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Special Crash Investigations: On-Site Driver Air Bag Non-Deployment Crash Investigation; Vehicle: 2007 Cadillac Escalade; Location: Texas; Crash Date: August 2020

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Each crash represents a unique sequence of events, and generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicles or their safety systems. This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was published.

16. Abstract

This on-site investigation documented the fixed-object crash of a 2007 Cadillac Escalade and the non-deployment of the driver's frontal air bag system. The Cadillac was originally equipped with frontal air bags, seat-mounted side impact air bags, inflatable curtain (IC) air bags, and front-seat belt pretensioners. The crash occurred when the unbelted 41-year-old male driver lost control of the vehicle during a police-reported lane change maneuver. The front plane of the Cadillac struck an impact attenuator located in the gore area at an exit ramp on a multi-lane interstate highway, and the driver sustained fatal injuries. The SCI investigation determined that the Cadillac was operating with a rebuilt/salvage title. At the inspection, irregularities were found in the electrical wiring at the steering column that was determined to be non-original equipment. Additionally, the wiring from the clockspring to the squibs of the driver's frontal air bag inflator was not connected. Inconsistencies also were identified after inspecting the Cadillac's underhood fuse panel compared with the fuse panel documented in the owner's manual. Based on obtained medical documents, the unbelted driver's fatal injuries resulted from his contact and loading of the steering wheel/column and windshield.

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On-Site Driver Air Bag Non-Deployment Crash Investigation
Office of Defects Investigation
Case Number: CR20030
Vehicle: 2007 Cadillac Escalade
Location: Texas
Crash Date: August 2020

Background

This on-site investigation documented the fixed-object crash of a 2007 Cadillac Escalade and the non-deployment of the driver's frontal air bag system (Figure 1). The Cadillac was originally equipped with certified advanced compliant frontal air bags, seat-mounted side impact air bags, inflatable curtain (IC) air bags, and front-seat belt pretensioners. The crash occurred when the unbelted 41-year-old male driver lost control of the vehicle during a lane change maneuver, according to the police report. The front plane of the Cadillac struck an impact attenuator in the gore area at an exit ramp on a multi-lane interstate highway. None of the air bags in the Cadillac deployed, and the pretensioners did not actuate. The driver sustained fatal injuries.

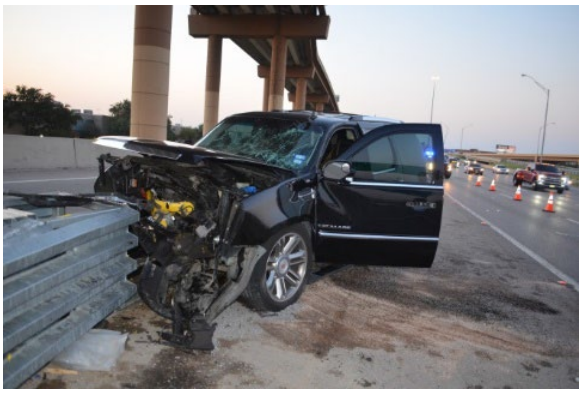


Figure 1. On-scene police image showing the Cadillac and the frontal damage (image provided by the investigating police department)

Notification of the crash was forwarded to the National Highway Traffic Safety Administration via a crash technician working in NHTSA's Crash Investigation Sampling System. Further research of the crash was requested due to the non-deployment of the frontal air bag, and an on-site investigation was assigned to the Special Crash Investigation team at Crash Research & Analysis, Inc., in September 2020. A copy of the police crash report (PCR), police images, and an Event Data Recorder (EDR) file were forwarded to the SCI team. The team initiated communications with the police investigator and the vehicle's insurer to obtain permission for the vehicle inspection that occurred in September 2020.

On-site activities of the investigation included the inspection of the Cadillac to measure the exterior damage profiles, measure the interior damage and intrusion, document the interior occupant contact, and assess the manual and supplemental restraint systems for condition and usage. The Cadillac was equipped with an EDR that was imaged by the CISS researcher with the

Bosch Crash Data Retrieval (CDR) tool. The police removed the EDR and placed it in evidence. The crash site was inspected, documented by total station, and imaged with digital photography.

The SCI investigation determined that the Cadillac was operating with a rebuilt/salvage title. At the inspection, irregularities were found in the electrical wiring at the steering column that was determined to be non-original equipment. Additionally, the wiring from the clockspring to the squibs of the driver's frontal air bag inflator was not connected. Inconsistencies also were identified after inspecting the Cadillac's underhood fuse panel compared with the fuse panel documented in the owner's manual. Based on obtained medical documents, the unbelted driver's fatal injuries resulted from his contact and loading of the steering wheel/column and windshield.

Summary

Crash Site

The crash occurred in the gore area of an urban freeway at an exit ramp location in the afternoon. The National Weather Service reported the conditions as fair at the time of the crash with a temperature of 39 ºC (103 ºF), 30 percent humidity, and southeasterly winds at 16 km/h (10 mph). The police-reported conditions were clear and dry.

The freeway was physically divided by a concrete Jersey barrier that transitioned to a W-beam guardrail median barrier in the vicinity of the crash site. The crash occurred in the southbound travel direction that consisted of five through lanes and a right exit lane that transitioned to an exit ramp that was physically divided from the through lanes by concrete Jersey barriers (Figure 2). An elevated section of roadway was above the exit lane with large diameter concrete support pillars located between the exit ramp and the through lanes. The road surface was bituminous and curved left for southbound traffic. The superelevation was level. All southbound travel lanes were delineated by dashed white lane lines with a solid yellow east edge line and a solid white west edge line that formed the edge of the exit lane. The posted speed limit was 97 km/h (60 mph). An impact attenuator was mounted at the south edge of the gore area and protected traffic from the end of the Jersey barriers (Figure 3). The damaged attenuator was still present at the time of SCI inspection. A crash diagram is included at the end of this report.

Figure 2. Southbound trajectory view of the Cadillac's approach to the crash site

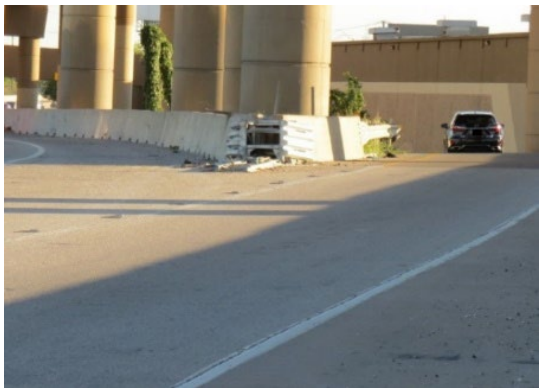


Figure 3. Southbound view of the location of the impact attenuator

The attenuator struck by the Cadillac was a Smart Cushion[1] model SCI100GM manufactured by Hill and Smith, Inc. The attenuator (Figure 4) was approved and conformed to the test level 3 requirements of the Manual for Assessing Highway Safety (MASH) and the National Cooperative Highway Research Project (NCHRP 350). The length, width, and height of the device were 6.55 m (21.5 ft), 61 cm (24.0 in), and 84 cm (33.0 in), respectively. The following details pertaining to the impact attenuator were obtained from its manufacturer's website.

