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ON-SITE HEAVY TRUCK UNDERRIDE INVESTIGATION

CASE NUMBER - IN10030
LOCATION - OKLAHOMA
VEHICLE - 2009 WABASH NATIONAL SEMI-TRAILER
CRASH DATE - August 2010

Submitted:

October 14, 2010

Contract Number: DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

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15. *Supplementary Notes*
On-site heavy truck underride investigation involving a 2007 Volvo VNL 6x4 truck tractor pulling a 2009 Wabash National Semi-Trailer.

16. *Abstract*

This on-site investigation focused on the rear impact guard of a 2009 Wabash National semi-trailer. The semi-trailer was being pulled by a 2007 Volvo VNL 6x4 truck tractor. The Volvo was parked heading east on the outside shoulder of an interstate highway. The light condition was dark with overhead lighting and the weather was cloudy and dry. The warning lights on the tractor and the semi-trailer were flashing. The driver of the Volvo had also placed three reflective triangles on the shoulder at 7.6 m (24.9 ft), 22.3 m (73.1 ft), and 32.4 m (106.3 ft) west of the back of the semi-trailer. A 2001 Chevrolet C1500 Silverado was traveling east in the first lane from the right. It was occupied by a restrained 26-year-old male driver and a restrained 37-year-old female front right passenger. The Chevrolet traveled onto the outside shoulder and the front plane impacted the rear impact guard of the semi-trailer. The impact bent the impact guard and displaced it forward. The Chevrolet underrode the semi-trailer and impacted the left rear wheels of the semi-trailer. The front right passenger of the Chevrolet sustained fatal injuries. The front right passenger's air bag suppression switch was set to the "Air Bag Off" position and her air bag did not deploy. The driver of the Chevrolet sustained a police-reported A (incapacitating) injury and was transported by ambulance to a hospital. The driver of the Volvo was not injured. The semi-trailer and the Chevrolet were towed due to damage. The Volvo tractor was driven from the crash scene.

17. *Key Words* Underride Rear Impact Guard Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
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This on-site investigation focused on the rear impact guard of a 2009 Wabash National semi-trailer (**Figure 1**). This crash was brought to our attention by the National Highway Traffic Safety Administration (NHTSA) on August 23, 2010. The investigation was assigned on August 24, 2010. The crash involved a 2001 Chevrolet C1500 Silverado pickup truck and the Wabash National semi-trailer, which was pulled by a 2007 Volvo VNL 6x4 truck-tractor. The crash occurred in August, 2010, at 0117 hours, in Oklahoma and was investigated by the Oklahoma Highway Patrol. The inspection of the Wabash National semi-trailer, Chevrolet, and the crash scene was conducted on August 31-September 1, 2010. This report is based on the police crash report, crash scene inspection, vehicle inspections, and evaluation of the evidence.

Figure 1: The damaged 2009 Wabash National semi-trailer and rear impact guard

CRASH CIRCUMSTANCES

Crash Environment: This crash occurred on the outside shoulder of the eastbound lanes of a 6-lane divided interstate highway. The light condition was dark with overhead lighting and the weather was cloudy and dry. The trafficway had three through lanes in each direction and was divided by a concrete median barrier. Each travel lane was approximately 3.7 m (12 ft) in width. The outside bituminous shoulder of the eastbound lanes was 3.1 m (10.2 ft) in width. The roadway pavement markings on the eastbound lanes consisted of a solid white outside edge line, broken white lane lines, and a solid yellow median edge line. The roadway surface was level, dry bituminous. The Crash Diagram is on page 7 of this report.

