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

ODI RESUME

Investigation: EA 06-003
Prompted By: PE05-061
Date Opened: 03/08/2006 Date Closed: 05/22/2007
Principal Investigator: Michael Lee
Subject: Front Air Bag Crash Sensor Failure

Manufacturer: DaimlerChrysler Corporation
Products: 2005-2006 DaimlerChrysler Minivans (Dodge Caravan and Grand Caravan, and Chrysler Town and Country)
Population: 960,569

Problem Description: Frame rail-mounted front air bag crash sensors can fail due to corrosion. The failure may cause the frontal air bags to deploy late or reduce the driver air bag inflation level in certain types of frontal crashes.

FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
Complaints:	37	1,588	1,625
Crashes/Fires:	0	0	0
Injury Incidents:	0	0	0
# Injuries:	0	0	0
Fatality Incidents:	0	0	0
# Fatalities:	0	0	0
Other*:	0	40,415	40,415

*Description of Other: Warranty claims for sensors with brass bushings.

Action: This Engineering Analysis is closed (Recall 07V-192).

Engineer: *Michael Lee* MTL Date: *05/22/2007*
Div. Chief: *Thomas Z. Cooper* Date: *05/22/2007*
Office Dir.: *Kathleen C. DeMeter* Date: *05/22/2007*

Summary: DaimlerChrysler (DCC) will replace the frame rail-mounted front air bag crash sensors in approximately 270,958 MY 2005 DaimlerChrysler Minivans (NHTSA Recall No. 07V-192). These vehicles are equipped with front crash sensors with brass bushings and were built between April 24, 2003 and February 2, 2005. This action covers vehicles originally sold, or currently registered, in 27 states (Alaska, Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, West Virginia and Wisconsin) and the District of Columbia.

Vehicles sold or currently registered outside of these states, approximately 133,128 MY 2005 Minivans, will receive a lifetime warranty on the front crash sensors. Although these vehicles use the same brass bushing sensors and were built during the same period as the ones described above, they experience significantly lower failure rates because of reduced road salt exposure. DCC will also provide written notification to all affected vehicle owners.

NHTSA and DCC differ regarding the significance and impact of the defect, but in the interest of remedying the affected vehicles expeditiously and to avoid a protracted dispute, DCC is implementing steps to replace the subject components. Based on these actions, the agency has decided that further use of its resources does not appear to be warranted. Accordingly, this investigation is closed. The closing of this investigation does not constitute a finding by NHTSA that no safety-related defect exists in the subject vehicles. The agency will monitor the issue and reserves the right to take further action if warranted by the circumstances.

Background: On November 10, 2005, ODI opened a Preliminary Evaluation (PE05-061) to investigate allegations of front air bag crash sensor failures on model year (MY) 2005 DaimlerChrysler Minivans manufactured by DaimlerChrysler Corporation (DCC). On March 8, 2006, the investigation was upgraded to an Engineering Analysis (EA06-003). During EA06-003, ODI expanded the scope of the investigation to include MY 2005 and 2006 DaimlerChrysler Minivans (herein referred to as subject vehicles).

Subject Vehicles: As of May 2006, a total of 960,569 subject vehicles were sold in the U.S.; 622,820 were MY 2005 and 337,749 were MY 2006.

Resolution: Regional Recall 07V-192 and Lifetime Warranty

DCC will replace the frame rail-mounted front air bag crash sensors (herein referred to as front crash sensors) in approximately 270,958 MY 2005 DaimlerChrysler Minivans.[1] These vehicles are equipped with front crash sensors with brass bushings and were built between April 24, 2003 and February 2, 2005. This action covers vehicles originally sold, or currently registered, in 27 states and the District of Columbia.[2]

Vehicles sold or currently registered outside of these states, approximately 133,128 MY 2005 Minivans, will receive a lifetime warranty on the front crash sensors. Although these vehicles use the same brass bushing sensors and were built during the same period as the ones described above, they experience significantly lower failure rates because of reduced road salt exposure. DCC will also provide written notification to all affected vehicle owners.

