ENGINEERING ANALYSIS CLOSING REPORT

SUBJECT: Speed Control Deactivation Switch Fires.

EA No: EA02-025 **Date Opened:** 06-Sep-2002 **Date Closed:** 30-Jun-2004

BASIS: On May 13, 1999, Ford notified ODI of a safety defect that could result in engine compartment fires in approximately 279,000 model year (MY) 1992 through 1993 Lincoln Town Car, Ford Crown Victoria and Mercury Grand Marquis vehicles (NHTSA Recall No. 99V-124, Ford Recall No. 99S15). According to Ford, the speed control deactivation switches (SCDS) installed in Lincoln Town Car vehicles built from November 4, 1991 through November 30, 1992 and Ford Crown Victoria and Mercury Grand Marquis vehicles built from February 5, 1992 through November 30, 1992 may contain defects that could result in fires. Ford indicated that the defective switches could develop internal leaks that "could result in internal corrosion in the switch which could create a conductive path to ground, ultimately resulting in sufficient internal heat to result in a fire." Because the subject switches receive uninterrupted battery voltage, the fires can occur when the vehicle has been parked with the key in the "OFF" position. Vehicles repaired under the recall received new speed control deactivation switches.

On September 20, 2001, ODI opened a Recall Query (RQ01-002) to investigate allegations of 15 engine compartment fires in MY 1992 through 1994 Town Car, Crown Victoria, and Grand Marquis vehicles that all reportedly occurred while the vehicle was parked with the ignition "OFF." Eleven of the complaints were confirmed by ODI to be outside the scope of Ford's recall. On September 6, 2002, RQ01-002 was upgraded to an Engineering Analysis, EA02-025, covering approximately 1.9 million MY 1992 through 1997 Town Car, Crown Victoria, and Grand Marquis vehicles.[1] The upgrade was based on 47 reports of engine compartment fires in vehicles that were not included in Ford's recall.

ALLEGED DEFECT: Failure of the speed control deactivation switch that results in switch overheating or fire (Figure 1).

Figure 1. Speed Control Deactivation Switch Fire, MY 1993 Town Car.

[1] The population in the EA opening resume includes the vehicles covered under Ford's recall and some vehicles built without the subject speed control deactivation switches.

SUBJECT SWITCH DESCRIPTION: The subject components are hydraulic pressure switches that function as redundant safety switches to interrupt power to the speed control servo during brake application.[2] The normally closed switch opens at brake system pressures produced by approximately 5-10 lbs of pedal force, breaking the circuit to the speed control servo and causing speed control to disengage. The deactivation switch is mounted on the brake-proportioning valve, which is located on the rear bulkhead on the left (driver's) side of the engine compartment beneath the brake master cylinder (Figure 2). Texas Instruments (TI) manufactured the switches.

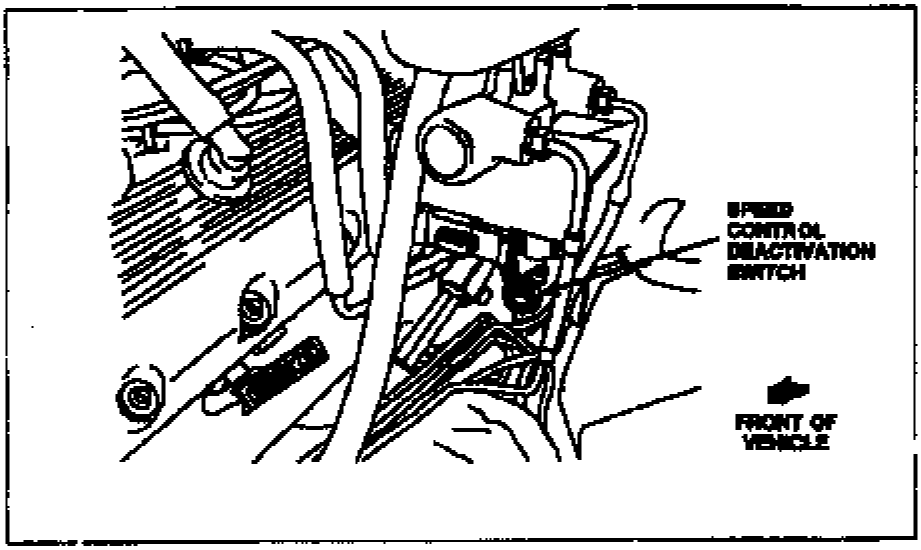

Figure 2. Speed Control Deactivation Switch Location.

A multi-layer diaphragm and gasket seal the interface between the hydraulic and electrical sides of the switch. The diaphragm consists of three layers of Kapton 500FN131 (Kapton sandwich), a high performance polyimide polymer film supplied by DuPont. Each Kapton FN layer is a composite structure consisting of a 3 mil (76.2 μm) core of Kapton HN film with 1 mil (25.4 μm) laminates of Teflon FEP on each side. TI used three layers of Teflon-coated Kapton to enhance the durability of the switch. The Kapton sandwich (hexport seal, middle seal, and washer seal) is clamped between the hexport cup and the washer with a gasket on the hexport side.

The Teflon-Kapton-Teflon system is used in the subject switches because water will degrade the mechanical properties of Kapton and brake fluid is hygroscopic (i.e., will absorb water from humid air). Teflon, which is unaffected by water, provides a boundary layer to protect the Kapton substrate from hydrolytic attack by moisture in the brake fluid. Hydrolytic degradation of the Kapton is a function of: (1) the concentration of water in the brake fluid; (2) the amount of time the Kapton is exposed to water-contaminated brake fluid; and (3) temperature.

Brake fluid pressure acts against the switch converter through the Kapton diaphragm to actuate the switch snap disk during brake application (Figure 9). Actuation of the snap disk allows the spring arm of the switch movable contact to lift off the stationary contact, breaking the speed

[2] The brake light switch, which senses brake pedal position, is the primary deactivation device.

control circuit to the servo clutch. When brake pressure fluid drops, the snap disk is released, forcing the contacts back together through the transfer pin to reset the switch and allow speed control function to resume.

The switch receives uninterrupted voltage from the battery. The switch contacts normally conduct up to 0.75 amps to the speed control clutch when speed control is engaged and 0.005 amps when not engaged. A 15-amp fuse provides over-current protection for the speed control circuit.[3]

Switch & Base Polymer Information	Snap Switch (Town Car)	Quiet Switch (Crown Victoria, Grand Marquis)
Ford service part number	F2VY-9F294-AA	F2AZ-9F924-A
TI part number	77PSL2-1	77PSL3-1
Switch "open" pressure range, psi	90-160	90-200
Base polymer supplier	Ticona	GE Plastics
Trade name/grade	Celanex 4300	Noryl GTX839
Generic family	PBT	PPE/PA blend
Heat deflection temperature at 0.45 Mpa , °C (°F)	220 (428)	254 (489)
Melt temperature, °C (°F)	225 (437)	280-305 (536-581)
Base color	Brown	Natural
UL flammability rating	HB	HB

Table 1. Subject switch identification and plastic base material.

Two versions of the switch were used in the subject vehicles. The Town Car vehicles use the so-called "snap" switch and the Crown Victoria and Grand Marquis vehicles use the so-called "quiet" switch. Table 1 compares some of the characteristics of the two switches. Similar switches were used by Ford in a number of other platforms with electrically actuated speed control.

FAILURE MECHANISM: There are two significant stages in the failure mechanism associated with the alleged defect. The first stage involves the development of a leak path from the hydraulic side of the switch to the electrical side of the switch. The second stage involves the corrosion of the switch contacts and the development of a resistive short to ground that generates heat in the switch cavity, which can result in melting of the plastic base and, in some cases, ignition.

There have been two general failure mechanisms identified for brittle cracking of the switch Kapton diaphragms: (1) normal "end of life" failure caused by repetitive cycling fatigue of the Kapton and Teflon laminates; and (2) early fatigue failure caused by the imposition of local high stresses on the Kapton/Teflon composite during the manufacturing process.[4] The former is thought to begin on the washer side of the washer seal (electrical side of the Kapton seals), where the highest stresses occur on the Kapton seals due to contact with the washer and converter. According to DuPont, the most likely causes of early life failures are the cumulative effects of

[3] Fuse 12 in the Town Car vehicles and Fuse 7 in the Crown Victoria and Grand Marquis vehicles.
[4] Described by DuPont in its September 3, 2003 letter to ODI.

service cycling stresses and high localized stresses introduced during the manufacturing process in certain switches, leading to early fatigue, or hydrolytically induced degradation of the Kapton mechanical properties.

DuPont indicated that hydrolytic degradation of the Kapton could be caused (1) by water-contaminated brake fluid penetrating a cracked Teflon layer (Figure 10); (2) by water penetrating a stressed – and thus more permeable – Teflon layer; or (3) by some combination of (1) and (2). This condition is thought to originate on the Teflon layer that is in contact with the brake fluid and lead to failure of the hexport seal. A Kapton substrate that has been degraded from such exposure can become brittle and crack. Figure 11 shows a radial Kapton crack that appears to have resulted from stress concentrations imposed by assembly processes. If the process is repeated in the middle seal and the washer seal a leak path is created from the hydraulic side of the switch to the electrical side. DuPont indicated that it was these early fatigue type failures that were observed in switches removed from the recalled population.

Water-contaminated brake fluid in the electrical cavity results in corrosion of the switch electrical contacts. Brake fluid and corrosion products (i.e., loose metal fragments) in the electrical cavity may then cause a resistive short to ground to develop from the stationary contact, carrying battery voltage, to the hexport body. From Ohm's Law, the leakage current (I) is determined by the relationship $I = V/R$, where V is system voltage (12 to 14.5 volts) and R is the resistance of the short to ground. The short to ground generates heat in the switch cavity proportional to the product of the square of the leakage current and the resistance ($P = I^2R$). Arcing may also occur between the contacts and from the powered contact to the hexport body (Figure 12). The heat may melt the plastic switch base (Figure 13) and the arcing may provide the source of ignition.

This condition is sometimes detected by evidence of brake fluid leakage (e.g., brake fluid on the pavement, brake fluid observed dripping from the switch, low pedal). Continued contact corrosion results in increased contact resistance, which will eventually cause the speed control to become inoperative (this effect can also result from water intrusion through the connector seal or from mechanical failure of switch components, such as a sticking transfer pin). Inoperative speed control is the most commonly reported symptom of switch failure.

The leakage current that results from the resistive short condition can also provide symptoms of switch failure. These include: (1) difficulty shifting the vehicle out of PARK; (2) inoperative brake lamps; (3) brake warning light illumination on the dash; and (4) dead battery. The first three symptoms result from conditions where the leakage current is great enough to cause the 15-amp circuit protection fuse to open. If the fuse opens, the subject switch and stop lamp switch are isolated from battery voltage and the speed control, stop lamps, and brake-transmission shift interlock become inoperative. The operator will not be able to shift out of PARK. A switch fire cannot occur after the fuse has opened, unless the fuse is replaced without diagnosing the problem and replacing the switch.