Pre-Crash: The Volvo was parked heading east on the outside shoulder and was located approximately 1 meter (3.3 ft) south of the roadway edge line. The warning lights on the Volvo and the semi-trailer were flashing. The driver had also placed three reflective triangles on the shoulder at 7.6 m (24.9 ft), 22.3 m (73.1 ft), and 32.4 m (106.3 ft) west of the back of the semi-trailer. The Chevrolet was occupied by a restrained 26-year-old male driver and a restrained 37-year-old female front right passenger. The Chevrolet was traveling east in the first lane from the right. The Chevrolet departed the roadway onto the outside shoulder and approached the rear of the semi-trailer (**Figure 2**). The Chevrolet's Event Data Recorder (EDR) reported the Chevrolet's travel speed as 97 km/h (60 mph) at one second prior to Algorithm Enable (AE). The brake switch circuit status was recorded as "Off" for the eight seconds of pre-crash recording. The front right passenger's air bag suppression switch was also recorded as "Suppressed" since the vehicle's air bag suppression switch was set to the "Air Bag Off" position.

Crash: The front plane of the Chevrolet (**Figure 3**) impacted the impact guard (event 1, **Figure 4**) and underrode the back of the semi-trailer. The impact guard engagement on the Chevrolet began at the front right bumper corner and the direct damage extended 102 cm (40.2 in) across the bumper. The direct damage on the impact guard began at the left corner and extended 88 cm (62.9 in) to the right. The Chevrolet penetrated 112 cm (44 in) under the semi-trailer contacting the mud flap, mud flap bracket, and left rear tires. The mud flap was entrapped on the front right portion of the Chevrolet's bumper (**Figure 3**). The Chevrolet rotated clockwise approximately 45 degrees to final rest and remained under the semi-trailer heading southeast.

Figure 2: Approach to the area of impact (arrow)

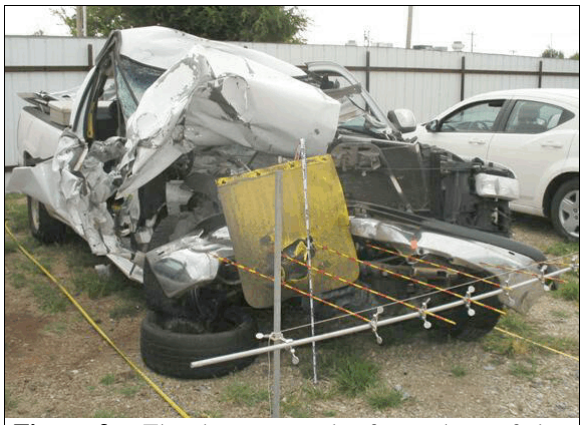


Figure 3: The damage on the front plane of the Chevrolet from the impact with the back plane of the semi-trailer

Post-Crash: The police, emergency medical personnel, and rescue personnel responded to the crash scene. The front right passenger of the Chevrolet was entrapped within the vehicle. She was pronounced deceased at the crash scene. The driver of the Chevrolet was transported by ambulance to a medical facility. The driver of the Volvo sustained no injury. The Chevrolet and the semi-trailer were towed due to damage.

CASE VEHICLE

The 2007 Volvo VNL was a 6x4 truck-tractor (VIN:4V4NC9TG77N------) equipped with a 15-liter, I6 diesel engine. The truck-tractor was pulling a 2009 Wabash National dual-axle, 16 m (53 ft) van-type semi-trailer (VIN 1JJV532W79L-----).

Figure 4: Direct damage on the impact guard and Wabash semi-trailer from the impact by the Chevrolet

SEMI-TRAILER AND DAMAGED REAR IMPACT GUARD DOCUMENTATION

The remains of a possible identification placard was present on the impact guard. Only the dates 2004 and 2005 were readable. The impact guard was constructed of 64 mm (0.25 in) thick welded steel plate. The two primary vertical supports were bolted onto the center frame rails on the floor of the semi-trailer. The two outer vertical supports of the impact guard were bolted onto the back cross-member of the semi-trailer. The crash displaced the left corner of the impact

guard's horizontal member (**Figure 5**) forward 44 cm (17.3 in). The left outer vertical support of the impact guard was displaced forward 52 cm (20.5 in) and was broken off the horizontal member. The undeformed width of the horizontal member was 240 cm (94.5 in), which excluded the 5 cm (2 in) width of the vertical supports welded on each end of the horizontal member. The width of the semi-trailer was 259 cm (102 in). The lateral distance from the projected side of the semitrailer to the undeformed right end of the horizontal member, which excluded the 5 cm (2 in) width of the vertical support was 9.5 cm (3.7 in). The distance from the bottom of the horizontal member to the ground was 42 cm (16.5 in). The left rear tires of the semi-trailer were displaced forward 44 cm (17.3 in) by the impact. The distance from the back of the semi-trailer to the rear tires in their undamaged position was 68 cm (26.8 in). **Figure 7** on page 5 of this report presents the measurements of the underride guard and positions of the damaged rear wheels of the semi-trailer.

