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Cost and Weight Added by The FMVSS for Model Years 1968 to 2019 for Passenger Cars and LTVs

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16. Abstract NHTSA began to evaluate the cost of its Federal Motor Vehicle Safety Standards (FMVSSs) in 1975. The agency's contractors perform detailed engineering teardown analyses for representative samples of vehicles to estimate how much specific FMVSSs add to the weight and cost of a vehicle. This report combines all these reports and other data sources to estimate the cost and weight added by all the FMVSSs, and by each individual FMVSS, to MY 2019 passenger cars and light trucks and vans (LTVs), and in all earlier model years (MYs), back to 1968. The total cost of safety technologies that are linked to the FMVSS (attributable to a specific standard or voluntarily added in advance of the standard) added an average of $2,428 (in 2019 dollars) and 239 lb to the average passenger car in MY 2019. An average of $2,269 (in 2019 dollars) and 207 lb was added to the average LTV in MY 2019. Approximately 9.2 percent of the cost and 7.2 percent of the weight of a MY 2019 passenger car could be linked to FMVSSs, while 5.9 percent of the cost and 4.8 percent of the weight of a MY 2019 LTV could be linked to FMVSSs.			
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List of Abbreviations

ABS	antilock brake system
AMC	American Motors Corporation
ANPRM	advance notice of proposed rulemaking
ANSI	American National Standard Institute
ATD	anthropomorphic test device, also known as a crash test dummy, is an advanced instrument for measuring human injuries in vehicle crash tests
CFR	Code of Federal Regulations; up-to-date text of NHTSA regulations may be downloaded from the electronic CFR, Title 49, https://ecfr.io/Title-49/cfrv6#500 Regulations other than FMVSS are referenced as Part numbers (e.g., Part 563, "Event data recorders"). FMVSS are referenced as Part 571 followed by the FMVSS number (e.g., Part 571.103 = FMVSS No. 103, "Windshield defrosting and defogging systems")
CHMSL	center high-mounted stop lamp
CNG	compressed natural gas
CUV	crossover utility vehicle
CY	calendar year
DRL	daytime running lights
EAD	energy-absorbing device on a steering column
ESC	electronic stability control
FARS	Fatality Analysis Reporting System (a census of fatal crashes in the United States since 1975)
GDP	gross domestic product – The GDP deflator (implicit price deflator for GDP) is a measure of the level of prices of all new, domestically produced, final goods and services in the United States in a specified year.
GM	General Motors
GVWR	gross vehicle weight rating (specified by the manufacturer, equals the vehicle's curb weight plus maximum recommended loading)
HPR	high penetration resistant windshield
LATCH	lower anchors and tethers for children
LED	light-emitting diode
LTVs	light trucks and vans (includes pickup trucks, SUVs, CUVs, minivans, and full-sized vans with GVWR of 10,000 lb or less)
MPV	multipurpose passenger vehicle (includes SUVs, CUVs, minivans, and full-sized vans designed to carry people, with rear windows - not a cargo van, with GVWR of 10,000 lb or less)

MY	model year
NASS	National Automotive Sampling System (a probability sample of police-reported crashes in the United States since 1979, investigated in detail)
NCSS	National Crash Severity Study (a probability sample of police-reported towaway crashes in seven multicounty areas, 1977-79, investigated in detail)
NPRM	notice of proposed rulemaking
RPE	retail price equivalent
SNPRM	supplemental notice of proposed rulemaking
SUV	sport utility vehicle
TPMS	tire pressure monitoring system
TTI(d)	thoracic trauma index for the dummy in a side-impact test
UMTRI	University of Michigan Transportation Research Institute
VW	Volkswagen

Acknowledgements

In 1975 the National Highway Traffic Safety Administration proposed to evaluate the costs as well as the benefits of existing Federal Motor Vehicle Safety Standards. Warren LaHeist, under the general direction of Frank Ephraim, planned to estimate costs based on teardown or reverse engineering. The first contract to evaluate costs of specific FMVSSs was awarded in 1977 and completed in 1978. During 1978 to 2001 Robert Lemmer, Bruce Spinney, Gregory Rymarz, or LaHeist managed the cost-analysis program. Spinney also developed NHTSA's "macro-analysis" for computing mark-ups from direct variable costs to final consumer costs.

A report summarizing the cost analyses and estimating the overall consumer cost of the FMVSS was proposed first in NHTSA's 1998 to 2002 Evaluation Plan and again in the 2004 to 2007 plan. LaHeist outlined the report in 1998 to 1999 and drafted text for some of the FMVSS. After LaHeist retired, Rymarz worked up initial spreadsheets and text for many of the remaining FMVSSs from 1999 to 2001. Marcia Tarbet was assigned to the cost-analysis program when she joined NHTSA in 2002 and completed the report in 2004. It covered MYs 1968 to 2001. NHTSA proposed to update the 2004 report in its 2008 to 2012 Evaluation Plan. Jennifer Dang headed the cost-analysis program after Tarbet retired in 2007. Shirley Florus was assigned to head the cost-analysis program when she joined NHTSA in 2008 and has coordinated all the cost teardown contracts and contractors since that time. Dr. Charles Kahane was the Evaluation Division chief from 1995 to 2014, and James Simons was the Director of the Office of Regulatory Analysis and Evaluation from 1998 to 2014. Both supervised the development of the 2004 Cost Report completed by Tarbet. Simons with the help of Kahane updated the first report, which included MYs 1968 to 2001, with a second report that included MYs 1968 to 2012 in November 2017 under the guidance of Lawrence Blincoe of NHTSA. This third report by Simons with the help of Kahane, under the guidance of Blincoe, updates the analysis to include MYs 1968 to 2019.

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Executive Summary

NHTSA issues FMVSSs for new motor vehicles and equipment to reduce the number of crashes and the risk of deaths and injuries. The 100-series FMVSSs are crash avoidance standards, the 200-series regulates crashworthiness, and the 300-, 400- and 500-series address the risk of fires, hazards during normal operation, and certain special vehicles. Manufacturers of new vehicles and equipment must conform and certify compliance to the FMVSSs. The initial FMVSSs went into effect on January 1, 1968.

NHTSA began to evaluate the cost of the FMVSSs in 1975. The agency's contractors perform detailed engineering teardown analyses, for representative samples of vehicles, to estimate how much specific FMVSSs add to the weight and cost of a vehicle. These analyses employ a process known as reverse engineering. Whereas conventional engineering proceeds from design and raw materials to mass-produced product, reverse engineering includes a step-by-step teardown or disassembly of each finished item into sub-assemblies and finally into individual component parts. The contractor weighs the components, identifies the type, unit cost and amount of raw material needed, identifies the processes to make the parts, and estimates the labor, variable burden, and tooling required to produce individual components and assemble them. These direct variable costs determined by the contractor are then marked up by a 1.51 factor determined by NHTSA to account for manufacturer's fixed costs and dealer markups to derive a retail price equivalent consumer cost.

NHTSA and its contractors have evaluated virtually all the cost- and weight-adding technologies introduced in passenger cars and light trucks and vans (including pickup trucks, SUVs, crossover utility vehicles, minivans, and full-sized vans with gross vehicle weight rating of 10,000 lb or less) in response to the FMVSSs. The agency has estimated the cost and weight added by all the FMVSSs, and by each individual FMVSS, to MY 2019 passenger cars and LTVs, and also in all earlier MYs, back to 1968. All costs are estimated in 2019 dollars. All the contractor studies completed to date are available in one NHTSA docket at www.regulations.gov. Search under docket number NHTSA-2011-0066. For some of the FMVSSs (like FMVSS No. 139 – new pneumatic radial tires for light vehicles, FMVSS No. 202 – head restraints upgrade, FMVSS No. 226 – ejection mitigation), where a cost teardown analysis has not been completed, this analysis uses estimates from NHTSA's regulatory analyses. This report updates the earlier report by Simons (2017) titled *Cost and Weight Added by the Federal Motor Vehicle Safety Standards for MY 1968-2012 Passenger Cars and LTVs*. Several NHTSA evaluations are quoted in this document. To review the evaluations go to NHTSA.gov, click on More info > Data > Publications, Data and Data Tools > Crash Data Publications (CrashStats) > View by Topics, then scroll down the left side and click on Regulatory Evaluations, then find the report using the DOT HS number or the year published.

After determining the cost and weight of safety technologies linked to the FMVSSs, we divide them into those voluntarily supplied by the automobile manufacturers and those attributable to FMVSSs. The baseline MY for each FMVSS is determined individually and is defined as the last MY in production as of September 1 before a Notice of Proposed Rulemaking was published in the Federal Register. The only exception to this rule is lap belts for the front outboard seats, which were required by several States before NHTSA was established. The baseline for lap belts for the front outboard seats is based on the first State requirement and not a NHTSA NPRM. The installation rate of safety technologies, before or during the baseline year, are considered voluntary installation by the manufacturers. Voluntary compliance is assumed to carry over after the baseline year and it is assumed to be the same as the compliance percentage during the baseline year. The attributable cost of an FMVSS, in this report, includes the cost of all equipment or specific safety technologies added or modified primarily for the purpose of meeting (or even exceeding) the requirements of the standard, provided these modifications took place after the baseline MY. Attributable costs will be the difference between the installation rates for MYs after the baseline year through MY 2019 minus the voluntary baseline level. Safety equipment that was already in place in 100 percent of the fleet of passenger cars and LTVs by MY 1965, before NHTSA was established – e.g., the basic hydraulic brake system, a horn, or windshield wipers – is defined as Safety1965 and its cost is not included in the estimates of this report: neither in the attributable nor the voluntary column.

The cost of an FMVSS is the incremental cost over the Safety1965 equipment. The cost of these technologies will tend to decline over time as companies learn how to make the products more efficiently, and as their production volumes increase. As manufacturers gain production experience, they refine component designs, manufacturing techniques and assembly methods, and optimize raw material and component sources. This learning process enables them to maximize efficiency and reduce production costs. In this report we estimate the effect of this learning curve on costs that are derived mainly from cost teardown studies.

There are several safety technologies that are installed in some vehicles today for which NHTSA has not proposed an NPRM as of January 2021. The report does not include technologies such as forward collision warning or automatic braking, adaptive automatic cruise control, lane departure warning, lane keeping systems, blind spot warning, etc., because they are not linked to an FMVSS.

Furthermore, the report is limited to passenger cars and LTVs; the cost of FMVSSs in heavy trucks, buses, or motorcycles has not been estimated, nor has the cost of motor vehicle equipment, such as child restraints, been included.

The Cost and Weight Added by FMVSSs in MY 2019. NHTSA estimates that the total cost of safety technologies (attributable and voluntarily added) that are linked to FMVSSs added an average of $2,428 (in 2019 dollars) and 239 lb to the average passenger car in MY 2019 (see Table 1a). Since passenger cars cost an average of $26,385 (in 2019 dollars)[1] and weighed an estimated average of 3,300 lb in MY 2019, 9.2 percent of the cost and 7.2 percent of the weight of a new MY 2019 passenger car could be linked to FMVSSs. Of the total of 239 lb added, 165 lb (69%) are attributable and 74 lb (31%) are voluntary. Of the total $2,428 cost added, $1,604 (66%) is attributable and $824 (34%) is voluntary.

Safety technologies linked to FMVSSs added an average $2,269 (in 2019 dollars) and 207 lb to the average LTV in MY 2019 (see Table 1b). With LTVs costing an average of $38,207 (in 2019 dollars) and weighing an estimated 4,337 lb in MY 2019, 5.9 percent of the cost and 4.8 percent of the weight of a new LTV could be linked to the FMVSS. For MY 2019 for LTVs, of the total

[1] Retail prices based on average consumer expenditures by the Bureau of Economic Analysis for 2019 for passenger cars and LTVs. Source is Table 7.2.5.S, Auto and Truck Unit Sales, Production, Inventories, Expenditures, and Price. www.bea.gov/itable/. The average weights are based on MY 2019 specifications from the 2019 Wards Automotive Yearbook weighted by MY 2019 sales from the factory installed equipment pages of the 2020 Wards Automotive Yearbook.

of 207 lb added, 136 lb (66%) are attributable and 71 lb (34%) are voluntary. Of the total $2,269 cost added, $1,368 (60%) is attributable and $901 (40%) is voluntary.

We use the term "average" cost to designate that the cost of the technology has been multiplied by the percentage of the fleet equipped with the safety technology. There could be several reasons why less than 100 percent of the vehicles are equipped with a safety technology. First, before a requirement, manufacturers may have supplied the safety countermeasure in only a few make/models or to their higher priced models. Second, the effective dates of a requirement may be phased-in over time (for example, 35% of the vehicles must meet the standard in the first year, 70% in the second year, and 100% in year three and thereafter). Third, the standard might not affect all passenger cars; for example, not all passenger cars have seat back locks, because seat back locks were only used on 2-door cars. Thus, if the safety technology costs $100 and 50 percent of passenger cars in MY 2019 are equipped with that safety technology, the increased cost of the average passenger car is $50.

There are a total of 60 separate cost items representing 49 separate technologies and 25 different FMVSSs for which weights and costs are included in Table 1a for passenger cars, and 59 separate cost items representing 47 separate technologies and 24 different FMVSSs for which weights and costs are included in Table 1b for LTVs. As an example, lap belts, lap/shoulder belts, automatic belts, frontal air bags, pretensioners, load limiters, adjustable anchorages, and manual on-off switches are all different technologies, but they are all counted as one standard (FMVSS No. 208). When we count the number of separate cost items, each of the different seat positions for lap belts and lap/shoulder belts, for example, (front seat outboard, front seat center, rear seat outboard and rear seat center) are counted separately. The standards with costs for passenger cars that did not have costs for LTVs include FMVSS No. 207 seat back locks and FMVSS No. 401 interior trunk release. The one standard for LTVs that does not have costs for passenger cars is FMVSS No. 206 for sliding doors. Not all these safety technologies occur in each year, for example lap belts may occur in the early years and lap/shoulder belts in the following years.