- The Smart Cushion crash attenuator is a revolutionary, speed-dependent product that varies stopping resistance during an impact. The Smart Cushion crash attenuator allows

[1] https://hillandsmith.com/products/smart-cushion/

lighter and slower-moving vehicles to have longer ride-down distances and lower ride-down g-forces.

- Unlike fixed-resistance attenuators, the Smart Cushion attenuator does not reach maximum stopping resistance unless a vehicle is traveling at the maximum design speed. This fully re-directive, non-gating, bi-directional impact attenuator was designed for maximum safety and reusability, as well as outstanding durability before, during, and after an impact.
- The hydraulic porting of the attenuator ensures that the proper resistance is used to stop the vehicle before it reaches the end of the cushion's usable length. The Smart Cushion was specifically designed for durability and resetability to enable resets to be performed in less than 30 minutes.

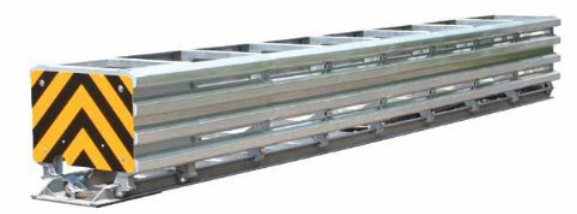


Figure 4. Exemplar view of the Smart Cushion impact attenuator (image obtained from an internet site)

Pre-Crash

The unbelted 41-year-old male driver of the Cadillac was traveling in a southerly direction on the freeway. He resided in an area served by the exit ramp. It was likely that he was attempting to exit at this location at the time of the crash. Given the day of the week, time of day, and locale, it is highly probable that traffic volume on the freeway would have been heavy. Post-crash toxicology detected the presence of the methamphetamines in the driver's blood at 1.105 ng/ml.

The police crash report stated that the Cadillac was in the left-most lane of a five-lane highway. The PCR stated he steered the vehicle in an attempt to exit the roadway. Tire marks observed by the police at the scene indicated that a vehicle had steered "aggressively" to the right across the southbound lanes, recovered, and steered back to left and then to the right a second time as it approached the exit. The yawing tire marks approached the exit at a relatively high angle. The location of the tire marks also indicated that the vehicle's right plane/aft aspect would have struck the W-beam guardrail on the right roadside, prior to the exit ramp. Guardrail damage was observed during the SCI scene inspection.

Since the crash occurred on a late Friday afternoon (peak travel time) and the trafficway was an extremely well-traveled urban interstate, regardless of day/time, it is improbable that the Cadillac was able to traverse five lanes of travel and steer to the two right lanes without conflict with other vehicles. The SCI inspection of the Cadillac determined that the only impact damage to the vehicle was located on the vehicle's front plane. There was no physical evidence on the vehicle related to a guardrail impact. Further, the crash reconstruction indicated that the Cadillac approached the impact attenuator on a linear trajectory (shallow approach angle, less than 10 degrees). The reconstruction of the crash suggested a linear trajectory of the Cadillac prior to

impact with the impact attenuator; therefore, the yaw marks and guardrail damage cited in the police report did not pertain to this crash.

The Cadillac driver apparently attempted to exit the interstate from an undetermined lane, and the vehicle continued on a tracking or near-tracking trajectory to strike the attenuator. There was no evidence of avoidance actions by the driver at the crash scene to suggest braking or steering maneuvers.

Crash

The front plane of the Cadillac struck the face of the impact attenuator. This face plate remained engaged to the deformed front plane of the Cadillac at the time of the SCI inspection. The direction of the impact force was in the 12 o'clock sector. The energy of the crash was absorbed by the attenuator, as it fully compressed (an estimated 6 m [20 ft]) against the V-shaped edge of the intersecting concrete Jersey barriers (Figure 5). The leading edge of the concrete barrier was fractured from engagement of the attenuator. The compression of the attenuator and vehicle deformation suggested an impact speed in excess of 89 km/h (55 mph) based on level 3 MASH testing.[2] In the MASH TL3 test, a full compression of the attenuator was observed with a 2,270 kg (5,000 lb) pickup truck test vehicle at 100 km/h (62 mph). However, the compressed attenuator from the test configuration could be reset and reused.

In the crash under investigation, the Cadillac weighed an estimated 2,585 kg (5,700 lb). Therefore, equivalent momentum dictates that an impact speed, comparable with the test configuration, would be approximately 89 km/h (55 mph). In the crash, the attenuator fully compressed, struck, and cracked the concrete barrier. The attenuator was deformed laterally, and it did not appear that it could be reused. The damaged condition of the attenuator suggested that the impact speed was more than 89 km/h (55 mph).

Figure 5. North-facing lookback view of the deformed attenuator

[2] https://hillandsmith.com/wp-content/uploads/2019/07/SC-Manual-ATT2019-071519.pdf and https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/aashto_guidancecfm.cfm

Post-Crash

The Cadillac rebounded from the compressed impact attenuator and rotated clockwise approximately 20 degrees (Figure 6). Passersby notified the emergency response system; the police, fire, and emergency medical personnel were dispatched to the crash site. The driver was removed from the Cadillac and transported to a local trauma center. Cardiopulmonary resuscitative efforts were attempted; however, the driver was pronounced deceased approximately 40 minutes after the crash. The Cadillac was subsequently towed from the crash site to a police impound facility, where it was inspected for this SCI investigation.