Testing conducted by Ford and TI determined that leakage currents of less than 15 amps could result in switch melting and ignition. During Ford's investigation prior to 99V-124, testing of a switch with a conductive liquid repeatedly injected into the electrical cavity produced increasing leakage currents of 1 to 2 amps at 14 volts, with transients of 10 amps. Ford's report indicated that "these lab conditions were capable of melting or igniting the switch plastic bases in a 3 hour controlled environment."

CONTRIBUTING FACTORS: The factors contributing to the alleged defect can be divided into three general categories: (1) design factors; (2) manufacturing/assembly factors; and (3) use factors. It is in the second category where the subject vehicles and the recalled vehicles are believed to differ.

Design factors. There are switch and vehicle design factors that can contribute to the alleged defect condition in the subject vehicles. The switch factors basically involve the diaphragm capacity and factors that influence diaphragm stress. Parameters that may affect diaphragm durability include: (1) diaphragm design, including material selection, coating system and number of seals; (2) baseline load on the seals resulting from switch assembly (i.e., crimping); (3) cyclic load on the seals due to pressure cycling; (4) the geometry of the mating surfaces to which the seals conform, which determine the strain state and stress concentrations of the seal in the relaxed and stressed (i.e., "switched") conditions; and (5) the nature of the surfaces of components contacting the seals.

Vehicle design factors include those affecting switch durability and aspects of the electrical system that may influence the risk of fire should an internal short develop. Vehicle factors affecting switch durability include the ambient and brake fluid temperatures that the switch, and particularly the diaphragm material, will experience during service (i.e., switch/diaphragm operating and hot soak thermal histories) and the switch cycling pressures. Electrical system design factors include the circuit protection design and the delivery of uninterrupted battery voltage to the switch. The latter may have a dual influence as it may promote contact corrosion in a switch cavity containing conductive liquid and it provides the source of energy that causes overheating and ignition of the switch base to potentially occur in the key OFF condition.

Manufacturing factors. TI identified the following manufacturing factors that may influence durability of the subject switches: "(1) the crimping process; (2) the process for inserting the 3-layer Kapton/Teflon diaphragm; (3) damage to the Kapton diaphragm during the manufacturing process; and (4) the process for loading the gasket in the correct location and avoiding any damage to the gasket during the process." The first process was an issue in 1991, at the outset of production of the subject "snap" switches, when some switches produced on the automatic-load crimping machine did not pass Ford's durability specification. TI has indicated that the problems were resolved before switches from this machine were shipped for use in subject models and that no other changes in the crimping process occurred that could explain the higher failure experience in the recalled vehicles.

The second and third factors could damage the diaphragm and lead to premature failures. According to TI there is no information indicating that these problems occurred during the manufacture of the subject switches. The fourth factor, involving the installation of the hexport gasket, could result in damage to the gasket, which could result in leakage from the hydraulic side of the switch to the electrical side. An August 1992 TI document describes a problem with hexport gasket positioning. Ford has cited this document as a possible reason for the change in failure experience in vehicles built after October 1992 that would explain the difference between the failure experience in the recalled vehicles and the subject vehicles. However, TI believes that switch failures related to gasket positioning are likely to occur very early in the life of the vehicle and have not been identified in any of the survey/inspection efforts of switches returned from recalled vehicles.

According to Ford, no vehicle manufacturing factors have been identified that relate to the alleged defect condition and there have been no changes in vehicle manufacturing processes that could relate in any way to SCDS durability in the recalled vehicles or the subject vehicles. TI has indicated that the system of using vacuum to draw brake fluid into the system during vehicle assembly may, in certain circumstances, affect the Kapton diaphragm condition. TI stated that, "During the manufacturing process for Capri vehicles in Australia, a vacuum was created using a system that was sufficiently powerful to pull the Kapton out of place and impair its utility for the Capri switches." According to Ford, the switch internal cup height was reduced by four percent in December 1992 to address concerns with potential open circuit conditions developing under vacuum. TI does not believe that the change was implemented in production of subject switches.

Use/service factors. Use factors include the number and magnitude of pressure cycles imposed on the diaphragms; the climate (e.g., ambient temperature and humidity); the type, contamination, and temperature of the brake fluid; speed control usage (relates to availability of warning symptoms); and improper repairs.

With regard to the number and magnitude of pressure cycles, Ford has submitted information for a 1992 Crown Victoria indicating that severe usage customers (90^{th} Percentile Drivers) apply the brakes approximately 1.8 million times in 150,000 miles of service with an estimated durability index[5] of $4.31 x 10^8$. Ford estimated that the average customers apply the brakes approximately 740 thousand times in 150,000 miles of service with an estimated durability index of $1.79 x 10^8$. According to Ford, the impulse test (500,000 cycles @ 1450 psi) in the durability specification has a durability index of $7.25 x 10^8$, approximately 68 percent greater than the 90^{th} Percentile Driver after 150,000 miles. TI believes that the number of switch cycles is a more significant factor in diaphragm durability than the magnitude of the pressure cycles.

Environmental factors are believed to affect the rate that the mechanical properties of the diaphragm material change due to thermal and chemical aging (ambient temperature) and the amount of water contamination that aged brake fluids may have absorbed at a given service interval (humidity).

The improper diagnosis and repair of SCDS failure has been a factor in some fire incidents. In these vehicles a repair technician or consumer replaced the 15-amp circuit fuse, in some cases with a larger fuse, or replaced the fuse with a circuit breaker after the fuse had opened. These repairs failed to diagnose the SCDS as the source of the high-current condition, thus allowing the short circuit condition to continue and cause an underhood fire.

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[5] The sum of the products of total brake applications and rear brake line pressures at mild, moderate, and severe braking maneuvers.

POPULATION: The subject vehicles are MY 1993 through 1997 Ford Town Car, Crown Victoria and Grand Marquis vehicles equipped with electronic speed control that were built after the production range recalled by Ford in 99V-124. Ford has sold over 1.4 million subject vehicles in the United States. Table 2 shows the vehicle sales volumes and complaint data by model and model year.

MY	Model			Total
	Town Car	Crown Victoria	Grand Marquis	
1993	72,987	67,696	50,783	191,466
1994	113,022	94,403	94,887	302,312
1995	107,727	94,084	94,188	295,999
1996	90,764	102,431	95,031	288,226
1997	104,977	116,212	127,977	349,166
Total	489,477	474,826	462,866	1,427,169

Table 2. Subject vehicle population.

FAILURE DATA: ODI used the following criteria to determine whether an incident would be counted as a speed control deactivation switch fire for the purposes of this investigation: (1) the fire originated in the area where the speed control deactivation switch is located (left-rear corner of the engine compartment, beneath the master cylinder); and (2) there was evidence of speed control deactivation switch failure prior to the fire (e.g., inoperable speed control, speed control deactivation switch fuse open – sometimes repeatedly, difficulty shifting out of PARK, evidence of brake fluid leakage from the switch) or (3) evidence of speed control switch failure discovered was during post-fire forensic examination. Using these criteria, ODI identified a total of 35 fire incidents that appeared to be related to SCDS failure in the subject vehicle population (Table 3).

Category	ODI	Ford	Total
Complaints	5	30	35
Fires	5	30	35
Injury incidents	0	0	0
Injuries	0	0	0
Fatal incidents	0	0	0
Fatalities	0	0	0

Table 3. Failure summary.

Table 6 provides a breakdown of the fires by model and model year. Because switch durability and manufacturing process issues were the primary factors under consideration with respect to the alleged defect, EA02-025 focused on MY 1993 through 1995 vehicles, the oldest vehicles and the vehicles built nearest the production range of the recalled vehicles. For this reason, Ford's failure data for the MY 1996 and 1997 vehicles is limited to that collected in RQ01-002. ODI has received only one complaint related to the alleged defect in MY 1995 through 1997 subject vehicles.

DESIGN/PROCESS CHANGES: Table 4 summarizes the design and manufacturing process changes from the introduction of the subject switches through the end of MY 1997, when Ford stopped using the switches in the subject models.

Date	Change	Reason
Oct-91	TI begins production of speed control deactivation switches for MY 1992 Town Car vehicles using prototype ("manual crimp") manufacturing process.	Parts produced using "automated crimp" manufacturing process leaked during the durability portion of validation testing.
Jan-92	TI begins production of speed control deactivation switches using "automated crimp" manufacturing process.	Parts produced from "automated crimp" process pass validation testing after overhaul of auto-load crimp machine.
Apr-92	TI begins production of "quiet" speed control deactivation switch for MY 1992 Crown Victoria and Grand Marquis vehicles.	Reduce switch cycling noise in Crown Victoria and Grand Marquis vehicles.
Aug-92	TI corrects problem with "grossly misplaced" gaskets.	Eliminate potential for gasket damage and early-life leakage failures.
Dec-92	Internal cup dimension changed 0.004 inches from 0.091 in. to 0.087 in. nominal.	To address concerns with potential open circuit condition under vacuum.
2003	Change suppliers from TI to HiStat-Stoneridge and redesign switch.	TI stops supplying switch to Ford.

TABLE 4. Design/manufacturing process changes.

There has not been a specific design or process change identified that explains the difference in fire experience between the recalled population and the subject vehicles. TI has indicated that the subject switches are basically the same in design and manufacture as the recalled switches and the switches used as replacement parts in the recall remedy. While not claiming a connection to the alleged defect, Ford has noted the change in the cup dimension in December 1992 and also questioned whether a concern with mispositioned gaskets in mid-1992 switch production could explain the high fire rate in the recalled vehicle population. TI has indicated to ODI that the cup change was not implemented in the subject switches.

WARRANTY: During RQ01-002 and EA02-025, Ford provided information on about 745 warranty claims relating to speed control deactivation switch repairs in the subject vehicles. Ford's standard warranty coverage for subject Crown Victoria and Grand Marquis vehicles is three years or 36,000 miles. The coverage for Town Cars vehicles is four years or 50,000 miles. Table 8 shows the warranty claims and claim rates for the speed control deactivation switches by model and model year, as well as the counts and rates for claims with specific symptoms associated with the alleged defect.

It should be noted that symptoms associated with the alleged defect typically do not occur during the warranty period. The failure mechanism takes time to develop as can be seen in the recall population, which did not experience problems with switch fires until the vehicles reached 4-6 years and 60-100 thousand miles of service. In the subject vehicles, the claim frequencies were similar for the Town Car vehicles and the Crown Victoria/Grand Marquis vehicles, despite the longer standard coverage for the Town Car vehicles. The MY 1995 vehicles had the highest claim frequencies for both populations.