Table 1a. Weight and cost per average vehicle of all safety technologies voluntarily supplied or attributable to FMVSSs by MY passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	25.0	8.7	33.6	$257.68	$93.96	$351.64
1969	32.1	15.7	47.7	$278.17	$137.10	$415.26
1970	32.4	23.1	55.5	$278.79	$170.46	$449.25
1971	32.9	25.8	58.7	$278.94	$176.87	$455.81
1972	34.9	32.3	67.2	$285.29	$219.50	$504.79
1973	35.0	45.8	80.8	$283.41	$257.22	$540.63
1974	34.8	52.3	87.1	$281.76	$277.77	$559.54
1975	34.6	52.1	86.7	$280.54	$277.93	$558.47

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1976	34.4	53.0	87.3	$279.58	$326.98	$606.56
1977	32.0	50.9	82.9	$268.88	$320.16	$589.04
1978	31.5	49.8	81.3	$266.66	$319.38	$586.03
1979	30.9	48.1	78.9	$263.08	$308.62	$571.70
1980	31.0	48.3	79.3	$261.47	$308.15	$569.62
1981	30.8	47.8	78.6	$262.07	$307.15	$569.22
1982	30.2	47.3	77.5	$255.52	$305.14	$560.66
1983	30.1	46.9	77.1	$254.95	$304.05	$558.99
1984	30.1	46.9	77.0	$252.05	$302.85	$554.90
1985	30.0	46.5	76.5	$250.16	$301.48	$551.63
1986	32.0	47.2	79.2	$290.67	$314.74	$605.41
1987	34.4	48.3	82.7	$324.28	$336.33	$660.61
1988	35.6	50.0	85.6	$325.60	$352.27	$677.87
1989	35.3	53.1	88.4	$326.49	$381.44	$707.93
1990	36.0	64.9	101.0	$352.31	$559.29	$911.59
1991	37.1	66.2	103.3	$389.23	$581.69	$970.92
1992	40.3	67.3	107.5	$492.29	$619.89	$1,112.18
1993	42.9	71.8	114.7	$539.59	$685.45	$1,225.04
1994	46.8	83.8	130.5	$616.71	$837.94	$1,454.65
1995	46.7	93.0	139.7	$606.72	$941.22	$1,547.94
1996	52.6	98.1	150.7	$629.66	$961.10	$1,590.76
1997	52.5	106.5	159.0	$623.27	$984.94	$1,608.21
1998	53.9	105.8	159.7	$655.63	$965.66	$1,621.29
1999	55.4	104.6	160.0	$693.89	$944.54	$1,638.43
2000	56.1	103.9	160.0	$705.34	$926.61	$1,631.95
2001	57.4	102.9	160.3	$734.73	$906.16	$1,640.90
2002	57.9	101.7	159.7	$742.33	$886.62	$1,628.96
2003	58.0	101.3	159.3	$725.37	$870.69	$1,596.07
2004	65.8	102.1	167.9	$776.45	$928.04	$1,704.48

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2005	66.7	102.1	168.9	$782.06	$916.55	$1,698.62
2006	67.8	103.4	171.2	$828.68	$962.56	$1,791.23
2007	65.4	109.6	175.0	$832.98	$1,056.64	$1,889.62
2008	65.9	117.1	183.0	$834.07	$1,241.90	$2,075.96
2009	66.1	124.8	191.0	$832.85	$1,324.84	$2,157.69
2010	70.7	128.9	199.6	$845.33	$1,424.48	$2,269.82
2011	71.8	129.6	201.4	$855.78	$1,434.81	$2,290.60
2012	73.3	133.0	206.3	$860.61	$1,457.98	$2,318.59
2013	73.6	150.3	223.9	$859.95	$1,502.49	$2,362.44
2014	73.7	157.6	231.3	$852.97	$1,536.61	$2,389.58
2015	73.6	161.4	235.0	$843.06	$1,566.84	$2,409.90
2016	73.6	164.1	237.7	$837.60	$1,594.14	$2,431.74
2017	73.6	164.4	238.1	$831.44	$1,581.04	$2,412.48
2018	73.8	165.2	239.0	$827.74	$1,597.80	$2,425.55
2019	73.6	165.2	238.9	$823.49	$1,604.48	$2,427.97

Table 1b. Weight and cost per average vehicle of all safety technologies voluntarily supplied or attributable to FMVSSs by MY LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	13.9	4.7	18.6	$139.43	$67.57	$207.00
1969	14.1	4.6	18.6	$140.04	$65.41	$205.45
1970	14.2	5.2	19.4	$142.06	$79.79	$221.85
1971	14.3	5.3	19.6	$142.05	$80.42	$222.47
1972	14.8	11.6	26.4	$143.41	$128.54	$271.94
1973	15.7	13.7	29.5	$157.05	$143.02	$300.07
1974	16.7	13.9	30.6	$161.45	$147.22	$308.67
1975	16.7	15.8	32.5	$161.23	$159.04	$320.27
1976	16.8	16.9	33.7	$161.73	$165.68	$327.42
1977	16.6	17.0	33.6	$165.09	$207.46	$372.55

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1978	16.4	17.3	33.7	$163.17	$207.83	$371.00
1979	16.2	16.8	33.0	$164.21	$208.90	$373.10
1980	16.1	17.6	33.7	$162.94	$216.05	$378.99
1981	15.8	17.6	33.5	$161.96	$215.32	$377.28
1982	15.9	20.0	35.9	$158.16	$230.99	$389.15
1983	17.0	20.3	37.3	$164.21	$231.91	$396.11
1984	17.4	20.4	37.8	$166.02	$231.24	$397.25
1985	17.9	20.6	38.5	$167.92	$231.47	$399.39
1986	18.1	20.8	38.9	$167.89	$231.22	$399.11
1987	25.6	21.1	46.7	$362.07	$231.47	$593.54
1988	29.7	21.2	50.9	$453.19	$231.05	$684.25
1989	38.2	21.3	59.5	$629.23	$230.66	$859.89
1990	45.0	22.1	67.1	$734.21	$234.58	$968.80
1991	42.3	24.8	67.2	$738.13	$239.82	$977.95
1992	37.7	29.9	67.6	$717.40	$311.77	$1,029.17
1993	38.8	32.4	71.1	$712.28	$336.96	$1,049.24
1994	39.3	53.3	92.6	$691.38	$425.70	$1,117.08
1995	42.4	63.3	105.7	$730.62	$626.56	$1,357.18
1996	49.0	70.3	119.4	$744.43	$724.52	$1,468.95
1997	48.6	72.7	121.4	$743.63	$755.48	$1,499.10
1998	47.7	75.5	123.3	$740.70	$793.52	$1,534.22
1999	47.4	74.7	122.2	$735.53	$777.19	$1,512.72
2000	47.3	73.2	120.6	$735.19	$758.78	$1,493.97
2001	47.6	73.0	120.5	$750.56	$744.24	$1,494.80
2002	48.3	72.8	121.1	$767.46	$734.53	$1,501.99
2003	51.5	72.6	124.1	$805.40	$721.09	$1,526.49
2004	62.1	74.7	136.8	$849.11	$829.74	$1,678.85
2005	63.1	75.6	138.6	$862.90	$837.19	$1,700.09
2006	63.5	77.2	140.6	$884.91	$844.04	$1,728.96

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2007	60.5	86.0	146.5	$907.97	$946.96	$1,854.93
2008	61.6	92.6	154.2	$940.83	$1,092.69	$2,033.52
2009	62.0	98.1	160.1	$942.03	$1,180.38	$2,122.41
2010	68.2	101.2	169.5	$965.83	$1,221.76	$2,187.59
2011	68.9	101.8	170.8	$955.60	$1,225.12	$2,180.72
2012	68.7	103.8	172.4	$943.30	$1,234.37	$2,177.67
2013	69.0	107.8	176.8	$932.58	$1,253.33	$2,185.92
2014	69.8	114.0	183.8	$929.10	$1,292.57	$2,221.67
2015	70.0	120.9	190.9	$917.69	$1,326.36	$2,244.05
2016	70.4	125.9	196.3	$913.23	$1,339.12	$2,252.35
2017	71.0	134.2	205.2	$908.48	$1,350.55	$2,259.03
2018	71.7	135.6	207.3	$906.84	$1,368.95	$2,275.79
2019	71.5	135.7	207.2	$901.31	$1,367.90	$2,269.21

Table 2 shows the average weight and cost for passenger cars and LTVs that are voluntarily supplied or attributable for MY 2019 that are linked to FMVSSs by their standard number with a description of the safety countermeasure. Several of the technologies show the same weight and cost for passenger cars as for LTVs. By MY 2019, most of these technologies were in 100 percent of passenger cars and LTVs and the same technology was applied to both passenger cars and LTVs. There are a variety of reasons why the weight and cost for passenger cars and LTVs might be different for different safety technologies. One is that LTVs generally have more seating positions in MY 2019 than passenger cars, leading to more cost for seat belts, head restraints, etc. A second difference is in FMVSS No. 214, where passenger cars needed a lot of structure and padding to meet a dynamic test, while LTVs passed the dynamic test with no changes.

Table 2. Weight and cost per average vehicle of all safety technologies voluntarily supplied or attributable to FMVSSs in MY 2019

FMVSS	Description	Passenger Cars		LTVs	
		Weight	Cost	Weight	Cost
104	Windshield Wiping and Washing	2.1	$16.63	2.1	$16.62
105	Dual Master Cylinder	1.0	$13.65	1.0	$13.65
105	Power Booster	7.9	$45.13	7.9	$45.13
105	Brake Warning Light	0.0	$0.00	0.0	$0.48
135	Antilock Braking System	10.7	$401.94	10.7	$401.94
108	Side Marker Lamps	1.3	$36.74	1.3	$36.74
108	Center High Mounted Stop Lamps	0.9	$9.12	0.9	$9.12
108	Amber Rear Turn Signal	0.1	$0.82	0.0	$0.54
111	Outside Rearview Mirror	1.8	$13.93	1.8	$13.93
111	Rear Visibility Cameras	4.0	$122.52	3.5	$112.67
113	Hood Latch System	0.8	$3.60	0.8	$3.60
118	Power Windows	0.1	$17.82	0.1	$14.37
124	Accelerator Controls	0.0	$0.53	0.0	$0.53
126	Electronic Stability Control	1.8	$103.21	1.8	$103.21
138	Tire Pressure Monitoring System	1.5	$155.62	1.6	$165.38
139	Tire Upgrade	0.0	$3.04	0.0	$3.04
141	Minimum Sound Requirements	0.1	$3.32	0.0	$1.10
201	Seat Back, Instrument Panel Padding, Glove Box	5.4	$31.83	4.8	$21.08
201	Upper Interior Protection	1.9	$12.35	1.9	$12.35
202	Head Restraints Front	10.9	$49.43	11.0	$49.95
202	Head Restraints Rear	13.3	$61.81	15.8	$74.84
203/204	Steering Assembly	1.9	$25.11	1.9	$25.11
205	HPR Windshield	1.1	$7.76	1.1	$7.76
206	Door Locks, Sliding Doors on LTVs	0.0	$0.00	0.1	$0.70
207	Seat Back Locks	0.3	$1.68	0.0	$0.00
208	Seat Belts	19.9	$205.54	23.6	$234.86
208	Frontal Air Bags	12.8	$364.90	12.8	$364.90

FMVSS	Description	Passenger Cars		LTVs	
		Weight	Cost	Weight	Cost
214	Side Door Beams	24.3	$61.38	29.5	$35.12
214	Structure/Padding for Dynamic Side Impact Test	39.0	$145.40	0.0	$0.00
214	Side Air Bags/Window Curtains	15.8	$273.71	14.8	$262.78
216	Roof Crush Initial Standard	2.9	$4.46	0.0	$0.00
216	Roof Crush Upgrade	35.4	$102.61	35.8	$103.62
225	Lower Anchors and Tethers for Children	1.6	$5.72	1.7	$6.20
226	Ejection Mitigation	2.3	$39.28	2.9	$42.34
301	Fuel System Integrity - 1976-1978	1.2	$40.05	1.2	$40.05
301	Fuel System Integrity - 2007-2009	14.9	$45.52	14.9	$45.52
401	Interior Trunk Release	0.1	$1.82	0.0	$0.00
	Total	238.9	$2,427.97	207.2	$2,269.21

Those technologies that contributed most significantly to the weight and cost of a passenger car and LTV (ranked by total cost) for MY 2019 are:

- **Antilock Braking Systems and Electronic Stability Control.** ABS became attributable when ESC in FMVSS No. 126 was proposed because ABS provides the basic elements necessary for ESC to function properly. ABS was voluntarily supplied in some vehicles starting in 1986 and became attributable starting in MY 2008 for that percentage of the passenger car and LTV fleet that was not already voluntarily supplied with ABS in MY 2007 (baseline year). ABS is the single most costly countermeasure ($401.94) and is much more costly than ESC ($103.21), but ESC needs the ABS components to function properly. Together these technologies add $505.15 and 12.5 lb to both passenger cars and LTVs in MY 2019. For MY 2019, the portion of these costs that are attributable to the FMVSS for passenger cars are $92.85 for ABS and $82.39 for ESC, totaling $175.24 or about 35 percent of the total $505.15 cost. The portion of these costs that are attributable to the FMVSS for LTVs are $21.70 for ABS and $52.18 for ESC, totaling $73.88 or about 15 percent of the total $505.15 cost. A lower proportion of total costs for ABS and ESC are attributable for LTVs than passenger cars because a higher proportion of LTVs were voluntarily supplied with ABS and ESC than passenger cars by the baseline year.
- **Frontal Air Bags.** By the late 1990s, passenger cars and LTVs had a frontal air bag at both the driver's and right-front passenger's seating position. Air bag designs have changed several times over the years with depowering, occupant sensing, and multi-stage inflators. Dual frontal air bags add $364.90 and 12.8 lb to passenger cars and LTVs as of MY 2019. For MY 2019, all of these costs are attributable to the FMVSS because, except

for small test fleets, all air bags were introduced subsequent to the October 14, 1983, NPRM.

- **Side Air Bags and Window Curtains**. Torso air bags in the front seat were voluntarily introduced in some vehicles in 1996, window curtains to protect the head were voluntarily introduced in some vehicles in 1998, and torso air bags in the rear seat were voluntarily introduced in some vehicles in 2004. Window curtains have become wider over time as NHTSA required a pole test at an oblique angle with both a mid-seating position for a 50th percentile male dummy and a forward seating position for a 5th percentile female dummy. In MY 2019, torso bags for the front outboard seats were installed in 100 percent of all passenger cars and LTVs (1.79% in passenger cars and 0.01% in LTVs of these were combination bags in convertibles). Window curtains, which covered up to three rows of seats (could be one row in a regular cab pickup, two rows in a passenger car, three rows in minivans and some SUVs, and up to five rows of seats in 15-passenger full-size vans), were installed in all passenger cars and LTVs that didn’t have combination bags (1.79% of passenger cars and 0.01% of LTVs). In MY 2019, 22.03 percent of passenger cars and 5.73 percent of LTVs had rear-seat torso bags. The combined cost and weight of these side air bags for passenger cars as of MY 2019 was $273.71 and 15.8 lb, while for the average LTV at the equipment installation rates, it was $262.78 and 14.8 lb. For MY 2019, the portion of these costs that are attributable to the FMVSS are $199.67 for passenger cars or 73 percent of the total $273.71 cost. For MY 2019, the portion of these costs that are attributable to the FMVSS are $214.63 for LTVs or about 82 percent of the total $262.78 cost.
- **Seat Belts**. The primary component of the occupant protection system is the seat belt. They are highly effective at saving lives and preventing serious injuries in rollovers, frontal crashes, and many types of side impacts. Seat belts evolved from lap belts with manual adjustments to manual 3-point belts that combine the lap belt and shoulder harness into a single device with locking retractors. All front- and rear-outboard seats, and rear-center seats now have manual 3-point belts. The front-center seat, for example in pickup trucks, can still have a manual lap belt. Pretensioners, load limiters, and adaptable anchorages are included with these seat belt estimates. Together these seat belt technologies add $205.54 and 19.8 lb to passenger cars and $234.86 and 23.6 lb to the average LTV as of MY 2019. For MY 2019, the portion of these costs that are attributable to the FMVSS are $79.62 for passenger cars or 39 percent of the total $205.54 cost. For MY 2019, the portion of these costs that are attributable to the FMVSS are $118.47 for LTVs or 50 percent of the total $234.86 cost.

