



U.S. Department  
of Transportation

**National Highway  
Traffic Safety  
Administration**

# ODI RESUME

**Investigation:** PE 14-001  
**Date Opened:** 01/23/2014  
**Investigator:** Kareem Habib  
**Approver:** Frank Borris  
**Subject:** Brake Actuator malfunction

**Date Closed:** 08/22/2014  
**Reviewer:** Jeff Quandt

## MANUFACTURER & PRODUCT INFORMATION

**Manufacturer:** Toyota Motor Corporation  
**Products:** MY 2007-2008 Toyota Camry hybrid  
**Population:** 100,491

**Problem Description:** Brake Actuator malfunction, resulting in possible deactivation of ABS/VSC functions and, in some cases, reduced power assisted braking.

## FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
<b>Complaints:</b>	72	685	734**
<b>Crashes/Fires:</b>	1	0	1
<b>Injury Incidents:</b>	1	0	1
<b>Number of Injuries:</b>	2	0	2
<b>Fatality Incidents:</b>	0	0	0
<b>Other*:</b>	0	864	864

\*Description of Other: Brake Actuator warranty claims

\*\* Total eliminates duplicates received by ODI and manufacturer.

## ACTION / SUMMARY INFORMATION

**Action:** This Preliminary Evaluation is closed.

### Summary:

On June 25, 2014, Toyota initiated a Warranty Enhancement Program (ZE1) to extend warranty coverage for the brake actuator assembly and skid control ECU/brake pedal stroke sensor in certain MY 2007 to 2011 Toyota Camry hybrid vehicles. Toyota's program covers repairs related to two conditions: internal malfunctions of the Brake Actuator assembly; and overly sensitive monitoring logic for the Brake Pedal Stroke Sensor. Primary coverage provides warranty enhancement until November 30, 2015, with no mileage limitation. After the primary coverage period ends, secondary coverage is provided for 10 years or 150,000 miles from the date of first use, whichever occurs first. In addition, on July 10, 2014, Toyota initiated Limited Service Campaign EOU to replace the Brake Reservoir Tank in MY 2007 through 2011 Toyota Camry hybrid vehicles. The LSC will be available until June 30, 2017, and will only be available at an authorized Toyota dealer.

ODI's analysis of failure data determined that the majority of records were related to the Brake Actuator condition, which appeared to be the causal component in 734 complaints/field reports and 864 warranty claims. The Brake Pedal Stroke Sensor (80 reports/189 claims) and Brake Reservoir Tank (91 reports/44 claims) conditions were identified in far fewer records. Analysis of the failure data indicate that each condition provides warning prior to any reduction in power assisted braking, with less than 10 percent of all reports and claims involving diagnostic codes or complaint narratives indicating increased braking effort or reduced brake effectiveness. In addition, most of the incidents in which reduced braking assist appears to have occurred involved operation in a reduced assist mode and not a sudden, complete loss of power assisted braking. ODI assessed reduced assist mode in a subjective driving evaluation which indicated that the brake system provided normal and hard deceleration capability with reasonable

increases in pedal effort. Less than one percent of reports and claims analyzed by ODI included evidence indicating a complete loss of power assisted braking occurred and this mode requires operation for a significant period of time with multiple audible and visual warnings. Repair expense was cited in many of the complaints reviewed by ODI, especially those related to the Brake Actuator, which had repair costs exceeding \$3,000 according to some complaints. High repair cost appears to have been a factor in the only crash identified by ODI for the fault conditions identified by Toyota, which involved a Brake Actuator failure that was diagnosed but the owner declined repair approximately eight months prior to the reported crash incident.

This preliminary evaluation is closed. The closing of this investigation does not constitute a finding that a safety-related defect does not exist. For additional information regarding this investigation, including analysis of the Brake Actuator, Brake Pedal Stroke Sensor, and Brake Reservoir Tank fault conditions and failure experience, see Attachment A to this closing resume.

ODI reviewed complaints and field reports (“reports”) and warranty claims related to Brake Actuator, Brake Pedal Stroke Sensor or Brake Reservoir Tank malfunctions in MY 2007 and 2008 Toyota Camry hybrid vehicles and identified 910 vehicles with at least one report and 1,097 with at least one warranty claim. Eighty-one percent of the reports were related to the Brake Actuator, which had a report rate of 7.3 incidents per thousand vehicles (IPTV). Seventy-nine percent of warranty claims were related to the Brake Actuator, which had a combined claim rate of 0.86 percent of vehicles sold. Table 1 provides a breakdown of field data reviewed by ODI by reporting source/category.