Figure 5: Damage to the impact guard; horizontal scale is in 10^{ths} of meter; each increment on vertical scale is 5 cm (2 in)

OTHER VEHICLE

The 2001 Chevrolet C1500 Silverado was a rear wheel drive, 5-passenger, 4-door, extended cab pickup truck (VIN: 2GCEC19T411-------) equipped with a 5.3-liter, V-8 engine, 4-speed automatic transmission, anti-lock brakes with electronic brake force distribution, and an EDR. The front row was equipped with bucket seats, lap-and-shoulder safety belts, redesigned driver and front right passenger frontal air bags, and an air bag suppression switch for the front right passenger seating position.

Exterior Damage: The direct damage on the front plane of the Chevrolet involved the front bumper, right head lamp/turn signal assembly, hood, right fender, and right front wheel. The direct damage began at the front right bumper corner and extended 102 cm (40.2 in) along the bumper. Crush measurements were taken at the bumper level and the maximum residual crush was 87 cm (34.3 in) occurring at C_6 (**Figure 6**). The right side wheelbase was reduced 58 cm (22.8 in), while the left side wheelbase was extended 17 cm (6.7 in). The induced damage involved the left portion of the front bumper, roof, windshield, both A-pillars, and right side doors.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	102	87	120	0	10	67	80	85	87	24	0
in		40.2	34.3	47.2	0.0	3.9	26.4	31.5	33.5	34.3	9.4	0.0

Damage Classification: The Collision Deformation Classification for the Chevrolet was 12FZEW4 (0 degrees). The WinSMASH program was used to calculate a Barrier Equivalent Speed (BES) based on the frontal crush. The calculated BES was 68.1 km/h (42.3 mph). The WinSMASH program could not be used to calculate a Delta V for the Chevrolet since an impact with a heavy truck is out of scope for the program. The vehicle's EDR reported a maximum velocity change (Delta V) of -55.9 km/h (-34.74 mph) occurring at 110 ms after AE.

Figure 6: The crush on the front of the Chevrolet; the baseline was set 11 cm (4.3 in) longer than the vehicle's overall length to clear the displaced front left bumper corner

The vehicle manufacturer's recommended tire size was P235/75R16. The Chevrolet was equipped with P225/70R16 size tires. The vehicle's tire data are presented in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	276	40	241	35	6	8	None	No	No
LR	179	26	241	35	6	8	None	No	No
RR	241	35	241	35	5	6	None	No	No
RF	Flat	Flat	241	35	6	7	De-beaded	No	Yes

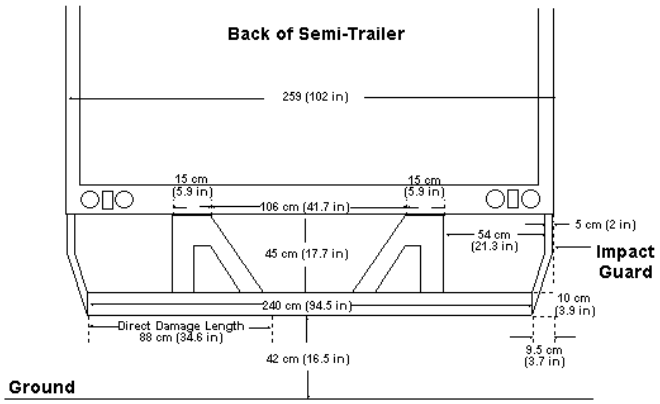
Event Data Recorder: The EDR was imaged using version 3.4 of the Bosch Crash Data Retrieval tool. The EDR reported a deployment event and a non-deployment event. The ignition cycle count for the non-deployment event indicated that it was not related to this crash. The EDR reported the SIR warning lamp as "Off." The front right passenger's air bag was reported as "Suppressed" since the vehicle's air bag suppression switch was set to the "Air Bag Off" position. The driver's safety belt switch circuit was reported as "Buckled." The reported velocity change reached a maximum value of -55.91 km/h (-34.74 mph) at 110 ms following AE. The EDR reported the vehicle's speed as 103 km/h (64 mph) at 5 seconds prior to AE, decelerating to 96.6 km/h (60 mph) at 1 second prior to AE. The brake switch circuit status was reported as "Off" for the entire 8 seconds of the pre-crash brake switch circuit recording. The EDR report is attached at the end of this report[1].