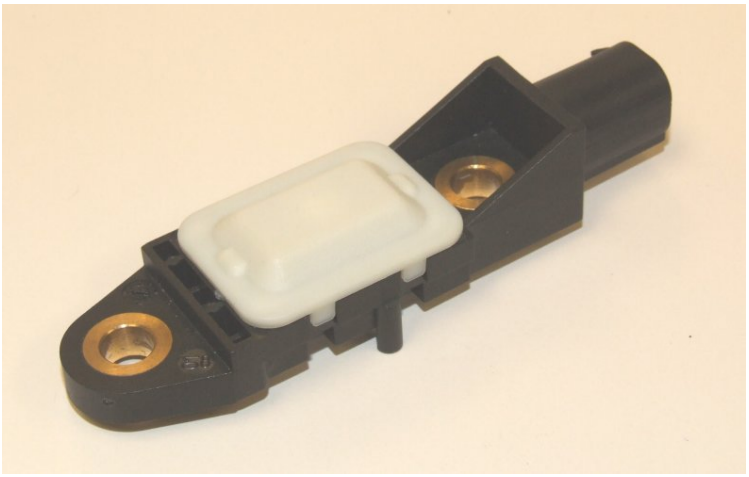
Description of Frontal Air bag System: The subject vehicles are equipped with advanced dual frontal air bags with multi-stage inflators and seat belt pretensioners for the front outboard seating positions. These components work with the Occupant Restraint Controller (ORC) located in the passenger compartment. The multi-stage inflators are designed to provide different air bag inflation levels based on crash severity. To help the system decide whether to deploy the frontal air bags and what characteristics to apply (i.e. low-, mid-, or high-stage), the system consists of left and right front crash sensors (subject components) mounted on the frame rails behind the front bumper and a central crash sensor inside the ORC. Based on the crash signals from the central crash sensor and the front crash sensors, the ORC decides whether to deploy the air bags. The primary function of the subject components is to detect frontal offset and oblique impacts and deploy the air bags in a timely manner. In addition, the ORC performs overall system diagnostic functions.

[1] The MY 2005 DaimlerChrysler Minivan was a newly designed, early introduction vehicle sold beginning in January 2004.

[2] The affected states are Alaska, Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, West Virginia and Wisconsin.

Description of Subject Components: Each front crash sensor consists of a black plastic-molded housing, with its internal circuit board covered and sealed by a white plastic cap, connector terminal housing, and two mounting bushings for fasteners. Steel fasteners mount the sensor onto the steel frame rail. A photograph of a new subject component is shown below. The sensor is connected to the ORC by a connector assembly (not shown in the photo) by inserting it into the connector housing. Robert Bosch Corporation (Bosch) is the supplier of the subject components.

New Brass Bushing Front Crash Sensor



Alleged Defect/Failure Description

The alleged defect is the failure of the front crash sensors due to corrosion caused by the use of dissimilar metals—in this case, brass bushings secured with steel fasteners to a steel frame rail—exposed to road splash water (especially salt water) that accelerates the rate of corrosion. Metal corrosion eventually leads to cracking of the sensor's plastic housing starting near the bushings and propagating to the connector housing and molded plastic at the circuit board. Water enters through the cracks, reaches the sensor's internal components (connector pins and circuit board), corrodes them, and damages the sensor, causing it to malfunction. The failure manifests itself as increased electrical resistance.

When the electrical resistance exceeds a specified range, the ORC triggers a fault code and illuminates the vehicle's air bag warning lamp, which disables the affected front crash sensor. If the air bag warning lamp illuminates as result of a front crash sensor fault, depending on the version of the ORC used, the ORC will either: (a) use a "backup" calibration mode and not accept any input from either front crash sensor, or (b) remain in normal operation mode and continue to accept input from the good sensor but not from the failed sensor.[3]

[3] In the latter scenario, the ORC will enter a "backup" calibration mode only when both front crash sensors trigger a fault code--i.e. when they both fail.