- **Tire Pressure Monitoring Systems**. Direct TPMS systems were voluntarily introduced in some vehicles in 2001 and TPMS was required in all passenger cars and LTVs in MY 2008. Compliant indirect TPMS systems, which are less expensive than direct systems, were introduced in a few vehicles starting in MY 2009, and the percentage of indirect systems grew to their highest level in MY 2017 and has since decreased. The average cost and weight for TPMS in passenger cars for MY 2019 is $155.62 and 1.5 lb. The average cost and weight for TPMS in LTVs for MY 2019 is $165.38 and 1.6 lb. The average TPMS cost and weight is higher for LTVs than passenger cars because passenger cars have a higher percentage of indirect systems (10.1%) than do LTVs (4.1%) in MY 2019. For MY 2019, the portion of these costs that are attributable to FMVSSs are

$151.99 for passenger cars or 98 percent of the total $155.62 cost. For MY 2019, the portion of these costs that are attributable to FMVSSs are $164.67 for LTVs or 99.6 percent of the total $165.38 cost.

- **Side Impact Protection – Dynamic Crash Test As It Affected Passenger Cars**. For passenger cars, vehicle side structures were substantially reinforced and padded to meet NHTSA's dynamic crash tests effective for all passenger cars in MY 1997. LTVs already passed the dynamic test without additional countermeasures. These changes add $145.40 and 39 lb to MY 2019 passenger cars. For MY 2019, the portion of these costs that are attributable to the FMVSS are $128.26 for passenger cars or 88 percent of the total $145.40 cost.

The top two weight increases for passenger cars and the top weight increase for LTVs for MY 2019 are from side impact standards. The dynamic crash test requirement of FMVSS No. 214 added 39.0 lb to passenger cars, side door beams added 24.3 lb to passenger cars and 29.5 lb to LTVs, and side air bags added 15.8 lb to passenger cars and 14.8 lb to LTVs. Together these three side impact improvements added 33.1 percent (79.1 out of 238.9 lb) of the total weight increase for passenger cars and 21.4 percent (44.2 out of 206.9 lb) of the total weight increase for LTVs of all weight added by the FMVSS for MY 2019. Of the 79.1 lb added by FMVSS No. 214 for passenger cars, 65.6 lb (82.9%) are attributable to the FMVSS. Of the 44.2 lb added by FMVSS No. 214 for LTVs, 41.5 lb (94%) are attributable to the FMVSS.

Seat belts added 19.9 lb for passenger cars (of which 9.2 lb or 46.5% are attributable to the FMVSS) and 23.6 lb for LTVs (of which 14.2 lb or 60% are attributable to the FMVSS) for MY 2019.

Historical Trend of the Cost and Weight Added by FMVSSs for Model Years 1968 to 2019. Figure 1 and Figure 2 show the total cost and weight of FMVSSs over time for passenger cars and LTVs. Table 1a and Table 1b show the weight and cost voluntarily supplied and attributable by FMVSSs in vehicles of each MY from 1968 to 2019. There is not a steady progression in the weight and cost of FMVSSs over time because of three factors. The first is the downsizing of the fleet. You'll notice the weight of safety technologies added to passenger cars decreases from 1976 to 1985. Downsizing can only be discerned in our analysis when we have cost teardown studies of the same FMVSS in two or more time periods. There are only six safety technologies for which we have two or more cost estimates at different times. Costs can decrease over time because of downsizing, but more likely as a result of the learned efficiencies derived from production experience and economies of scale. This process is often represented by a learning curve, which depicts a gradual reduction in production costs over time. Thus, if no new safety technologies are introduced and a higher percentage of the fleet doesn't get an existing safety technology, then costs would come down as a result of the learning curve. Costs decreased from 1976 to 1985 for passenger cars and in a variety of other years for both passenger cars and LTVs. Most of the time when costs decrease over just a year or so, it is due to the learning curve. The third factor is the introduction of new safety technologies into the fleet, which typically results in an increase in costs. A few new safety technologies, like disc brakes, were less expensive than the drum brakes they replaced. Since drum brakes were part of Safety1965, and we did not include the cost of drum brakes as part of FMVSS No. 105, we did not reduce the cost of FMVSS No. 105 because disc brakes were less expensive.

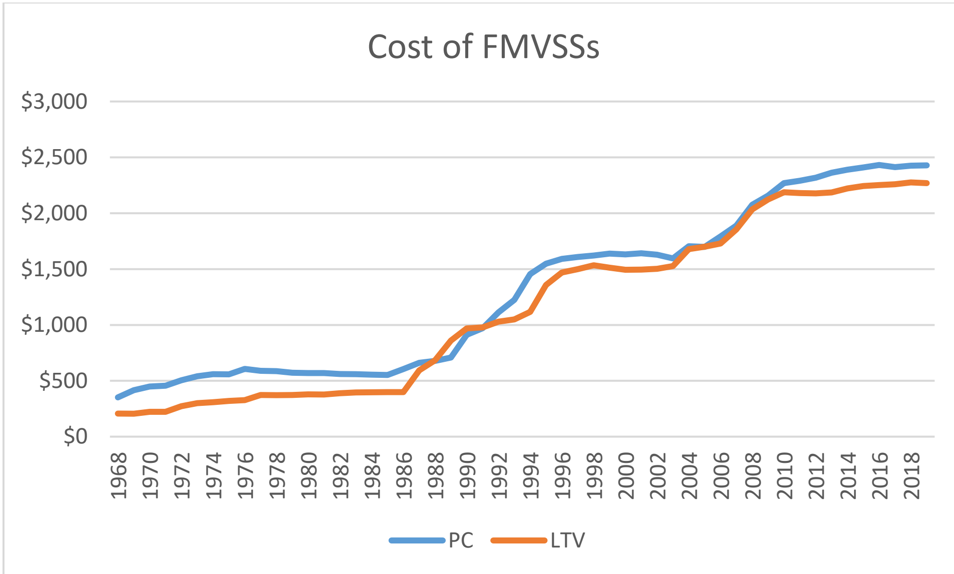

Figure 1. Total cost of FMVSSs for passenger cars and LTVs 1968 to 2019

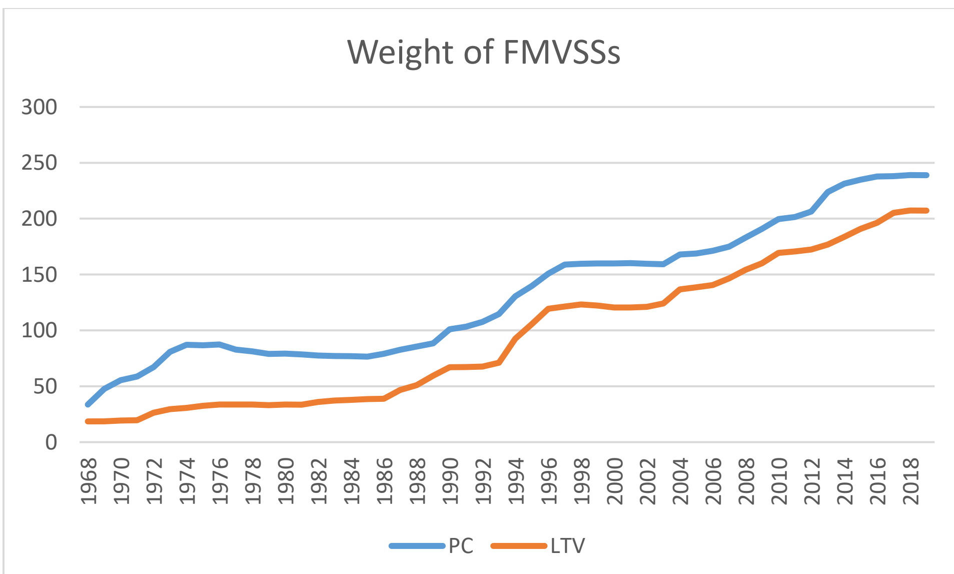

Figure 2. Total weight of FMVSSs for passenger cars and LTVs 1968 to 2019

Several of the initial safety technologies were installed by all passenger car and LTV manufacturers before NHTSA was established. These safety technologies have been defined as Safety1965 if they were installed in all passenger cars and LTVs by MY 1965. These technologies are not included in the costs because by our definition there are no incremental costs associated with them. The one exception is lap belts for front outboard seating positions, where several States required their installation. The safety technologies installed in passenger cars or LTVs in MY 1968, including voluntarily supplied and those attributable to the initial FMVSSs that are counted in the analysis include: windshield wiping and washing systems, dual master cylinder brakes, power boosters for brakes, a warning light brake lamp, side marker lamps, amber rear turn signals, an outside driver-side rearview mirror, a dual latch hood latch system, a mechanical latch for a glove box compartment door, instrument panel padding, seat back padding, front seat head restraints, energy absorbing steering assemblies, high penetration resistant windshields, sliding doors in LTVs, seat back locks, lap belts at all seat positions, and lap/shoulder belts at the front outboard seat positions. The MY 1968 voluntary and attributable incremental costs totaled $351.64 and 33.6 lb for the average passenger car.

Many safety technologies were installed in LTVs later than in passenger cars, typically after they had been required in passenger cars but before the FMVSS were extended to LTVs. In MY 1968, voluntarily supplied and attributable safety equipment added $207.00 and 18.6 lb to LTVs.

By MY 1976, passenger car voluntary and attributable cost had increased to $606.56 and weight to 87.3 lb. Side door beams were installed in response to the original quasi-static crush requirement of FMVSS No. 214. A much larger percentage of the fleet had power boosters for brakes, and all front outboard seats had head restraints. Seat belts were substantially upgraded: drivers and right-front passengers received integral 3-point belts with locking retractors. The increase in cost and weight for LTVs ($327.42 and 33.7 lb) was lower than in passenger cars, as side door beams were not installed in LTVs.

Passenger car costs decreased from MY 1977 to 1985 as no major new FMVSSs went into effect and the learning curve was reducing costs introduced in earlier years. LTV costs increased at a relatively slow pace until MY 1987, when rear-wheel ABS was voluntarily added to about 16 percent of new LTVs. This slow increase in costs through MY 1986 resulted from extending passenger car standards to LTVs, including padded instrument panels, seat back padding, head restraints, collapsible steering columns, and fuel tank integrity.

Passenger car costs increased steadily from MY 1986 to 1989 before taking a big jump in MY 1990. During MYs 1986 to 1989 there was an increasing percentage of the fleet being voluntarily supplied with ABS, and during MYs 1987 to 1990 the percentage of automatic belts increased – only to be phased out by MY 1997.

The cost of FMVSSs exceeded $1,000 per vehicle in MY 1992 in both passenger cars and LTVs and then exceeded $2,000 per vehicle in MY 2008 in both passenger cars and LTVs.

The slowly increasing costs from MYs 2012 to 2019 were the result of increasing percentages of passenger cars and LTVs that have ejection mitigation window curtains with rollover sensors and meet the upgraded roof crush standard.

The noticeable jumps in cost occurred in:

- MYs 1987 to 1990 with rear-wheel ABS for LTVs;
- MYs 1990 to 1994 with four-wheel ABS for passenger cars and MYs 1992 to 1996 for LTVs;
- MYs 1990 to 1995 with frontal air bags for passenger cars and MYs 1992 to 1998 for LTVs;
- MYs 2006 to 2008 with tire pressure monitoring systems for passenger cars and LTVs;
- MYs 2007 to 2009 with side air bags for passenger cars and MYs 2007 to 2010 for LTVs;
- MYs 2007 to 2011 with large jumps in the percentage of LTVs supplied with ESC;

- MY 2010 with a large jump in the percentage of passenger cars supplied with ABS and ESC; and
- MYs 2013 to 2016 with rear visibility cameras for passenger cars and LTVs.

Looking at the percentage of attributable costs to total safety technology costs for passenger cars from MYs 1968 to 2019, attributable costs started at 27 percent for MY 1968 and then slowly increased to 66 percent by MY 2019 and averaged 55 percent. Attributable costs for LTVs started at 33 percent in 1968 and slowly increased to 60 percent by MY 2019. However, there were a couple years (MYs 1990 and 1991) when ABS was voluntarily added to many LTVs where the percentage of attributable costs to total costs dipped down to 24 and 25 percent. The average for LTVs was 49 percent over the entire period (calculated by comparing column 6 to column 7 of Table 1a and Table 1b, summing these percentages and dividing by 52 years). This means that based on the methodology used in this analysis, vehicle manufacturers voluntarily would have spent a little more than half (49% to 55%) of the total costs to add safety countermeasures to vehicles.

Compared to total weight added by FMVSSs, attributable weight for passenger cars started at 26 percent for MY 1968, increased relatively quickly to 60 percent for MY 1974, then slowly increased to 69 percent for MY 2019. The attributable weight compared to total weight for LTVs started at 25 percent for MY 1968, increased slowly to 56 percent by MY 1982, dipped down to around 35 percent with the voluntary introduction of ABS in MY 1989 to 1991, then increased to 66 percent by MY 2019. The average attributable weight from MY 1968 to 2019 compared to total weight was 61 percent for passenger cars and 52 percent for LTVs, both higher than the average percentage attributable for costs.

Federal Motor Vehicle Safety Standards

Section 1 – Background and Methodology

NHTSA has a legislative mandate under Title 49 of the United States Code, Chapter 301, Motor Vehicle Safety, to issue FMVSSs and Regulations to which manufacturers of motor vehicles and equipment must conform and certify compliance. Chapter 301 defines an FMVSS as a minimum standard for motor vehicle performance or motor vehicle equipment performance that is practicable, meets the need for motor vehicle safety, and provides objective criteria. The requirements are specified in such a manner "that the public is protected against unreasonable risk of crashes occurring as a result of the design, construction, or performance of motor vehicles and is also protected against unreasonable risk of death or injury in the event crashes do occur."