Condition	Complaints & Field					Warranty	
	ODI reports (VOQs)	Toyota consumer reports	Toyota field reports	Total reports	Report rate (IPTV)	Claims	Claim rate (%)
Brake Actuator	72	245	453	734	7.3	864	0.86
Stroke Sensor	5	6	70	80	0.8	189	0.19
Brake Reservoir	2	8	88	91	0.9	44	0.04

**Table 1. Field experience by brake system condition.**

**BRAKE ACTUATOR:** The Brake Actuator controls the hydraulic pressure of each of the four wheel cylinders using the output signal of the skid control ECU. It is located in the engine compartment, near the right front wheel. The Brake Actuator includes hydraulic power source (pump, pump motor, accumulator, relief valve, motor relays, and accumulator pressure sensor) and hydraulic control (master cylinder cut solenoid valves, pressure appliance solenoid valves, pressure reduction solenoid valves, master cylinder pressure sensors, and wheel cylinder pressure sensors) components.

Toyota identified a surface wear condition with the pressure appliance solenoid valves that can lead to reduced accumulator pressure. Reduced accumulator pressure results in more frequent operation of the pump motor to maintain required accumulator pressure, which is the initial symptom to operators of a potential problem with the accumulator. Increased leakage results in diagnostic trouble code (DTC) C1391 (Accumulator Leak Malfunction) being stored and illumination of multiple warning lights (“Brake”, “ECB”, “ABS”, Slip Indicator, and/or “Master Warning Light”). When C1391 is set, the ABS/VSC system is deactivated, but fully assisted braking is still available on all four wheels. Continued operation with C1391 set allows further deterioration of the valve, until the accumulator cannot reach its maximum pressure, resulting in the setting of DTCs C1256 (Accumulator Low Pressure) or C1252 (Brake Booster Pump Motor On-Time Abnormally Long).

Toyota indicated that it takes approximately 2,000 miles from the setting of C1391 before valve leakage is bad enough to set C1256 or C1252. At this stage, in addition to the warning lights, a continuous loud warning buzzer will sound to alert the driver to the brake system problem and the brake system goes into “Front Manual Brake and Rear Assist Brake” fail-safe mode with reduced power assist provided to the driver. Continued operation in this mode, with pump motor noise, warning lights and buzzer will eventually result in failure of the pump motor due to excessive run time, setting DTC C1253 (Pump Motor Relay Malfunction) and complete loss of brake assist. The mechanical braking system is fully functional for the front wheels in this mode, but no brake function is available in the rear wheels.

ODI's analysis of consumer report, field report and warranty data related to Brake Actuator malfunctions found that over 90 percent of failures are repaired prior to any reduction of braking assist and only about 1 percent reached the final stage of failure with complete loss of braking assist (Table 2)

Stage	Symptoms	DTC's	Brake Effects		% Field Data	
			Assist	ABS/VSC	Rpts	Warranty
1	Pump motor noise	None	Full assist	Normal	37%	31%
2	Multiple warning lights & message	C1391	Full assist	Off	55%	61%
3	Multiple warning lights, message & buzzer	C1252 C1256	Reduced assist	Off	7%	7%
4	Multiple warning lights, message & buzzer	C1253	No assist	Off	1%	<1%

**Table 2. Stages of Brake Actuator internal valve leakage failure progression by: a) symptoms; b) associated DTCs; c) effects on brake function; and d) proportion of field data reaching each stage prior to repair.**

**BRAKE PEDAL STROKE SENSOR:** The Brake Pedal Stroke Sensor is a contact switch that detects the amount of brake pedal stroke and inputs the results to the skid control ECU. The skid control ECU calculates the braking force required by the driver based on signals from the Brake Pedal Stroke Sensor and the master cylinder pressure sensor. The ECU calculations primarily use input from the Brake Pedal Stroke Sensor during initial pedal application and then relies mostly on master cylinder pressure.