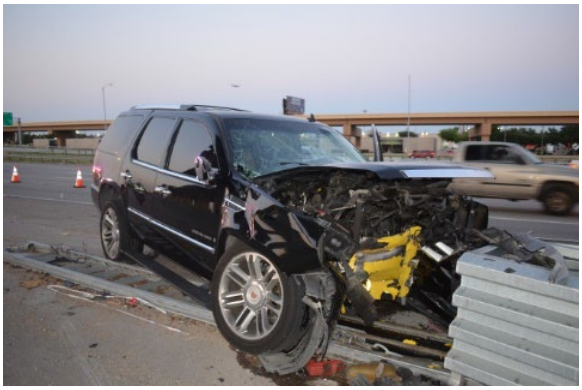


Figure 6. Northeast view, on-scene police image of the Cadillac engaged with the compressed impact attenuator

2007 Cadillac Escalade

Description

The 2007 Cadillac Escalade (Figure 7) was a full-size, 4-door SUV manufactured in March 2006 and identified by Vehicle Identification Number: 1GYFK63877Rxxxxxx. Due to the electronic odometer and post-crash damage, the vehicle's odometer reading at the time of the crash was unknown. A vehicle history report stated that there was an odometer rollback, as the odometer reading at the time of a previous crash was 363,013 km (225,572 mi). The last reported odometer reading was 198,446 km (123,312 mi) on January 28, 2020, some eight months prior to this crash. The body-on-frame configuration had a 295 cm (116.1 in) wheelbase and was powered by a 6.2-liter gasoline engine linked to a 6-speed automatic transmission with all-wheel drive. The gross vehicle weight rating was 3,221 kg (7,100 lb) with front/rear axle ratings of 1,610 kg (3,550 lb) and 1,860 kg (4,100 lb).

Standard equipment included electronic brakeforce distribution, electronic stability control, a tire pressure monitoring system, and traction control. The service brakes were power-assisted, 4-wheel disc with ABS. The steering system was hydraulic power-assisted rack-and-pinion. The vehicle manufacturer recommended tire size was P265/65R18 with cold tire pressures of 210 kPA (30 PSI). At the time of the crash, the Cadillac was equipped with Bridgestone Dueler H/L Alenza all-season radial tires, size P285/45R22, mounted on OEM-style alloy wheels. All tire tread measured 3 mm (4/32) or greater. None of the tires' rotation was restricted, and nor were any tires damaged.

Figure 7. Front right oblique view showing the severity of the frontal damage

The interior of the Cadillac was configured for seating of seven occupants (2/2/3) with front row bucket seats, second row captain's chairs, and a split-back third row seat. All were surfaced with black leather. The front row bucket seats were 8-way power-adjustable with reclining seatbacks and adjustable head restraints. Both head restraints were in the full-down positions. At the time of the SCI inspection, the second row right seatback was folded flat as was the third row left seat back. Both second row seats and the left and right positions of the third row were configured with adjustable head restraints. All were in the full-down positions. The back aspects of the front and second row head restraints were equipped with integrated DVD entertainment system monitors.

Safety systems consisted of manual 3-point lap and shoulder seat belts for all seven positions and frontal, front seat-mounted, and roof side rail-mounted IC air bags. Based on the evidence of the driver's severe contact and loading of the frontal components and the lack of loading evidence on the seat belt system, it was determined that the driver was not belted. No air bags deployed, and the front seat belt retractor pretensioners did not actuate.

Vehicle History

The known vehicle history was reported and gleaned from a Carfax report. The Cadillac had five previous owners and one previous crash that produced a salvage title prior to the ownership involved in this crash.

The Cadillac was first sold in California to Owner 1 as new on March 3, 2006. The vehicle was titled in Texas, with a reported mileage of 55 km (34 mi). During this ownership, routine maintenance was performed, and the vehicle was sold at auction on July 30, 2009, with a reported odometer reading of 105,435 km (65,516 mi).

Owner 2 purchased the Cadillac and titled the vehicle in Tennessee on October 15, 2009, at a reported odometer reading of 105,440 km (65,519 mi). No service history was reported during this ownership. Owner 3 purchased and titled the vehicle in Tennessee on March 18, 2010. The reported odometer reading at this transaction was 110,501 km (68,664 mi). Again, no service history was recorded.

Owner 4 purchased the Cadillac on May 4, 2012, with an odometer reading of 143,147 km (88,950 mi). The vehicle was titled in Tennessee on May 12, 2012. Several routine maintenance issues were addressed during this ownership, the first one at 203,000 km (126,000 mi) and the second at 259,000 km (161,000 mi). The vehicle history report indicated that a recall was issued on July 6, 2016, for the passenger air bag inflator. The NHTSA Recall No. was 16V381, and the Manufacturer Recall No. was 2049151. At the time this recall was announced, a remedy was not yet available.

On May 23, 2017, the Cadillac was involved in a crash that resulted in damage to the front plane/ left aspect. The insurance company declared the vehicle a total loss. Images of the damage were obtained from an online website that reported the odometer at 363,013 km (225,572 mi). According to the report, there was no air bag deployment associated with this crash. A salvage title was issued on July 23, 2017. On October 7, 2017, a rebuilt title was issued in Texas, and Carfax reported a potential odometer rollback to 154,704 km (96,131 mi) on October 16, 2017. The Cadillac was sold on October 17, 2017, and the damage history was disclosed by the seller.

Owner 5 purchased the Cadillac in 2018. A rebuilt title was issued in Texas on December 26, 2018. Maintenance was performed in Texas on June 5, 2019, at a reported odometer reading of 180,462 km (112,137 mi). Failed emission testing was reported on December 4, 2019, at 186,035 km (115,600 mi); again on December 9, 2019, at 187,247 km (116,353 mi); and again on December 31, 2019, at 192,284 km (119,483 mi). Unspecified maintenance was performed on January 10, 2020, at 194,733 km (121,005 mi). The Cadillac passed emissions testing on January 28, 2020, at 198,446 km (123,312 mi). The last recorded data on the history report were a

salvage title/certificate issued on February 6, 2020, under this same ownership. This crash occurred in August 2020.

NHTSA Recalls and Investigations

A VIN search of NHTSA's recall database www.nhtsa.gov/recalls in October 2021 for the Cadillac involved in this crash yielded one unrepaired recall and no open investigations. The recall was dated February 5, 2021, and was identified by NHTSA Recall No. 21V050 and the manufacturer recall number N212328760. The recall was related to the potential safety risk involving a rupture of the passenger's frontal air bag inflator installed as original equipment. The determination was made that the propellant in these inflators may degrade after long-term exposure to high humidity and temperature cycling that could cause the inflator to rupture during a deployment.

Exterior Damage

The Cadillac sustained severe frontal damage from its impact with the attenuator. The combined width of direct and induced damage involved the full 168 cm (66.0 in) width of the deformed end plane (Figure 8). The direct contact damage began 38 cm (15.0 in) left of center and extended 85 cm (33.5 in) to the right involving the left, center, and right aspects of the plane. The impact separated the bumper beam from the left frame rail mount and crushed the beam and right frame rail rearward. The engine and transmission were displaced rearward.