NHTSA has a comprehensive program to evaluate existing motor vehicle regulations to determine their effectiveness, benefits, and costs. The program includes evaluation of the weight and initial consumer cost of components that have been modified or added to motor vehicles in order to comply with the performance requirements of existing regulations. Since the late 1970s, NHTSA has sponsored cost studies of automotive safety equipment, and contractors have performed detailed engineering teardown analyses to provide definitive cost and weight estimates of this equipment. Results from these various analyses have been scattered among many hard-copy contractor's reports, using different economic years and sometimes-inconsistent methods of averaging costs across models. These contractor reports are available to the public in NHTSA Docket No. 2011-0066.

The aim of this report, which supersedes reports published by NHTSA in Tarbet (2004) and Simons (2017), is to estimate the overall cost of FMVSSs and the cost of each standard with a uniform methodology, updating the results to MY 2019. In general, the process is to determine the percentage of passenger cars and the percentage of LTVs that had the technology installed in their vehicles in each model year, to determine the weight and cost of that technology, to apply a learning curve to the cost of the technology, to determine the average weight and cost that each technology added to the average passenger car and the average LTV in each model year 1968 to 2019, and finally to determine whether the costs and weights were added voluntarily by manufacturers or are attributable to the standard.

The percentage of the new passenger cars and new LTVs that have each technology are derived from several sources. Sometimes it is as simple as noting that every new vehicle was required to meet a NHTSA standard by a certain date and matching that MY with sales. However, for most new standards issued since the 1980s, NHTSA has set the effective date based on a phase-in schedule. For example, 25 percent of each manufacturer's production from September 1, 2000, to August 31, 2001, must meet the standard, 50 percent in year 2, etc. The phase-in schedule method was designed to reduce cost and engineering demands so that manufacturers did not have to redesign every model in their fleet at the same time. NHTSA required manufacturers to submit pre-MY data with projected sales by make-model to make sure that manufacturers planned to meet or exceed the phase-in schedule. Overall compliance was later checked with real sales data. Sometimes the percentage of new vehicles with a new technology is based on compliance data supplied by automobile manufacturers to NHTSA. Sometimes the percentage of the fleet with a new technology is based on data provided by *Ward's Automotive Yearbooks* (see, for example, Stark & Powers, eds., 1965-1974) (particularly the Factory Installed Equipment spreadsheets); other times (particularly when we are considering voluntarily supplied technology before the start of a phase-in effective date) it comes from examining information about the installation of new safety countermeasures provided in the literature or on the internet on every make-model and weighting that data by sales information. The percentage of the fleet that meets a standard may be based on a sample of vehicles that have been tested or have been visually inspected. At times very little data exists on the percentage of vehicles supplied with a given technology when it is an optional feature on a vehicle. Here we may rely on data reported in crash investigations (mainly from the Fatality Analysis Reporting System) to help determine the percentage of the fleet for which a particular technology was supplied. We do our best to derive the most credible data for the percentage of the new vehicle fleet sold with the relevant technology.

Cost and weight data for the major components of the motor vehicle equipment were extracted from contractor and NHTSA reports. Care was taken to determine the economic year used for the cost data in each study. All cost data were converted to 2019 dollars using the gross domestic product implicit price deflator from the Bureau of Economic Analysis (see the discussion around Table 5 for the process of converting cost estimates from older year's dollars to 2019 dollars). The report also describes what vehicle modifications were made in response to the various FMVSS and explains how the cost estimates were derived. In summary, the report estimates the incremental cost and weight of meeting the FMVSS in passenger cars and LTVs, with the year-by-year breakdown of the cost and weight per passenger car and LTV over a 52-year period, from MYs 1968 to 2019.

The Cost of an FMVSS

The report attempts to answer two questions:

1. What is the incremental consumer cost of safety that is linked to the FMVSSs?
2. How much of that linked incremental consumer cost was attributable to the FMVSS requirements as set by NHTSA, as compared to the cost of safety equipment that was installed voluntarily by automobile manufacturers?

Both questions are analyzed on a per vehicle basis (passenger cars separated from LTVs) and for every MY from 1968 to 2019. At the same time, we estimate how much weight has been added to the vehicle for safety countermeasures in answering both questions.

To answer these questions, several definitions and assumptions are necessary, including what is included and what is not included in the analysis.

What is included: NHTSA has cost teardown studies of almost all its FMVSSs that estimate the RPE consumer cost of safety countermeasures that are linked to an FMVSS. Only incremental costs are included over the safety equipment that was standard equipment on every MY 1965 passenger car and LTV, defined as Safety1965. Safety1965 is a new concept for this report. When the safety equipment is not included in every 1965 passenger car and LTV, then it will be assigned as voluntary or attributable costs as discussed below. When the safety equipment is upgraded after MY 1965 the costs of newer safety equipment minus the cost of the Safety1965 equipment will be the incremental cost included in the analysis. The full cost of any linked safety equipment, not defined as having a Safety1965 equipment counterpart, is included in the analysis.

We take care to distinguish between the safety component required in the FMVSS and the basic part. For example, FMVSS No. 201 requires the glove box to stay closed in a frontal crash and when subjected to certain specific inertial loads. We are only interested in the cost of the latching mechanism of the glove box and not the cost of the glove box itself. We include in the report the difference in cost between the post-1965 latching system and the Safety1965 latching system.

Table 3 shows the basic safety equipment that came with every MY 1965 passenger car and LTV that has been defined as Safety1965. Some have common names, like drum brakes, which distinguish them from later technology, like disc brakes, but others do not, like a basic roof structure. Safety1965 includes what was standard equipment in MY 1965. It's not always easy to distinguish between what was standard equipment in MY 1965 and what the equipment was on a vehicle certified to compliance in MY 1968 (and these two different versions of the same equipment might have the same name, like door locks), but that is one of the jobs that the contractor must perform in the typical cost teardown study. In theory, the contractor should tear down door locks from MYs 1968 and 1965 matching make/models and determine whether there is any cost and weight difference that is attributable to the standard. There is a discussion for each FMVSS later in the report that describes what teardown studies were performed, how we interpret the data provided by the contractor and other relevant data, what we believe is Safety1965, and what are the changes in technology that led to cost and weight increases linked to FMVSSs.

Table 3. Basic safety equipment that came with every MY 1965 passenger car and LTV defined as Safety1965

FMVSS	Technology
None	Horn
103	Windshield defrosting and defogging system
104	Single-speed windshield wiping system
105	Single master cylinder
105	Drum brakes
106	Brake hoses
108	Headlamps, running lights, stop lamps
108	Amber front turn signal, red rear turn signal
111	Inside rearview mirror
113	Hood latch system – single latch
201	Friction latch for glove box compartment door
201	Armrests, sun visors
201	Instrument panel with no padding or cover
202	Seat back with no head restraint – 22" tall
203/204	Rigid steering column
205	Standard windshield
205	Tempered glass for side windows

FMVSS	Technology
206	Door locks, latches, and hinges
214	Door structure with no side door beams
216	Roof structure
219	Hood
301	Fuel tank

What is not included?

1. The cost of Safety1965 is not included. For this report, safety countermeasures that were standard equipment in 100 percent of both passenger cars and LTVs for MY 1965 are defined as Safety1965. These safety countermeasures were in vehicles before September 9, 1966, when President Lyndon Johnson signed the National Traffic and Motor Vehicle Safety Act into law. These earlier safety countermeasures are mainly the basic safety equipment, and include lights, turn signals, brakes, steering system, horn, etc. Often NHTSA's first safety standards simply required what had long been in vehicles. If the equipment was already in place on a vehicle by MY 1965, and the standard essentially mandated Safety1965, and no changes were made to the safety equipment when the standard took effect, this standard does not add cost to the vehicle. We assume there is no incremental cost, and the cost of Safety1965 that was already there will not be attributed to FMVSSs and will not be considered as voluntarily provided before the NPRM. For example, every passenger vehicle that came under FMVSS No. 103 already had a windshield defrosting and defogging system by MY 1965, long before NHTSA proposed the standard; there is no evidence that these systems were upgraded to meet the standard. No voluntary or attributable cost is assigned to FMVSS No. 103. Thus, the cost of Safety1965 equipment like brakes, lights, turn signals, the horn, etc. that were standard on every passenger car and LTV by MY 1965 are not included in this analysis.
2. NHTSA has not estimated changes made to the basic frame of a motor vehicle to improve its safety in frontal dynamic crash tests required by FMVSS No. 208. The frame of the vehicle would be a very difficult cost teardown study for several reasons. First, the frame of every vehicle is unique and the frame most likely changes with every redesign of the vehicle as they learn more about how the vehicle reacts to a crash and as their crash modeling improves. Second, the frame changed significantly with downsizing and since that time has changed continually for several other reasons. The manufacturers have often changed the materials used in the frame to lighten and strengthen the frame and in some cases to reduce costs. The ability to use different materials in the frame, from a production standpoint, has resulted in a long-term trend toward stronger steels, high-strength low alloy steels and aluminum alloys. Third, there are more crash tests to which the manufacturers design; for example the Insurance Institute for Highway Safety (IIHS) offset tests and NHTSA research on oblique tests have resulted in changes being made to the frame. So, the frame continues to change, and not all changes to the frame are necessarily related to safety; some are related to fuel economy and others to design or cost. You'd have to do a teardown of many vehicles over time, including MY 1965

vehicles to determine the Safety1965 baseline frame costs and weights, to try to get an estimate of how the frame costs have changed over time; even then you wouldn't know how much safety affected the change in costs.

We did include the frame in side impact cost teardowns when we estimated the impact of the FMVSS No. 214 pole test. There were additions to the frame of the vehicle to deflect some of the forces to the far side of the vehicle – essentially braces from one side of the vehicle to the other; some were under the vehicle and others went through the instrument panel. We also included the frame in analyzing changes made for FMVSS No. 301R, when the frame was changed to reduce the chance of fuel leakage and a resulting fire from the test crash in a rear impact.

3. We are not trying to estimate the costs of every part of the vehicle that is related to safety. We are trying to estimate the incremental costs that are linked to FMVSSs. This report does not include estimates of costs of safety countermeasures – like automatic emergency braking, blind spot detection, or lane departure warning – that had not been proposed by NHTSA or linked to an FMVSS as of January 2021.

What definitions and assumptions are needed? Basic definitions are needed to determine what safety countermeasures are linked to an FMVSS and what is the appropriate baseline from which to determine attributable and voluntary incremental costs. Because NHTSA does not know why manufacturers installed safety equipment before the effective date of a final rule, a rule of thumb must be established to determine the baseline and when the installation can be considered attributable to a rulemaking proceeding and when the installation is considered voluntary. The baseline is different for every FMVSS and is dependent upon the NPRM.

Further discussion of these definitions and assumptions follows.

Linked to an FMVSS

We only count safety countermeasures that are linked to an FMVSS. There are two ways that a safety countermeasure could be linked to an FMVSS. First, NHTSA proposed it or proposed a performance standard in an NPRM that resulted in the safety countermeasure being used to meet a future standard. The proposal does not have to be a final rule at the time the countermeasure is installed. Second, even if it hasn't been proposed, NHTSA evaluated a safety countermeasure and found it to be effective at reducing fatalities, injuries, or crashes. Since NHTSA writes mostly performance standards and not necessarily design standards, some safety countermeasures, never actually proposed and possibly never actually discussed in an NPRM, are used to help meet a standard or enhance the safety of other equipment used to meet a standard. Example 1: NHTSA has never proposed seat belt pretensioners or load limiters, per se. However, those countermeasures enhance the safety of seat belts. Furthermore, those countermeasures have been evaluated and proven to have benefits in meeting FMVSS No. 208, and NHTSA has performed a cost teardown study on those systems. Pretensioners and load limiters have been included in this analysis as voluntary. Example 2: NHTSA has never proposed rear-window defogging and defrosting systems. NHTSA's evaluation was unable to conclude that rear-window defoggers reduce police-reported crashes. Thus, rear-window defoggers are not linked to an FMVSS because they have never been proposed and NHTSA has not proven safety benefits. The cost of rear-window defoggers and defrosters are not included in this analysis. Example 3: Intermittent windshield wipers are related to FMVSS No. 104, Windshield wiping and washing systems. However, they have never been proposed or evaluated by NHTSA, and by our definition are not linked to an FMVSS.

Voluntary

Voluntary costs are assumed at two different times in relation to the baseline. First, voluntary costs can occur before an NPRM (on or before the baseline year). The voluntary cost of safety technologies installed by manufacturers includes safety modifications that took place in MYs before an NPRM and are linked to an FMVSS. To be considered voluntary, these safety countermeasures had to provide some level of safety and not necessarily meet every aspect of the future FMVSS. As discussed above, Safety1965 equipment is not considered voluntary. In the discussion of each standard, we will identify the attributable costs as well as the voluntary costs.

Second, voluntary compliance after the baseline year is assumed to be the same as the compliance during the baseline year. Thus, if the baseline year is MY 1999, voluntary compliance for MYs 2000 to 2019 are assumed to be the same as in the baseline year of MY 1999. In other words, we assume that without the rulemaking, voluntary compliance would have stayed at the same level as it was in the baseline year for all years through MY 2019. This is consistent with the methodology on voluntary compliance used in NHTSA's Final Regulatory Impact Analyses.

Attributable to an FMVSS

The attributable cost of an FMVSS, in this report, includes the incremental cost of all equipment or specific safety technologies added or modified primarily for the purpose of meeting (or even exceeding) the requirements of the standard over and above the voluntary compliance, provided these modifications took place after the baseline year. Essentially, if it is an incremental cost over the voluntary compliance level linked to an FMVSS that occurs after the baseline year, then it is attributable to the FMVSS.

The Appropriate Baseline Year

The build up to a final rule (which can include possible Congressional action, possible ANPRM, NPRM, possible SNPRM, final rule, possible petitions for reconsideration, possible amended final rule) is different for almost every rulemaking. When manufacturers decide to install safety equipment prior to its requirement as a standard, their intent is difficult to determine. They may be installing it to voluntarily provide added safety, a selling point that is an advantage in the marketplace. Alternately, they may be doing it in anticipation of possible forthcoming regulation, determining that their redesign cycle for specific models dictates current rather than future redesign efforts. It is thus difficult to make subjective judgments regarding manufacturers' intent until such time as NHTSA's intent to regulate is made apparent through the formal rulemaking process. This difficulty can be seen in the diverse scenarios that precede the publication of a final rule. For example, the circumstances can include: there was an Act of Congress requiring a specific action by a specific date; there was an Act of Congress requiring NHTSA to examine a specific safety problem and solve it, but Congress did not specify a specific countermeasure; there was an FMVSS requiring passenger cars to meet a standard, but the final rule for LTVs occurred many years later; there were occasions when there were many years between an NPRM and the final amended final rule; there were occasions when there were years of NHTSA and others research on the subject; there were occasions when there were years of safety countermeasures supplied voluntarily by different manufacturers; in some cases NHTSA planning documents identified upcoming rulemakings; etc. To not have to make a subjective decision for every rulemaking, we developed a rule of thumb to determine not only an appropriate baseline, but also when a safety countermeasure was voluntarily provided and when it was attributable to an FMVSS.

