EVALUATION OF FMVSS NO. 301, "FUEL SYSTEM INTEGRITY," AS UPGRADED IN 2005 TO 2009

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Contents

Background & Introduction: Upgraded FMVSS No. 301 Tests

Upgraded Rear Impact and Side Impact Tests

- **Subject Vehicles**

  Vehicles with Gross Vehicle Weight Rating (GVWR) less than 10,000 lbs.

- **Test Process**

  The rear/side of the subject vehicle is hit by a barrier

- **Requirements on Fuel Spillage**

1. Fuel spillage should not exceed 20 g from the impact moment until the vehicle has ceased.
2. Fuel spillage should not exceed a total of 142 g in the 5-minute period following cessation of motion.

Background & Introduction:
FMVSS No. 301 Rear Impact Upgrade

Test Condition

Table 1

	Prior Test	Upgraded Test
Barrier	Rigid Barrier	Moving Deformable Barrier (MDB)
Weight of Barrier	4,000 lbs.	3,015 lbs.
Impact Speed	30 mph	50 mph

Upgraded rear impact test has a higher level of crash forces, impact velocity, and absorbed crush energy than the prior test.

Phase-In Schedule

NHTSA issued the phase-in schedule on December 1, 2003.

Table 2

Model Year (MY)	Required Certification Percentage
2007	40 %
2008	70 %
2009 and later	100 %

Background & Introduction:
FMVSS No. 301 Side Impact Upgrade

Test Condition

Table 3

	Prior Test	Upgraded Test
Barrier	MDB	MDB
Weight of Barrier	4,000 lbs.	3,015 lbs.
Impact Speed	20 mph	33 mph

- Vehicles in MY 2005 and later must certify to the side impact upgrade.
- There is no phase-in schedule for the upgraded FMVSS No. 301 side impact test.

Background & Introduction: Purpose and Settings of Evaluation

Purpose of Evaluation

To test the effectiveness of the upgraded FMVSS No. 301 in reducing fatal post-crash fires.

Settings of Evaluation

- **Target Population**

  Vehicles with GVWR less than 10,000 lbs.

- **Upgraded Rear Impact Test**
  - Post-crash-fire related confounding variables (economic climates, gasoline prices) need to be removed.
  - MY 2004-2011 and CY 2008-2011
- **Upgraded Side Impact Test**
  - New Car Assessment Program (NCAP): only 3 out of 103 vehicles (MY 1997-2000) did not meet the fuel-spillage criterion in the side impact test.
  - MY 1995-2011 and CY 1995-2011

Background & Introduction: Database

Fatality Analysis Reporting System (FARS)

Principal Impact

The most severe damaged location in a crash event

	O'clock Position
Rear Impact	5, 6, or 7
Side Impact	2, 3, 4, 8, 9, or 10

Sampling System-Crashworthiness Data System (CDS)

- CDS documents the occupants' injuries based on the data from the hospitals and treatment facilities.
- CDS cannot always identify the exact cause of a fatality.
- The injury severity is assessed with the Abbreviated Injury Scale (AIS) from 1 (minor) to 6 (fatal).

Background & Introduction: Statistical Analysis Methods

Odds Ratio and Effectiveness

Table 4

	Events	No Events
Experimental Group	N_1	N_2
Control Group	N_3	N_4

- Odds Ratio = $(N_1N_4) / (N_2N_3)$
- Effectiveness = 1 – Odds Ratio = 1 - $(N_1N_4) / (N_2N_3)$
- The effectiveness indicates the increased/decreased likelihood of the event occurrence when switching from the control group to the experimental group.

Pearson's Chi-Squared Test

Pearson's Chi-squared test exams whether there is a statistically significant association between the groups and the event occurrences.