The crush profile was measured on an 87 cm (34.3 in) wide Field L. The maximum crush was 79 cm (31.1 in) located at the right frame rail, 54 cm (21.3 in) right of center. The residual crush profile documented across the deformed bumper beam was as follows: C1 = 16 cm (6.3 in), C2 = 76 cm (29.9 in), C3 = 75 cm (29.5 in), C4 = 75 cm (29.5 in), C5 = 77 cm (30.3 in), and C6 = 79 cm (31.1 in). The right wheelbase was shortened 9 cm (3.5 in). All four doors remained closed during the crash. Rescue personnel opened the driver's door at the crash scene to evaluate and remove the driver. The right front door was opened at a later time. Both doors were not re-latched due to body distortion. The windshield was completely fractured and starred by driver contact. There was no deformation to the hood. The collision deformation classification (CDC) assigned to the damage was 12FDEW4.

Figure 8. Frontal damage to the Cadillac with the face of the attenuator still engaged in the damage

The WinSMASH program could not be used to determine velocity change since yielding objects are out of scope for the program. However, the barrier equivalent speed calculated by WinSMASH was 71 km/h (44 mph), and the result is considered to be borderline.

Interior Damage

The Cadillac sustained frontal damage that resulted in minor intrusion of the occupant compartment. Maximum intrusion occurred at the left instrument panel and measured 8 cm (3.1 in). The left toe pan intruded 5 cm (2.0 in), displacing the foot pedals rearward. The right toe pan intrusion was 3 cm (1.2 in). The fractured windshield was sagged into the occupant space at the time of inspection.

The unbelted Cadillac driver contacted interior components directly forward of his seated position, causing substantial damage. Most notably, he loaded, deformed, and fractured the alloy steering wheel rim and spokes. The lower sector of the rim was displaced forward 6 cm (2.4 in) and displaced vertically approximately 3 cm (1 in). The spokes/mounting flange was fractured, resulting in complete separation of the wheel from the column. The driver's loading force also fully compressed the energy-absorbing steering column. Compression of the steering column fractured the column-mounted transmission shift lever from the column. The on-scene police images showed the steering wheel in place, compressed against the instrument panel (Figure 9).

At the time of the SCI inspection, the fractured and deformed steering wheel rim was separated from the steering column, hanging by three wire bundles (Figure 10). The wires, which were connected to the horn, heated the steering wheel control and the switches that operated the cruise control. The wiring appeared to be irregular and not original. This was corroborated at a local GM dealership. The connectors on the two yellow air bag wires from the clockspring were not connected to the squibs of the air bag inflator. Refer to the Supplemental Restraint Systems and Air Bag Non-Deployment section of this report for more details on the driver air bag, its condition, and the wiring.

Figure 9. Overall view of the driver's compartment and the occupant contact to the frontal components (image provided by the investigating police officer)

Figure 10. SCI inspection image of the observed position of the fractured steering wheel rim and wiring

The lower left instrument panel/knee bolster was deformed from driver contact. The driver's left knee/lower leg contacted the intruding left aspect of the knee bolster. The polymer panel was deformed with compression of the steel backer panel. His right knee deformed and fractured the polymer panel, also deforming the backer panel.

The laminated windshield was fractured full height and width due to frontal structure displacement. There was no bond separation or holing of the laminated windshield. The driver's forehead struck and fractured the windshield in a star pattern directly below the windshield header (Figure 11). Hair was observed embedded into the fracture site. His scalp contacted the fabric-covered windshield header and sun visor directly above the windshield contact point. The header and visor were scuffed with hair on the visor. The visor was not damaged or displaced.

Figure 11. Overall image of the left forward interior showing the driver contacts

Event Data Recorder

The Cadillac was equipped with a sensing and diagnostic module that had EDR capabilities. The EDR could record and store one non-deployment event and two deployment events. The non-deployment event could be overwritten by another non-deployment event of greater magnitude or erased after 250 ignition cycles. The EDR was removed from the vehicle during the police investigation and retained as evidence. A desktop imaging technique was used to image the EDR using the Bosch Crash Data Retrieval tool and software version 19.3. There were no stored or recorded events in the EDR. Refer to the Air Bag Non-Deployment section for discussion. The EDR output is attached to this report as Appendix A and reported with software version 21.2.1.

Manual Restraint Systems

The Cadillac was equipped with 3-point continuous loop lap and shoulder seat belt systems for all seven occupant positions. The driver's seat belt system retracted onto an emergency locking

retractor that was equipped with a pretensioner. The upper B-pillar-mounted D-ring was adjusted to the full-up position.

The police inspected the seat belt and found the webbing intact (Figure 12). At the time of the SCI inspection, the webbing was cut for unknown reasons, and the latch plate was missing. The location of the cut was on the lap belt portion of the webbing. Inspection of the webbing was unremarkable for contact or crash-related loading evidence. The webbing could be extended and retracted as designed. The observed evidence suggested that the pretensioner did not actuate. However, due to the lack of EDR data, status of pretensioner actuation is unknown. The physical evidence observed at the SCI inspection indicated that the driver was not belted at the time of the crash.

Figure 12. On-scene police image documenting the intact driver's seat belt system prior to being cut for unknown reasons

Supplemental Restraint Systems

The Cadillac was equipped with a certified advanced 208-compliant (CAC) frontal air bag system that consisted of dual-stage driver's and passenger's frontal air bags, a front-row right occupant presence (weight) sensor, seat track positioning sensors, seat belt buckle switches, and front seat belt retractor pretensioners. Side impact protection was provided by front seat-mounted air bags and IC air bags that provided protection for all three rows. None of the air bags deployed in this crash, and the retractor pretensioners did not actuate.

The driver's frontal air bag was mounted in the center of the four-spoke steering wheel rim (Figure 13). Driver loading of the steering wheel/column fractured the steering wheel spokes and center hub, thus separating the steering wheel and air bag module from the column.

During the SCI inspection, the driver's frontal air bag module was separated from its mounted location in the steering wheel rim and inspected (Figure 13). The driver air bag inflator was identified by Part No.: AB14?M1M?150 and Generator Type BA01090 (the question marks denote undetermined characters, possibly 8 or 0). An additional identifier of BAM-PT-1073 was stamped below the generator type. The manufacturer was Autoliv of Ogden, Utah. A date of 2012 was stamped on the inflator, indicating that this inflator was a replacement, although the Cadillac had no Carfax-reported history of air bag deployment or replacement. Furthermore, an

online search was conducted for exemplary OEM inflators, and it was observed that the wiring connectors were pink and white, not green and yellow as seen on the inflator in question (Figure 14).

