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ON-SITE CERTIFIED ADVANCED 208- COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-04-029
LOCATION - TEXAS
VEHICLE - 2004 GMC YUKON
CRASH DATE - June 2004

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October 11, 2005
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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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16. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash that involved a 2004 GMC Yukon (case vehicle) and a 1986 Chevrolet Camaro Sport Coupe (other vehicle), which collided head-on on a two-lane frontage road for a divided U.S. highway. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including manufacturer certified advanced 208-compliant air bags, as well as an Event Data Recorder (EDR), and the case vehicle's driver (33 year-old, female) did not sustain any police reported injuries as a result of the crash. The case vehicle was traveling southwest in a left curve. The Chevrolet was traveling northeast in a right curve approaching the case vehicle. The Chevrolet crossed the centerline and its front impacted the front of the case vehicle causing both stages of the case vehicle's driver air bag to deploy. The case vehicle's driver was most likely seated in an upright driving posture with both hands on the steering wheel, her left foot on the floor and her right foot on the brake pedal. Her seat track was adjusted to the middle position, her seat back was in an upright position, the tilt steering wheel was located in its center position, and the adjustable pedals were adjusted to the full forward position. The evidence indicated the case vehicle's driver was restrained by her integral, three-point, lap-and-shoulder-safety belt system. The driver loaded her safety belt system during the crash and most likely contacted her deployed air bag. She was not injured as a result of the crash.					
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This investigation was brought to NHTSA's attention on or before September 22, 2004 by NASS GES sampling activities. This crash involved a 2004 GMC Yukon (case vehicle) and a 1986 Chevrolet Camaro Sport Coupe (other vehicle), which collided head-on on a two-lane frontage road for a divided U.S. highway. The crash occurred in June 2004, at 6:39 a.m., in Texas and was investigated by the Texas Highway Patrol. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including manufacturer certified advanced 208 compliant air bags, as well as an Event Data Recorder (EDR), and the case vehicle's driver [33-year-old, White (unknown if Hispanic) female] did not sustain any police reported injuries as a result of the crash. This contractor inspected the case vehicle, downloaded the EDR and inspected the scene on October 6, 2004. This contractor was unable to contact the driver of the case vehicle and was unable to locate the Chevrolet. This report is based on the police crash report, scene and case vehicle inspections, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling southwest in a left curve of a two-lane, undivided frontage road for a U.S. highway, which was also a business route for a nearby Interstate highway. The Chevrolet was traveling northeast in a right curve approaching the case vehicle. The Chevrolet crossed the centerline and its front impacted the front of the case vehicle causing both stages of the case vehicle's driver air bag to deploy. The case vehicle rotated clockwise, traveled a short distance and came to rest facing southwest with the back portion of the case vehicle partially over the centerline of the roadway. The Chevrolet rotated clockwise and departed the north side of the roadway, traveled down the front slope of a shallow ditch and came to rest at the bottom of the ditch facing northwest. At the time of the crash, the weather was cloudy, the light condition was dawn, the roadway was dry and traffic density was light.

The CDC for the case vehicle was determined to be **12-FZEW-3 (0 degrees)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used to reconstruct the case vehicle's Delta V. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 42 km.p.h. (26.1 m.p.h.), -42 km.p.h. (-26.1 m.p.h.), and 0 km.p.h. (0 m.p.h.). The EDR data indicated that the case vehicle's maximum recorded longitudinal Delta V was -35.59 km.p.h. (22.12 m.p.h.).

Immediately prior to the crash, the case vehicle's driver was most likely seated in an upright driving posture with both hands on the steering wheel, her left foot on the floor and her right foot on the brake pedal. It is likely she was bracing for the impact. At the inspection of the case vehicle, her seat track was adjusted to the middle position, her seat back was in an upright position, the tilt steering wheel was located in its center position, and the adjustable pedals were adjusted to the full forward position (i.e., nearest the toe pan). The evidence indicated the case vehicle's driver was restrained by her integral, three-point, lap-and-shoulder- safety belt system.