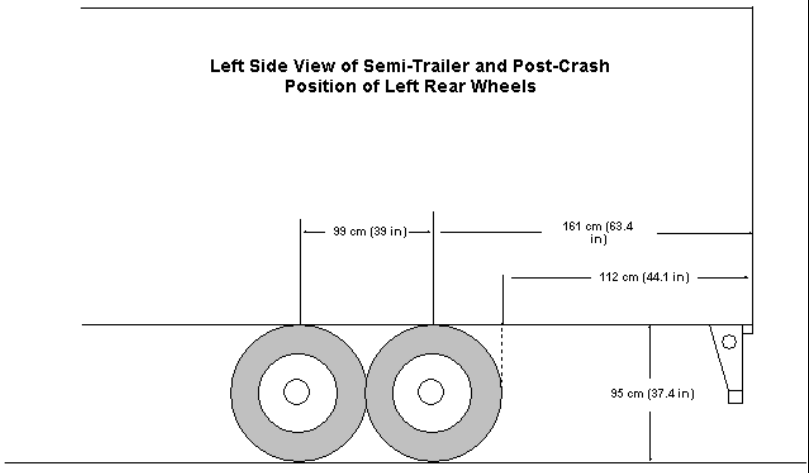
1. Please note that for confidentiality purposes, page 6 is not included with the EDR report

Other Vehicle's Driver: Based on the police crash report, the driver of the Chevrolet (26-year-old male) was restrained by the lap-and-shoulder safety belt. He sustained an A (incapacitating) injury and was transported by ambulance to a medical facility.

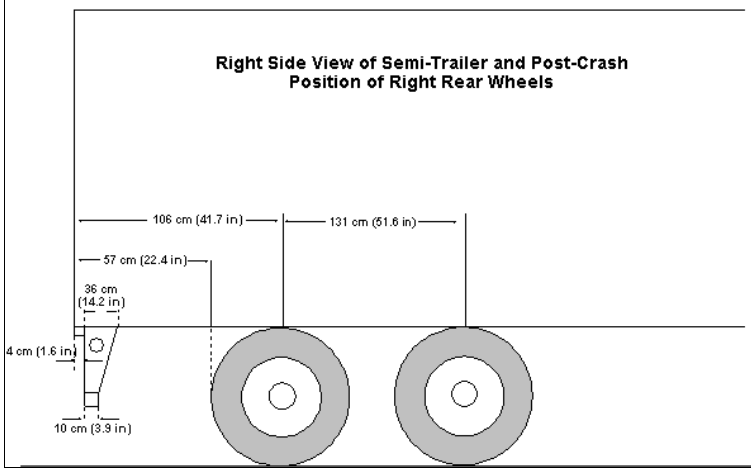
Other Vehicle's Front Row Right Passenger: The front row right passenger of the Chevrolet (37-year-old female) was restrained by the lap-and-shoulder safety belt. She sustained a fatal injury and pronounced deceased at the crash scene. The front right passenger's air bag did not deploy since the vehicle's air bag suppression switch was set to the "Air Bag Off" position.