When the ORC is in its "backup" calibration mode or when an impact occurs on the same side as the failed sensor, the frontal air bags may deploy late. Either condition may also reduce the driver air bag inflation level in certain types of frontal crashes—particularly frontal offset crashes. Late deploying air bags may cause air bag-induced injuries and/or result in reduced air bag protection.

Production and Material Changes/Modifications: Table 1 is a summary of the modifications in the production and material of the subject components.

Table 1. Sensor Changes

Model Year	Change Date Assembly Plant	Description of Change	Change Designation[4]
Early 2005	May 2004 Windsor June 2004 St. Louis	New fastener and lower torque for mounting sensors and modified mounting impression to prevent stripping, not seating and cracking sensor housing	MOD1
Mid-2005	Jan. 2005 St. Louis Feb. 2005 Windsor	Material of sensor mounting bushings changed from brass to steel for resistance to corrosion	MOD2
Mid-2006	Mar. 2006 St. Louis Apr. 2006 Windsor	Material of sensor plastic housing changed from a material referred to by DCC as Ultradur to one referred to as Crastin that has greater resistance to moisture absorption	MOD3

Service Bulletins: DCC issued two service bulletins in March and May 2005, which instructed its dealers to order the steel bushing sensor and connector assembly together. The latter bulletin also instructed dealers to use new washers and to replace both the left and right front crash sensors and connector assemblies when servicing the subject vehicles.

Complaints and Reports: To date, ODI has received 37 Vehicle Owner's Questionnaires (VOQ) on allegations of failure of the subject components and/or illumination of the air bag warning lamp on the subject vehicles. As of its July 2006 data submission, DCC had approximately 1,588 customer complaints, field reports, and legal and other claims related to possible sensor failure.[5] Most of the complaints involved MY 2005 vehicles equipped with brass bushing sensors.

Warranty Claims: As of its July 2006 data submission, DCC had 30,300 warranty claims for replacement of the subject components on the subject vehicles. In March 2007, DCC reported to ODI that it had 40,415 warranty claims on MY 2005 vehicles equipped with brass bushing sensors.

[4] Change designations will appear in "ODI Analysis" section of this report.
[5] Multiple reports on the same VIN are counted as separate reports and are included in the total.

NHTSA Testing and Analysis

Failed Sensor Analysis. The agency's Vehicle Research and Test Center analyzed several allegedly failed subject components from VOQ complaint vehicles. All sensors examined had brass bushings (no failed steel bushing sensors were available for analysis) that exhibited corrosion. Evidence of corroded metal residue was also found on the plastic portions of the sensor, particularly along its inboard side where the sensor attaches to the frame rail (Photos 1 and 2). The analysis showed that there were electrolytic paths between the bushings and connector pins, and evidence of corrosion on the sensor circuit board and the positive connector pin (Photo 3, connector pins). Cracks and voids were found in the sensor's plastic housing. The cracks appear to be a migration pathway within the sensor housing.