The EDR data indicated the driver applied the brakes just prior to the crash. The pre-crash braking most likely locked the driver's safety belt retractor and caused the driver to continue

forward into her lap-and-shoulder belt just prior to the crash. The case vehicle's impact with the Chevrolet then caused the driver to continue forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated. The driver loaded her safety belt and her face and chest most likely made contact with her deployed air bag. The driver most likely rebounded off the air bag and remained restrained in her seat as the case vehicle rotated clockwise to its final rest position. The driver was most likely able to exit the case vehicle without assistance.

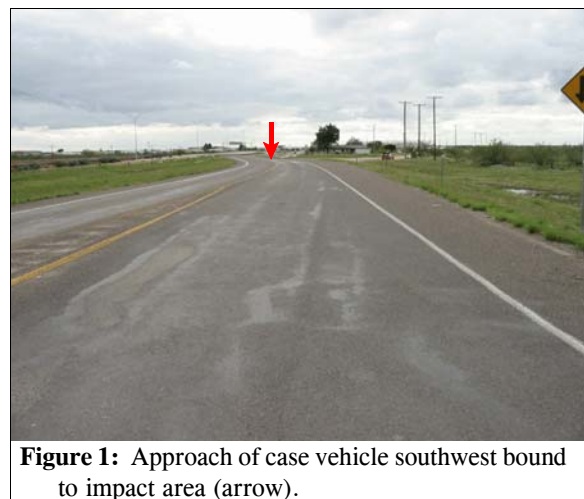
The police crash report indicated the driver was not injured as a result of the crash and was not transported from the scene. The case vehicle driver's use of her lap-and-shoulder safety belt system and the deployment of her air bag prevented her from sustaining any injury in this crash.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was a two-lane, undivided frontage road for a U.S. highway, as well as the business route for a nearby Interstate highway. The trafficway traversed in a northeasterly and southwesterly direction. The southwest bound travel lane was 3.2 meters (10.5 feet) in width and was bordered by a bituminous shoulder 2.3 meters (7.5 feet) in width. The northeast bound travel lane was 3.5 meters (11.5 feet) in width and was bordered by a bituminous shoulder 1.6 meters (5.2 feet) in width. Roadway pavement markings consisted of solid white edge lines, a solid yellow no-passing line for northeast bound traffic, and a broken yellow centerline with equidistant raised pavement reflectors. The roadway formed a shallow "S" curve, and a two-lane county roadway intersected the roadway from the southwest to form a "Y" intersection at the middle of the "S" curve. The crash occurred within this intersection. The speed limit was 88 km.p.h. (55 m.p.h.), and there were no speed limit signs posted in the vicinity of the crash scene. At the time of the crash, the light condition was dawn, the atmospheric condition was cloudy, and the roadway pavement was level, dry bituminous with an estimated coefficient of friction of 0.72. Traffic density was light and the site of the crash was rural with some commercial activities. See the Crash Diagram at the end of this report.

Pre-Crash: The case vehicle was in its lane traveling southwest in a left curve approaching the "Y" intersection (**Figure 1**), and the driver was intending to continue southwest bound. The Chevrolet was traveling northeast in a right curve, also approaching the "Y" intersection (**Figure 2** below). The crash occurred within the "Y" intersection (**Figure 3** below) in the case vehicle's travel lane. The case vehicle's EDR data indicated that the driver applied the brakes just prior to the crash.

Crash: The front of the Chevrolet impacted the front of the case vehicle (**Figure 4** below) causing both stages of the case vehicle's driver air bag to



deploy. The case vehicle's front right air bag did not deploy because there was no front right passenger seated in the case vehicle. The sensors in the front right seat properly determined the absence of a passenger and suppressed deployment of the front right air bag.