We could have chosen the effective dates as required by the FMVSS. However, that would underestimate the real attributable cost of the FMVSS for years leading up to the effective dates. We know that manufacturers try to design anticipated safety requirements into their vehicles as their new models are being redesigned to save the cost of retrofitting existing models in the future. We know that manufacturers don't have the capability to redesign and test all their makes/models in one MY and that is why we have phased-in effective dates. Choosing the effective dates as the attributable dates would mean that every safety measure introduced before the effective date would be considered voluntary compliance. Since redesign cycles often dictate the timing of vehicle safety designs changes, choosing the effective dates did not seem appropriate. The goal is to get our best estimate of the cost of the FMVSS for each year, and to recognize that the manufacturers often voluntarily provided safety features as part of their marketing strategy or safety strategy.

We wanted to designate a rule of thumb, so that we could consistently assign a baseline year for each FMVSS and vehicle type (passenger car versus LTVs) and be able to distinguish between voluntary costs and attributable costs, without having to make a subjective decision for each rulemaking. The one consistent identifiable date for every rulemaking is the NPRM. The NPRM signals the real start of a rulemaking, with an identifiable test procedure and draft language. It seems logical to use the NPRM date to help define the baseline year. Typically, NHTSA has considered September 1 as the start of a new model year. We decided to choose the last model year in production as of September 1 before the publication of an NPRM in the Federal Register as the baseline date. In some cases, like TPMS, there were starts and stops to the rulemaking process and more than one NPRM was published. In this case, we apply the baseline year to the first NPRM on the subject. We recognize that this rule of thumb may not be precise for every safety technology, but we believe it will be a reasonably accurate basis for assigning attribution to most FMVSS.

All model year vehicles meeting the final rule on or before the first September 1 before an NPRM would be considered voluntary. For example, if an NPRM were published in the Federal Register in October 2000, the baseline date would be set at September 1, 2000 (MY 2001). Similarly, if an NPRM were published in the Federal Register in August 2001, the baseline date would be set at September 1, 2000 (MY 2001). All complying vehicles with the final rule (or in some cases parts of the final rule) in MY 2001 and earlier would be considered voluntary costs. Voluntary compliance for MYs 2002 to 2019 is assumed to be at the same level as compliance in the baseline year of MY 2001. For all model year vehicles starting after the baseline year (MY 2002 in our example), the difference between complying vehicles in that model year and the voluntary assumption for the baseline year of MY 2001 would be considered attributable to the final rule. For example, if 30 percent of passenger cars met a standard in MY 2001 (the baseline year), 50 percent of passenger cars met the standard in MY 2002, and 100 percent of passenger cars met the standard in MY 2003, the assumptions would be as follows.

	MY 2001 baseline	MY 2002	MY 2003 and later
Percent Complying	30%	50%	100%
Voluntary	30%	30%	30%
Attributable		20%	70%

We have made one exception to the rules for attributable and voluntary set out above. The only exception to these rules is for lap belts for the front outboard seats, which were required by several States before NHTSA was established. The baseline for lap belts for the front outboard seats is based on the first State requirement and not a NHTSA NPRM. See the discussion under FMVSS No. 208, Occupant crash protection.

Incremental Costs – Other Notes

This report also includes weight and cost impacts if new technology became available after the effective date and manufacturers improved the performance of their countermeasure above the level of the standard. For example, side impact air bags became available and were installed by vehicle manufacturers after the effective date required dynamic testing of FMVSS No. 214 and are included in the analysis.

For some FMVSSs there is an entirely new type of equipment provided and, in these cases, the incremental cost is the total cost of the added safety equipment. For example, the center high mounted stop lamp was an added-on device and little, if any, change was made to any other part of the vehicle to accommodate the lamp.

We have only estimated costs of FMVSSs that have permanent costs. If an FMVSS causes redesign costs for a few model years, but ultimately does not result in any new equipment, we have not estimated a cost. For example, the requirements of FMVSS No. 101 resulted in relocating and changing the visual appearance of the controls and displays. The engineering labor to redesign these controls and displays is not considered a permanent cost and is not included in this analysis.

This report is limited to initial consumer costs of FMVSS, i.e., the likely effect of the FMVSS on the initial purchase price of a vehicle. Lifetime costs for maintaining or, when necessary, replacing components are not included; however, on an average vehicle basis, these costs tend to be negligible for most FMVSS. The notable exceptions, where maintenance costs may not be negligible are TPMSs (because batteries used in the direct system tire monitors won't last forever) and possibly frontal air bags (because of replacements of air bags and supporting structures after crashes). Not all crashes resulting in air bags being deployed result in additional maintenance costs. Many frontal air bag deployments, more side air bag deployments, and most rollover crashes result in the vehicle being totaled and the air bags not being replaced.

The cost of an FMVSS may change over time, because of more efficient design, a more efficient production process, new types of materials, or vehicle downsizing. For example, head restraints became less expensive due to more efficient design, and side door beams due to all these factors, including vehicle downsizing. We are interested in tracking the costs over time. Sometimes we have more than one cost teardown study on the same technology and can track how costs have changed over time,. but this occurs in only a few instances. We have chosen five of those instances to develop an estimate of the learning rate for motor vehicle safety technologies. This rate is applied in a standardized learning curve methodology to estimate how costs change over time. More discussion of how the learning curve is calculated will follow in a subsequent section. In the 2017 report and in this report, unlike the 2004 report, we estimate the effect of the learning curve on costs.

Presentation of Cost and Weight Data in This Analysis

Since different readers could decide to make different choices about the baseline and what are voluntary versus attributable costs, we have provided the weights and costs using a four-step process. First, we show the baseline costs as determined by our cost teardown studies or other NHTSA estimates converted to 2019 dollars for every NHTSA FMVSS for which we have data. Second, if we determine that these costs are linked to an FMVSS for passenger cars or LTVs, we show the percentage of each new model year's fleet that are equipped with the countermeasure. Third, we show the weights and costs after applying the learning curve for all MYs in which the countermeasures were installed. These estimates are weighted by the percentage of the fleet that is equipped to determine average vehicle costs. The sensitivity analysis presents a scenario for which no learning curve is applied. Fourth, we apply the baseline, voluntary, and attributable definitions to those cost estimates. The executive summary tables are a compilation of the tables after the fourth step that include the average weights and costs by MY and distributes them between voluntary and attributable.

Cost and Weight Analysis Methodology

The teardown or reverse engineering methodology typically used by a NHTSA contractor for the collection of cost and weight data is described below.

- **Cost Study Sampling Plan**. An integrated cost sampling plan is developed to provide for the selection of a group of comparable makes and models that are representative of vehicle systems prior to and after the effective date of the standards. The plan is designed to identify a representative cross-section of vehicle sizes, models, and manufacturers, without the need to individually examine every make-model passenger vehicle produced in the affected years. Make-models of passenger vehicles are selected, and system components purchased, for cost analysis. These make-models should:
    - have over 50,000 annual sales volume,
    - include matching pre- and post-standard vehicles of the same make-model (unless the FMVSS resulted strictly in add-on equipment, in which case it is only necessary to sample the post-standard vehicles),
    - represent the variety of designs or differences in the types of parts used to meet the FMVSS,
    - represent the major domestic and import auto manufacturers,
    - represent vehicle weights or sizes ranging from small to large, and
    - represent the vehicle types (passenger car, SUV/CUV, van, or pickup truck).
- **Teardown Process**. The cost and weight estimates are based on detailed engineering analysis of the individual pieces and assemblies of which the system is composed, employing a process known as reverse engineering. Whereas conventional engineering

proceeds from design to mass-produced product and proceeds back through the various manufacturing processes to the design, this procedure includes a step-by-step teardown or disassembly of each item into sub-assemblies and finally into individual component parts. The teardown sequence is the reverse of the assembly sequence. The components and parts are carefully cataloged and tagged as they are being disassembled. The parts are gauged, measured, manufacturing method determined, and, if possible, the vendor for outsourced parts identified. Even parts that were welded or irreversibly attached are carefully disassembled. The system components are physically torn down into their most elemental parts to identify the process operation by which each elemental part is made in terms of:

    - labor minutes,
    - direct materials and scrap,
    - machine occupancy hours or station times, and
    - machinery, equipment, and tooling utilized.

  The components are laid out on a pegboard, with one-inch squares, and photographed next to appropriate identification labels so the photos can be compared with the cost estimates.

- **Technical Analysis**. The parts from the comparable vehicle systems are analyzed (in some contractor reports) to determine:
    - changes between the pre- and post-standard make-models,
    - reasons for the changes, i.e., differentiate between changes for meeting the FMVSS and changes for unrelated reasons such as:
        - styling,
        - cost reduction, and
        - product improvement (functional improvements not related to the requirements of the FMVSS).

  The net result of the analysis is the accurate and complete identification of all changes in the component parts of the selected systems that are attributable to the requirements of the specified FMVSS.

- **Cost Analysis**. Costs are determined by production decisions, whereas prices are the results of marketing decisions based on an assessment of what the traffic will bear when faced with a competitive environment of substitutes. To arrive at a price that will pass in the trade, the vehicle manufacturer engages in a form of cost/price arbitrage across his entire model lineup. At the low end of the pricing scale, competition from other manufacturers may prevent a company from charging a price sufficient to cover the full cost of producing a vehicle line at planned volumes. However, the company can cover this shortfall in other market segments where competition is less intense by charging prices that, on a volume basis, generate sufficient margins to cover the full costs of a vehicle line plus a contribution to overall corporate overhead and profit that offsets the shortfall.

In developing cost estimates for proposed and existing safety standards, all components identified in the technical analysis that changed because of the implementation of the FMVSS are cost analyzed to determine their consumer price. The cost comparison is performed in two stages. The first (micro-analysis) considers the elements of cost that vary from one part to another (variable costs), and the second (macro-analysis) considers those elements of cost that do not vary (fixed costs).

- **Micro-analysis**. The micro-analysis consists of the teardown process itself and the identification of the following costs for each elemental part where applicable:
    - ***Variable Manufacturing Costs***
        - **Direct material cost** is estimated by judging the weight of the component in the rough state and multiplying that weight by its cost per pound factor appropriate to the material, gauge, grade, etc. Included in direct material cost, or as a separate line item, should be an allowance for scrap material because of the production process. Most scrap can be sold or recycled, so the appropriate amount is a net cost for scrap per unit.
        - **Direct labor costs** are determined by time and motion analysis of each labor input per cycle or operation. Each labor input or operation is timed in terms of labor minutes or fraction thereof. The hourly rate is divided by 60 minutes to obtain labor cost per minute. Labor cost is determined by multiplying labor minutes (usually a fraction) by labor cost per minute.
        - **Variable manufacturing burden** is an accounting classification that includes all costs that vary directly with production volume but cannot be specifically attached to each unit of end product. Examples would include electric power, indirect labor such as materials handling, and perishable tools.
    - ***Fixed Burden (Fixed Factory Overhead)***
        - Depreciation per Unit (Allocated)
        - Amortization of Special Tooling per Unit (Allocated)

  Using prevailing labor and material costs, the variable manufacturing costs and total manufacturing costs for each elemental part, component, subassembly, and complete assemblies that constitute each system under study are determined. Specific cost elements that must be isolated and identified include the following.

    - Direct labor dollars per unit
    - Direct material costs and scrap allowances per unit
    - Variable burden cost per unit, including indirect labor and other costs that vary with production volume
    - Fixed burden per unit

- Capital investments required at prevailing annual sales volumes – property, plant, equipment, and tooling
- Depreciation schedules for property, plant, and equipment
- Amortization schedules for special tooling

Cost estimation is performed using operation worksheets, which identify raw materials, labor, and machine utilization for each operation of the manufacturing process. The worksheets are used to record the component, subassembly, and assembly processing methods. A worksheet is prepared for each part and subassembly. The following items of information are collected on each operation worksheet.

- Identifying numbers
- Material type, gauge, quality, blank size
- Finished weight
- Rough weight
- Percent scrap
- Production volume
- Tooling cost and amortization
- Number of parts per safety system
- Operations
- Type of equipment pieces per hour
- Number of machines
- Made in-house or purchased

The manufacturing operations are determined, their operation numbers are listed, and the operations described on the worksheet. Various equipment stations in the manufacturing plan are associated with each operation. Their codes are listed, as well as the pieces per hour, for the equipment. Next the estimator must determine the number of machines required for the operation. There is an interaction between the number of people and the number of machines a person can operate. To determine the labor per part requires estimating this interaction. In addition to estimating the cost of individual parts, the cost of assembling parts into subassemblies and assemblies, where appropriate, is developed by determining the operations necessary to achieve the assemblies. The variable cost includes only those costs associated with the manufacture of the part or assembly, i.e., direct labor and direct material costs associated with making the part or assembly. Also included in the variable cost is the variable burden, which includes such things as set-up costs, inbound freight, perishable production tools, and other miscellaneous costs that vary with production volume changes.

- **Macro-analysis**. The macro-analysis develops the pricing template used to derive the estimated retail price impact of safety requirements imposed by NHTSA. The teardown process described above does not isolate all of the elements that must be accounted for in order to arrive at a price that covers full cost plus profit margin. Discretionary costs such as selling, general, and administration; research and development; taxes other than income; pension expense; and plant maintenance and repair must be allocated to each unit of product. Furthermore, after covering discretionary costs, there should be sufficient residual for income taxes and a bottom line net profit (Spinney, 1989 and Spinney et al., n.d.).

Accounting Basis for the Macro-Analysis

Over the last 40 years, NHTSA has developed and refined a technique for approximating the pricing structure of automotive manufacturers. This technique involves the derivation of markup factors from financial analysis of company income statements and consists of isolating the major corporate cost and expense accounts and rearranging them according to a template that reflects cost behavior rather than Generally Accepted Accounting Principles. Under the behavioral approach, costs and expenses are defined as variable, fixed, or discretionary.

Variable costs (or variable manufacturing costs) are defined as costs that are constant per unit of input but vary directly in total with changes in production volume. Direct labor, direct material, and variable burden all fit this definition. Fixed costs are constant in total regardless of volume. The only true fixed costs are depreciation and amortization. Most factory and corporate overhead accounts costs have a fixed component and a variable component that can increase or decrease at management's discretion—hence the name discretionary costs.

Variable manufacturing costs are engineered into the production process and cannot be changed to an appreciable degree on a per unit basis at planned production volumes. On the other hand, fixed costs and discretionary costs can be allocated on a per unit basis according to a rationale of management's choosing. It is this allocation process that establishes the pricing structure of the company. To approximate this allocation process, variable costs must be isolated to the degree possible from fixed and discretionary costs.

Income statements prepared according to generally accepted accounting principles do not segregate cost and expense accounts based on behavior. The Cost of Sales account, for example, includes both variable and discretionary costs. To approximate the cost/price arbitrage process, the variable manufacturing costs must be segregated from fixed and discretionary costs. Through analysis of Form 10-K Corporate Annual Reports filed annually with the Securities Exchange Commission by domestic manufacturers, NHTSA has isolated three discretionary cost accounts to be subtracted from Costs of Sales.