Photo 1. Failed Sensor – Outboard side as installed on vehicle

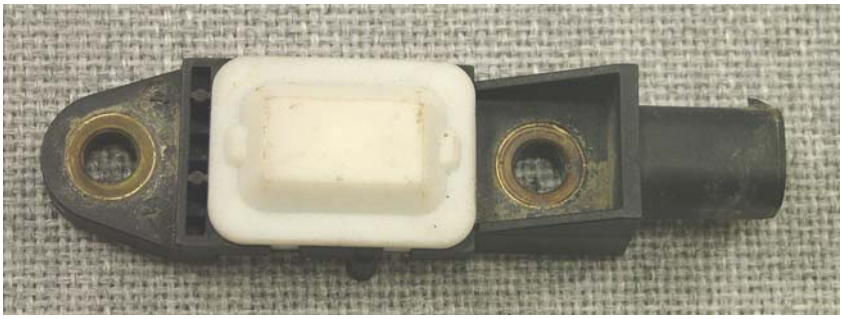
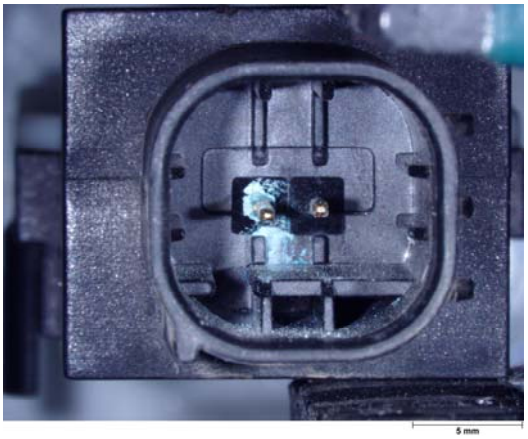


Photo 2. Failed Sensor – Inboard side as installed on vehicle

Photo 3. Corroded Connector Pin – Top view of terminal housing



Crash Tests. To evaluate the potential risk to occupant safety from the alleged defect in the subject vehicles, NHTSA conducted two vehicle crash tests at MGA Research Corporation. The tests were selected from the matrix of crash test modes specified in Federal Motor Vehicle Safety Standard (FMVSS) No. 208, Frontal Crash Protection.

With the left front crash sensor disconnected prior to each test to simulate the alleged defect condition in the test vehicle, the ORC in the test vehicle remained in the "backup" calibration mode. Table 2 below briefly presents the results of the two tests. The test results are discussed later in the "ODI Analysis" section of this report.

Table 2. Vehicle Crash Tests

Crash Test Mode	Crash Test Dummy	Air bag Time-to-Fire	Test Results
25 mph, left 40% offset deformable barrier	5th female (belted)	98 ms	All criteria met except for driver neck tension -- 3349 N (FMVSS 208's neck tension criterion for 5th female is 2620 N)
25 mph, left 30 degree rigid barrier (i.e. oblique)	50th male, (unbelted)	30 ms	All injury criteria in FMVSS 208 were met

Both test vehicles were MY 2005 Minivans equipped with brass bushing sensors. The Minivan used in the left offset deformable barrier (ODB) crash test was an early production vehicle built in January 2004, which used a different crash sensor calibration (i.e., algorithm) from some of the subject vehicles produced later, including the vehicle used in the left 30-degree oblique crash test, which was built in June 2004.

ODI Analysis

Warranty Claim Analysis. ODI's analysis of warranty claim data indicates that the MY 2005 vehicles equipped with brass bushing front crash sensors have experienced a high replacement rate. As shown in Table 3, warranty claim rates for the brass and steel bushing sensor-equipped vehicles are 7.22 and 0.20 claims per 100 vehicles, respectively. DCC and Bosch's warranty-returned parts analysis showed that the majority of the subject components suffered corrosion damage.

Table 3. Warranty Claims by Sensor Bushing Type

Bushing Type	No. of Claims	Approx. No. of Vehicles	Claims/100 Vehicles
Brass	29,192	404,548	7.22
Steel	1,108	556,021	0.20

Figure 1 shows warranty claims by repair date and modification.[6] The graph indicates a continuing warranty claim trend for all versions of sensors.