Figure 2: Approach of Chevrolet northeast bound to impact area (arrow)



Figure 3: View northeast to area of impact, double head arrow shows area of impact and final rest of case vehicle, single head arrow shows area of final rest of Chevrolet in ditch



Figure 4: Overview of damage to front of case vehicle from impact with the Chevrolet, each stripe on rods is 5 cm (2 in)



Figure 5: View back to area of impact from final rest location of Chevrolet, orange flags shows furrows from Chevrolet's tires

Post-Crash: As a result of the impact, the case vehicle rotated clockwise, traveled a short distance and came to final rest facing southwest with the back left portion of the case vehicle partially over the centerline of the roadway (**Figure 3**). The impact caused the Chevrolet to rotate clockwise approximately 225 degrees, depart the north side of the roadway, travel down the front slope of a shallow ditch and come to final rest at the bottom of the ditch facing northwest (**Figure 5**).

CASE VEHICLE

The 2004 GMC Yukon was a rear wheel drive, four-door sport utility vehicle (VIN: 1GKEC13Z14R-----) equipped with a 5.3L, V-8 engine, four-speed automatic transmission electronic traction control, tire inflation monitor and power adjustable pedals,. Braking was

achieved by power-assisted, four wheel, anti-lock brakes. The front seating row was equipped with driver and front right bucket seats with adjustable head restraints; integral, lap and shoulder safety belt systems with seat belt buckle switch sensors and seat position sensors, dual stage driver and front right passenger air bags and a front right passenger occupant detection and automatic air bag suppression system. The second seating row was equipped with bucket seats with adjustable head restraints and three-point, lap-and-shoulder safety belt systems. The third seating row was equipped with a split bench seat with an adjustable head restraint and integral, three-point, lap-and-shoulder safety belt for the left passenger and a lap belt for the center seat passenger. The right passenger seat had been removed. Driver and front right passenger, seat back-mounted side impact air bags are an option, but the case vehicle was not so equipped.

The various sensors in the case vehicle’s advanced occupant restraint system analyze a combination of factors including the predicted crash severity and driver and front right passenger seat belt usage to determine the front air bag inflation level appropriate for the severity of the crash. For the front right seat position, an occupant pressure sensor and a seat belt tension sensor provide data to the electronic control module. The electronic control module (a) compares the seat pressure and seat belt tension data to threshold values, (b) determines if the front right air bag should be suppressed or enabled, and (c) communicates the decision to the air bag control module. The air bag will be suppressed when the seat pressure is at or below the established threshold, or there is above normal tension on the safety belt (e.g., a secured child seat). The air bag will be enabled if the pressure is above the threshold and the seat belt tension is normal (e.g., a restrained adult occupant) or below (e.g., unrestrained occupant).

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle sustained direct damage to its front bumper, grille, right headlamp/turn lamp assembly, hood and right fender (**Figure 6**) due to the impact with the Chevrolet. The direct damage began at the right corner of the front bumper and extended 102 centimeters (40.2 inches) along the case vehicle’s front bumper. Crush measurements were taken at the bumper level (**Figure 7** below). Maximum crush was measured as 64 centimeters (25.2 inches) occurring at C₄. The table below shows the case vehicle’s crush profile.



Figure 6: Direct damage to front of case vehicle from impact with Chevrolet

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	64	148	10	21	45	64	55	32	27	0
in		40.2	25.2	58.3	3.9	8.3	17.7	25.2	21.7	12.6	10.6	0.0

The case vehicle’s right side wheelbase was reduced 17 centimeters (6.7 inches) and the left side wheelbase was reduced 5 centimeters (2 inches). Induced damage involved the left portion of the front bumper, left headlamp/turn lamp assembly, hood, right fender, right front door, right “A”-pillar and right roof side rail, and the windshield.



Figure 7: Crush to front of case vehicle, each stripe on rods is 5.0 centimeters (2.0 inches)

The recommended tire size was: P265/70R16. However, the evidence indicates the case vehicle was equipped with P275/55R18 tires. This was the size of the right front tire, which was jammed in the wheel house from damage. The left front, left rear and right rear tires and one tire found in the back of the vehicle were size: P265/70R16. These tires were made by two different manufacturers, and the left front, left rear and right rear wheels were bolted to the hub with only three of the six lug nuts. This evidence indicates the original left front, left rear and right rear wheels had been removed and replaced with these wheels. The case vehicle’s tire data are shown in the table below.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	Unk	Unk	241	35	Unk	Unk	Not original	No	Unk
RF	0	0	241	35	5	6	Cut in sidewall	No	Yes
LR	Unk	Unk	241	35	Unk	Unk	Not original	No	Unk
RR	Unk	Unk	241	35	Unk	Unk	Not original	No	Unk