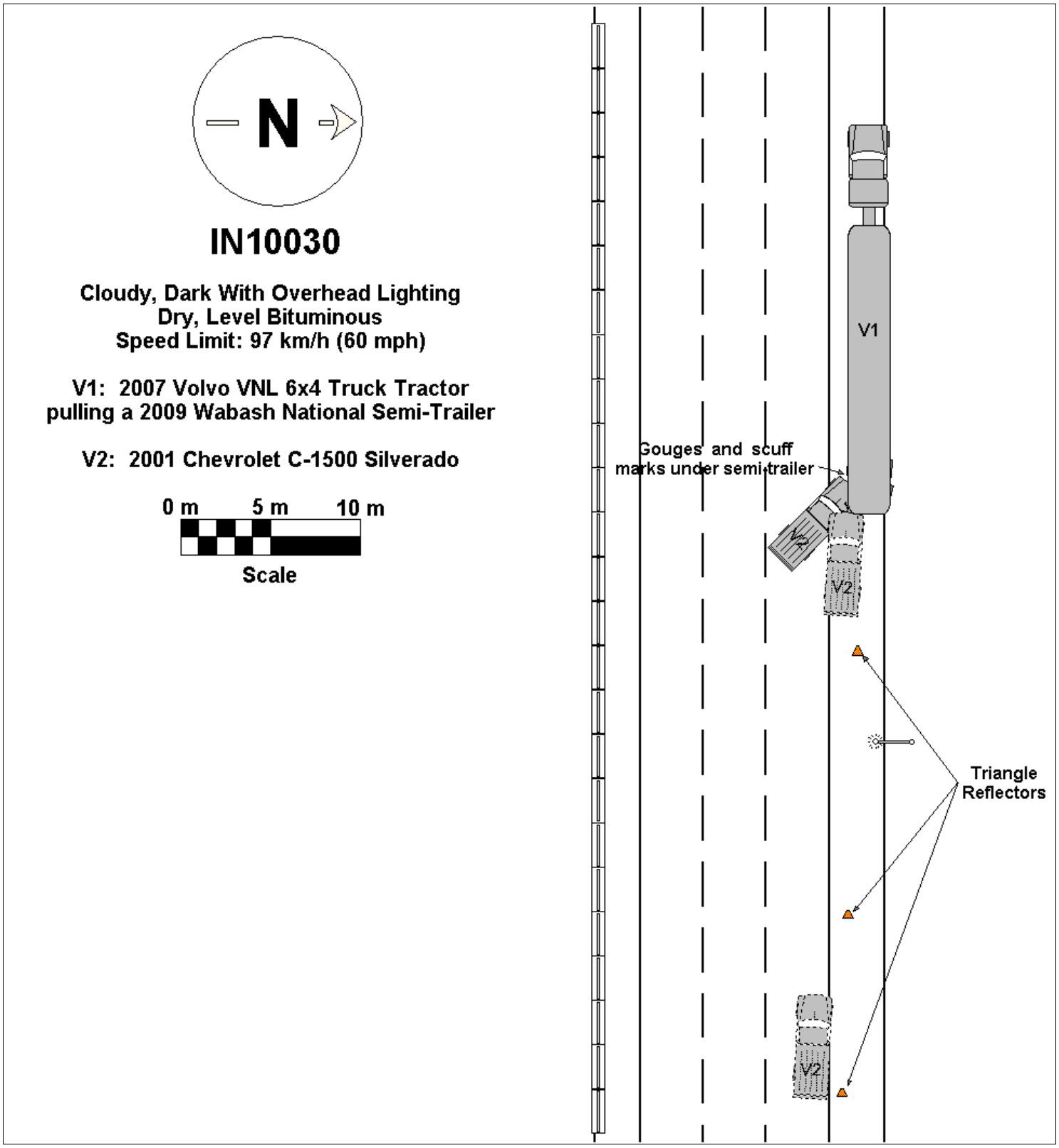
Figure 7





Distance from back of semi-trailer to non-displaced rear tires = 68 cm (26.8 in)