Figure 1. Warranty Claims by Repair Date and Modification

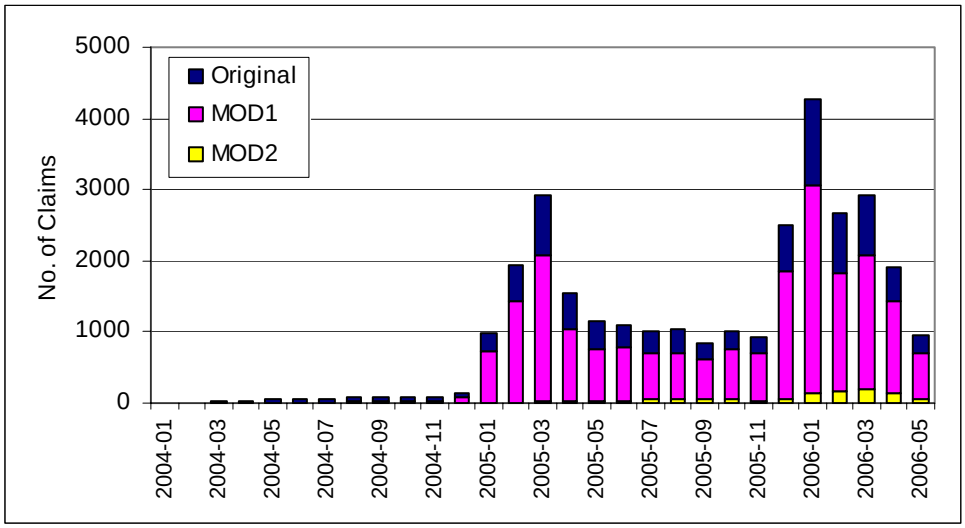
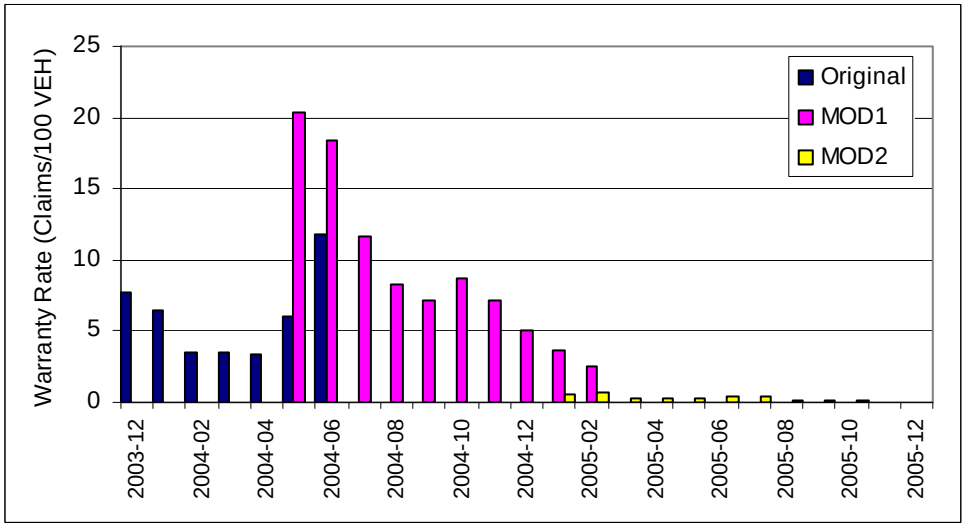


Figure 2 shows warranty rate by vehicle build month and modification. The sensor mounting changes (MOD1) do not appear to have reduced the warranty rate of the subject components. In fact, the changes appear to have caused an increased warranty rate for the first two or three production months before reaching the levels prior to the changes. But the use of steel bushings (MOD2) significantly reduced the warranty rate.

Figure 2. Warranty Rate by Build Date and Modification



[6] Refer to Table 1 (page 4) for description of change designations. One warranty claim on MOD3 steel bushing sensors is not shown in Figures 1 and 2.

The brass bushing sensors have experienced a much longer field exposure than the steel bushing sensors—approximately two years versus less than one year as of mid-2006.[7] A more accurate warranty rate comparison of the two sensors is to look at the cumulative warranty rate for the first 12 months in service for each sensor population (Figure 3). The graph indicates that the brass bushing sensors have experienced a much higher warranty rate during the same exposure period, 3.32 vs. 0.22 claims per 100 vehicles, at the end of the period.