Vehicle Interior: Inspection of the case vehicle’s interior revealed no evidence of occupant contact to any components or surfaces (**Figure 8**). There was no evidence of compression of the energy absorbing steering column or deformation of the steering wheel rim (**Figure 9** below), and the power adjustable pedals were not displaced or deformed (**Figure 10** below). The front right toe pan was observed to be intruded longitudinally 25 centimeters (9.8 inches).



Figure 8: Overview of case vehicle’s steering wheel and instrument panel



Figure 9: Case vehicle's steering wheel and steering column showing lack of deformation



Figure 10: Case vehicle's power adjustable brake and accelerator pedals

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be **12-FZEW-3 (0 degrees)**.

The WinSMASH reconstruction program, missing vehicle algorithm, was used to reconstruct the case vehicle's Delta V. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 42 km.p.h. (26.1 m.p.h.), -42 km.p.h. (-26.1 m.p.h.), and 0 km.p.h. (0 m.p.h.). The EDR data indicates that the case vehicle's maximum recorded longitudinal Delta V was -35.59 km.p.h. (22.12 m.p.h.). The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a manufacturer certified advanced 208-compliant front air bag system. Both stages of the driver's air bag deployed in the crash. The front right air bag did not deploy because there was no front right passenger in the case vehicle at the time of the crash.

The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of symmetrical "I" configuration cover flaps made of pliable vinyl. Each flap was 7 centimeters (2.8 inches) in width at the top seam, 5 centimeters (2 inches) in width at the bottom seam and 12 centimeters (4.7 inches) in height along the center seam. The distance between the mid-center of the driver's seat back, as positioned at the time of the vehicle inspection and the front surface of the air bag's fabric at full excursion was 41 centimeters (16.1 inches). An inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points (**Figure 11**). There was no



Figure 11: Case vehicle's steering wheel and air bag module cover flaps, steering wheel is rotated counterclockwise approximately 120 degrees

evidence of damage during the deployment to the air bag module cover flaps or the air bag fabric, and no evidence of occupant contact to the air bag was observed. The deployed driver's air bag (**Figure 12**) was round with a diameter of approximately 63 centimeters (24.8 inches). The air bag was designed with two tethers, each approximately 13 centimeters (5.1 inches) in width and had two vent ports (**Figure 13**), each approximately 3 centimeters (1.2 inches) in diameter, located at the 10 and 2 o'clock positions.



Figure 12: Case vehicle's driver air bag

The front right passenger air bag was located in the middle of the instrument panel (**Figure 14** below) above the glove box door. The deployment of the front right passenger air bag was properly suppressed by the case vehicle's occupant detection and air bag suppression system because there was no front right passenger in the case vehicle at the time of the crash.



Figure 13: Case vehicle's driver air bag vent ports at top of air bag

CRASH DATA RECORDING

The download of the case vehicle's EDR was done during the vehicle inspection via direct connection to the SDM. The EDR data indicated that both stages of the driver's air bag deployed. The EDR reports for the deployment event are presented at the end of this report (**Figures 16, 17 and 18**). The system status report showed that the SIR warning lamp was off, the driver's seat belt switch circuit was recorded as buckled, and the front right passenger's seat belt switch circuit was recorded as unbuckled. The maximum SDM recorded longitudinal velocity change was recorded as -35.59 km.p.h. (-22.12 m.p.h.) occurring 107.5 milliseconds after algorithm enable. In addition, the system status report shows that the first stage deployment criteria was met 7.5 milliseconds after algorithm enable, and the second stage deployment criteria was met 17.5 milliseconds after algorithm enable. The deployment event recording was complete with no multiple events associated with the record.