- Maintenance and Repairs
- Research and Development
- Taxes Other Than Income

Upon subtraction, the three accounts are reclassified under the general head of Fixed/Discretionary Costs. The remainder of Costs of Sales constitutes estimated Variable Manufacturing Costs.

Each manufacturer's income statement is reformatted according to this methodology and the process is called common sizing. The result is a template that enables the analyst to study a company's cost structure and compare it against competitors. The completed template is shown in Table 4.

Table 4. Sample cost/price corporate template

Manufacturing Operations Exclusive of Financing Subsidiaries

Net Sales	$100,000,000	100.0%
Variable Manufacturing Costs	74,000,000	74.0%
Contribution Margin	$ 26,000,000	26.0%
Fixed/Discretionary Costs:		
Maintenance and Repairs	$ 3,500,000	3.5%
Research and Development	3,000,000	3.0%
Taxes other than Income	2,000,000	2.0%
Selling, General, & Administration	7,000,000	7.0%
Pension Costs	2,000,000	2.0%
Depreciation	3,500,000	3.5%
Amortization of Special Tooling	2,500,000	2.5%
Amortization of Intangibles	500,000	0.5%
Total Fixed/Discretionary Costs	$ 24,000,000	24.0%
Income from Continuing Operations	$ 2,000,000	2.0%
Other Income (Expense)-Net	1,000,000	1.0%
Income before Interest and Taxes	$ 3,000,000	3.0%
Interest Income (Expense)-Net	(500,000)	0.5%
Income before Income Taxes	$ 2,500,000	2.5%
Income Tax Expense (Credit)	875,000	0.9%
Net Income	$ 1,625,000	1.6%

Note: The dollar amounts are hypothetical; however, the percentages of sales for each account reflect long-run weighted averages of General Motors, Ford, and Chrysler.

The key to NHTSA's pricing template lies in the relationship between net sales, variable costs, and contribution margin. Net sales represents total wholesale revenue less returns and allowances. Variable costs have been defined above and account for 74 percent of net sales. The contribution margin rate of 26 percent on sales represents the remainder left for fixed/discretionary cost coverage. Since the template reflects company-wide operations, it reflects the fixed/discretionary cost/price recovery arbitrage process across all product lines whereby a manufacturer meets its profit objectives at expected volumes.

Thus, the pricing formula used by NHTSA to approximate wholesale price for a new safety feature only includes variable costs, which are determined by detailed analysis of the production process, and a markup percentage on variable costs equal to the corporate wide contribution margin rate. If variable costs account for 74 percent of sales and contribution margin accounts for 26 percent, then the markup factor on variable costs to wholesale price would be 1.35 (100% / 74%). Over the years this markup factor has changed little, generally being in the range of 1.35 to 1.36. Most of the cost teardown studies use the 1.36 markup factor.

To arrive at the manufacturer suggested retail price, wholesale price needs to be marked up to cover the dealer margin. Currently and historically, dealer margin is about 11 percent on wholesale on a fleet-wide weighted average basis. The completed pricing formula is:

Variable costs * 1.36 * 1.11 **OR** Variable costs * 1.51

In 2012, during the process of setting the final rule for MYs 2017 to 2025 passenger car and LTV fuel economy, NHTSA and the Environmental Protection Agency reviewed this macro analysis process for setting the RPE value of 1.50. Their findings were: "However, an analysis of historical RPE data (1972-1997 and 2007) indicates that although there is year to year variation, the average RPE has remained at approximately 1.50" (NHTSA, 2012).[2] We use a 1.51 markup factor (variable cost * 1.51) in this report to estimate a RPE consumer cost.

Inconsistencies and Variations in Contractors' Approaches to Estimating the Cost and Weight of an FMVSS

Over the years that NHTSA and its contractors have been performing cost and weight analyses, the contractors' reports have not necessarily used a consistent methodology to select vehicles for analysis, to determine which parts of the vehicle truly were changed due to the standard, or to sales-weight the results. There are a variety of legitimate reasons for these results. The main reason is that until the contractor performs the pre- and post-standard analysis, you may not know which parts were changed due to the standard and which ones were not. But the contractor reports on what his tasks were, what vehicles and parts were cost-estimated, etc. After the findings have been analyzed and interpreted, you can come to a better understanding of the impact of the standards. In this analysis, we attempt to correct for this later knowledge and develop our best estimate of the impact of the standards. Thus, the contractor's studies provide information used in this report, but the contractor's reports themselves should not be considered the best estimate of the overall average cost of the standard. We now discuss, in general, issues we have found with various contractor reports, which indicate why some of the contractor's studies cannot be used for this report without interpretation by NHTSA.

- **Selection of Vehicles/Definition of Effect of the FMVSS**
    - The contractor tore down pre- as well as post-standard vehicles. Costs attributed to the standard are allocated based on the following criteria.
        - Without further analysis, the contractor attributed the entire difference in the cost and weight of the pre- and post-standard subsystems to the standard. For example, with FMVSS No. 216, some motor vehicles were redesigned in the year the standard took effect. The cost of styling-related changes was included in the cost of the teardown study but should not have been.
        - Only part of the difference is attributed to the standard, while the rest of

[2] The fuel economy analysis also discusses a different macro methodology known as the indirect cost multiplier (ICM). NHTSA has chosen the RPE method for analyzing its safety standards.

the difference is attributed to styling, product improvement, or other factors unrelated to the FMVSS. For example, with the original 1968 version of FMVSS No. 201, a comparison of various interior structures in pre- and post-standard passenger cars indicated that costs in some structures might be consistently higher for the post-standard specimens, which probably indicates they were modified because of the standard. However, costs in other structures went up in some specimens and down in others, which indicates the modifications were merely for styling or production efficiency and not needed for meeting the standard.

- The contractor only performed the physical teardown of post-standard vehicles' subsystems believed to be affected by an FMVSS. This approach works best for a standard that added on an entire subsystem, with no other change in pre-existing equipment on other subsystems. However, contractors have also used this approach on other occasions, such as when contract funding was insufficient to study pre-standard vehicles. Costs attributed to the standard are allocated based on the criteria listed below.
    - The full cost of the new equipment is attributed to the FMVSS, because the cost in the pre-standard vehicle is zero. For example, with No. 108, center high mounted stop lamps were added as standard equipment in MY 1986 to reduce rear-impact crashes but did not result in changes to any other rear lighting system.
    - The contractor does not attribute the full cost of the equipment to the FMVSS, because the contractor asserts or assumes that some of this equipment either already existed in the pre-standard vehicle (although no such vehicles were torn down) or was not added because of the FMVSS, but for some other reason. For example, with the FMVSS No. 214 upgrade dynamic test requirement, some of the components partially contributed to both pre- and post-revision requirements of FMVSS No. 214. The contractor used engineering evaluation and judgment to assign a percentage of the identified costs as a contribution towards the additional requirements imposed by the revised standard. NHTSA may agree or disagree with the contractor's judgment in these cases.
    - The contractor limited the teardowns to post-standard vehicles, even though the equipment was not strictly an add-on, and did not even discuss what parts were there before the standard was implemented, or if the new equipment was safety related. For example, with FMVSS No. 201, a study of the interior components of 1982 MY trucks was conducted to determine the impact of the standard on LTVs. No pre-standard make-models were studied to serve as a baseline. Since some of the make-models were extensively redesigned in 1982, the contractor was unable to directly compare the components of the pre- and post-standard LTVs and did not estimate the average cost increase.

- **Teardown Sample Selection**. Some contractors selected a sample of motor vehicles too small to make a meaningful sales-weighted average. Ideally, to calculate a sales-weighted average, six or more vehicles should be in the sample selection; otherwise, an arithmetic average will be calculated on five vehicles or less. In addition, even a larger sample size can be too small if it does not adequately represent a cross-section of vehicle sizes, body styles, and manufacturers. For example, with FMVSS No. 214, an analysis of the impact of the dynamic requirements on 2-door passenger cars was conducted on only two import cars representing the compact and midsize categories.
- **Definition of Pre- and Post-FMVSS**. Some contractor reports used the model year immediately before the FMVSS as the pre-standard model year. . Their rationale was that if manufacturers complied with the standard in that year, their modifications were voluntary and should not be attributed to the standard. Other contractors used a model year several years before the standard as the pre-standard model year. In some cases, we have adjusted by eliminating some vehicles from the study, because they were changed pre-standard to meet the standard.

Methods Used in This Report to Make the Estimates More Uniform

- **Criteria for Averaging Costs Across the Make-Models in the Teardown Sample**
    - If the teardown sample is reasonably large (six or more vehicles) and reasonably representative of the vehicles on the road, we will use only sales-weighted averaging. Otherwise, we will take a simple arithmetic average of the costs in the teardown sample.
    - A sales-weighted average for the cost and weight figures of the make-models studied is calculated to provide a more accurate representation of the average cost differentials. This is accomplished by multiplying the cost and weight figures of each make-model by a weight relevant to its importance, adding the results, and dividing the total by the sum of the weights. The weight in this instance is the volume figures based on the new passenger vehicle sales or registrations for each make-model studied. The volume figures for MYs 1965 to 1974 were obtained from Ward's Automotive Yearbook (Stark & Powers, 1965-1974) and the volume figures for MYs 1975 to 2001 on up were obtained from the R. L. Polk National Vehicle Population Profile (Polk & Co., n.d.). Most of the 2002 to 2019 volume figures used in sales weighting are from Ward's Automotive Yearbook (Binder, 2002-2017; Norris, 2018-2020).
    - If we can reasonably expect the same type of equipment in two make-models of similar design with different names (e.g., Ford Taurus and Mercury Sable), we will do sales-weighted averaging by fundamental car groups. This method was used for FMVSS No. 214, side door beams.

      Fundamental car/truck groups are composed of passenger vehicles that have the same automotive manufacturer, belong to the same functional class, and have the same wheelbase. NHTSA staff has defined the fundamental car/truck groups and have used these classifications in several evaluation reports. The criterion to use the fundamental car/truck group for the volume figures is based on the premise that the make-models from the same manufacturer utilize common structure and mechanisms for all make-models sharing a common body size. However, these vehicles are not necessarily identical except for the nameplate and may vary to some extent in weight or appearance.

  - If the equipment, however, might not be the same because it is tied into the appearance of the vehicle or for other reasons (consumer preference, vehicle manufacturer design choices), we will sales-weight by sales for the specific make-model in the teardown sample. For example, with FMVSS No. 202, vehicle manufacturers installed adjustable or nonadjustable (integral or fixed) head restraints in response to the standard and did not necessarily install the same head restraints in different make-models belonging to the same fundamental car group.
  - If the contractor has looked at several pre- and post-standard vehicles, we will take a sales-weighted average of only the make-models where there are matching pre- and post-standard vehicles. We will then weight the difference between the pre- and post-standard costs in each of these matched pairs by the sales of the post-standard vehicles. If we can't do all of this, we will just take the simple arithmetic averages, otherwise we run the risk of getting spurious costs due to shifts in the sales mix.
  - In general, if the contractor has looked at pre- and post-standard vehicles, we will take the incremental cost difference between the two. However, there are certain cases where this gives too low an estimate, because even the equipment in the pre-standard vehicle was added after the rulemaking process began. In those cases, we will use the full cost of the equipment in the post-standard vehicles like we did for FMVSS No. 214 side door beams in LTVs.

- **FMVSS Modifications Versus Redesigns Unrelated to FMVSS**
  - If the contractor has attributed to the FMVSS costs that are plainly due to other redesign reasons, we will deduct those costs if that is simple to do. For example, with FMVSS No. 214, changes in the body pillars of 1973 make-model passenger cars were a result of model redesign and not directly related to the standard; therefore, the weight and consumer cost for them were not included in the side door strength calculations.
  - If there is no simple way to do it, we may limit ourselves to the make-models in the contractor's sample that we know were not redesigned in the year the FMVSS went into effect. For example, by singling out only the pre- and post-standard FMVSS No. 216 make-models that did not receive any overall redesign, it is plausible that any changes were specifically due to the standard.

- **Linear Interpolation When Weights Change Over Time**. If we have two weight estimates for the standard, i.e., 10 lb in 1980 and 5 lb in 1990; and, unless we have additional information that pinpoints the time of the weight reduction, we will assume a standard weight of 10 lb each year until 1980, a declining linear rate (in this case, 0.5 lb per year) from 1980 to 1990, and then a weight of 5 lb each year from 1990 onward.

- **Adjusting for Different Markup Values**. Several of the cost teardown studies used a different markup value between variable costs and consumer price. The markup from variable costs to consumer price varied quite a bit (typically between 1.40 and 1.64) before NHTSA settled on a standard markup of 1.51, which didn't occur until after Spinney's (1989) paper was published. For example, the cost teardown for FMVSS No. 201 for passenger cars (Docket No. 2011-0066-0063) used a 1.40 markup from variable costs to consumer price and the cost teardown for FMVSS No. 208 for automatic belts (Khadilkar et al., 1988, 1988a, 1988b, 1988c) used a 1.64 markup from variable costs to consumer costs. In those cases, we have adjusted those costs to be consistent with the 1.51 markup used in this analysis. Several cost teardown studies used a markup value of 1.52; those were not changed to 1.51. In all, 6 of 60 passenger car cost estimates and 7 of 59 LTV cost estimates were adjusted to make the markup values consistent with the standard 1.51 value.
- **Adjusting for Inflation**. The labor and material rates used by contractors to estimate the costs were compiled from publicly available sources such as the U.S. Department of Labor, Bureau of Labor (under Employment, Hours, and Earning), and from union contracts. Material costs were determined from the contemporary market price for the appropriate material. These costs are based on U.S. automotive (Detroit, Michigan area) manufacturing practices, labor rates, material costs, and tooling/equipment costs. This information is publicly available in the Commodity Research Bureau Commodities Yearbook as well as automotive union contracts. The labor and material rates were updated periodically, and each cost study was based on a given economic year.

  In this report, all cost data have been converted to 2019 dollars. Even though a particular standard may have been studied in an earlier economic year, using the GDP implicit price deflator adjustments can bring the original cost data to 2019 economics. For example, the first contractor's teardown study done for NHTSA was in 1978 economics. The implicit price deflator for 1978 is 35.801 and 112.345 for 2019. To bring the 1978 data to 2019 economics, the original cost estimates are multiplied by the factor of 112.345/35.801 = 3.1380 (the ratio of the implicit price deflator for 2019 relative to that of 1978) (Bureau of Economic Analysis, 2024). The indexes for 1976 to 2019 are shown in Table 5.

  Note: When we discuss cost teardown studies or other data, all of the costs will be converted to 2019 economics (2019$). The learning curve is then applied to estimate the change in costs from the year it was evaluated up through MY 2019, based on cumulative sales over that timeframe.