Figure 3. Cumulative Warranty Rate for First 12 Months in Service

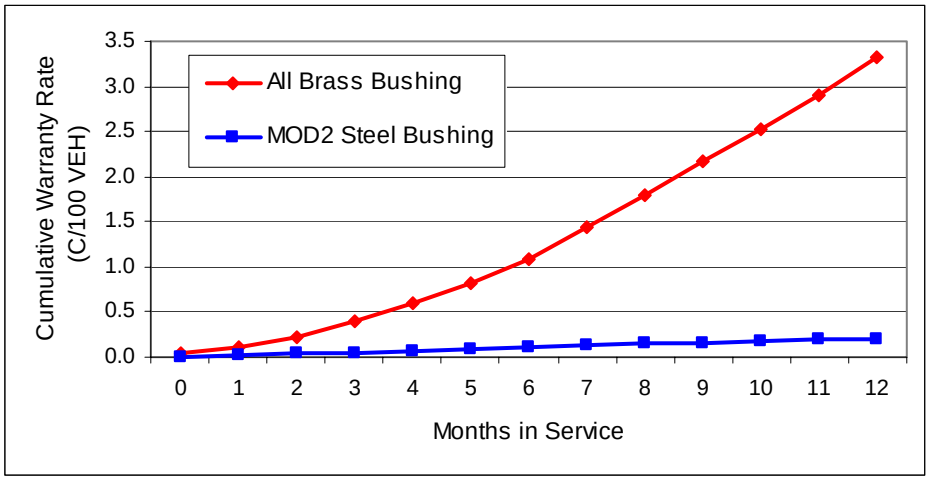


Table 4 shows the warranty rates of brass bushing sensors by state in descending order.[8] The shaded states are included in the first action described above and were selected based on the higher rates. They include 20 states in which road salt is used (Connecticut, Delaware, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia and Wisconsin), plus the District of Columbia, and seven other states (North Dakota, South Dakota, Utah, Nebraska, Kentucky, Kansas and Alaska).

In addition to the high warranty rates noted above, DCC's own sensor durability testing (i.e. exposure to water, salt, and freeze/thaw temperature cycling) and analysis showed that front crash sensors with brass bushings cracked and leaked after relatively few test cycles while the sensors with steel bushings and Crastin sensor housing did not fail after many more test cycles.

[7] Of the steel bushing sensors, MOD2 sensors and MOD 3 sensors have experienced a field exposure of approximately one year and three months, respectively.

[8] The data was provided by DCC in March 2007 and it does not include fleet vehicles in the rate calculation.

Table 4. Warranty Rate by State, Brass Bushing Sensors Only

State	C/100 Veh	State	C/100 Veh	State	C/100 Veh
VT	63.89	SD	6.45	TN	0.98
ME	40.97	WV	6.18	SC	0.96
NY	38.08	AK	3.11	NC	0.85
MA	36.18	UT	2.55	GA	0.68
MI	33.77	NE	2.55	AL	0.67
NH	33.14	KY	2.49	OK	0.66
OH	26.52	MD	2.33	WA	0.64
RI	25.23	KS	2.11	TX	0.59
WI	15.74	MO	1.80	AR	0.52
MN	14.49	DE	1.72	OR	0.49
IL	10.82	CO	1.51	CA	0.45
PA	9.67	WY	1.47	AZ	0.43
CT	9.45	HI	1.15	MS	0.43
ND	8.95	FL	1.10	NM	0.37
IN	8.41	VA	1.10	LA	0.32
IA	7.17	ID	1.02	NV	0.17
NJ	6.77	MT	0.99	DC	N/A

NHTSA's Crash Tests. The 25-mph ODB vehicle crash test with the left front crash sensor disconnected produced late deploying air bags (time-to-fire of 98 ms) and a high driver neck tension measurement (3349 N). The crash dummy's face and chest were very close to the steering wheel when the driver air bag started to deploy. The late deploying air bag produced a high chest load, which caused the dummy's head to accelerate downward and generated the subsequent tensile force in the neck. In the 25-mph oblique test without the left front crash sensor, the air bags deployed in a timely manner and the dummy injury numbers were all within FMVSS 208's specified limits.

