U.S. Department of Transportation
National Highway Traffic Safety Administration

ODI RESUME

Investigation: EA 02-030
Prompted By: PE02-050
Date Opened: 10/22/2002 Date Closed: 03/09/2004
Principal Investigator: BRUCE YORK-B
Subject: ENGINE COMPARTMENT FIRES

Manufacturer: GENERAL MOTORS CORP.
Products: 1996-2002 GM LESABRE/PARK AVE/REGAL/88/98/RIVIERA/BONNEVILLE
Population: 3534455

Problem Description: Engine backfire during cold crank resulting in explosive rupture of plastic intake manifold with potential for fuel injector assembly leakage and fire.

FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
Complaints:	38	416	454
Crashes/Fires:	26	299	325
Injury Incidents:	0	2	2
# Injuries:	0	2	2
Fatality Incidents:	0	0	0
# Fatalities:	0	0	0
Other*:	0	0	0

*Description of Other:

Action: This Engineering Analysis has been closed. Recalls 03V-473 & 04V-090.

Engineer: *Bruce York* Date: *03/09/2004*
Div. Chief: *Jeffrey L. Quandt* Date: *03/09/2004*
Office Dir.: *Kathleen C. DeMeter* Date: *03/09/2004*

Summary: EA02-030 is closed with GM's actions in 03V-473 and 04V-090 recalling approximately 529,000 my 1998-99 C- and H-body vehicles equipped with defective fuel pressure regulators. These vehicles were equipped with plastic intake manifolds that are unable to contain pressures that occur in some backfire events and defective fuel pressure regulators with leaking diaphragms that can provide a source of fuel to produce a combustible air-fuel mixture in the manifold. The closing of this investigation does not constitute a finding by ODI that no safety defect exists in the vehicles that are not included in GM's recalls. ODI will continue to monitor the incidence of manifold ruptures and related fires in other my 1995-2002 GM passenger cars equipped with the subject intake manifold.

For additional information, see the attached closing report.

VMJ 3-10-04

CLOSING REPORT

The subject vehicles are equipped with the General Motors (GM) 3800 Series II V6 engines (GM RPO L36). These engines were introduced in model year (MY) 1995 and use plastic intake manifolds[1] that cannot contain the pressures generated in some backfire events (Figure 1). The intake manifold in the subject vehicles was redesigned in MY 2003 vehicles to increase the burst strength above the range necessary to contain backfire pressures. The alleged defect is the explosive rupture of the plastic intake manifold, typically during attempted cold start, with the potential for severe engine compartment fire if the manifold failure compromises the integrity of the fuel injection assembly. GM refers to these failures as Manifold Over-Pressurization (MOP) incidents.

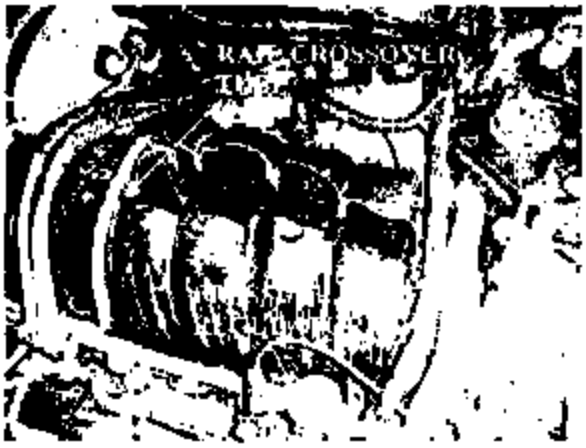

Figure 1. Ruptured manifold.

The alleged defect in the subject vehicles involves the following three factors occurring together: (1) the accumulation of a combustible mixture of fuel vapors in the manifold; (2) the presence of an energy source to ignite the air-fuel mixture; and (3) the failure of the intake manifold structure to contain the backfire pressure pulse. As noted, the final factor is present in all MY 1995-2002 vehicles equipped with L36 engines. GM has identified the first factor in certain MY 1998-99 vehicles equipped with pressure regulators supplied by Delphi Corporation. The ignition system is considered the principle source of energy for the second factor, from either mis-timed or mis-directed spark commands that can occur with varying frequencies throughout the subject vehicle population.[2]

When a mis-timed or mis-directed spark is commanded to a cylinder with an open intake valve and a combustible air-fuel mixture is present in the manifold, a backfire event can occur. These events tend to occur in low battery conditions and have virtually all happened during cold-crank starting attempts. According to GM, when a vehicle has a low battery voltage and does not start when cranked, the crankshaft can "rock back." Crankshaft "rock back" results in a false crank position sensor signal that can lead to a mis-timed spark upon engine restart.

Explosive rupture of the upper section of the intake manifold in the subject vehicles frequently results in substantial damage to the fuel injection assembly, which can result in a severe fuel leak and fire. The forces produced by the manifold rupture are transmitted to the fuel rail crossover tube, which can be bent upward with sufficient force to pull a fuel injector free from the engine resulting in a severe fuel leak. If an ignition source is present, the fuel leakage can result in a severe engine compartment fire.[3]

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[1] Thirty-three percent glass fiber-reinforced nylon 66 (Zytel 70G33).

[2] According to GM, hot unburned combustion gases from a partial burn event in a cylinder can also be a source of ignition energy for a combustible air-fuel mixture in the manifold.

[3] The high ratio of fire incidents among total manifold rupture failures (70%) suggests that the heat from the released backfire gases may be a common ignition source in many incidents.