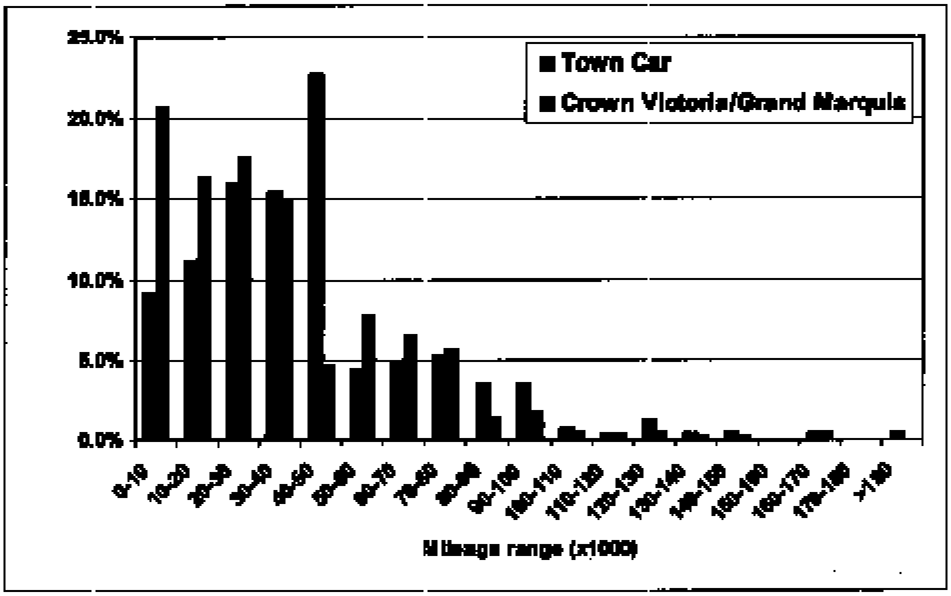

Figure 3. Distribution of SCDS warranty claim data by model and mileage.

The claim rates are low, with only the MY 1995 Crown Victoria and Grand Marquis vehicles reaching a rate as high as a tenth of a percent. Many of the claims involved vehicles well beyond the standard coverage age or mileage, indicating either extended coverage or goodwill repairs. Approximately 1.3 percent of all claims involved some sort of thermal event. Six percent of the claims indicated a switch failure resulting in an open fuse and/or difficulty shifting out of PARK. Twelve percent of the claims indicated evidence of brake fluid leakage.

PART SALES: Ford provided information about sales of approximately 45 thousand speed control deactivation switches for service use in the subject vehicles, through July 2003.

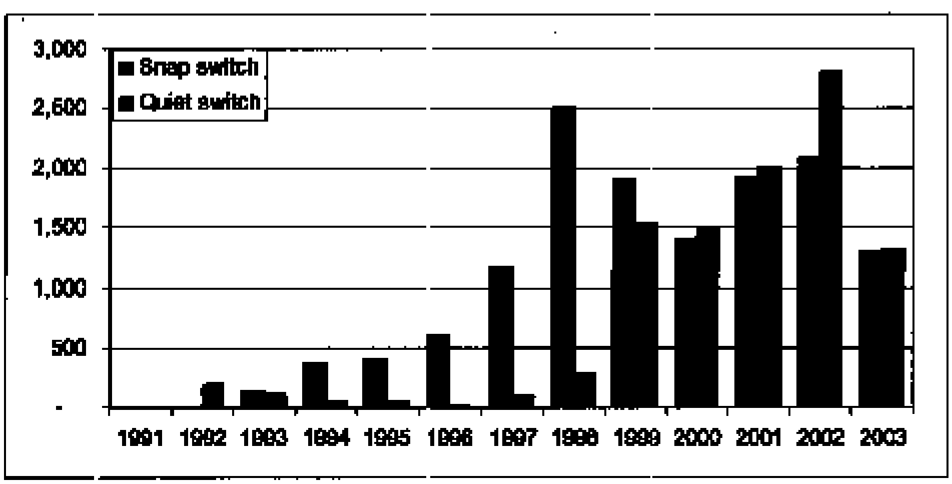

Figure 4. Service part sales of subject switches
by switch and sales year (through July 2003).

Figure 4 shows the annual sales of the "snap" and "quiet" switches. Ford also sold the recall kit, which consisted of a "snap" switch and a switch electrical connector, as a service part in non-recall vehicles. In 1999 and 2000, sales of the recall kit were higher than sales of the "snap" and "quiet" switches in subject vehicles. Figure 5 shows the annual combined sales of the switches and kits by model. Annual sales peaked at over 15,000 units in 1999, when Ford initiated recall 99V-124. Since 1999 sales have been relatively constant at about 7,000 units per year.

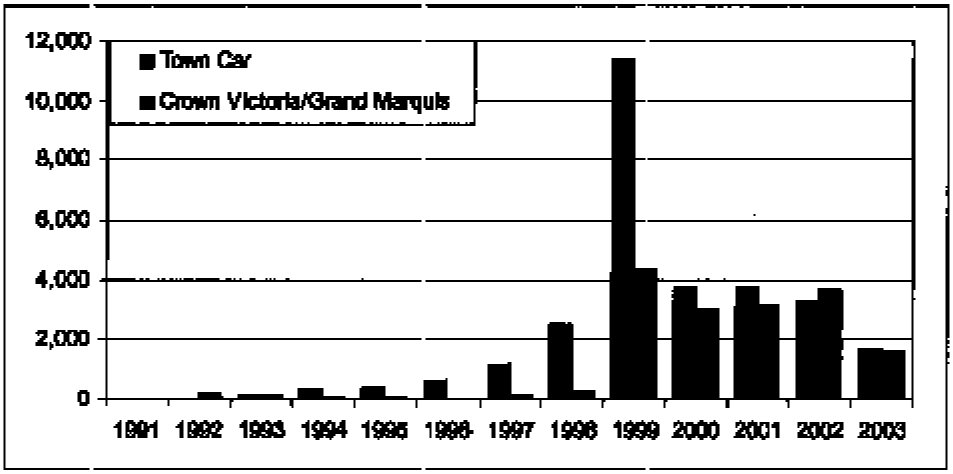

Figure 5. Combined service part sales of switches and kit by model and sales year (through July 2003).

Ford also provided information and analysis from its Unified Database, a part sales tracking system used by Ford to facilitate parts availability. Ford's UDB data provides a sampling of post-warranty vehicle repair information from selected dealers throughout the United States.

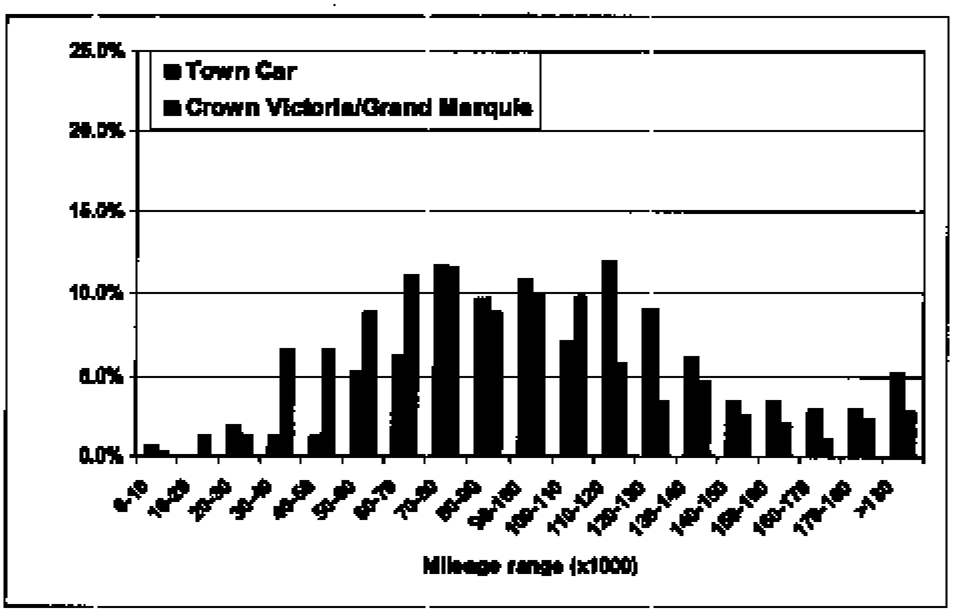

Figure 6. Distribution of SCDS part sales UDB data by model and mileage.

Figure 6 shows the mileage distribution of Ford's UDB data for the subject switches in MY 1993 through 1995 Town Car, Crown Victoria, and Grand Marquis vehicles. The Town Car has about the same percentage of sales as the Crown Victoria and Grand Marquis vehicles from 70,000 to 100,000 miles. The Crown Victoria and Grand Marquis have a greater percentage of sales than Town Car at less than 70,000 miles and the Town Car has a greater percentage at greater than 100,000 miles. A breakdown of UDB data by failure mode/symptom is provided in Table 9.

ADDITIONAL INFORMATION:

Ford durability specification. Ford's durability specification requires that the switches not leak after 500,000 impulse cycles at 2 Hz with the following conditions: 107°C (224°F) ambient temperature, 135°C (275°F) brake fluid temperature, 0 to 1450 psi cycling pressure, and 100 percent DOT 3 (no moisture content). These values are well above the maximum temperature, 101°C (213°F), and pressure, 1200-1300 psi, which the switches experience in service in the subject vehicles. According to Ford, the durability specification is about 68 percent more demanding than a 90^{th} Percentile Driver over 150 thousand miles.

Switch durability testing. TI tested the subject switches to failure using the Ford durability specification and various conditions of Kapton (laminated or monolithic), brake fluid moisture content, and cycling frequency. Note that the latter has the effect of extending the exposure time at the extreme test temperatures for a given number of cycles. The tests were conducted at the specified ambient temperature, brake fluid temperature, and cycling pressure.

Kapton	Brake Fluid ($DOT3/H_2O$)	Freq (Hz)	Test Results – Cycles and Hours to Failure					
			Minimum		Average		Maximum	
			Cycles	Hours	Cycles	Hours	Cycles	Hours
Laminated	100/0	2.00	1,075,000	149.3	1,141,136	158.5	1,212,896	168.5
Laminated	100/0	0.50	268,000	148.9	332,000	184.4	365,000	202.8
Laminated	95/5	0.25	61,000	67.8	Unknown		109,000	121.1
Monolithic	100/0	0.50	53,000	29.4	78,333	43.5	95,000	52.8

Table 5. TI durability test results.

Table 5 summarizes the results of some of the TI testing. The greatest number of cycles to failure were achieved using the Ford specification at 2 Hz. Decreasing cycle frequency from 2 Hz to 0.5 Hz reduced the average number of cycles to failure by 71 percent, while increasing the average time to failure by 16 percent. Adding 5 percent water to the brake fluid and further decreasing cycle frequency to 0.25 Hz resulted in significant reductions in both the cycles and time to failure. These results suggest that chemical aging mechanisms (e.g., heat, hydrolysis) may be more significant than mechanical aging (i.e., fatigue) in the Ford durability specification.

Ford return part analysis. In response to EA02-025, Ford provided information concerning analyses of 12 speed control deactivation switches from subject vehicles that were returned from the field in 2002 through 2003. While the switch history and reason for replacement were not available for most of the switches, they were apparently selected from parts exhibiting anomalous conditions in the field (e.g., inoperative speed control or overheating). Four of the switches had leak paths from the hydraulic side of the switch to the electrical side through cracks in the Kapton seals. Three of these switches exhibited signs of overheating, including one that was involved in a fire. The other eight switches had developed contact corrosion that was attributed to water intrusion through the connector seal. The Kapton diaphragms were intact in these switches.