Figure 14: Overview of case vehicle's front right instrument panel, front right air bag located above glove box door

The pre-crash data indicates the case vehicle's driver was accelerating from five seconds to two seconds prior to the crash (i.e., algorithm enable). At one second prior to the crash, the percent throttle was recorded as zero, and the brake switch circuit status was recorded as on, indicating the driver took her foot off the accelerator and applied the brakes just prior to the crash.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash, the case vehicle's driver [33-year-old, White (unknown if Hispanic) female; unknown height and weight] was most likely seated in an upright driving posture with both hands on the steering wheel, her left foot on the floor and her right foot on the brake pedal. It is likely she was bracing for the impact. At the time of the case vehicle inspection, the driver's seat track was adjusted to the middle position, her seat back was in an upright position, the tilt steering wheel was located in its center position and the adjustable pedals were adjusted to the full forward position.

The evidence indicates the case vehicle's driver was restrained by her manual, three-point, lap-and-shoulder safety belt system. The safety belt showed no obvious signs of loading, but the shoulder belt guide was pulled out of the seat (**Figure 15**). Driver safety belt usage was also supported by the EDR data, which indicated the driver's safety belt was buckled. In addition, the police report indicated the driver was using her lap-and-shoulder belt in the crash.



Figure 15: Case vehicle driver's shoulder belt guide pulled out of the seat

The EDR data indicated the driver applied the brakes just prior to the crash. The pre-crash braking most likely locked the driver's safety belt retractor. The case vehicle's impact with the Chevrolet then caused the driver to continue forward and load her lap-and-shoulder belt, and her face and chest most likely made contact with her deployed air bag. The driver most likely rebounded off the air bag and remained restrained in her seat as the case vehicle rotated clockwise to its final rest position. The driver was most likely able to exit the case vehicle without assistance.

CASE VEHICLE DRIVER INJURIES

The police crash report indicated the case vehicle's driver did not sustain any injury as a result of the crash and was not transported from the scene for medical treatment. It is not known if the driver subsequently sought medical treatment, or lost any work days as a result of the crash. The case vehicle driver's use of her lap-and-shoulder safety belt system and the deployment of her air bag prevented her from sustaining any injury in this crash.

OTHER VEHICLE

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The 1986 Chevrolet Camaro Sport Coupe was a two door, rear-wheel drive passenger car (VIN: 1G1FP87H4GL-----) equipped with a 5.0L, V-8 engine. The Chevrolet was not equipped with a driver or front right passenger air bag.

Exterior Damage: The Chevrolet was not inspected. With no available vehicle photographs, a CDC could not be estimated. The Chevrolet was towed due to damage.

Chevrolet's Occupants: According to the police crash report, the Chevrolet's driver [21-year-old, White (Hispanic) male] was restrained by his manual, three-point, lap-and-shoulder, safety belt system. The police crash report indicated the driver sustained an "A" (incapacitating) injury and was transported by ambulance to a treatment facility.

EVENT DATA RECORDER DATA

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1GKEC13Z14Rxxxxxx System Status At Deployment															
SIR Warning Lamp Status	OFF														
Driver's Belt Switch Circuit Status	BUCKLED														
Passenger's Belt Switch Circuit Status	UNBUCKLED														
Ignition Cycles At Deployment	1176														
Ignition Cycles At Investigation	1180														
Maximum SDM Recorded Velocity Change (MPH)	-22.12														
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	107.5														
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	7.5														
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	17.5														
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A														
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A														
Time Between Non-Deployment And Deployment Events (sec)	N/A														
Frontal Deployment Level Event Counter	1														
Event Recording Complete	Yes														
Multiple Events Associated With This Record	No														
One Or More Associated Events Not Recorded	No														
Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.93	-2.48	-4.03	-7.44	-11.78	-15.81	-20.15	-21.70	-21.70	-21.70	N/A	N/A	N/A	N/A	N/A
PRE-CRASH DATA															
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status											
-5	23	1664	39	OFF											
-4	25	2048	44	OFF											
-3	30	2240	39	OFF											
-2	33	2368	39	OFF											
-1	32	1280	0	ON											

Figure 16: Case vehicle's System Status at Deployment report