FMVSS No. 301 Rear Impact Upgrade: Frequency Table of Fatal Post-Crash Fires in Rear Impacts

MY versus Fatal Post-Crash Fires in Rear Impacts

FARS: MY 2004-2011 and CY 2003-2011

Table 5

MY	Fires	No Fires	Rate of Fires
2004	35	1,320	2.58 %
2005	29	1,135	2.49 %
2006	22	949	2.27 %
2007	19	732	2.53 %
2008	5	451	1.10 %
2009	2	240	0.83 %
2010	1	168	0.59 %
2011	1	68	1.45 %

There is a significant decrease in the rate of fatal post-crash fires after MY 2007, where is the 1st year of the phase-in schedule.

FMVSS No. 301 Rear Impact Upgrade: Fire-Reducing Effectiveness

Certification versus Fatal Post-Crash Fires in Rear Impacts

- Manufacturers provided NHTSA the upgrade status of each make model in every MY since MY 2006.
- It is assumed that there is no certified vehicle in MY 2005 or earlier.

Table 6

FARS: MY 2004-2011 and CY 2008-2011			
	Fires	No Fires	Rate of Fires
Certified Group	12	1,160	1.02 %
Uncertified Group	40	1,680	2.33 %

There is a significant difference in the rate of fatal post-crash fires between the certified group and uncertified group.

FMVSS No. 301 Rear Impact Upgrade: Fire-Reducing Effectiveness

Certification versus Fatal Post-Crash Fires in Rear Impacts

Table 7

	Point Estimation	Interval Estimation
Odds Ratio	43.45 %	-
Fire-Reducing Effectiveness	56.55 %	(16.82 %, 77.31 %)

- If a rear-impacted vehicle switches from the uncertified group to the certified group, then the likelihood of experiencing a fatal post-crash fire will be reduced by around 57 %.
- The interval estimation is built based on 95 % confidence level.

Table 8

Pearson's Chi-Squared Test	***p-value***=0.0097

There is a statistically significant association between the upgrade certification and fatal post-crash fires in rear impacts.

FMVSS No. 301 Rear Impact Upgrade: Percentage of Fatalities Attribute to Burns

CDS: CY 1991-2011

- There are 59 fatally injured occupants involving post-crash fires in rear impacts.
- An occupant often experienced more than one injury in a crash.
- It is necessary to distinguish:

1. Injuries: fatal or non-fatal
2. Cause of a fatality: burns or impact trauma

Percentage of Fatalities Attribute to Burns

Assumptions

1. In this analysis, injuries with AIS 5 or 6 in a fatality are equally considered to be potential contributors to the fatality.
2. Injuries are mutually independent in a fatality case.

FMVSS No. 301 Rear Impact Upgrade: Percentage of Fatalities Attribute to Burn

- Example 1: AIS 6 BURNS
  AIS 2 ARM AMPUTATION
  AIS 2 ARM AMPUTATION

→ Percentage of fatalities attributable to burns = 100 %

- Example 2: AIS 6 BURNS
  AIS 5 BRAIN UNK INJURY
  AIS 3 SKULL FRACTURE
  AIS 2 LIVER LACERATION
  AIS 2 SPLEEN LACERATION

→ Percentage of fatalities attributable to burns = 50 %

- Based on 59 cases in CDS: CY 1991-2011:
  The overall estimated percentage of fatalities attributable to burns is 62.23 %.

FMVSS No. 301 Rear Impact Upgrade: Life-Saving Effectiveness

Life-Saving Effectiveness

- Life-saving effectiveness indicates the reduction in the likelihood of experiencing fatal burns in a rear impact fire.
- Life-Saving Effectiveness

= (Fire-Reducing Effectiveness) X (Percentage of Fatalities Attributable to Burns)

Table 9

	Point Estimation	Interval Estimation
Fire-Reducing Effectiveness	56.55 %	(16.82 %, 77.31 %)
Fatalities Attributable to Burn	62.23 %	-
Life-Saving Effectiveness	35.19 %	(10.43 %, 47.96 %)

If a vehicle switches from the uncertified group to the certified group, then the likelihood of experiencing fatal burns in a rear impact fire will be reduced by around 35 % (with range 10.43 % to 47.96 %).