Ford survey. During a meeting with ODI on February 12, 2004, Ford presented preliminary information regarding its analysis of speed control deactivation switches that were recently collected from subject vehicles in various parts of the country. These switches were removed from subject vehicles at Ford dealerships throughout the United States without regard to switch history or symptoms. The switches were analyzed to assess the condition of the Kapton seals and the electrical contacts.

An April 20, 2004 report from Ford's Central Laboratory summarizes the findings of the complete survey that involved 42 switches, including 15 from dealers in Georgia and Florida – states with higher than average failure rates for the subject switches. The switch histories ranged from 9.0 to 11.5 years old and from 35,629 to 379,891 miles. The averages were 9.9 years old and 104,789 miles. The oldest switch was manufactured in October 1992, during the vehicle production range of 99V-124.

Ford's detailed analyses of the first 13 switches found most had tears in the Teflon layer on the hexport side of the hexport seal (the only Teflon layer initially exposed to brake fluid). One of the hexport seals had a crack in the Kapton, but none had Teflon tears on the side opposite the hexport. There were no cracks or tears observed in the Teflon or Kapton in the middle and washer seals.

Regarding the full set of 42 seals analyzed by Ford's lab, one of the switches (from a 1995 Grand Marquis in Georgia with unknown mileage) showed leakage of brake fluid from the hydraulic side to the electrical side of the switch. Examination of the switch found that tears and delamination in the Teflon overlays and cracks in the Kapton substrates formed the leak path. A second switch (from a 1995 Grand Marquis in Florida with 379,891 miles) showed evidence of water intrusion, but no evidence of brake fluid leakage through the seals.

FORD'S POSITION: Ford believes that there is no evidence of a defect trend in the speed control deactivation switch in the subject vehicles and that the scope of recall 99V-124 adequately addressed the potential for switch failures resulting in engine compartment fire in Town Car, Crown Victoria, and Grand Marquis vehicles. Ford stated that the alleged underhood fire incidents in the subject vehicles have "striking similarities" to incidents reported in vehicles that were not equipped with the switch and that many of the incidents have been erroneously attributed to switch failure:

> **A defect trend in the speed control deactivation switch has not been identified. Ford compared the alleged incidents to those events included in the recall. Ford's comparison reveals a distinct difference in the performance of the switch in the subject vehicles to those included in the recall** [Figure 7]. **Ford's investigation of the**

alleged underhood fire incidents in the subject vehicles revealed striking similarities between these alleged incidents and those reported during the recall investigation where the vehicles were not even equipped with the suspect switch.

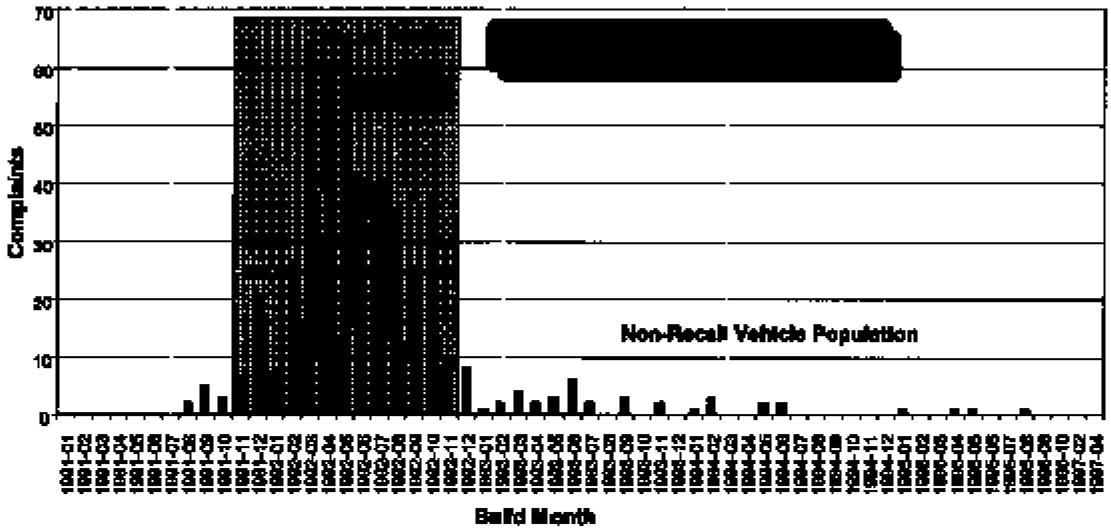

Figure 7. Ford analysis of Town Car fire experience by build month, recall range vs. pre- and post-recall ranges.

While reports alleging failure of the switch leading to heat, smoke, melting or fire exist, there is little, if any, credible information to support the allegations. In fact, in many of these reports, there is substantial credible evidence to the contrary.

Ford attributed many of the allegations to publicity surrounding the recall and subsequent ODI investigations:

It appears that the publicity surrounding the original recall, the RQ investigation and the instant engineering analysis has created a public perception that any fire (or other thermal event) occurring in or near the subject vehicle or any similar vehicle, i.e., those produced before incorporation of the switch, must be the result of a speed control deactivation switch problem irrespective of the factual circumstances and information to support such an allegation.

Ford concluded that there is no safety-related defect trend related to the speed control deactivation switch in the subject vehicles and that the scope and remedy of Recall 99V-124 [Ford 99S15] were appropriate. Ford also concluded that there is no correlation between complaint and part sales data concerning speed control deactivation switch failures and a safety defect trend related to underhood fire:

Based upon the substantially lower report rate of the subject vehicles compared to those produced during the Safety Recall 99S15 period and the results of our analysis of a large volume of information in the preparation of this response, Ford concludes

that there is no safety defect trend related to the speed control deactivation switch in the subject vehicles and that the remedy and scope of Safety Recall 99S15 were appropriate. Additionally, based upon the inverse trend of increasing speed control function complaints and decreasing underhood fire allegations across the 99S15 and subject vehicles, Ford also concludes that there is no correlation between reports of loss of speed control and a safety defect trend related to underhood fire.

TI POSITION: Texas Instruments does not believe that there is a safety-related defect associated with the subject switches, either in the subject vehicles or in the recalled vehicles.

TI does not believe that there is a safety defect associated with the subject switches. The switch is not subject to any federal motor vehicle safety standard and thus is not out of compliance with any such standard. The switch design and operation do not give rise to any safety hazard or to an unreasonable risk to motor vehicle safety.

TI further stated that switch failure cannot result in fire if the current is limited to the levels required to operate the system:

Laboratory testing results previously produced by Ford to NHTSA and included in TI's production also indicate that the level of electrical current applied to the switch during cruise control operation (typically 0.5 amps) did not result in sufficient heating to cause melting or ignition of the switch even in the presence of conductive fluid in the electrical cavity of the switch. The test results indicate that if the system current is limited to this level, the only result of fluid in the electrical cavity is that the switch could become inoperable, disabling the operation of the vehicle's cruise control function. TI does not believe that this constitutes a safety defect.

TI indicated that, as of September 10, 2003, it was aware of 14 claims that the subject switch caused a fire in a non-recalled subject vehicle. TI denied liability in each of the claims.

ODI ANALYSIS: To assess the alleged defect in the subject vehicles ODI analyzed the underhood fire incidents reported to ODI and Ford; SCDS repair information from Ford's warranty and UDB data bases; and non-fire insurance data for the subject vehicles, recalled vehicles, and select peer vehicles from 1993 through 2003.

Fire data. After analyzing all of the known fires reported to Ford and ODI, there were 260 incidents identified where the SCDS could not be completely eliminated as a possible cause. A breakdown of these incidents by model, model year, and key position is provided in Table 7. Table 10 shows the numbers and rates of these incidents by model, region, and key position.

Ford and TI disputed that the speed control deactivation switch was the cause in virtually all of the incidents. The amount and quality of the evidence varied considerably in the incidents reviewed by ODI. Therefore, to better assess which fires had evidence of SCDS involvement, ODI carefully analyzed all of the available information and called consumers to gather additional information when necessary. As previously noted, ODI established the following criteria to determine whether an incident would be counted as a speed control deactivation switch fire for the purposes of this investigation: (1) the fire originated in the area where the speed control deactivation switch is located (left-rear corner of the engine compartment, beneath the master cylinder); and (2) there was evidence of speed control deactivation switch failure prior to the fire (e.g., inoperable speed control, speed control deactivation switch fuse open – sometimes repeatedly, difficulty shifting out of PARK, evidence of brake fluid leakage from the switch) or (3) evidence of speed control switch failure was discovered during post-fire forensic examination.

Using these criteria, ODI identified a total of 35 fire incidents that appeared to be related to SCDS failure in the subject vehicle population. The cumulative failure frequency trends of the SCDS fires and the total fires where SCDS could not be completely eliminated are shown in Figures 14-16. The trends indicate an increase in fire experience after 7-8 years in service in the MY 1993 and 1994 vehicles and that SCDS fire experience begins after about 6-7 years in service.

Warranty and UDB data. Both warranty and post-warranty part sales sampling data submitted by Ford provide information concerning the failure mode/symptoms associated with service repairs. These data are shown in Tables 8 and 9. Table 11 provides a comparison of SCDS fire, warranty and UDB data in two geographic regions with similar subject vehicle populations. The data in each of these categories are greater in the southern Gulf Coast states than in the northern Great Lakes states. These differences become more pronounced with increasing vehicle age and mileage, especially for the Town Car vehicles (Figure 8).[6]

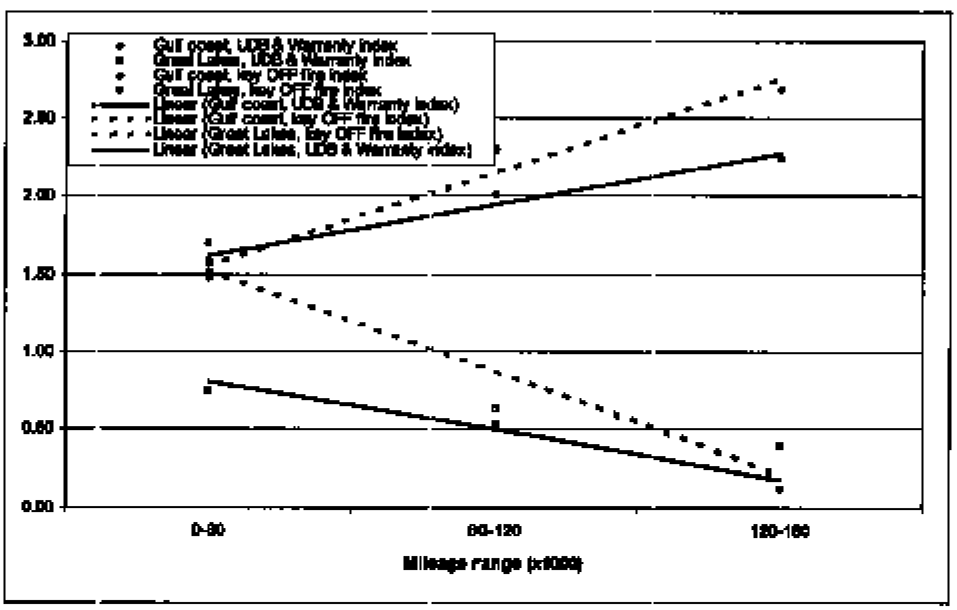

Figure 8. Rate indices by region, category, and mileage range; MY 1993-95 Town Car
(rate index = %category/%population, value of 1.0 indicates normal/average).

