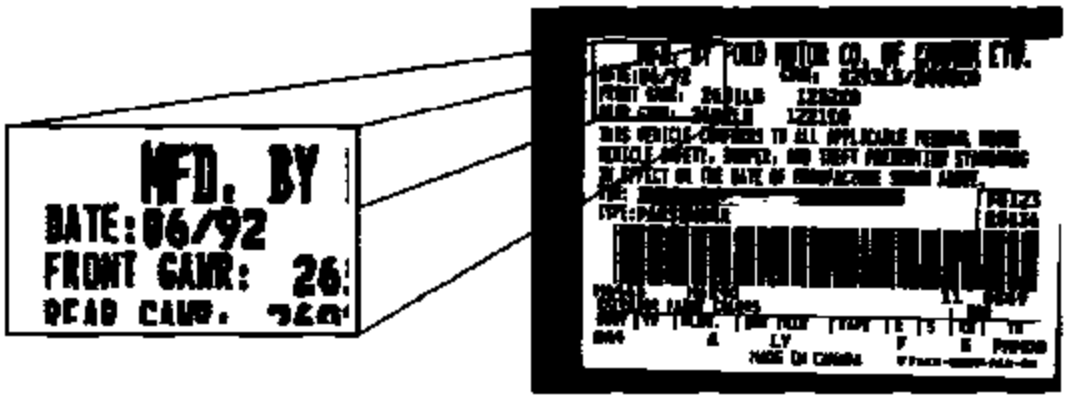
Thank you for your assistance with this questionnaire.

Sincerely,

Robert C. Esser
Project Engineer

QUESTIONNAIRE INSTRUCTIONS

- **Open the Driver's door of your vehicle.**
- **Find the Manufacturer's Certification Label. It will be located either on the rear edge of the door or the rear of the door opening, near the door latch. (Example in photo below)**
- **Find the date that is imprinted on the label (listed as month/year)**
- **Copy the date onto the "Vehicle Build Date" line in the Questionnaire Response section below.**



This rest of this questionnaire concerns leakage or failure of the steel brake line that runs to the rear wheels. It is located underneath the car near the left frame rail. Leakage can be due to corrosion and/or abrasion. Please respond to one of the following three situations.

If the brake line to the rear wheels has never required repair, check the "Rear Brake Line Has Not Required Repair" box in the Questionnaire Response section below.

If the brake line to the rear wheels has required repair at any time that you are aware of, even if it occurred before you owned the vehicle, check the "Rear Brake Line Has Been Repaired" box in the Questionnaire Response section below.

If the brake line to the rear wheels is currently in need of repair, check the "Rear Brake Line Currently Needs to be Repaired" box in the Questionnaire Response section below.

QUESTIONNAIRE RESPONSE

Current Mileage: _____ Contact Name: _____

Vehicle Build Date: _____ Daytime Phone: _____

Do not contact me ☐ Do not share with Manufacturer ☐

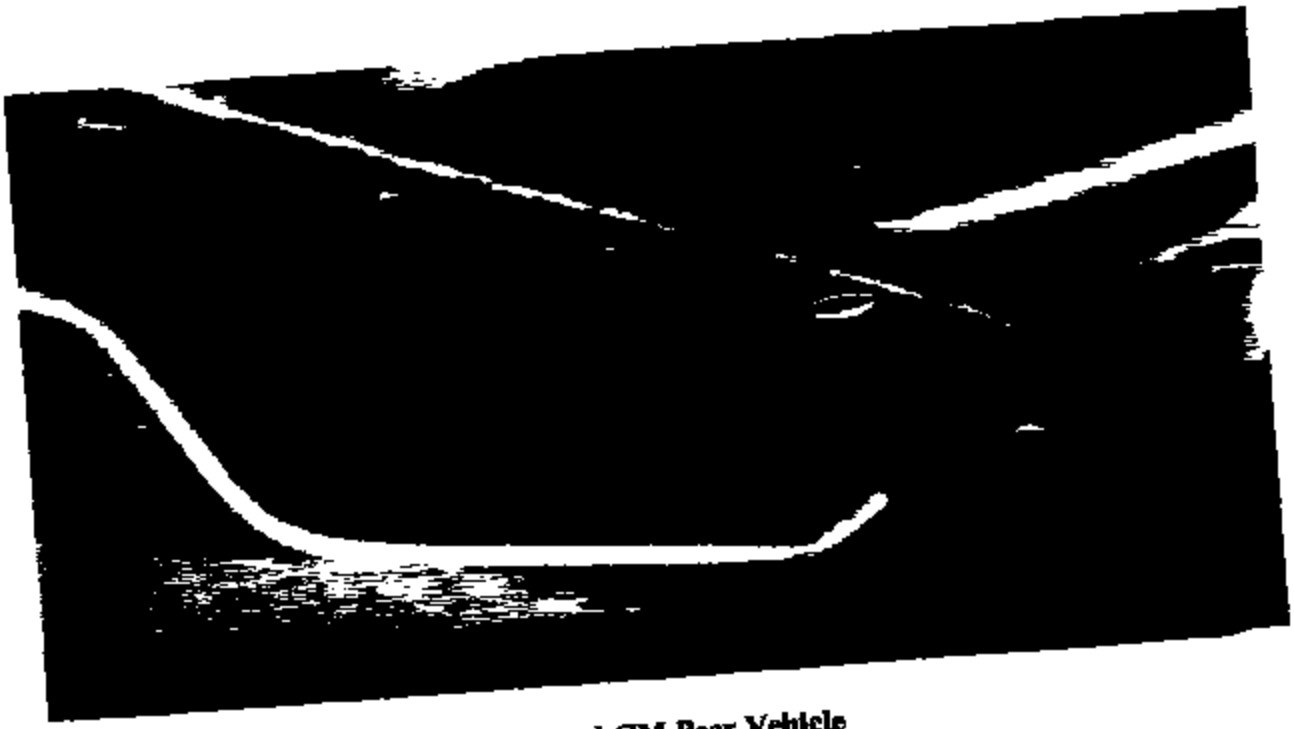
REAR BRAKE LINE HAS NOT REQUIRED REPAIR ☐