According to several failure analysis reports provided by Toyota, the Brake Pedal Stroke Sensor contact switch can wear and debris may accumulate on the contact surface resulting in high resistance spots. Under these conditions, DTC C1247, "stroke sensor malfunction will be stored, the previously mentioned warning lights will be illuminated and the ABS/VSC system is deactivated while full assist is maintained on all four wheels. Due to an overly sensitive monitoring logic, the Skid Control ECU may temporarily enter the reduced assist mode activating a loud continuous buzzer in addition to the warning lights. ODI's analysis of field data related to Brake Pedal Stroke Sensor malfunctions found that approximately 95 percent did not involve any loss of braking assist (Table 3).

Stage	Symptoms	DTC's	Brake Effects		% Field Data	
			Assist	ABS/VSC	Rpts	Warranty
1	Multiple warning lights, msg & non-linear brake feel	C1247	Full assist	Off	96%	95%
2	Multiple warning lights, message & buzzer	C1247	Reduced assist	Off	4%	5%

**Table 3. Stages of Brake Pedal Stroke Sensor failure progression by: a) symptoms; b) associated DTCs; c) effects on brake function; and d) proportion of field data reaching each stage prior to repair.**

**RESERVOIR TANK:** The Brake Reservoir Tank consists of two chambers, separated by a filter, and a brake fluid level warning switch. During normal operation, a small amount of brake fluid circulates through the actuator, master cylinder, and the reservoir tank. Fluid that returns to the master cylinder-

side chamber of the reservoir tank passes to the actuator-side chamber through a filter. Toyota determined that a fatty acid compound leaching out of the brake hoses may clog the filter over a long period of time in some vehicles. This condition causes the fluid level in the actuator-side chamber to decrease. If the fluid falls below the low-level threshold, the “Brake” warning light will be illuminated but brake function continues to operate normally until DTC C1202 (Master Reservoir Level Malfunction) is set. According to Toyota, the low-level condition is most likely to occur when the vehicle is first started. The transition to fail-safe mode can occur at any time when operating with the low reservoir level condition, based on other system diagnostic signals. The DTC may be cleared and system returned to normal operation if level is restored above the low-level threshold for a certain period of time during operation. Many owners reported hearing the pump noise when the brake warning lamp is illuminated, prior any reduction of assist. ODI’s analysis of field data related to Brake Reservoir Tank filter clogging (primarily dealer requests for technical assistance) found that roughly half may have resulted in fail-safe operation with reduced assist (Table 4).

Stage	Symptoms	DTC’s	Brake Effects		% Field Data	
			Assist	ABS/VSC	Rpts	Warranty
1	Brake warning light	None	Full assist	Off	42%	52%
2	Multiple warning lights	C1202	Reduced assist	Off	58%	48%

**Table 4. Stages of Brake Reservoir Tank failure progression by:**  
**a) symptoms; b) associated DTCs; c) effects on brake function; and**  
**d) proportion of field data reaching each stage prior to repair.**

**BRAKE PERFORMANCE:** ODI evaluated the safety risks associated with the Brake Actuator, Brake Pedal Stroke Sensor and reservoir tank fault conditions by several methods, including: 1) analyzing crash incidents allegedly caused by brake system faults; 2) analyzing reports and warranty claims to identify incidents alleging brake system performance concerns related to the Brake Actuator, stroke sensor and brake reservoir assembly fault conditions; 3) reviewing test data submitted by Toyota; and 4) conducting subjective braking evaluations in test drives of vehicles operating in reduced assist and no assist fail-safe modes.

These analyses identified no crashes related to the subject conditions, found that over 90 percent of failures were detected and repaired prior to any reduction of braking assist, and observed that braking performance in Front Manual/Rear Assist fail-safe mode provides sufficient braking assist for normal and emergency braking with moderate increases in pedal effort. ODI’s review of test data and subject test drive evaluations observed that operation with no braking assist requires significantly higher pedal efforts and would present safety concerns if this mode occurred with no warning and sufficient frequency in the field data. However, as previously noted, this stage of failure is only associated with the Brake Actuator condition and requires operating with audible/visual warnings for a significant period of time before it can be reached and was observed in only a few of the incidents analyzed by ODI.