N
IN10030
Cloudy, Dark With Overhead Lighting
Dry, Level Bituminous
Speed Limit: 97 km/h (60 mph)
V1: 2007 Volvo VNL 6x4 Truck Tractor
pulling a 2009 Wabash National Semi-Trailer
V2: 2001 Chevrolet C-1500 Silverado
0 m
5 m
10 m
Scale
V1
Gouges and scuff
marks under semi-trailer
V2
V2
Triangle
Reflectors

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	2GCEC19T411******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	IN10030.CDR
Saved on	Wednesday, September 1 2010 at 11:01:47 AM
Collected with CDR version	Crash Data Retrieval Tool 3.4
Reported with CDR version	Crash Data Retrieval Tool 3.4
EDR Device Type	airbag control module
Event(s) recovered	Deployment Non-Deployment

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). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event may be overwritten by another Non-Deployment Event. This event will be cleared by the SDM, after approximately 250 ignition cycle. This event can be overwritten by a second Deployment Event, referred to as a Deployment Level Event, 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 before 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 contains Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within five seconds of one another. If a Deployment Level Event occurs within five seconds after the Deployment Event, the Deployment Level Event 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 Adjusted Algorithm Longitudinal Velocity Change:
Once the crash data is downloaded, the CDR tool mathematically adjusts the recorded algorithm longitudinal velocity data to generate an adjusted algorithm longitudinal velocity change that may more closely approximate the longitudinal velocity change the sensing system experienced during the recorded portion of the event. The adjustment takes place within the downloading tool and does not affect the crash data stored in the SDM, which is displayed in hexadecimal format. The SDM Adjusted Algorithm Longitudinal Velocity Change may not closely approximate what the sensing system experienced in all types of events. For example, if a crash is preceded by other common events, such as rough road, struck objects, or off-road travel, the SDM Adjusted Algorithm Longitudinal Velocity Change may be less than and some times significantly less than the actual longitudinal velocity change the sensing system experienced. For Deployment Events, the SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. Velocity Change data is displayed in SAE sign convention.

-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.

-Some of the Pre-Crash data may be recorded after Algorithm Enable (AE). If this occurs, it may affect the reported pre-crash data values, but does not affect other data such as SDM Adjusted Algorithm Longitudinal Velocity Change.

-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 present to send the pre-crash data

-Engine Speed is reported at two times the actual value in the following vehicles, if the vehicle is equipped with a 6.6L Duramax diesel engine (RPO LB7, LBZ, LLY, or LMM):
- -2001-2006 Chevrolet Silverado
- -2007 Chevrolet Silverado Classic
- -2001-2006 GMC Sierra
- -2007 GMC Sierra Classic
- -2006-2007 Chevrolet Express
- -2006-2007 GMC Savana
- -2003-2009 Chevrolet Kodiak
- -2003-2009 GMC Topkick

-Driver's Belt Switch Circuit Status indicates the status of the driver's seat belt switch circuit. If the vehicle's electrical system is compromised during a crash, the state of the Driver's Belt Switch Circuit may be reported other than the actual state.
-Passenger Front Air Bag Suppression Switch Circuit Status indicates the status of the suppression switch circuit.
-The Time Between 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 power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-If the vehicle is a 2000 - 2002 Chevrolet Cavalier Z24 or a Pontiac Sunfire GT, with a manual transmission (RPO MM5) and a 2.4L engine (RPO LD9), the Brake Switch Circuit Status data will be reported in the opposite state than what actually occurred, e.g. an actual brake switch status of "ON" will be reported as "OFF".
-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 Speed, Engine Speed, and Percent Throttle data are transmitted by the Powertrain Control Module (PCM), via the vehicle's communication network, to the SDM.
-Brake Switch Circuit Status data is transmitted by either the ABS module or the PCM, via the vehicle's communication network, to the SDM.
-The SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture. Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle's communication network.
-The Passenger Front Air Bag Suppression Switch Circuit is wired directly to the SDM.