[6] These analyses are based on information provided by Ford about states where vehicles were delivered for sale. Subsequent vehicle migration patterns could influence this analysis to some extent.

Insurance data. To assess the general fire experience in the subject vehicles in comparison with other large-sized passenger cars of similar age, ODI requested policy count and fire loss claim information from a major insurance company for the subject vehicles and several peer vehicles by model year and year of claim. The data was requested for MY 1992 through 1997 and claim years 1993 through 2003. ODI's analysis of the insurance data found that the MY 1992 Town Car vehicles recalled in 99V-124 experienced substantial increases in fire rates in 1997 and 1998, when the fire claim rate peaked at over 4 claims per thousand insured vehicles. The MY 1992 Crown Victoria and Grand Marquis vehicles had a less pronounced increase in 1998, but remained within the range of peer vehicles analyzed by ODI.

Figures 17 through 22 show the insurance fire claim rate trends of the subject vehicles and select peers for each model year. The MY 1993 data includes both recalled and non-recalled vehicles. Figure 23 shows the combined trends for MY 1994-97 subject vehicles by years of exposure. This analysis shows a moderate increase over time in the subject vehicles, particularly in the Town Car vehicles after 7 years in service. The insurance data is of limited use in evaluating a specific defect condition, since it is not limited to a specific location or cause. In addition, the insurance data could not be analyzed by key position or geographic trends.

OBSERVATIONS:

1. Ford initiated 99V-124 after a sharp increase in underhood fires in certain MY 1992 through early-1993 Town Car, Crown Victoria, and Grand Marquis vehicles where the incident mileage for the majority of vehicles ranged from 60 to 100 thousand miles and the time-in-service ranged from 4 to 6 years (see EA99-006).

2. While most of the subject vehicles are several years older than the population recalled by Ford in 99V-124, the rate of fires in the subject vehicle population is significantly lower than in the recalled vehicles based on ODI complaints, Ford complaints, and insurance non-crash fire claim data.

3. At the time of 99V-124, the recalled vehicles ranged in age from 6 to 7 years old and the subject vehicles from 2 to 6 years old. The subject vehicles currently range in age from 7 to 11 years old.

4. The incident mileages range from 50 to 180 thousand miles and the time-in-service ranges from 5 to 10 years, with all but 6 out of 35 occurring after more than 7 years in service.

5. Approximately 97 percent of the 35 SCDS fire incidents with known key position occurred with the vehicle parked and the ignition "OFF."

6. Insurance data indicate a moderately increasing trend in non-crash fires in the subject Town Car vehicles after 7 years of service.

7. Part sales data indicate a constant annual volume of about 7 thousand switches per year.

REASON FOR CLOSING: Based on the low rate of fire incidents where failure of the SCDS is involved and the age of the vehicles – 7 to 11 years – a safety-related defect trend has not been identified and further use of agency resources does not appear to be warranted. The closing of this investigation does not constitute a finding by NHTSA that no safety-related defect exists. The agency reserves the right to take further action if warranted by the circumstances.

Safety Defects Engineer — Date: 6/28/04

I Concur:

Chief, Vehicle Control Division — Date: 6/28/04

Director, Office of Defects Investigation — Date: 6/28/04

List of Tables

Model	MY	Production	ODI		Ford[7,8]		Total	
			No.	R/100k	No.	R/100k	No.	R/100k
Town Car	1993	72,987	1	1.4	11	15.1	12	16.4
	1994	113,022	1	0.9	2	1.8	3	2.7
	1995	107,727	0	0.0	2	1.9	2	1.9
	1996	90,764	0	0.0	1	1.1	1	1.1
	1997	104,977	0	0.0	0	0.0	0	0.0
	Total	**489,477**	**2**	**0.4**	**16**	**3.3**	**18**	**3.7**
Crown Victoria/ Grand Marquis	1993	118,479	0	0.0	3	2.5	3	2.5
	1994	189,290	3	2.1	9	4.8	12	6.3
	1995	188,272	0	0.0	1	0.5	1	0.5
	1996	197,462	0	0.0	1	0.5	1	0.5
	1997	244,189	0	0.0	0	0.0	0	0.0
	Total	**937,692**	**3**	**0.3**	**14**	**1.5**	**17**	**1.8**
Total	1993	191,466	1	0.5	14	7.3	15	7.8
	1994	303,212	4	1.3	11	3.6	14	4.6
	1995	295,999	0	0.0	3	1.0	3	1.0
	1996	288,326	0	0.0	2	0.7	2	0.7
	1997	349,166	0	0.0	0	0.0	0	0.0
	Total	**1,427,169**	**5**	**0.4**	**30**	**2.1**	**35**	**2.5**

TABLE 6. U.S. sales, complaints, and complaint rates by model and model year.

Model	MY	Production	Key OFF		Key ON		Key UNK		Total	
			No.	R/100k	No.	R/100k	No.	R/100k	No.	R/100k
Town Car	1993	72,987	34	46.6	3	4.1	22	30.1	59	80.8
	1994	113,022	22	19.5	5	4.4	25	22.1	52	46.0
	1995	107,727	4	3.7	3	2.8	12	11.1	19	17.6
	Total	**293,736**	**60**	**20.4**	**11**	**3.3**	**59**	**20.1**	**130**	**44.3**
Crown Victoria/ Grand Marquis	1993	118,479	20	16.9	2	1.7	17	14.3	39	32.9
	1994	189,290	28	14.8	6	3.2	31	16.4	65	34.3
	1995	188,272	8	4.2	1	0.5	17	9.0	26	13.8
	Total	**496,041**	**56**	**11.3**	**9**	**1.8**	**65**	**13.1**	**130**	**26.2**
Total	1993	191,466	54	28.2	5	2.6	39	20.4	98	51.2
	1994	303,212	50	16.5	11	3.6	56	18.5	117	38.7
	1995	295,999	12	4.1	4	1.4	29	9.8	45	15.2
	Total	**789,777**	**116**	**14.7**	**20**	**2.5**	**124**	**15.7**	**260**	**32.9**

TABLE 7. Fire rates by model, model year, and key position
(Total fires: includes all underhood fires where SCDS could not completely be eliminated as potential cause).

[7] Ford data includes consumer complaints, field reports, and legal claims (lawsuits and subrogation claims).
[8] Ford's data for MY 1992 through 1995 includes records through September 2003. The Ford data for MY 1996 and 1997 was last updated in October 2001.

Model	MY	Fire/Smoke/Melt		Open Fuse/ Stuck in Park		Brake Fluid Leak		Total	
		No.	% Prod	No.	% Prod	No.	% Prod	No.	% Prod
Town Car	1993	1	0.001	1	0.001	4	0.005	55	0.075
	1994	2	0.002	1	0.001	2	0.002	63	0.056
	1995	0	0.000	7	0.006	8	0.007	106	0.098
	1996	0	0.000	4	0.004	3	0.003	14	0.015
	1997	0	0.000	4	0.004	2	0.002	13	0.012
	Total	**3**	**0.001**	**17**	**0.003**	**19**	**0.004**	**251**	**0.051**
Crown Victoria/ Grand Marquis	1993	2	0.002	3	0.003	8	0.007	88	0.074
	1994	3	0.002	7	0.004	12	0.006	124	0.066
	1995	2	0.001	7	0.004	50	0.027	252	0.134
	1996	0	0.000	1	0.001	0	0.000	8	0.004
	1997	0	0.000	10	0.004	4	0.002	22	0.009
	Total	**7**	**0.001**	**28**	**0.003**	**74**	**0.008**	**494**	**0.053**
Total	1993	3	0.002	4	0.002	12	0.006	143	0.075
	1994	5	0.002	8	0.003	14	0.005	187	0.062
	1995	2	0.001	14	0.005	58	0.020	358	0.121
	1996	0	0.000	5	0.002	3	0.001	22	0.008
	1997	0	0.000	14	0.004	6	0.002	35	0.010
	Total	**10**	**0.001**	**45**	**0.003**	**93**	**0.007**	**745**	**0.052**

TABLE 8. SCDS warranty claim analysis by model, model year, and failure mode/symptom.

Model	MY	Fire/Smoke/ Melt/Burn		Open Fuse/ Stuck in Park		Brake Fluid Leak		Total	
		No.	% UDB	No.	% UDB	No.	% UDB	No.	% Prod
Town Car	1993	7	7.6	28	30.4	5	5.4	92	0.13
	1994	4	3.4	24	20.7	2	1.7	116	0.10
	1995	5	3.6	11	8.0	11	8.0	137	0.13
	Total	**16**	**4.6**	**63**	**18.3**	**18**	**5.2**	**345**	**0.12**
Crown Victoria/ Grand Marquis	1993	6	6.7	23	25.8	5	5.6	89	0.08
	1994	13	10.7	22	18.2	9	7.4	121	0.06
	1995	2	1.1	4	2.1	8	4.2	190	0.10
	Total	**21**	**5.3**	**49**	**12.3**	**22**	**5.5**	**400**	**0.08**
Total	1993	13	7.2	51	28.2	10	5.5	181	0.10
	1994	17	7.2	46	19.4	11	4.6	237	0.08
	1995	7	2.1	15	4.6	19	5.8	327	0.11
	Total	**37**	**5.0**	**112**	**15.0**	**40**	**5.4**	**745**	**0.09**

TABLE 9. SCDS part sales UDB analysis by model, model year, and failure mode/symptom.

Model	MY	Production	Key OFF		Key ON		Key UNK		Total	
			No.	R/100k	No.	R/100k	No.	R/100k	No.	R/100k
Town Car	Gulf coast	77,016	32	41.5	3	3.9	20	26.0	55	71.4
	Great Lakes	67,095	11	16.4	3	4.5	18	26.8	32	47.7
Crown Vic/ Grand Marq	Gulf coast	143,038	33	23.1	2	1.4	24	16.8	59	41.2
	Great Lakes	119,271	7	5.9	3	2.5	10	8.4	20	16.8
Total	Gulf coast	220,054	65	29.5	5	2.3	44	20.0	114	51.8
	Great Lakes	186,366	18	9.7	6	3.2	28	15.0	52	27.9

TABLE 10. Fire rates by model, region, and key position
(Total fires: includes all underhood fires where SCDS could not completely be eliminated as potential cause).

Model	MY	Production	SCDS Fire		SCDS Warranty		SCDS UDB		Total	
			No.	R/100k	No.	R/100k	No.	R/100k	No.	R/100k
Town Car	Gulf coast	77,016	9	11.7	98	127.2	196	254.5	303	393.4
	Great Lakes	67,095	2	3.0	48	71.5	34	50.7	84	125.2
Crown Vic/ Grand Marq	Gulf coast	143,038	11	7.7	217	151.7	198	138.4	426	297.8
	Great Lakes	119,271	3	2.5	96	80.5	55	46.1	154	129.1
Total	Gulf coast	220,054	20	9.1	315	143.1	394	179.0	729	331.3
	Great Lakes	186,366	5	2.7	144	77.3	89	47.8	238	127.7

TABLE 11. SCDS Fire, UDB & Warranty rates by model and region.