FMVSS No. 301 Rear Impact Upgrade: Adjusted Baseline Fatalities

Adjusted Baseline Fatalities

- Removing the life-saving effectiveness from the certified vehicles to estimate the number of fatalities when all vehicles did not meet the upgraded test.
- Baseline Year: CY 2007-2011

  FARS: There are 313 fatalities involving rear impact fires in CY 2007-2011.

Table 10

With Life-Saving Effectiveness	
Certified Vehicles	18
Uncertified Vehicles	295
Total Fatalities	313

Table 11

Without Life-Saving Effectiveness	
Adjusted Certified Vehicles	28
Adjusted Uncertified Vehicles	295
Adjusted Baseline Fatalities	323

- Adjusted baseline fatalities per year is around 65 (323/5).
- If all vehicles did not meet the FMVSS No. 301 rear impact upgrade, there would be around 65 fatalities per year.

FMVSS No. 301 Rear Impact Upgrade: Savable Lives in Rear Impact Fires

Savable Lives in Fatal Rear Impact Fires

- Savable Lives per Year
  = (Adjusted Baseline Fatalities per Year) X (Life-Saving Effectiveness)

Table 12

	Point Estimation	Interval Estimation
Adjusted Baseline Fatalities per Year	65	-
Life-Saving Effectiveness	35.19 %	(10.43 %, 47.96 %)
Savable Lives per Year	23	(7, 31)

- If all vehicles met the FMVSS No. 301 rear impact upgrade, the estimated savable lives per year is 23 (with range 7 to 31).

FMVSS No. 301 Side Impact Upgrade: Frequency Table of Fatal Post-Crash Fires in Side Impacts

MY versus Fatal Post-Crash Fires in Side Impacts

FARS: MY 1995-2011 and CY 1995-2011

Table 13

MY	Fires	No Fires	Rate of Fires
1995	220	10,651	2.02 %
1996	189	8,680	2.13 %
1997	184	8,884	2.03 %
1998	172	8,028	2.10 %
1999	165	8,170	1.98 %
2000	145	7,586	1.88 %
2001	146	6,471	2.21 %
2002	122	5,768	2.07 %

MY	Fires	No Fires	Rate of Fires
2003	100	4,819	2.03 %
2004	86	3,975	2.12 %
2005	72	3,191	2.21 %
2006	51	2,430	2.06 %
2007	41	1,685	2.38 %
2008	29	1,065	2.65 %
2009	3	426	0.70 %
2010	7	273	2.50 %

There is no significant decrease in the rate of fatal post-crash fires after MY 2005, where is the begin of the side impact upgrade.

FMVSS No. 301 Side Impact Upgrade: Fire-Reducing Effectiveness

Groups of MY versus Post-Crash Fires in Side Impacts

- Manufacturers did not provide NHTSA the status information of the side impact upgrade.
- Side-impacted vehicles with fatal post-crash fires are grouped by MY 2005.

Table 14

FARS: MY 1995-2011 and CY 1995-2011			
	Fires	No Fires	Rate of Fires
MY ≥ 2005	133	6,005	2.17 %
MY ≤ 2004	1,601	76,223	2.06 %

- There is no significant difference in the rate of fires between two groups of MY.

FMVSS No. 301 Side Impact Upgrade: Fire-Reducing Effectiveness

Groups of MY versus Post-Crash Fires in Side Impacts

Table 15

Pearson's Chi-Squared Test	***p-value***=0.5610

- There is no statistically significant association between two groups of MY and fatal post-crash fires in sides impacts.
- A large proportion of vehicles may have already complied with the side impact upgrade before NHTSA requested the upgrade certification.

Summary

FMVSS No. 301 Rear Impact Upgrade

- The rear impact upgrade shows a statistically significant likelihood reduction in fatal post-crash fires by 57 %.
- The rear impact upgrade would reduce 35 % of the fatalities caused by rear impact fires.
- The rear impact upgrade would save an estimated 23 lives per year.

FMVSS No. 301 Side Impact Upgrade

The side impact upgrade did not show a statistically significant likelihood reduction in fatal post-crash fires.

Thank You

Evaluation Report

You may access the report in PDF format at

http://www-nrd.nhtsa.dot.gov/Pubs/812038.pdf

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