Table 5. Implicit price deflators for GDP – indexes for 1976 to 2019

Year	Price Deflator	Multiplier to $2019
1976	31.491	3.5675
1977	33.448	3.3588
1978	35.801	3.1380
1979	38.771	2.8977
1980	42.273	2.6576

Year	Price Deflator	Multiplier to $2019
1981	46.273	2.4279
1982	49.132	2.2866
1983	51.056	2.2004
1984	52.898	2.1238
1985	54.571	2.0587
1986	55.670	2.0181
1987	57.046	1.9694
1988	59.059	1.9023
1989	61.374	1.8305
1990	63.671	1.7645
1991	65.825	1.7067
1992	67.325	1.6687
1993	68.920	1.6301
1994	70.392	1.5960
1995	71.868	1.5632
1996	73.183	1.5351
1997	74.445	1.5091
1998	75.283	1.4923
1999	76.370	1.4711
2000	78.078	1.4389
2001	79.790	1.4080
2002	81.052	1.3861
2003	82.557	1.3608
2004	84.780	1.3251
2005	87.421	1.2851
2006	90.066	1.2474
2007	92.486	1.2147
2008	94.285	1.1915
2009	95.004	1.1825
2010	96.111	1.1689

Year	Price Deflator	Multiplier to $2019
2011	98.118	1.1450
2012	100.000	1.1235
2013	101.755	1.1041
2014	103.638	1.0840
2015	104.717	1.0728
2016	105.801	1.0619
2017	107.794	1.0422
2018	110.420	1.0174
2019	112.345	1.0000

- **Adjusting for the Learning Curve Effect**. The cost of products goes down over time as companies learn how to make the products more efficiently, and as their production volumes increase. As manufacturers gain experience through production, they refine production techniques, raw materials, component sources, and assembly methods to maximize efficiency and reduce production costs. Typically, learning curves reflect initial learning rates that are relatively high, followed by slower learning as the easier improvements are made and production efficiency peaks. This eventually produces an asymptotic shape to the learning curve.

  To properly estimate the impact of learning under a cumulative volume approach, five things are required.

  1. A progress rate representing the remaining portion of the price after each doubling of cumulative volume.
  2. The direct cost of the technology at time n1.
  3. An estimate of the cumulative production volume for the specific technology at time n1.
  4. The direct cost of the technology at time n2.
  5. A history of the production of the technology between time n1 and n2.

  To explore the potential impacts of a learning curve, NHTSA has examined the cost and production changes for several safety technologies. NHTSA routinely performs teardown studies of the costs of safety technologies and in five cases we have cost teardown data developed to support a rulemaking as well as about 5 years later to evaluate the impacts of the regulation.[3] These data, together with actual production data, supply four of the five items

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[3] NHTSA also has cost data on energy absorbing steering columns (FMVSS Nos. 203 and 204) from two different times. However, the technology changed dramatically between the two times and costs went up slightly. Given the changes in technology, it didn't seem appropriate to include it with the other technologies in the learning curve calculations.

needed above, and this allows us to derive a progress rate specific to each technology.

The technologies examined were driver air bags, antilock braking systems,[4] 3-point manual outboard lap/shoulder belts with retractors,[5] dual master brake cylinders, and adjustable head restraints. The derived progress rate for each technology is shown in Table 6. The average progress rate for these five technologies is 0.93 and the average learning rate for a doubling of volume is 7 percent. In this report, the progress rate of 0.93 is used for all technologies except those with different rates in Table 6 and the exceptions discussed below.

- All manual belts, whether they be front seat or rear seat, outboard seats or center seats, lap belts or lap/shoulder belts, and pretensioners, load limiters or adjustable anchor, use the 0.96 progress rate.
- All head restraints, whether they be front seat or rear seat, adjustable or integral use the 0.91 progress rate.
- There are two FMVSS that do not have a typical countermeasure identified with them. These are FMVSS No. 216 Roof Crush Resistance and FMVSS No. 301 Fuel System Integrity. Passing these standards depends upon the design of the vehicle and each make/model must be designed and tested to assure it complies. Thus, there is no countermeasure (like an air bag) for which costs can be lowered by production volume efficiency. There is learning in the design process but not much chance of learning based on production volume. For these two standards we decided that a 0.98 progress rate would be closer to reality than the average 0.93 progress rate.
- No learning curve was used for automatic belts in passenger cars because a wide variety of automatic belts (2-point belts and 3-point belts) were used by different manufacturers at different times and the average cost of automatic belts changed over time.

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[4] For this analysis, rear-wheel and four-wheel antilock braking systems were combined since they use the same components and learning would have occurred. In a previous NHTSA analysis, only four-wheel ABSs were considered with a progress rate of 0.895. Averaging the five technologies in Table 6 in the previous analysis and this analysis resulted in rounding the progress rate results to 0.93.

[5] NHTSA has cost data on a variety of lap belt systems also. These were examined to estimate a progress rate with the following results: manual lap belt front-center seat without retractors – 0.946, manual lap belt rear-center seat without retractors – 0.913, manual lap belt rear-seat outboard with retractors – cost went up in later years. Because these are based on only a few belt make/models, we do not want to claim precision for these estimates and are using the 0.96 rate derived from outboard lap/shoulder belts with retractors, by far the most common type of belt system and the one for which we have the most robust cost data, for all belt-related technologies.

Table 6. Progress rate of studied technologies

Technology	Progress Rate	Learning Rate
Driver Air Bags	0.93	0.07
Antilock Braking Systems	0.87	0.13
Manual Lap/Shoulder Belts	0.96	0.04
Adjustable Head Restraints	0.91	0.09
Dual Master Brake Cylinders	0.95	0.05

Appendix A shows a sensitivity analysis of estimated costs using the range of progress rates calculated for Table 6. Appendix B shows important pieces of information used in the learning curve analysis.

In the analysis when there are two or more cost estimates for the same product over different time periods (for example, a cost estimate for four-wheel antilock brakes in MYs 1989 to 1990 vehicles and a cost estimate for four-wheel antilock brakes in MYs 2004 to 2006 vehicles) we have taken the latest cost estimate and its applicable time period (using the average MY 2005 vehicles) and used that in the learning curve equations. Our method calculates a higher estimated cost for years earlier than MY 2005 based on the learning curve going backwards and calculates lower costs for years after MY 2005, while pegging the exact estimate to MY 2005 vehicles. This method produces estimates that closely match the earlier (in this example MY 1989 to 1990) higher cost estimates since the progress rate was determined using both the earlier and later cost estimates.

We don't have a learning curve for weight, thus weight increases are held constant over time except for those instances where we have two or more different weight increases at different times. In those cases, we used linear interpolation between the years for which we have weight data. In the example above the weight increase from MY 1989 and 1990 would be used for MY 1990 and earlier and the weight increase for MY 2004 to 2006 would be used for MY 2004 to 2019, and a linear interpolation would be used from MY 1991 to 2003.

For the learning curve calculations, calendar years sales were used from 1960 to 2005 and MY sales were used from 2006 to 2019. Calendar year sales were the most consistently available set of sales figures over the 1960s and 1970s. Since many standards were effective in 1967 to 1968 and were being met by many manufacturers before that date, it was important to start counting production many years earlier. We chose 1960 as a starting point to count production toward the learning curve calculations. The difference between CY sales and MY sales is fairly small in most years and it eventually was easier to find compliance data that matched MY introductions of technology to MY sales. Table 7 shows the sales of passenger cars and LTVs used in the analysis.

Table 7. Passenger car and LTV sales (in millions of vehicles) used in the analysis

Year	Passenger Cars	LTVs	Year	Passenger Cars	LTVs
1960	7.12	0.87	1990	9.30	4.57
1961	5.82	0.84	1991	8.18	4.14
1962	7.31	0.90	1992	8.21	4.66
1963	8.05	1.10	1993	8.52	5.38
1964	8.29	1.19	1994	8.99	6.07
1965	9.86	1.38	1995	8.62	6.11
1966	9.51	1.37	1996	8.48	6.62
1967	8.46	1.28	1997	8.22	6.9
1968	10.44	1.62	1998	8.08	7.46
1969	10.07	1.70	1999	8.64	8.26
1970	8.56	1.51	2000	8.78	8.57
1971	10.12	1.77	2001	8.35	8.77
1972	10.41	2.14	2002	8.04	8.77
1973	11.42	2.72	2003	7.56	9.08
1974	8.85	2.44	2004	7.48	9.38
1975	8.61	2.28	2005	7.66	9.29
1976	10.10	2.96	2006	7.92	8.85
1977	11.17	3.43	2007	7.99	8.93
1978	11.30	3.81	2008	8.42	8.09
1979	10.65	3.32	2009	5.48	4.83
1980	8.97	2.44	2010	6.29	6.09
1981	8.53	2.19	2011	6.36	7.86
1982	7.98	2.44	2012	7.42	8.34
1983	9.18	2.92	2013	8.16	9.05
1984	10.39	3.98	2014	7.92	9.78
1985	11.04	4.64	2015	8.15	11.50
1986	11.46	4.90	2016	6.63	10.26
1987	10.28	4.95	2017	6.38	11.08
1988	10.54	4.92	2018	5.23	11.79
1989	9.78	4.76	2019	4.62	11.76

Table 8. Example calculations of cumulative sales for learning curve

Year	Passenger Cars Sales	LTVs Sales	Passenger Cars % Comply	LTVs % Comply	PC & LTV Annual Sales	PC & LTV Cumulative Sales
1999	8.64	8.26	20.53	15.00	3,012,792	3,012,792
2000	8.78	8.57	47.54	28.22	6,592,466	9,605,258
2001	8.35	8.77	63.43	35.47	8,407,124	18,012,382
2002	8.04	8.77	71.55	75.60	12,382,740	30,395,122
2003	7.56	9.08	100	100	16,640,000	47,035,122
2004	7.48	9.38	100	100	16,860,000	63,895,122
2005	7.66	9.29	100	100	16,950,000	80,845,122
2006	7.92	8.85	100	100	16,773,069	97,618,191
2007	7.99	8.93	100	100	16,920,422	114,538,613
2008	8.42	8.09	100	100	16,503,239	131,041,852
2009	5.48	4.83	100	100	10,313,556	141,355,408
2010	6.29	6.09	100	100	12,376,667	153,732,075
2011	6.36	7.86	100	100	14,211,098	167,943,173
2012	7.42	8.34	100	100	15,767,321	183,710,494
2013	8.16	9.05	100	100	17,216,732	200,927,226
2014	7.92	9.78	100	100	17,705,269	218,632,495
2015	8.15	11.50	100	100	19,645,917	238,278,412
2016	6.63	10.26	100	100	16,884,029	255,162,441
2017	6.38	11.08	100	100	17,455,174	272,617,615
2018	5.23	11.79	100	100	17,017,169	289,634,784
2019	4.62	11.76	100	100	16,384,283	306,019,067

An example of how the learning curve calculations work is discussed below. Upper interior head protection (FMVSS No. 201) in passenger cars is used as an example.

Step 1: Determine the cost of the technology (in 2019$) before the learning curve is derived. In this case it was $16.62.[6]

[6] In theory learning only applies to the variable cost and should not be applied to consumer cost. However, given NHTSA's methodology of multiplying variable cost times 1.51 to derive consumer costs, and the fact that the learning curve is all multiplicative, it doesn't matter whether learning is applied before or after the 1.51 multiplier

Step 2: Determine the average model year of the vehicles that met the standard that were in the teardown study so that we know the teardown base year for cumulative production. In this case it was MY 2001.

Step 3: Determine the cumulative sales of vehicles with upper interior head protection by the teardown base year. We will also use the number of vehicles with upper interior head protection sold in future years in the calculations. For this we need a percentage of the fleet with upper interior head protection for both passenger cars and LTVs multiplied by their respective sales in those years. Table 8 shows those results. The cumulative sales figures per year are used in the calculations. The cumulative volume in the teardown base year 2001 for FMVSS No. 201 is 18,012,382 vehicles sold.

Step 4: Determine -E, -E = the natural log of the progress rate divided by the natural log of 2. The progress rate for this technology is 0.93. So, –E = Ln(0.93)/Ln(2) = -0.105.

Step 5: Determine A, A = the natural log of the base price minus –E times the natural log of the teardown base year cumulative sales. A = Ln($16.62)-(-0.105)*Ln(18,102,382) = 4.559690621.

Step 6: To determine the cost of the technology per vehicle (C), for each year, you apply the formula C = EXP(A + -E*Ln(cumulative volume for that year)). For 1999 C = EXP(4.559690621+-1.05*Ln(3,012,792).

Step 7: Multiply the percentage of the fleet equipped with the technology by the learning curve cost to get the average price per passenger car. Table 9 shows the results. The base cost per vehicle ($16.62) is pegged to the teardown base year of 2001. Costs per vehicle are higher in preceding years and lower in later years, reflecting more efficient production methods, resource utilization, and vehicle design derived from cumulative production experience. The average cost per vehicle for 1999 of $4.11 is the learning curve cost of $20.04 multiplied by 0.2053 (the percentage of passenger cars meeting FMVSS No. 201 in 1999).

Table 9. Example calculations of average cost for learning curve

Model Year	**Cost No Learning**	**Learning Factor**	**Cost After Learning**	**% of Veh. Comply**	**Average Cost per Vehicle**
1999	$16.62	1.206	$20.04	20.53	$4.11
2000	$16.62	1.068	$17.75	47.54	$8.44
2001	$16.62	1.000	$16.62	63.43	$10.54
2002	$16.62	0.947	$15.73	71.55	$11.26
2003	$16.62	0.904	$15.03	100	$15.03
2004	$16.62	0.876	$14.56	100	$14.56
2005	$16.62	0.855	$14.20	100	$14.20

is applied. Thus, since you get the same answer with either methodology and to keep the analysis simpler and easier to follow, in this analysis learning is applied to consumer cost.

Model Year	Cost No Learning	Learning Factor	Cost After Learning	% of Veh. Comply	Average Cost per Vehicle
2006	$16.62	0.838	$13.92	100	$13.92
2007	$16.62	0.824	$13.69	100	$13.69
2008	$16.62	0.812	$13.50	100	$13.50
2009	$16.62	0.806	$13.39	100	$13.39
2010	$16.62	0.799	$13.28	100	$13.28
2011	$16.62	0.792	$13.16	100	$13.16
2012	$16.62	0.784	$13.03	100	$13.03
2013	$16.62	0.777	$12.91	100	$12.91
2014	$16.62	0.770	$12.80	100	$12.80
2015	$16.62	0.763	$12.68	100	$12.68
2016	$16.62	0.758	$12.59	100	$12.59
2017	$16.62	0.752	$12.50	100	$12.50
2018	$16.62	0.748	$12.43	100	$12.43
2019	$16.62	0.743	$12.35	100	$12.35

Figure 3 shows an example of how the learning curve eventually reaches a point where costs decline at such a slow rate that the impact of further production is relatively insignificant. It illustrates the practical impact of cumulative learning over time using a hypothetical production schedule for a new technology. The increments indicated on the x axis represent successive years in a technologies' production life. In this example, successive doublings of cumulative production occur in the first few years as production is ramped up over the initial levels that occurred as the technology was introduced into the fleet, possibly in luxury or specialty vehicles. However, within a few years cumulative volume exceeds the stabilized annual production volume, and doubling becomes increasingly difficult to obtain. Figure 3 reflects the natural limitation on increases in cumulative volume (and thus learning) that result from the finite nature of annual production levels.