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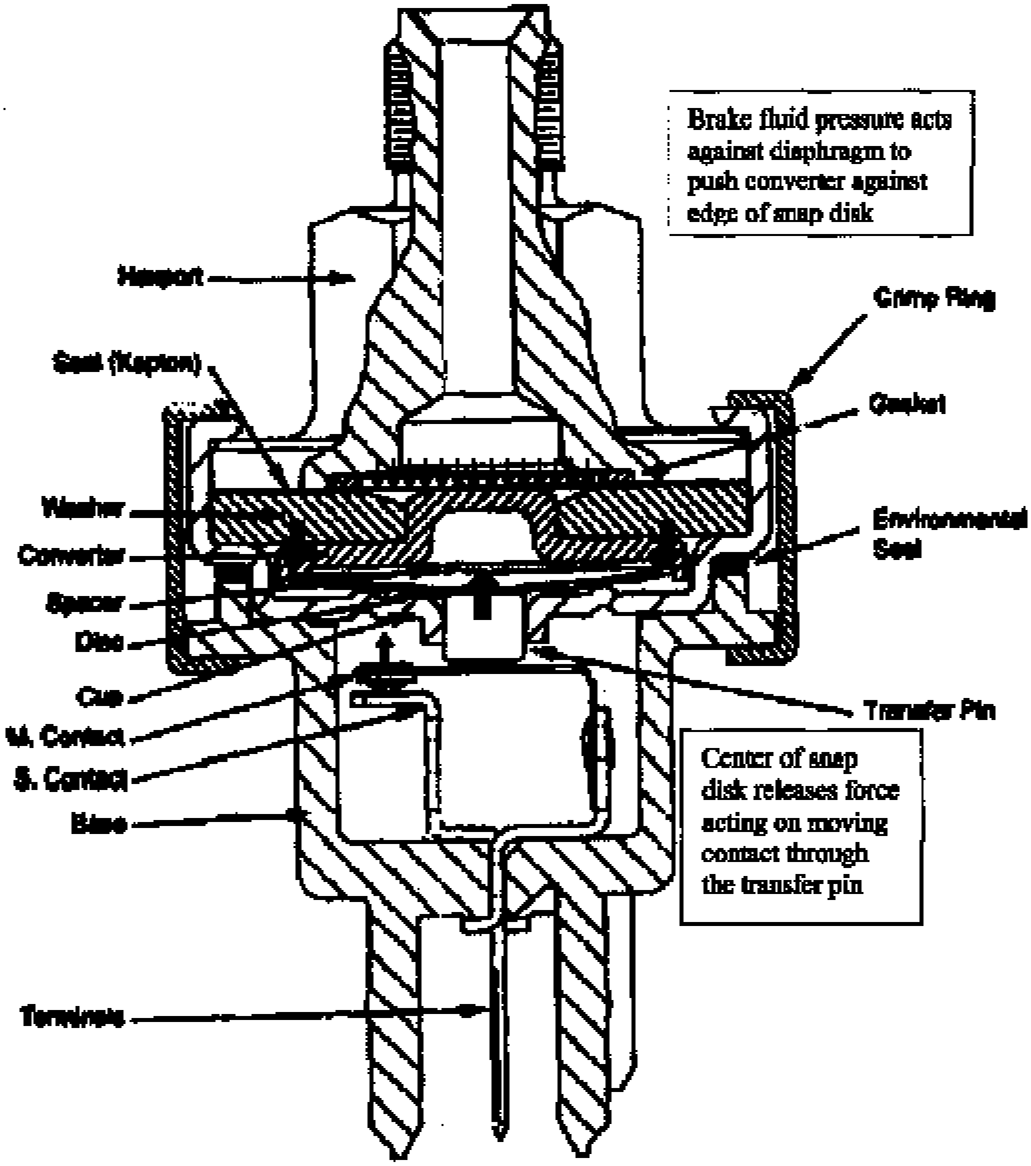

Figure 9. Speed Control Deactivation Switch.

Figure 10. Teflon cracking.

Figure 11. Crack through Kapton substrate with "Tear Drop" failure pattern.

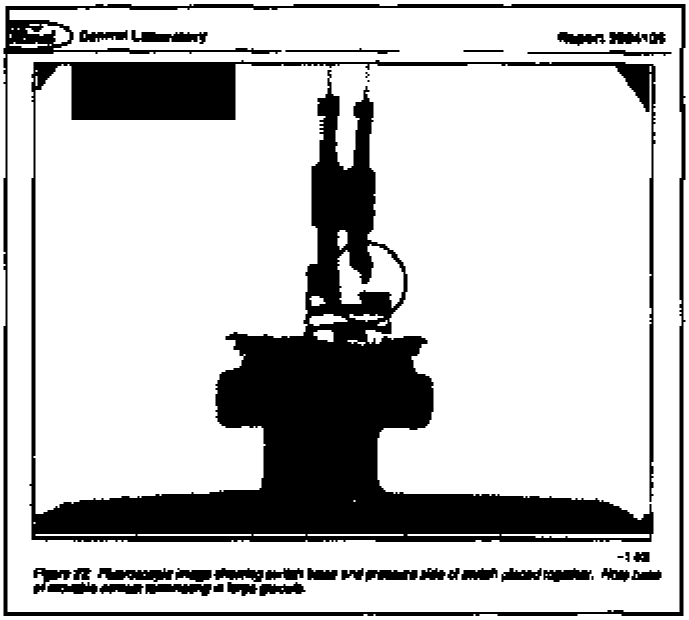

Figure 12. SCDS electrical cavity after contact corrosion and arcing (99V-124 Town Car).

Figure 13. SCDS with melted base.

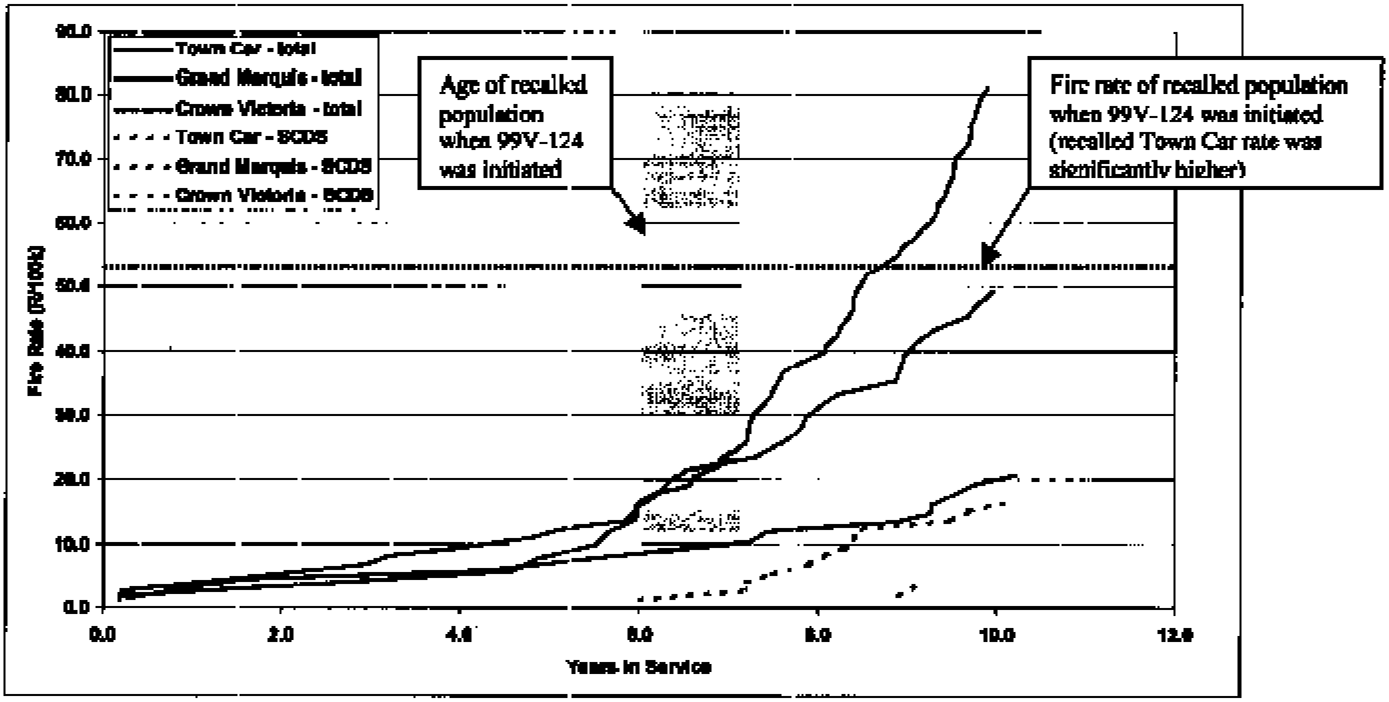

Figure 14. MY 1993 (post-recall production) cumulative fire rates, all underhood fires[9] and SCDS fires (ODI & Ford data).

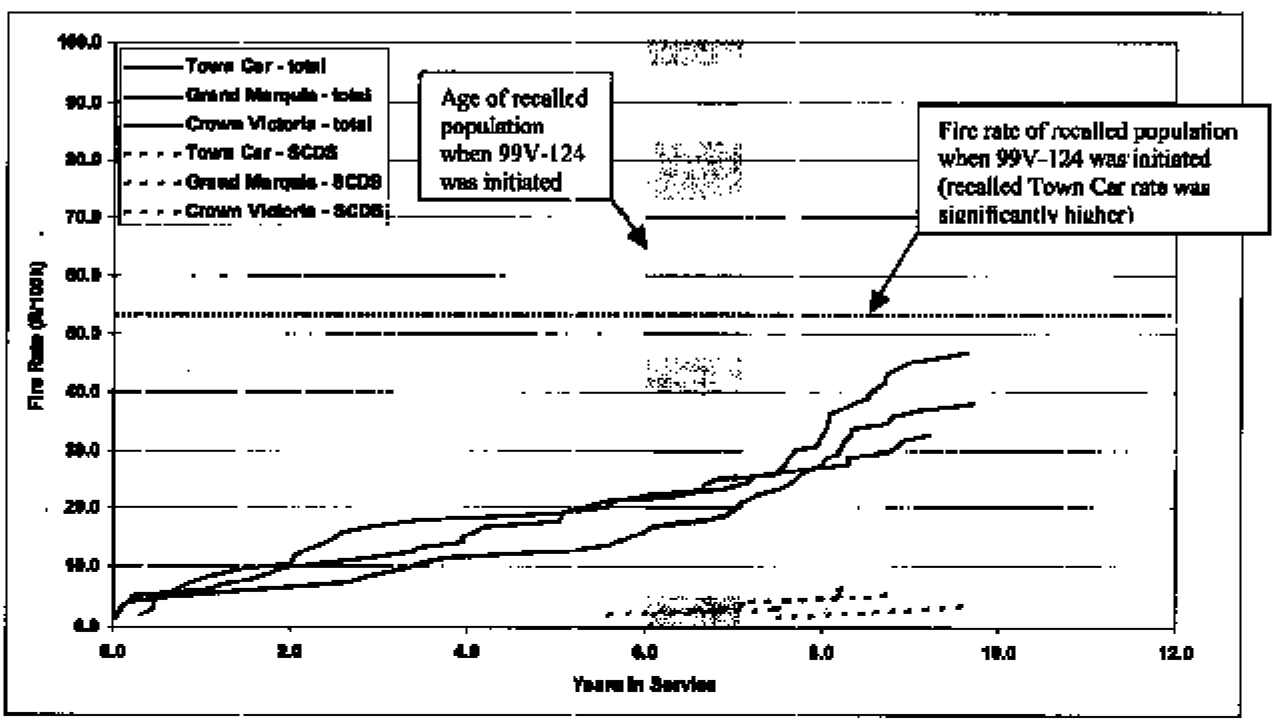

Figure 15. MY 1994 cumulative fire rates, all underhood fires[9] and SCDS fires (ODI & Ford data).