Figure 13. Driver's frontal air bag module in the fractured hub/spokes of the steering wheel

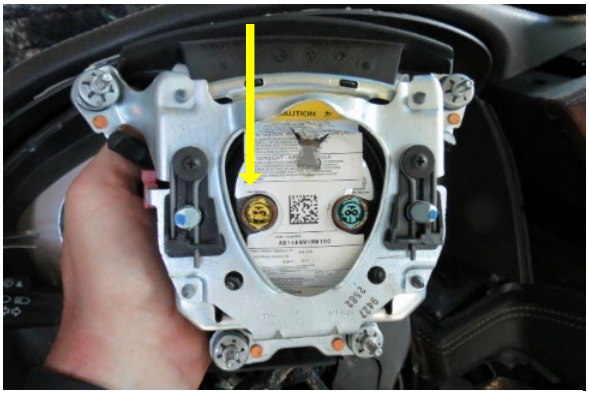


Figure 14. Backside of the driver's frontal air bag module and the inflator

During the inflator inspection, it was observed that there was contact damage to the inflator and the mounting bracket. During the driver's loading and compression of the steering wheel, the alloy structure fractured, and the backside of the inflator contacted the steering column shaft and containment nut, which gouged the label on the inflator and bent the mounting bracket. The contact terminal in the inflator's squib (denoted by the arrow in Figure 14) was damaged. The corresponding electrical connectors from the clockspring wires that should have engaged the squib terminals were not damaged, thus supporting the initial observation that these connectors were not attached to the inflator at the time of the crash. During the compression, the plastic jacket surrounding the clockspring was also fractured.

The passenger's frontal air bag was a top-mount design located in the right instrument panel. The front passenger seat was not occupied; therefore, the deployment of this air bag may have been suppressed by the occupant presence detection (weight) sensor of the right front seat.

Air Bag Non-Deployment

During the SCI inspection, several factors were identified that could have contributed to the non-deployment of the driver's frontal air bag.

- The vehicle history reported that the Cadillac was operating under a salvage title at the time of the crash. The Cadillac was involved in one previously documented crash during its fourth ownership. This crash occurred in May 2017, resulting in damage to the front plane/left aspect with induced damage of the left front fender area. The insurance company deemed the vehicle a total loss. The odometer reading at the time of the May 2017 crash was 363,013 km (225,572 mi). The Cadillac was subsequently sold and repaired with a salvage/rebuilt title issued in Texas. At this point in the vehicle's history, there was an apparent odometer rollback as the odometer reading was 154,704 km (96,131 mi) when the vehicle was offered for sale in October 2017.

During the inspection of the driver's frontal air bag module, it was observed that the manufacture date of 2012 was stamped on the driver's frontal air bag inflator with the manufacturer identified as Autoliv. This indicated that the air bag was replaced at some point during the vehicle's history without documentation in the history report.

- The extent of crash damage did not allow for a diagnostic check of the Cadillac's electrical system to determine the state of the air bag warning lamp in the instrument cluster. An inspection of the underhood fuse panel determined that two fuses supported the air bag circuit. These fuses were numbered #40 and #45 (Figure 15). Examination of the fuse panel (Figure 16) found that fuse #40 was intact. However, fuse #45 was missing. The locations of the fuses are denoted by the arrows in Figure 17. The effect of the missing fuse on the operation of the air bag circuit was not determined.

  For reference, a review of the 2007 Cadillac Escalade owner's manual[3] determined that the underhood fuse panel layout differed from the inspected panel. The air bag fuses labeled in the manual were #39 and #51, with the corresponding layout in Figure 17. Although undetermined, the differences in the fuse panels may be related to the salvage title and rebuild of the Cadillac.

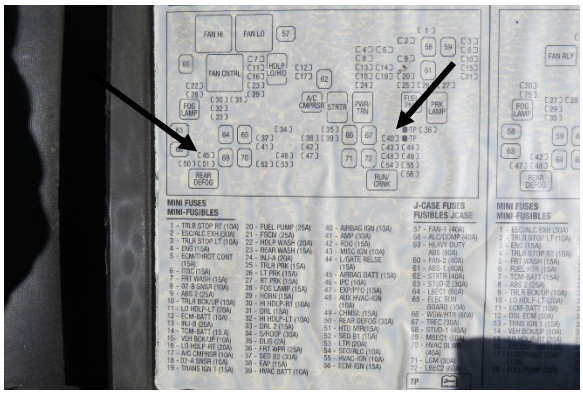


Figure 15. An image showing the map of the Cadillac's fuse locations

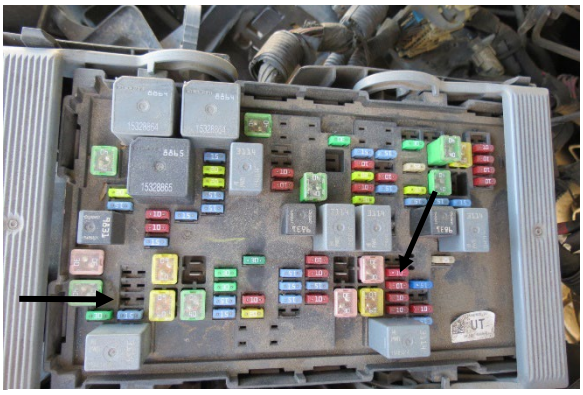


Figure 16. Image showing the underhood fuse panel of the Cadillac

[3] www.cadillac.com/bypass/pcf/gma-content-api/resources/sites/GMA/content/staging/MANUALS/0/MA6/en_US/4.0/2007EscaladeOwnersManual.pdf

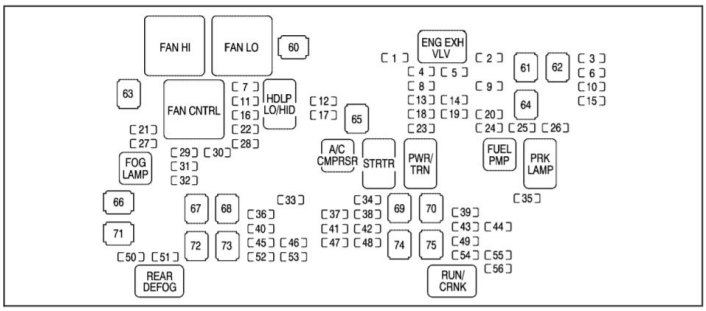


Figure 17. Underhood fuse layout from the 2007 Cadillac Owner's Manual

- Images obtained from the police showed the steering wheel resting atop the column (Figure 9 above). It was determined that the unbelted driver loaded the steering wheel rim and fractured the alloy hub and spokes of the steering wheel, completely separating the wheel from column. However, the initial observation by the SCI investigator found the steering wheel hanging from the column by three wire bundles (Figure 10 above). The exposed wiring looked irregular. A local Cadillac dealer, who was queried about the wiring, confirmed that it was not an OEM (Original Equipment Manufacturer) part.