REAR BRAKE LINE HAS BEEN REPAIRED ☐ Date of Repair: _____

REAR BRAKE LINE CURRENTLY NEEDS TO BE REPAIRED ☐

Appendix II

Selected Photos of Subject Vehicle Inspections



Typical GM Peer Vehicle
Area at Transmission Cross Member
Where Subject Vehicles Have Shrink Wrap
Or Mastic Patch

Appendix IV

Selected Photos of Chrysler Peer Vehicle Inspections

Typical Intrepid Peer Vehicle
Front Area

Typical Intrepid Peer Vehicle
Rear Area

Typical Intrepid Peer Vehicle
Inside Plastic Protector

Typical Intrepid Peer Vehicle
Area Between Plastic Protector and Fuel Tank

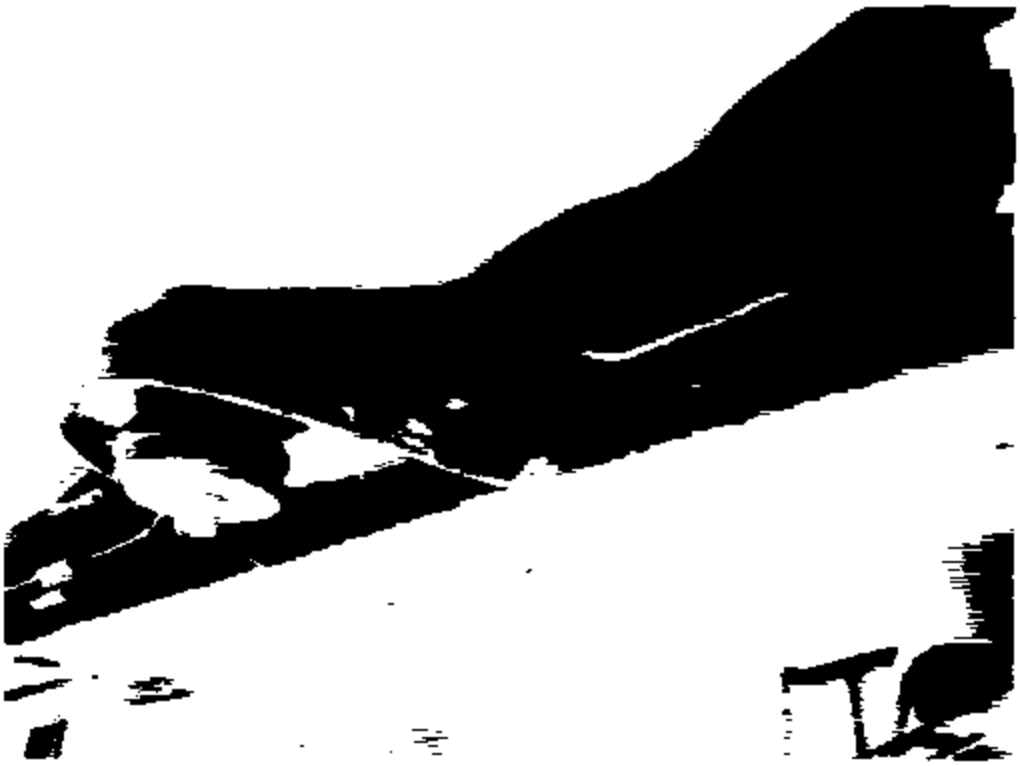
Typical Intrepid Peer Vehicle
Area Next to Fuel Tank

Appendix V

Selected Photos of Ford 1998 and Later

Exemplar Vehicle Inspections

Typical Ford 1998 and Later Exemplar Vehicle
Brake Line at Torque Box
(Black Colored Line)



Typical Ford 1998 and Later Exemplar Vehicle
Brake Line at Body Mount
(Black Colored Line)

Typical Ford 1998 and Later Exemplar Vehicle
Brake Line at Transmission Cross Member
(Black Colored Line)

Typical Ford 1998 and Later Exemplar Vehicle
New Style Mounting Bracket