A late deploying driver air bag suggests that a potential risk of serious or fatal injury similar to that depicted in 25-mph ODB crash test conditions may be present.

Bosch's Sensor Computer Simulations. Bosch conducted computer simulations to determine the air bag times-to-fire (TTF) and deployment levels in various crash modes and front crash sensor conditions. The majority of the simulation data indicated that the air bag system would deploy timely without input from the front crash sensors. These data also suggested, however, that in conditions without the front crash sensors, there is a potential for late deployment, most significantly, in the 25-mph and 40-mph ODB crash modes. The data also showed that reduced level of driver air bag inflation may occur during the 40-mph ODB crash mode.

DCC's Computer Simulation and Static Deployment Testing. DCC provided summary results (injury values) from its MADYMO computer modeling using Bosch's air bag TTFs to assess air bag system performance in the absence of the front crash sensors. Although the analysis suggests that the HIC and chest acceleration calculations in various crash

modes were within FMVSS 208's limits, due to limitations with MADYMO, the analysis did not include any neck injury calculations.

DCC also provided summary results (injury values) of its driver out-of-position static deployment FMVSS 208 testing that indicated the dummy injury values, including neck criteria, fell within FMVSS 208's limits. DCC did not, however, present data from any dynamic testing involving a disabled front crash sensor comparable to the tests conducted by the agency.

Air Bag Deployment Reports (Late Deployment, etc.). DCC stated that it had no reports of alleged late air bag deployment or reduced inflation or protection levels involving the subject vehicles. However, ODI believes that these incidents may be unreported because occupants of vehicles involved in a crash may be unaware that late deployment or reduced inflation event has occurred.

Also, there have been no reports of crashes in which the air bags deployed in subject vehicles with either known failed front crash sensors or an illuminated air bag warning lamp.

Air Bag Non-deployment Reports. A review of Bosch's air bag TTF data indicates that a disabled front sensor would pose a minimal risk that the air bags would fail to deploy during frontal crashes.

Several dozen reports of air bag non-deployment have been received on the subject vehicles. Based on its review, ODI could not identify a problem trend indicating the air bags should have deployed in the crashes. In some cases, it was inconclusive whether the air bags did not deploy due to an allegedly defective condition or because the crash did not meet the deployment criteria. Several non-deployment reports indicated that post-accident investigations revealed that a front crash sensor fault was stored in the vehicle's ORC but it could not be discerned whether a failed sensor caused a non-deployment. Also, reports of air bag non-deployment without any allegation of a specific air bag component failure are not uncommon because vehicle operators are generally unfamiliar with the precise crash conditions needed to deploy the air bags.

ODI received two non-deployment incidents reporting a driver fatality. One report involved a MY 2005 vehicle equipped with brass bushing sensors and the other was a MY 2006 vehicle equipped with steel bushing sensors. ODI was pursuing steps to inspect these vehicles when DCC offered to conduct the actions described above. As a result, ODI did not have the opportunity to collect information about the role of the front crash sensors in the vehicles.

NHTSA Databases.[9] A review of several NHTSA databases revealed no reported fatalities or serious injuries that could be related to late deployment or non-deployment of air bags

[9] Vehicle Owner's Questionnaire, Early Warning Reporting, National Accident Sampling System, and Special Crash Investigation.

in frontal crashes involving the subject vehicles.

Manufacturer's Assessment of the Alleged Defect

DCC has consistently stated that it does not believe the alleged defect presents an unreasonable risk to motor vehicle safety and provided the following assessment of the alleged defect in the subject vehicles.