- The yellow wire-jacketed leads from the clockspring were not connected to the squibs on the inflator of the driver's frontal air bag. During the driver's contact and compression of the wheel, the fracture of the alloy structure allowed the backside of the driver's frontal air bag inflator to contact the steering column shaft and containment nut. This contact gouged the label on the inflator and bent the mounting bracket. The plastic housing surrounding the clockspring also fractured. Additionally, the polymer connector of the inboard squib was fractured, and the terminal was displaced (Figure 14 above). The corresponding connectors on the aforementioned air bag wiring leads were not damaged (Figure 18). Further, had the connectors been engaged to the terminals, the isolated damage to the squib would not have occurred. It is the conclusion of the SCI investigation that the air bag wire connectors from the clockspring were not connected to the replacement driver's air bag module at the time of the crash.

Figure 18. Close-up image showing the two wire leads from the clockspring and the undamaged squib connectors

2007 Cadillac Escalade Occupant

Driver Demographics

Age/sex:	41 years/male
Height:	178 cm (70 in)
Weight:	130 kg (286 lb)
Eyewear:	Unknown
Seat type:	Bucket seat with adjustable head restraint
Seat track position:	Rear track
Manual restraint usage:	None
Usage source:	Vehicle inspection
Air bags:	Front, seat-mounted, and IC air bags; none deployed
Alcohol/drug data:	Alcohol = 0; positive for methamphetamine (1.105 ng/ml)
Egress from vehicle:	Removed by EMS
Transport from scene:	Transported to a Level 1 trauma center; DOA

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Full-thickness laceration of heart involving anterior right ventricle, interventricular septum, right atrium, and posterior aspects of intraventricular septum, right ventricle, and left ventricle	441016.6	Isolated IPC Front – Steering wheel (combination of rim and hub/spoke)	Certain
2	Transection of thoracic aorta	420210.5	Isolated IPC Front – Steering wheel (combination of rim and hub/spoke)	Certain
3	Bilateral flail chest: fractures of ribs left 1-6 posteriorly; bilateral 1-8 anteriorly and laterally	450214.5	Isolated IPC Front – Steering wheel (combination of rim and hub/spoke)	Certain
4	Right hemothorax	442200.3	Isolated IPC Front - Steering wheel (combination of rim and hub/spoke)	Certain
5	Left hemothorax	442200.3	Isolated IPC Front – Steering wheel (combination of rim and hub/spoke)	Certain
6	Gaping laceration of pericardium	441602.2	Isolated IPC Front – Steering wheel (combination of rim and hub/spoke)	Certain

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
7	Fracture of body of sternum, displaced posteriorly; fracture between manubrium and body of sternum	450804.2	Isolated IPC Front – Steering wheel (combination of rim and hub/spoke)	Certain
8	Mediastinal hemorrhage	442208.2	Caused by other injury (sternum fracture, #8)	Certain
9	Multiple superficial lacerations to liver	541822.2	Isolated IPC Front – Steering wheel rim	Certain
10	3 cm focus of subscapular hemorrhage in midline frontal area	110402.1	Isolated Roof – Front header	Certain
11	Superficial lacerations measuring up to 4 inches occupies a 4 ½ x 3 inch area on midline forehead	210602.1	Isolated Front – Windshield	Certain
12	Vertically oriented abrasions measuring up to 4 inches occupies a 4 ½ x 3 inch area on midline forehead	210202.1	Isolated Front – Windshield	Certain
13	Contusions measuring up to 1 inch occupy a 5 inch area on left breast	410402.1	Isolated Front – Steering wheel (combination of rim and hub/spoke)	Certain
14	Small abrasions measuring up to ¼ inch occupies 5 inch area on right breast	410202.1	Isolated Front – Steering wheel (combination of rim and hub/spoke)	Certain
15	Scattered abrasions measuring up to 1/8 inch on left breast	410202.1	Isolated Front – Steering wheel (combination of rim and hub/spoke)	Certain
16	Linear contusions measuring up to 2 inches on right upper quadrant of abdomen	510402.1	Isolated Front – Steering wheel rim	Certain
17	Contused abrasions measuring up to 2 inches occupies a 5 inch area on midline lower abdomen	510402.1	Isolated Front – Steering wheel rim	Certain
18	Multiple contusions up to 1 inch on dorsum of right hand	710402.1	Isolated Front – Center instrument panel	Probable
19	Multiple linear abrasions up to 1 inch on dorsum of right hand	710202.1	Isolated Front – Center instrument panel	Probable

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
20	Irregular abrasions measuring up to ¾ inch cover an 8 inch area on dorsum of right forearm	710202.1	Isolated Front Left instrument panel	Probable
21	Small abrasions measuring up to ½ inch on dorsum of left hand	710202.1	Isolated Front – Left instrument panel	Probable
22	Contusions measuring up to 3 inches occupy a 12 x 7 inch area extending from right knee to anterior lower leg	810402.1	Isolated Front – Left lower instrument panel (includes knee bolster)	Certain
23	Contusions measuring up to 3 inches occupy a 12 x 7 inch area extending from right knee to anterior lower leg	810402.1	Isolated Front – Left lower instrument panel (includes knee bolster)	Certain
24	Abrasions measuring up to 3 inches occupy a 12 x 7 inch area extending from right knee to anterior lower leg	810202.1	Isolated Front – Left lower instrument panel (includes knee bolster)	Certain
25	Abrasions measuring up to 3 inches occupy a 12 x 7 inch area extending from right knee to anterior lower leg	810202.1	Isolated Front – Left lower instrument panel (includes knee bolster)	Certain
26	1 inch contusion to left knee	810402.1	Isolated Front – Left lower instrument panel (includes knee bolster)	Certain
27	Multiple contusions measuring up to 1 inch on anterior lower left leg	810402.1	Isolated Front – Left lower instrument panel (includes knee bolster)	Certain
28	Multiple abrasions measuring up to 1 inch on anterior lower left leg	810202.1	Isolated Front – Left lower instrument panel (includes knee bolster)	Certain

Source: emergency room records and medical examiner report.

Driver Kinematics

The 41-year-old male driver was seated in an unknown posture, though his trajectory, contact points, and injuries would suggest that he was seated nominally upright. The power adjustable seat was set in a rear track position, and the seatback was reclined beyond a normal driving position at the time of the SCI inspection. It is probable that the first responders moved the seat track and/or the seatback prior to the removal of the driver from the vehicle. These seat-adjusted positions were similar to the positions observed in the on-scene police images. The adjustable head restraint was in the full-down position. The driver was not using the available seat belt

system. Although the lap belt webbing was cut at the time of the SCI inspection, the belt webbing was intact and retracted against the B-pillar in the on-scene police images.