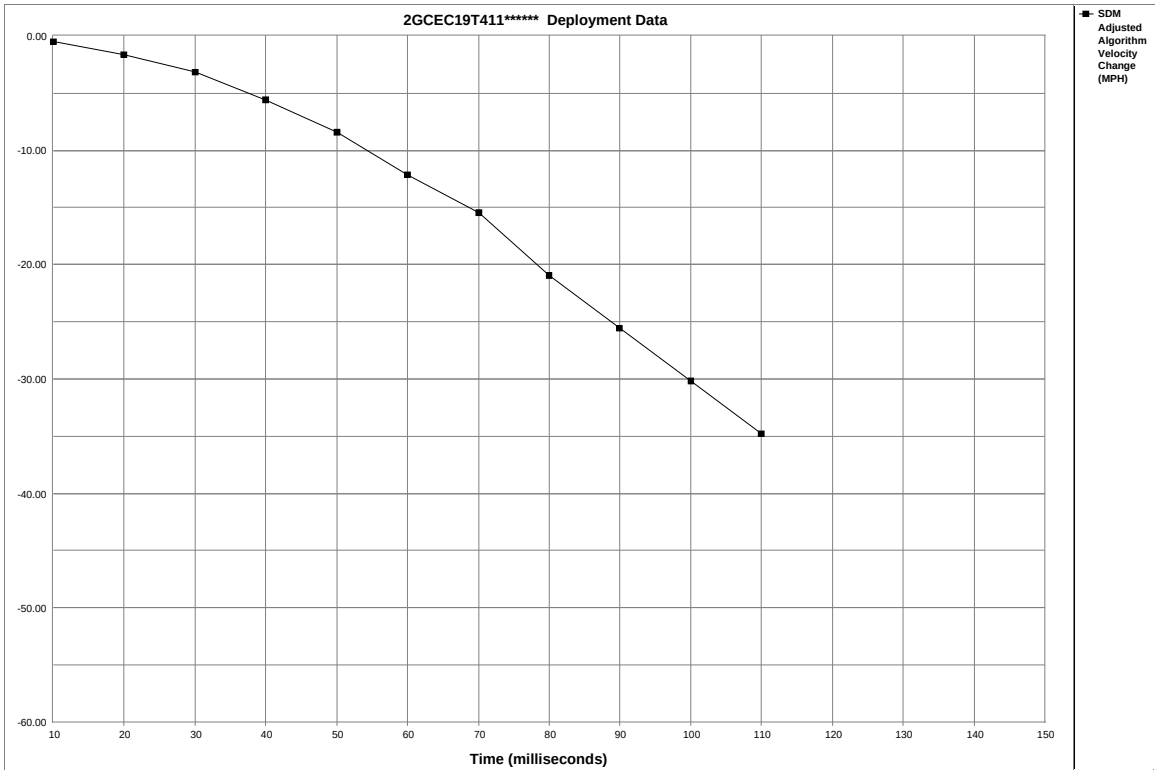
01023_SDMG-99JXZ01-07_r002

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger SIR Suppression Switch Circuit Status (if equipped)	Air Bag Suppressed
Ignition Cycles At Deployment	21017
Time Between Non-Deployment And Deployment Events (sec)	N/A

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	64	1664	0
-4	63	1664	0
-3	62	1600	6
-2	60	1600	17
-1	60	128	8

Seconds Before AE	Brake Switch Circuit Status
-8	OFF
-7	OFF
-6	OFF
-5	OFF
-4	OFF
-3	OFF
-2	OFF
-1	OFF



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Adjusted Algorithm Velocity Change	-0.50	-1.60	-3.14	-5.55	-8.41	-12.14	-15.43	-20.91	-25.52	-30.13	-34.74	N/A	N/A	N/A	N/A

System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger SIR Suppression Switch Circuit Status (if equipped)	Air Bag Suppressed
Ignition Cycles At Non-Deployment	20808
Maximum SDM Algorithm Longitudinal Velocity Change (MPH)	0.00

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	14	640	0
-4	8	576	0
-3	4	576	27
-2	10	1792	33
-1	16	2304	53

Seconds Before AE	Brake Switch Circuit Status
-8	OFF
-7	ON
-6	ON
-5	ON
-4	ON
-3	OFF
-2	OFF
-1	OFF