1. The front crash sensors are auxiliary sensors, designed to help detect offset deformable barrier and oblique crashes. They are not essential to deploy the frontal air bags in crashes when air bag deployment is necessary. The crash detection system is still functional without the front crash sensors and air bags will deploy if necessary.

2. Alkali or other corrosion products can attack the sensor's plastic housing and initiate cracking. Water enters the cracks, eventually corroding the connector pins. Also, initial cracks may have occurred during sensor mounting at the vehicle assembly plants in some early subject vehicles.

3. Complaint and warranty data on the subject components are primarily from the "salt belt" regions of the country. The failure rates of subject components have been drastically reduced since the use of steel bushing sensors, and the rates have fallen even lower since the use of Crastin sensor housing material.

4. The air bag warning lamp illuminates in the event of a front crash sensor failure and serves as a warning to vehicle occupants that the air bag system requires service.

5. Although Bosch's analysis showed that air bag TTF and deployment levels may be affected by the absence of one or both front crash sensors, this analysis is not necessarily an indication of what would occur in the real world.

6. DCC's MADYMO computer modeling showed that the HIC and chest acceleration levels were within acceptable limits in the following crash modes: 25-mph flat frontal, 25-mph left angle, 25-mph right angle, 25-mph ODB, and 40-mph ODB.

7. In NHTSA's 25-mph ODB crash test with the left front crash sensor disconnected prior to the test, the driver air bag does not contact dummy's head until after the neck tension spike us nearly over. The neck tension was an artificial spike caused by some (unknown) artifact of the crash dummy.

8. Static deployment tests showed that the driver air bags in the subject vehicles do not cause serious injuries to out-of-position (OOP) crash dummies.

9. Field data indicate that the alleged defect does not demonstrate a safety problem. There have been few reports of non-deployment or late deployment of air bags out of almost one million subject vehicles.

Conclusions

1. Analysis of warranty claim data showed that the MY 2005 DaimlerChrysler Minivans equipped with frame rail-mounted front crash sensors with brass bushings have experienced a very high replacement rate, especially in certain regions of the U.S. where road salt is used.

2. ODI's complaint-returned and DCC's warranty-returned parts analyses showed that the brass bushing sensors were damaged by corrosion.

3. In NHTSA's 25-mph left offset deformable barrier crash test of a MY 2005 DC Minivan with an early sensor calibration design and without the left front crash sensor, the vehicle satisfied the FMVSS 208 injury criteria for such a test except for the driver side dummy's neck tension component for the 5th-percentile female dummy.

4. In NHTSA's 25-mph left 30-degree oblique rigid barrier crash test of a MY 2005 DC Minivan without the left front crash sensor, the vehicle satisfied the FMVSS 208 injury criteria for such a test.

5. Bosch's sensor computer simulation data indicated potential for late air bag deployment in the 25-mph and 40-mph offset crash conditions. It also showed there is a potential for reduced air bag inflation levels in the 40-mph offset crash condition.

6. There are no known real-world incidents of late air bag deployment or improperly reduced levels of air bag inflation in the subject vehicles. However, ODI believes that these incidents may be unreported because occupants of vehicles involved in a crash may be unaware that late deployment or reduced inflation event has occurred.

7. ODI identified no problem trend indicating that the frontal air bags should have deployed from available non-deployment crash reports.

Reason for Closing: NHTSA and DCC differ regarding the significance and impact of the defect, but in the interest of remedying the affected vehicles expeditiously and to avoid a protracted dispute, DCC is implementing steps to replace the subject components. Based on these actions, the agency has decided that further use of its resources does not appear to be warranted. Accordingly, this investigation is closed. The closing of this investigation does not constitute a finding by NHTSA that no safety-related defect exists in the subject vehicles. The agency will monitor the issue and reserves the right to take further action if warranted by the circumstances.