**Crash analysis.** ODI analyzed 29 crashes reported by Toyota and 22 crashes reported to ODI that involved allegations of brake malfunctions. No evidence of brake malfunction was found in 19 of incidents provided by Toyota and the evidence was either insufficient to assess cause or pointed to other factors for the remaining 10 incidents.

Table 5 summarizes ODI's analysis of 22 VOQs alleging brake related crashes in subject vehicles. ODI analyzed information from owner/driver interviews, service records and accident records to identify incidents that may be related to the Brake Actuator, stroke sensor or brake reservoir conditions.

Brake Fault Category	Crash Category	VOQ's
Evidence of Brake Actuator fault	Potentially related crash	10594713
	No accident record/ minor impact	10559758, 10562294
	Unrelated crash (years prior to brake fault)	10586069, 10604604
Evidence of other fault condition	No accident record/ minor impact	10521852, 10582799
No evidence of brake system fault	Sudden acceleration claims	10290745, 10320639, 10330672, 10359067, 10360287, 10363766, 10318390, 10389747, 10574847
	No accident record/ minor impact	10399625, 10562805, 10578975, 10609047
Insufficient Information	No accident record/ minor impact	10575739
	No VIN provided	10561929

**Table 5. Analysis of ODI crash reports.**

ODI's analysis did not find evidence of Brake Actuator fault in 17 of the crash allegations, including 9 VOQs related to claims of sudden acceleration when parking or approaching stop signs. No evidence of brake system faults were found in any of these vehicles and investigation of some with pre-crash event data (EDR) available showed that the brakes were not applied in the seconds prior to impact.

ODI found evidence of Brake Actuator fault history for five of the vehicles with crash allegations. The alleged crash incidents for two of the vehicles pre-date the Brake Actuator malfunctions by approximately 2 years (VOQ 10586069) and 5 years (VOQ 10604604). The complaint for one of these (VOQ 10586069) involved a crash that occurred during original ownership but was submitted by the second owner, who was only aware of the incident from a CarFax report and had no knowledge that the crash was related to any braking issues or any other vehicle condition.

The other three crash allegations involved 1 crash and 2 minor impact incidents (e.g., curb strike). The crash and one of the minor impacts occurred after the vehicles had been operated for several months with known Brake Actuator faults after declining repairs due to cost. The single confirmed crash incident involved a rear-end collision into a disabled vehicle after a late brake application (the Camry driver did not see the disabled vehicle until a leading vehicle ahead swerved to avoid it). The service history for the subject vehicle involved in this incident showed that a faulty Brake Actuator had been diagnosed and repair declined approximately eight months prior to the crash and were declined again shortly after the crash.

**Field data analysis.** ODI’s analysis of failure data associated with the subject conditions found that the majority of complaints/repairs did not involve any allegations of brake performance concerns (Tables 2-4). Analysis of incidents that did allege performance issues related to wheel lock-up or brake effectiveness identified one potentially related crash with two injury allegations (Tables 5 & 6).

Condition	Stability concerns		Stopping concerns		Injuries
	Wheel lock-up allegations	Wheel lock-up resulting in control loss	Reduced braking effectiveness	Crashes	
Brake Actuator	12	0	79	1	2
Stroke sensor	3	0	10	0	0
Brake reservoir	2	0	57	0	0

**Table 6. Allegations of brake system performance concerns (all sources) and related safety consequences by brake condition.**

**VOQs:** The following 72 VOQ’s are associated with the closing resume for PE14-001:

- 10327915, 10455779, 10473784, 10485814, 10486535, 10491891, 10491897, 10494412, 10494863, 10499211, 10502717, 10504295, 10508177, 10508686, 10511312, 10512240, 10513560, 10513603, 10515021, 10515775, 10519847, 10521061, 10522141, 10533745, 10534131, 10537718, 10538281, 10542185, 10546711, 10548327, 10548893, 10549290, 10552561, 10552578, 10553723, 10555092, 10555704, 10555846, 10556137, 10556345, 10556501, 10556934, 10557124, 10558269, 10559109, 10559705, 10559758, 10561647, 10561910, 10561942, 10562294, 10563089, 10563674, 10563951, 10564647, 10564922, 10566117, 10566537, 10574119, 10576049, 10578399, 10583186, 10586069, 10587874, 10592601, 10593810, 10594223, 10594713, 10595969, 10598003, 10604604, 10605703