[9] "All underhood" includes all underhood fires where SCDS could not completely be eliminated as potential cause.

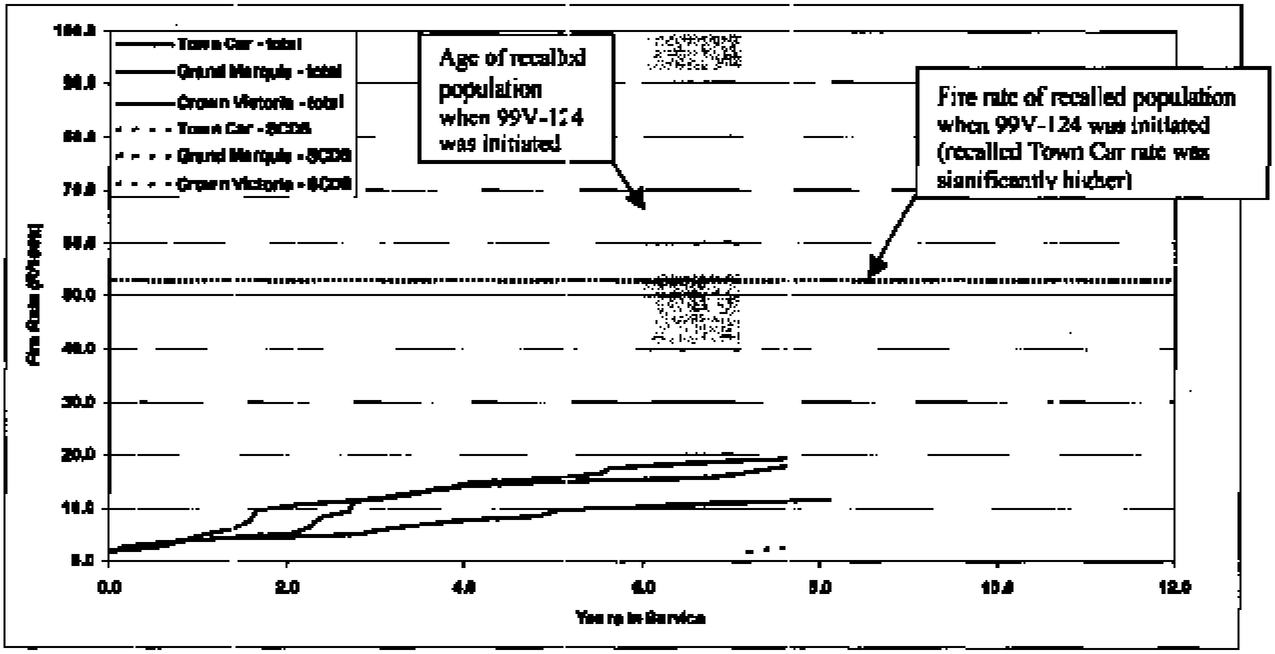

Figure 16. MY 1995 Cumulative Fire Rates, all underhood fires[9] and SCDS fires (ODI & Ford data).

[9] "All underhood" includes only all underhood fires where SCDS could not completely be eliminated as potential cause.

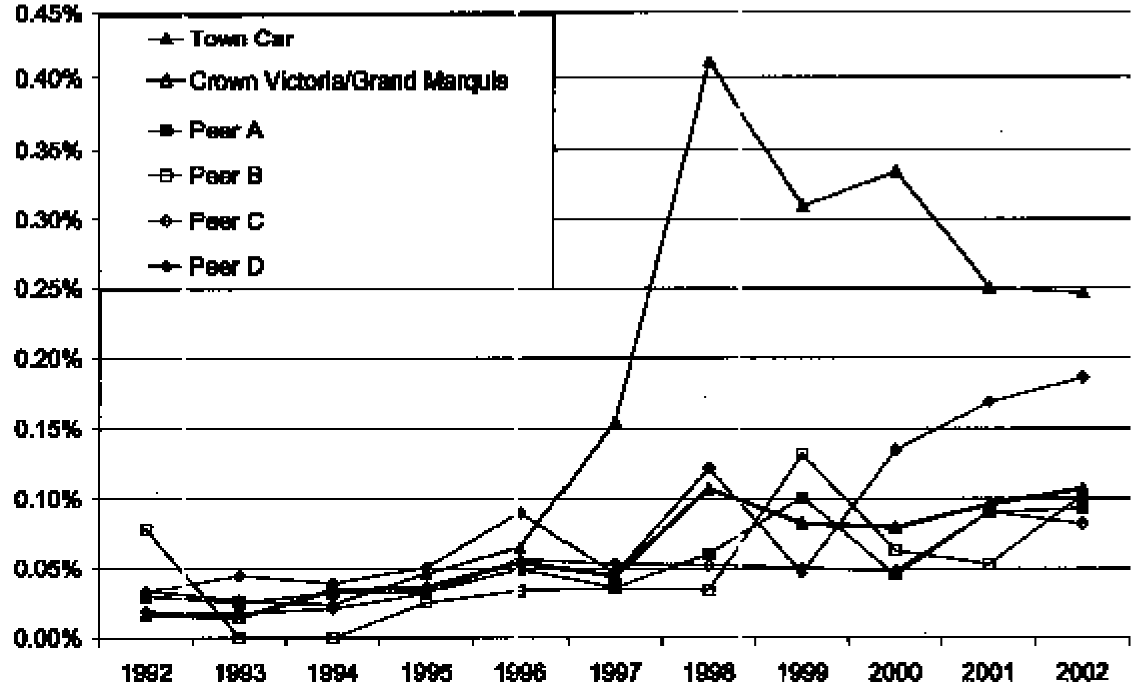

Figure 17. Insurance Claim Rates for Non-Crash Fire by Model and Claim Year, MY 1992 (includes recalled Town Car, Crown Victoria and Grand Marquis vehicles).

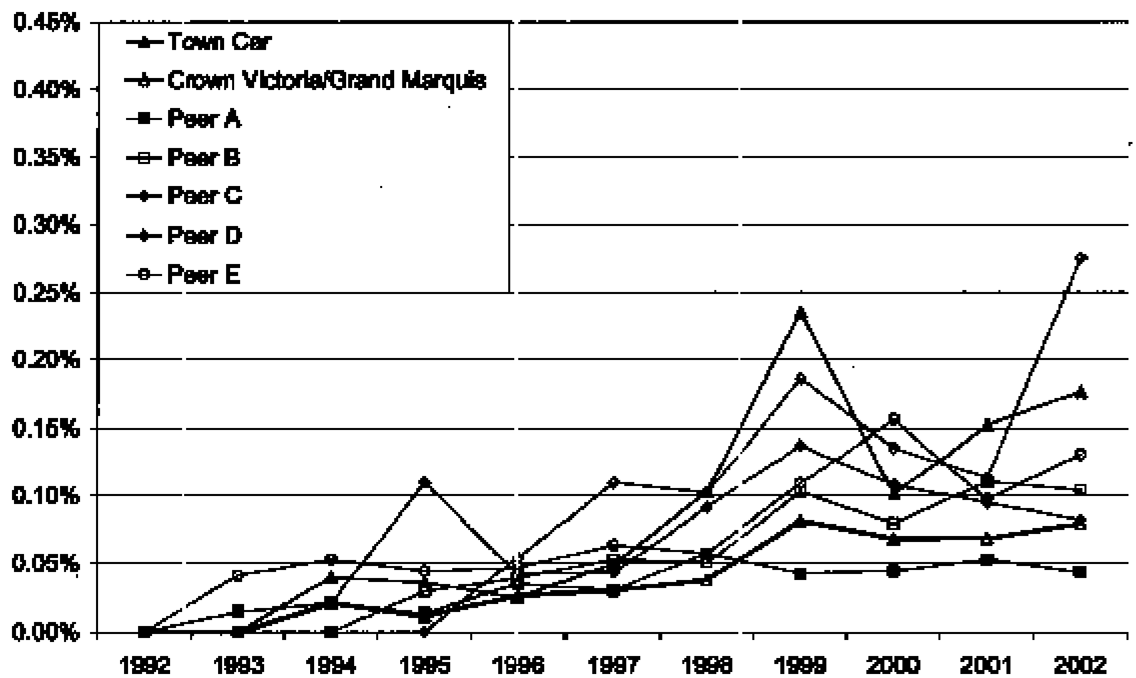

Figure 18. Insurance Claim Rates for Non-Crash Fire by Model and Claim Year, MY 1993 (includes recalled Town Car, Crown Victoria, and Grand Marquis vehicles).

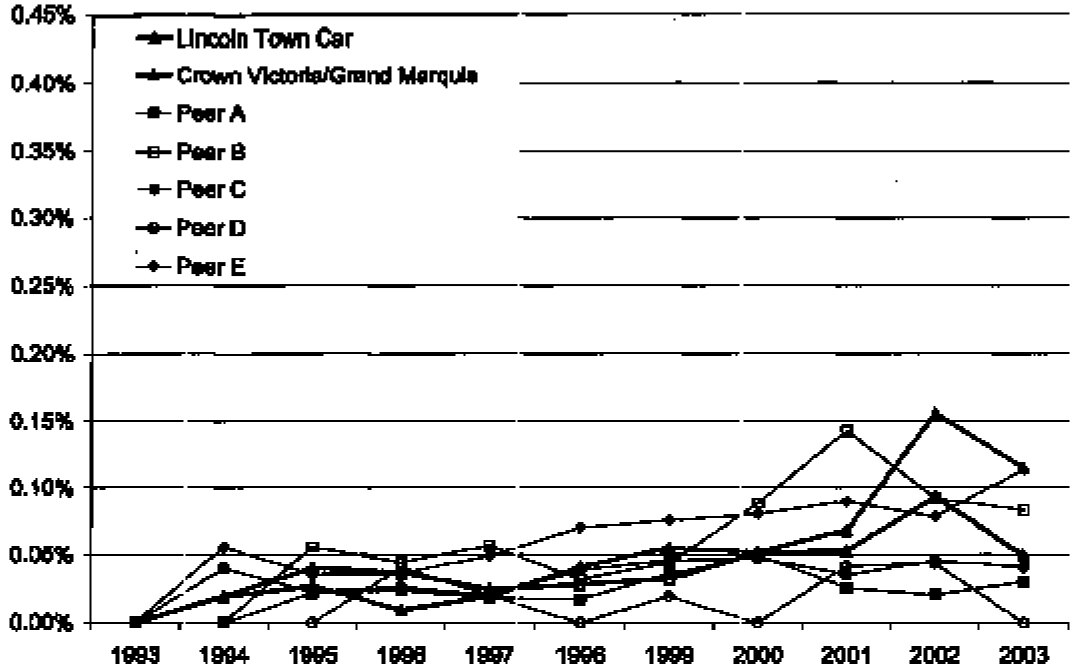

Figure 19. Insurance Claim Rates for Non-Crash Fire by Model and Claim Year, MY 1994.