The Cadillac engaged the impact attenuator on a linear trajectory, resulting in a 12 o'clock direction of force. The engagement fully compressed the attenuator that provided an initial ride-down of the crash forces and elongated the crash duration. As the attenuator was fully compressed, it contacted and fractured the protected concrete barrier; thus, the attenuator became a rigid structure.

The unbelted driver initiated a forward trajectory in response to the 12 o'clock direction of force during the ride-down of the attenuator. None of the supplemental air bags deployed. His torso contacted the steering wheel assembly and the non-deployed driver's frontal air bag module. The driver's knees contacted the knee bolster as he was now forward against the frontal components. As the attenuator fully compressed, the Cadillac experienced a sharp spike in the crash pulse, displacing the driver farther forward. His torso deformed the alloy steering wheel rim and spokes, as his loading force was transmitted into the energy-absorbing steering column. The driver fully compressed the energy-absorbing column and fractured the hub and spokes of the steering wheel. This engagement resulted in soft tissue contusions and abrasions of the chest, bilateral flail chest with fractures of the ribs 1–8, transection of the thoracic aorta, a full thickness laceration of the heart with multiple ventricular lacerations, bilateral hemothoraces, a gaping laceration of the pericardium, mediastinal hemorrhage, and sternal fractures. His abdomen engaged the lower steering wheel rim, resulting in abrasions and contusions of the abdomen and multiple lacerations of the liver.

The driver's knees and lower extremities contacted, fractured, and deformed the knee bolster on each side of the steering column, resulting in multiple contusions and abrasions of the knees and lower legs.

The back plane of the Cadillac pitched upward, which allowed the driver's head to strike the windshield, the windshield header, and the leading edge of the sun visor. The windshield was fractured directly in line with the steering column and immediately below the windshield header. Hair was embedded into the fractured glazing, with scuffs and hair in the fabric of the header and visor. The driver sustained vertically oriented abrasions with lacerations at the midline of the forehead from windshield contact. He sustained subcapsular hemorrhage of the scalp at the midline from the windshield header contact.

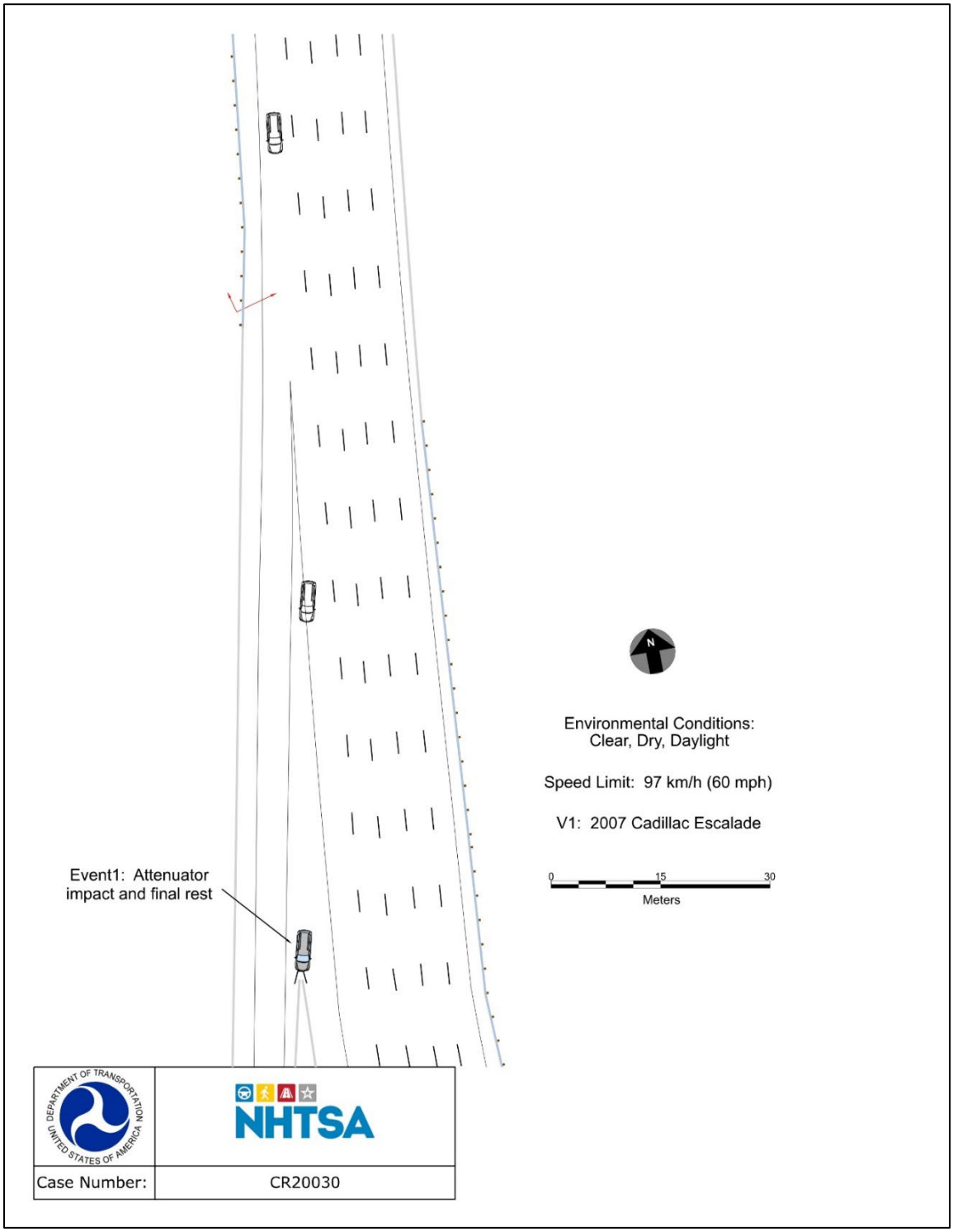
During the crash event, the driver's hands and arms contacted the mid instrument panel, resulting in abrasions of the hands and right forearm, with contusions over the dorsum of the right hand.

As the back plane of the Cadillac pitched upward, it rotated clockwise before coming to rest fully engaged against the impact attenuator. A laterally oriented scuff with hair was visible on the driver's sun visor, indicating that he probably slumped to his right as the vehicle headed to final rest. He was found in the Cadillac unconscious.

Medical and fire department personnel removed the driver from the vehicle and placed him on a backboard, where cardiopulmonary resuscitation was initiated. He was transported by ambulance

to a regional trauma center, where he was pronounced deceased 39 minutes following the crash. His body was transferred to the medical examiner's office for autopsy.