In July 1996, GM introduced new Powertrain Control Module (PCM) hardware[4] starting at Job #1 for MY 1996 vehicles. In April 1996, GM implemented changes in PCM programming related to cold start ignition strategies to reduce the potential for engine backfire in vehicles equipped with the new hardware.[5] In June 1996, GM conducted a recall to update PCM programming with the new software in approximately 276,000 MY 1996 and certain early-1997 subject vehicles to reduce the risk of backfire events and fires (96V-116). In March-April 1997 production of MY 1997 vehicles, GM implemented additional revisions to PCM programming related to cold start fuel injection pulse strategies to further reduce the potential for engine backfire during engine crank.[6] In July 1997, GM introduced new PCM hardware starting at Job #1 for MY 1998 vehicles.[7]

Reports of manifold ruptures and fires in MY 1996-2000 subject vehicles led ODI to open a Preliminary Evaluation (PE02-050) on June 13, 2002. The investigation was upgraded to an Engineering Analysis on October 22, 2002. ODI gathered information from GM on MY 1996-2003 vehicles equipped with the L36 engine.[8] ODI did not identify any correlation between the PCM changes in MY 1997 and the incidence of manifold rupture failures in subject vehicles. However, ODI's analysis did find increased failure rates in certain MY 1998-99 vehicles.

In a September 11, 2003 meeting with ODI, GM identified a defect condition in a fuel pressure regulator supplied by Delphi for use in MY 1998-99 C- and H-body vehicles. Tears in the diaphragms of these pressure regulators could leak fuel through the regulator vacuum tube to the intake manifold, supplying the fuel source necessary for the first element of the alleged defect. Vehicles equipped with the defective Delphi fuel pressure regulators had higher rates of manifold rupture and consequent engine compartment fires than subject vehicles with no identified defect in the fuel pressure regulator (Table 1).

TABLE 1. FAILURE DATA FOR MY 1996-02 SUBJECT VEHICLES.

Vehicles	Population	Manifold Rupture Complaints, with Fire		Manifold Rupture Complaints, Total	
		Rpts	R/100k	Rpts	R/100k
1998-99 C&H-cars	555,843	184	33.1	233	41.9
All other MY 1996-02	2,978,612	141	4.7	221	7.4
Total	3,534,455	325	9.2	454	12.8

Following the September 2003 meeting, GM provided ODI with design and manufacturing change information concerning the fuel pressure regulators used in the subject vehicles. GM's information indicated that in MY 1998 the diaphragm material was changed from a 0.018 inch thick "convoluted," single-ply, fluorosilicone construction used in MY 1996-97 vehicles to a 0.012 inch thick "flat cut," dual-ply, nitrile/PVC construction used in MY 1998-2000 vehicles. GM indicated that the reduced

[4] 32U PCM hardware.
[5] MOP 1 PCM software.
[6] MOP 2 PCM software.
[7] P04 PCM hardware (with MOP 2 software).
[8] While ODI did not collect data from GM on MY 1995 vehicles during EA02-030, these vehicles are also susceptible to manifold rupture failure.

thickness of the nitrile/PVC diaphragms made the parts susceptible to over-stretching and tearing during the assembly if excessive crimping forces were used in the staking process. Delphi implemented manufacturing changes to reduce the crimping forces in January 1999, during MY 1999 production. The diaphragm material was changed again in MY 2001 vehicles to a "convoluted," single-ply, nitrile-EFFBE construction. According to GM, the concerns with fuel pressure regulator diaphragm tearing and leakage are limited to Delphi dual-ply parts manufactured before the January 1999 process change.

In a November 12, 2003 letter, GM notified NHTSA that it was recalling approximately 96,000 MY 1998-99 Buick Park Avenue vehicles (C-cars) that were equipped with L36 engines and the defective Delphi fuel pressure regulators (03V-473). According to GM, the electrical system of these vehicles yielded greater frequencies of the low battery condition associated with mis-timed spark events. GM's action involved less than 20 percent of the vehicles equipped with the defective pressure regulators. These vehicles had the highest frequencies of manifold rupture incidents and fires in the subject vehicle population (Table 2). GM indicated that the recalled vehicles would receive new fuel pressure regulators with improved diaphragms.

The defective Delphi fuel pressure regulators identified by GM were also used in the MY 1998-99 H-cars (Buick LeSabre, Oldsmobile 88, and Pontiac Bonneville). These vehicles exhibited lower failure rates than the C-cars, but significantly higher rates of manifold ruptures and fires than MY 1998-99 W-cars equipped with pressure regulators supplied by Bosch (Table 2). In a February 16, 2004 letter, GM notified NHTSA that was also recalling approximately 434,000 MY 1998-99 H-cars with L36 engines to replace the defective fuel pressure regulators (04V-090).

TABLE 2. FAILURE DATA FOR MY 1998-99 SUBJECT VEHICLES.

Fuel Pressure Regulator	Vehicles	Recall	Population	Manifold Rupture Complaints, with Fire		Manifold Rupture Complaints, Total	
				Rpts	R/100k	Rpts	R/100k
Delphi	C-cars	03V-473	95,690	85	88.8	111	116.0
	H-cars	04V-090	460,153	80	17.4	112	24.3
Bosch	W-cars	-	464,700	15	3.2	22	4.7

EA02-030 is closed with GM's actions in 03V-473 and 04V-090 recalling approximately 529,000 MY 1998-99 C- and H-body vehicles equipped with the defective Delphi fuel pressure regulators. These vehicles were equipped with the subject plastic intake manifolds that are unable to contain pressures that occur in some backfire events and defective fuel pressure regulators with leaking diaphragms that can provide a source of fuel to produce a combustible air-fuel mixture in the manifold. The closing of this investigation does not constitute a finding by ODI that no safety defect exists in the vehicles that are not included in GM's recalls. ODI will continue to monitor the incidence of manifold ruptures and related fires in other MY 1995-2002 GM passenger cars equipped with the subject intake manifold.

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