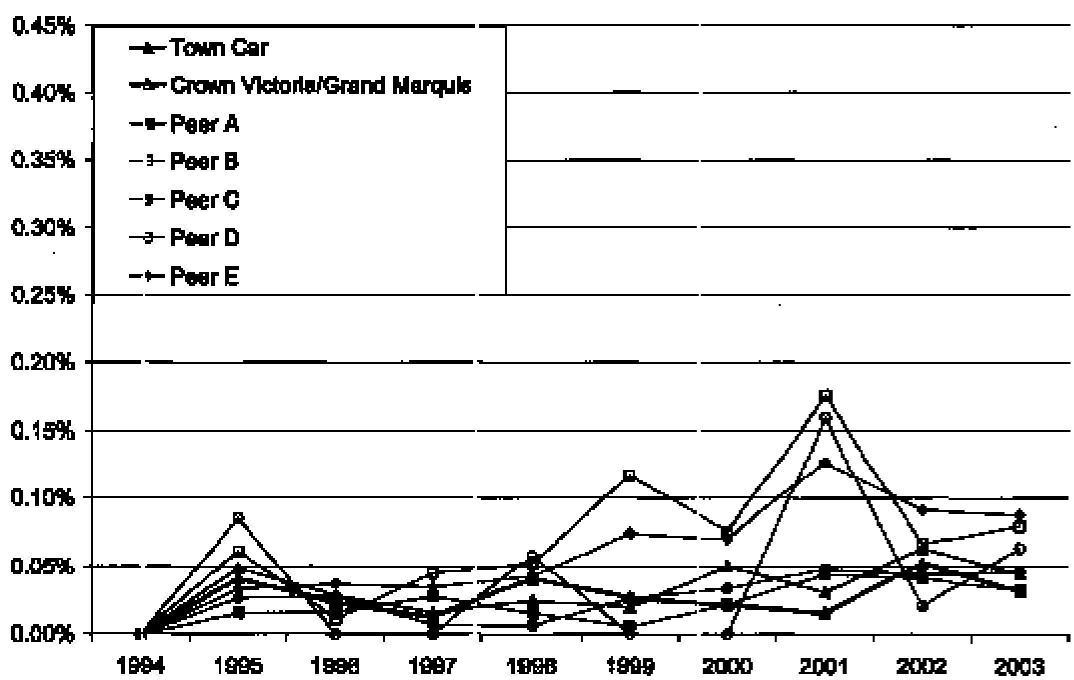

Figure 20. Insurance Claim Rates for Non-Crash Fire by Model and Claim Year, MY 1995.

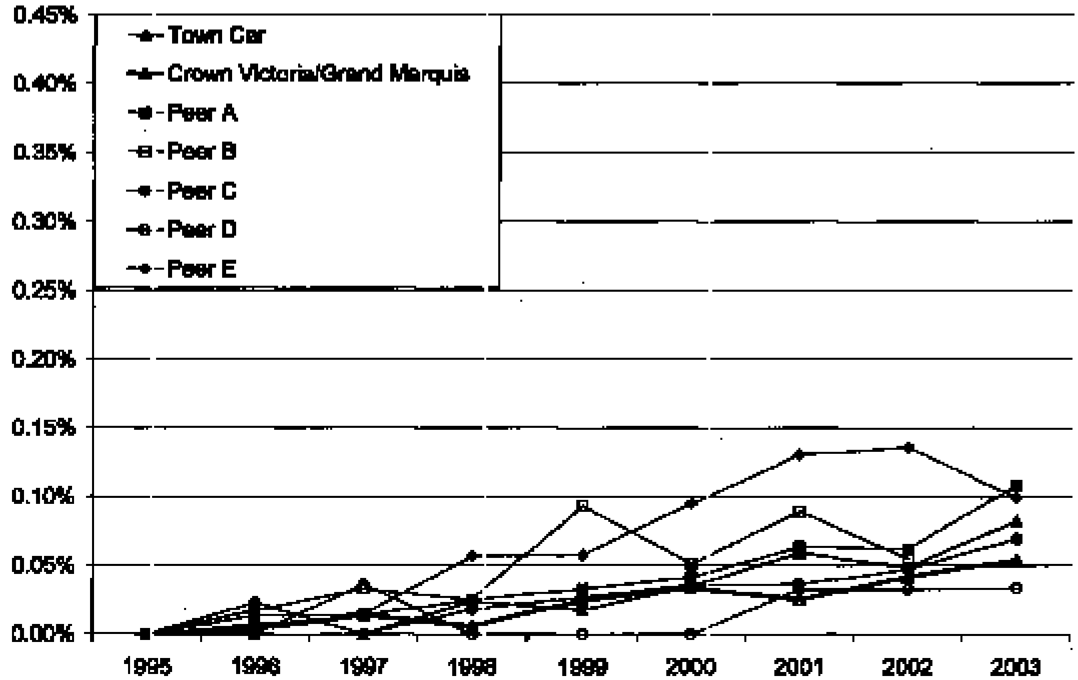

Figure 21. Insurance Claim Rates for Non-Crash Fires by Model and Claim Year, MY 1996.

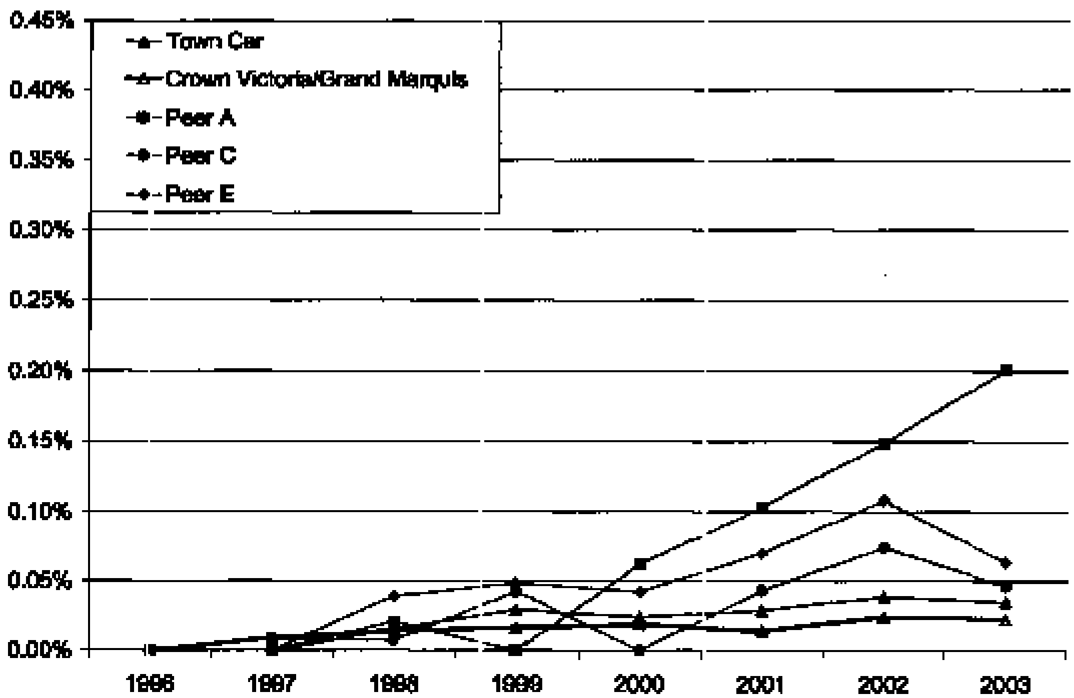

Figure 22. Insurance Claim Rates for Non-Crash Fires by Model and Claim Year, MY 1997.

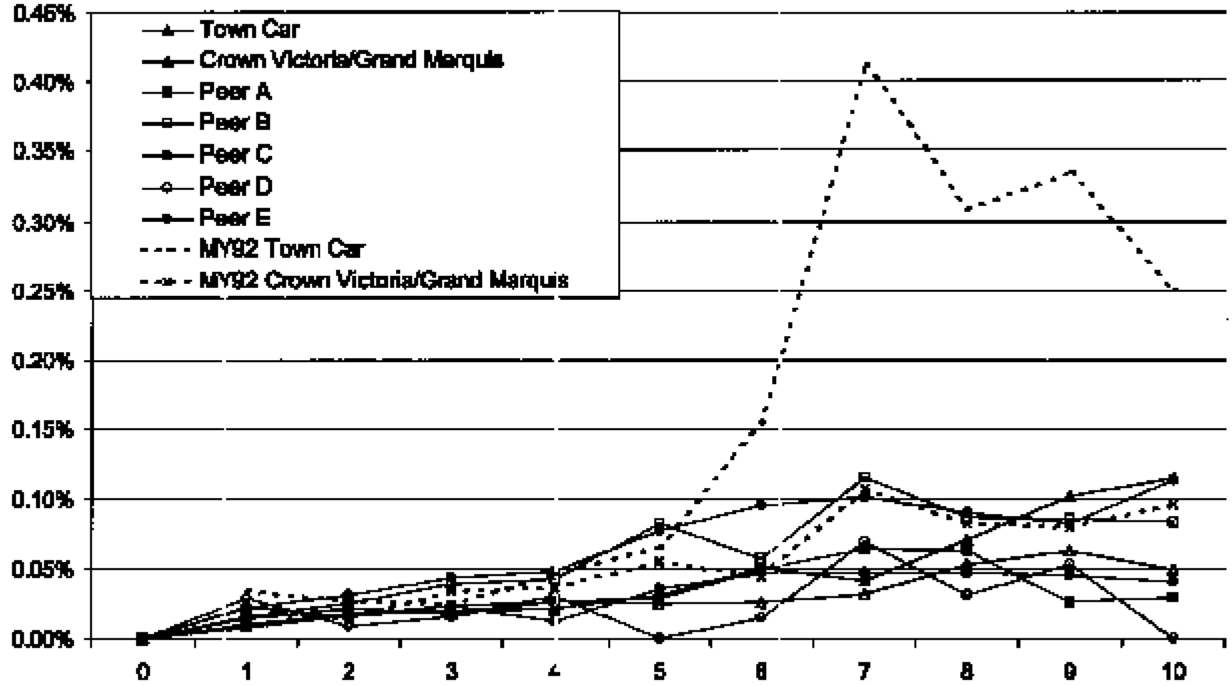

Figure 23. Insurance Claim Rates for Non-Crash Fires by Model and Exposure Years, MY 1994-97.