Crash Diagram



Appendix A: Event Data Recorder Report for 2007 Cadillac Escalade[4]

[4] The EDR report contained in this technical report was imaged using the current version of the Bosch CDR software at the time of the vehicle inspection. The CDR report contained in the associated Crash Viewer application may differ relative to this report.

IMPORTANT NOTICE: Robert Bosch LLC and the manufacturers whose vehicles are accessible using the CDR System urge end users to use the latest production release of the Crash Data Retrieval system software when viewing, printing or exporting any retrieved data from within the CDR program. Using the latest version of the CDR software is the best way to ensure that retrieved data has been translated using the most current information provided by the manufacturers of the vehicles supported by this product.

CDR File Information

User Entered VIN	1GYFK63877R******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	CR20030_V1_ACM.CDRX
Saved on	
Imaged with CDR version	Crash Data Retrieval Tool 19.3
Imaged with Software Licensed to (Company Name)	Company Name information was removed when this file was saved without VIN sequence number
Reported with CDR version	Crash Data Retrieval Tool 21.2.1
Reported with Software Licensed to (Company Name)	NHTSA
EDR Device Type	Airbag Control Module
Event(s) recovered	None

Comments

No comments entered.

Data Limitations

Recorded Crash Events:

There are two types of recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event records data but does not deploy the air bag(s). The minimum SDM Recorded Vehicle Velocity Change, that is needed to record a Non-Deployment Event, is five MPH. A Non-Deployment Event may contain Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle velocity change. This event will be cleared by the SDM, after approximately 250 ignition cycles. This event can be overwritten by a second Deployment Event, referred to as Deployment Event #2, if the Non-Deployment Event is not locked. The data in the Non-Deployment Event file will be locked, if the Non-Deployment Event occurred within five seconds of a Deployment Event. A locked Non Deployment Event cannot be overwritten or cleared by the SDM.

The second type of SDM recorded crash event is the Deployment Event. It also may contain Pre-Crash and Crash data. The SDM can store up to two different Deployment Events. If a second Deployment Event occurs any time after the Deployment Event, the Deployment Event #2 will overwrite any non-locked Non-Deployment Event. Deployment Events cannot be overwritten or cleared by the SDM. Once the SDM has deployed an air bag, the SDM must be replaced.

Data:

-SDM Recorded Vehicle Velocity Change reflects the change in velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. For Deployment Events, the SDM will record 220 milliseconds of data after Deployment criteria is met and up to 70 milliseconds before Deployment criteria is met. For Non-Deployment Events, the SDM can record up to the first 300 milliseconds of data after algorithm enable. Velocity Change data is displayed in SAE sign convention.

-The CDR tool displays time from Algorithm Enable (AE) to time of Deployment command in a Deployment event and AE to time of maximum SDM recorded vehicle velocity change in a Non-Deployment event. Time from AE begins when the first air bag system enable threshold is met and ends when Deployment command criteria is met or at maximum SDM recorded vehicle velocity change. Air bag systems such as frontal, side, or rollover, may be a source of an enable. The time represented in a CDR report can be that of the enable of one air bag system to the Deployment time of another air bag system.

-Maximum Recorded Vehicle Velocity Change is the maximum square root value of the sum of the squares for the vehicle's combined "X" and "Y" axis change in velocity.

-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.

-SDM Recorded Vehicle Speed accuracy can be affected by various factors, including but not limited to the following:

- -Significant changes in the tire's rolling radius
- -Final drive axle ratio changes
- -Wheel lockup and wheel slip

-Brake Switch Circuit Status indicates the open/closed state of the brake switch circuit.

-Pre-Crash data is recorded asynchronously. The 0.5 second Pre-crash data value (most recent recorded data point) is the data point last sampled before AE. That is to say, the last data point may have been captured just before AE but no more than 0.5 second before AE. All subsequent Pre-crash data values are referenced from this data point.

-Pre-Crash Electronic Data Validity Check Status indicates “Data Invalid” if:
    -The SDM receives a message with an “invalid” flag from the module sending the pre-crash data
    -No data is received from the module sending the pre-crash data
    -No module is present to send the pre-crash data
-Pre-crash data associated with this event will always be for the first event even if it is not recorded.
-Driver’s and Passenger’s Belt Switch Circuit Status indicates the status of the seat belt switch circuit.
-The Time Between Non-Deployment to Deployment Events is displayed in seconds. If the time between the two events is greater than five seconds, “N/A” is displayed in place of the time. If the value is negative, then the Deployment Event occurred first. If the value is positive, then the Non-Deployment Event occurred first.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-The ignition cycle counter relies upon the transitions through OFF->RUN->CRANK power-moding messages, on the GMLAN communication bus, to increment the counter. Applying and removing of battery power to the module will not increment the ignition cycle counter.
-Once a firing loop has been commanded to be deployed, it will not be commanded to be deployed again during the same ignition cycle. Firing loop times for subsequent deployment type events, during the same ignition cycle, will record the deployment times as N/A.
-Number of ignition cycles SIR Warning Lamp was ON/OFF Continuously counter can increment up to 99 cycles before resetting to zero. Thereafter, the counter represents the lamp on/off conditions for the ignition cycle in which a qualified crash event occurs.
-If more than one event is recorded, use the follow to determine which event the Multiple Event Data is associated with:
    -If a Deployment event and not locked Non-Deployment event are recorded, the Multiple Event Data is associated with the Deployment event.
    -If a Deployment event and a locked Non-Deployment event are recorded, then the Multiple Event Data is associated with both events.
    -If a Deployment event and Deployment event #2 are recorded, then the Multiple Event Data is associated with both events.
-All data should be examined in conjunction with other available physical evidence from the vehicle and scene.

Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Status Data (Pre-Crash) is transmitted to the SDM, by various vehicle control modules, via the vehicle’s communication network.
-The Belt Switch Circuit is wired directly to the SDM.

Hexadecimal Data:
Data that the vehicle manufacturer has specified for data retrieval is shown in the hexadecimal data section of the CDR report. The hexadecimal data section of the CDR report may contain data that is not translated by the CDR program. The control module contains additional data that is not retrievable by the CDR tool.

01005_SDMC-delphi_r005

Hexadecimal Data

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$DC  41 41
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Disclaimer of Liability

The users of the CDR product and reviewers of the CDR reports and exported data shall ensure that data and information supplied is applicable to the vehicle, vehicle's system(s) and the vehicle ECU. Robert Bosch LLC and all its directors, officers, employees and members shall not be liable for damages arising out of or related to incorrect, incomplete or misinterpreted software and/or data. Robert Bosch LLC expressly excludes all liability for incidental, consequential, special or punitive damages arising from or related to the CDR data, CDR software or use thereof.

DOT HS 813 263
February 2022

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

15453-020322-v3