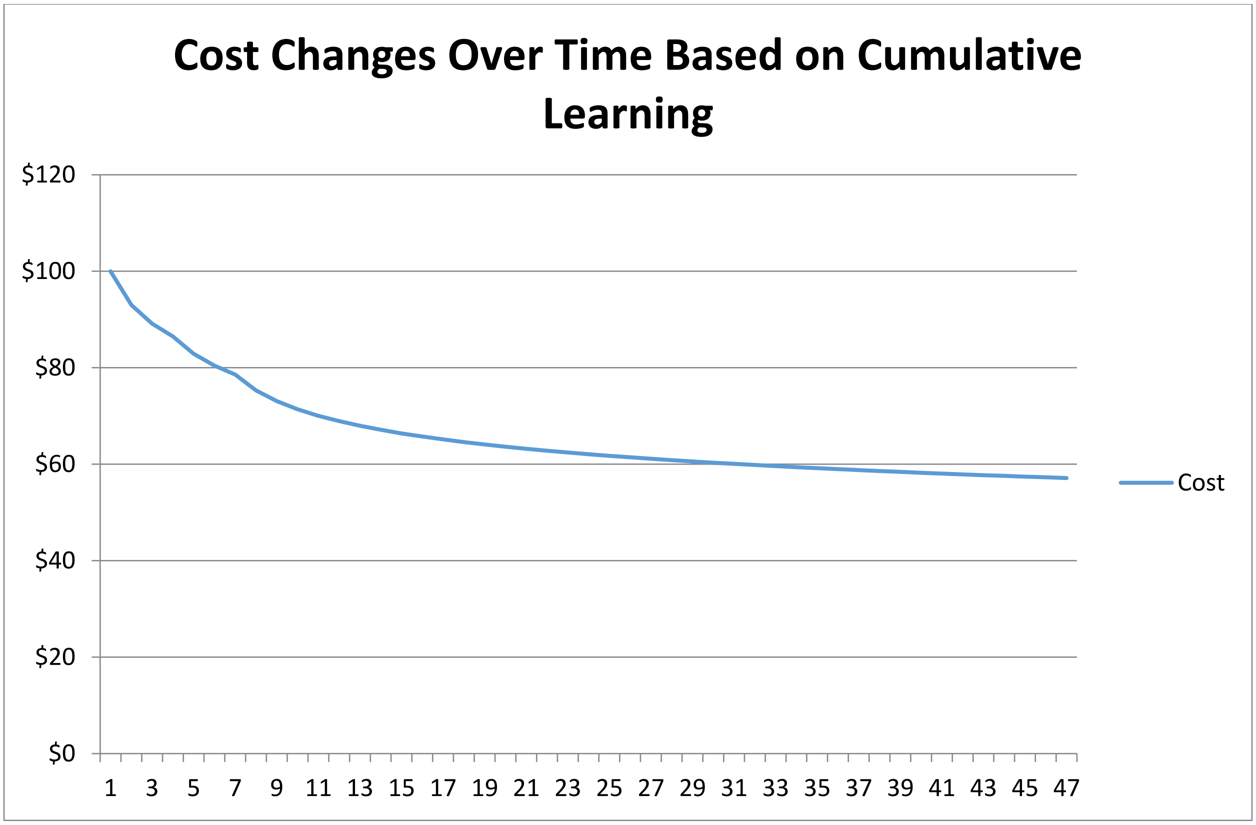

Figure 3. An example of how the learning curve reaches a point where costs decline at such a slow rate that the impact of further production is relatively insignificant

How We Determined the Average Price Paid and Weight of MY 2019 Passenger Cars and LTVs

We have an estimate of the average price paid for passenger cars and LTVs. This is not the same as the average manufacturer's suggested retail price. The manufacturer's suggested retail price is almost always different than what consumers paid for a vehicle for various reasons. Our estimate is based on the average consumer expenditure data from the Bureau of Economic Analysis for 2019 for passenger cars and LTVs. The source is Table 7.2.5S, Auto and Truck Unit Sales, Production, Inventories, Expenditures, and Price, found at www.bea.gov/itable/. The average consumer expenditure for a 2019 passenger car was $26,385, while the average consumer expenditure for an LTV was $38,207 in 2019$. The annual estimates of personal consumer expenditures for new motor vehicles are derived by summing monthly estimates and dividing by 12. A sales weighting analysis by month of sales for 2018 resulted in only a $10 difference in the average price paid for passenger cars and a $17 difference for LTVs. We chose the methodology of adding monthly estimates and dividing by 12 because it was easier to have a consistent methodology for the figures in Table 10. The Bureau of Economic Analysis puts together this information and the overall average expenditures use these detailed average transactions prices and the data on unit sales by model. For this report, we are defining the average price paid as being equivalent to the average personal consumer expenditure simply because it seems easier to understand the term price paid. In addition, we are assuming that the average price paid in CY 2019 will be very similar to the average price paid for MY 2019.

Table 10 shows the average price paid over time for selected years showing both the nominal value, the average price paid in that year, and the price paid in 2019 dollars (after adjusting based on the implicit GNP price deflator). The average price paid (in 2019 dollars) for passenger cars reached a peak in 1999 at $30,460 and has been declining since. Data for LTVs are only available in this data set starting in 2002. The average price paid (in 2019 dollars) for LTVs reached a peak in 2015 at $38,476 and has slightly declined since then.

Table 10. Average price paid per vehicle for passenger cars and LTVs in select years

Calendar Year	**Passenger Cars**		**LTVs**	
	Nominal Value	**Adjusted 2019$**	**Nominal Value**	**Adjusted 2019$**
1970	$3,543	$18,360		
1980	$7,574	$20,130		
1990	$15,045	$26,547		
2000	$21,047	$30,284		
2002	$21,866	$30,308	$26,173	$36,278
2010	$24,899	$29,104	$32,297	$37,752
2018	$26,288	$26,746	$37,335	$37,986
2019	$26,385	$26,385	$38,207	$38,207

We derived an estimate of the average weights of passenger cars and LTVs because there was no ready source of this information. The estimates are based on weights for each make/model and weighted by MY 2019 sales data. Weight by make/model are taken from the MY 2019 specifications from the 2019 Wards Automotive Yearbook and these are sales weighted by MY 2019 sales from the factory installed equipment pages of the 2020 Wards Automotive Yearbook. For each make/model there are a fairly large number (probably averaging about eight for passenger cars and SUVs and much more for pickups) of different weights depending upon body type and trim level and the engine in that model, including hybrids. For passenger cars we assumed the base weight applied to 66.6 percent of sales, and we averaged all other optional weights and assumed they apply to 33.4 percent of sales. We did not have a sales distribution on all the body styles, trim levels, and engine combinations. Thus, we assume two-thirds of passenger cars are purchased at the base vehicle weight and one-third are purchased at an average weight that is a simple average of all the other optional body styles (2-door, 4-door, hatchback, convertible, and station wagon), engines, or trim levels. The average weight for passenger cars under this 66.6 percent/33.4 percent assumption is 3,300 lb. There isn't a large variation in weight in most passenger cars (as shown in the table below). If you sales weighted just the base weights, the average weight would be 3,241 lb. Thus, under this methodology, all the other body styles, trim levels and optional engines only added 59 lb to the average weight of passenger cars.

We assumed that one-third of LTVs would be purchased at base vehicle weight and two-thirds would buy larger engines or other optional models that increase weight. The average weight for LTVs under this 33.4 percent/66.6 percent assumption is 4,337 lb. There is a larger variation in weight in LTVs, but mostly in pickup trucks. If you sales weighted just the base weights of all LTVs, the average weight would be 4,174 lb, a difference of 163 lb compared to the estimated average weight. We examined pickup trucks separately, just because they appeared to have larger differences between the base models and optional models. The average weight for pickup trucks under the 33.4 percent/66.6 percent assumption was 5,095 lb. If you sales weighted just the base weights of all pickup trucks, the average weight would be 4,857, a difference of 238 lb.

Table 11. Estimated average weight of MY 2019 vehicles

	Base Weight	Average Weight	Optional Weight	Ave. – Base Wt.
Passenger Cars	3,241	3,300	3,418	59
All LTVs	4,174	4,337	4,419	163
Pickup Trucks	4,857	5,095	5,214	238

Methods Used to Find Federal Register Notices

To find past NPRMs and final rules in the Federal Register, several methods were used. First, many of the citations were included in the reference section under FR in the Kahane (2015) report. Second, in the NHTSA web page www.nhtsa.gov under More Info, Data, Regulatory Analysis, Regulatory analyses from January 1971 to August 2018, many of the analyses from 1991 and later have the Federal Register cite and date and docket number. One can then go to the docket under www.regulations.gov and search using the docket number (e.g., nhtsa-2011-0148) to find the final rule. Or one can go to www.federalregister.gov under search Federal Register documents since 1994 and search for rules R or proposed rules PR. Third, to find Federal Register articles before these dates, we went to a subscription service www.shop.heinonline.org. To use this service, it helps to have a Federal Register cite. For most standards this can be found at the end of the standard in the Code of Federal Regulations (CFR). The CFRs from 1994 to present can be found online at www.ecfr.gov under Browse, select Title 49 for Transportation, then browse parts 500-571, 571.1 to 571.500. Usually the citations remain with the CFR, so you don't have to search older ones. This is one way to find how petitions for reconsideration amended the original standards. Once we found the Federal Register cites, we went to Heinonline.org, entered the cites and pulled up the actual Federal Register notice and read through it to find the information we were interested in. Every final rule in the Federal Register always refers back to the NPRM and provides the Federal Register cite for it. Heinonline can also be searched for key words and dates, such as power windows in the years from 1966 to 1970, and it will refer you to each of the entries in which power windows appears during that time frame. Heinonline has both Federal Register and copies of the CFR. The References section has a list of the Federal Register cites reviewed while working on this analysis. Since we did this work, a new service became available on the web. The entire Federal Register is now online in pdf format, courtesy of the Library of Congress, all the way back to its inception on March 14, 1936. You can access it at www.loc.gov/collections/federal-register. If you know the actual date of the notice you are looking for, you can access it more easily by Googling "Federal Register, October 18, 1979" for example.

The Major Differences Between This Report and the November 2017 Report

The Safety1965 concept is new to this report. This significantly changed both the way we count costs and the way we count voluntary and attributable costs. In previous reports if all LTVs met the standard before the LTV baseline, but not all passenger cars met the standard before the passenger car baseline, there would be no incremental costs included for LTVs, while there would be voluntary costs included for passenger cars before and after the baseline and attributable costs for the incremental percentage of the fleet that met the standard after the baseline. With the Safety1965 concept, all passenger cars and LTVs must meet the standard by MY 1965 in order for costs not to be counted. If not all passenger cars and LTVs meet the standard by MY 1965, then all the compliance before the baseline is considered voluntary, even if 100 percent of passenger cars and LTVs meet the standard before their baseline. The same difference applies to weight as applies to cost. As a result, the costs of some countermeasures were not counted at all in the November 2017 report, such as dual master cylinders, because they were in all passenger cars and LTVs in their baseline year of MY 1967. Under the Safety1965 concept these costs and weights are counted as voluntary, since they were not in all passenger cars and LTVs by MY 1965.

A second major difference between this report and the November 2017 report is that the multiplier from variable costs to consumer costs was made consistent in this report at 1.51. In the November 2017 report we took the contractors consumer cost estimates using whatever markup was used in the report. For this report, we went back and adjusted all the older multipliers to 1.51, except those that used 1.52, to make them consistent.

The Safety1965 concept results in more cost and weight being linked to the FMVSS and more cost and weight being considered voluntary. Table 12 compares this 2024 report to the Simons (2017) report for two MYs (1968 and 2012). Comparing MY 1968 data, the total weight increased by 13.1 lb and cost increased by $100.20 for passenger cars and weight increased by 8.1 lb and cost increased by $70.33 for LTVs, while some of the attributable weight and costs changed to voluntarily provided by the manufacturers. Comparing MY 2012 data, for passenger cars total weight was 34.9 lb more and costs were $150.40 more, while for LTVs total weight was 36.2 lb more and costs were $143.70 more in this report. Again, some of the attributable weight and costs were changed to voluntarily provided by the manufacturers under the Safety1965 concept and the voluntarily provided weights and costs are always higher in this Report than in the 2017 Report.

A third difference is that this report is in 2019 dollars, while the Simons (2017) report was in 2012 dollars. For Table 12, the cost estimates from the 2017 Report were brought up to 2019 dollars to provide a valid comparison.

Table 12. Comparison of Simons (2017) cost report to this report

	Passenger Cars		LTVs	
	Added Weight	**Cost 2019$**	**Added Weight**	**Cost 2019$**
MY 1968 Data				
2017 Report				
Attributable	14	$68.19	7.3	$108.23
Voluntary	6.5	$183.25	3.2	$28.43
Total	20.5	$251.44	10.5	$136.67
This Report				
Attributable	8.7	$93.96	4.7	$67.57
Voluntary	25.0	$257.68	13.9	$139.43
Total	33.6	$351.64	18.6	$207.00
MY 2012 Data				
2017 Report				
Attributable	132.7	$1,512.91	92.5	$1,207.10
Voluntary	38.7	$654.72	43.7	$824.03
Total	171.4	$2,167.63	136.2	$2,031.13
This Report				
Attributable	133.0	$1,457.98	103.8	$1,234.37
Voluntary	73.3	$860.61	68.6	$943.30
Total	206.3	$2,318.59	172.4	$2,177.67

Section 2 – FMVSS 100 Series

The FMVSS 100 series specify design and performance requirements for vehicles and vehicle subsystems that pertain to crash avoidance. The design-based standards require the presence of certain vehicle subsystems, specify design characteristics (size, shape, color, etc.), and describe how particular subsystems are to function. Thereby, they provide a large degree of uniformity in the operation of all make-models of vehicles. The performance-based standards outline specific capabilities that a vehicle or vehicle subsystem must demonstrate when actively tested. Several of the FMVSS 100 series contain a set of both design-based and performance-based criteria.

FMVSS No. 101, Controls and displays

FMVSS No. 101 became effective on January 1, 1968, and specifies requirements for the location, identification, and illumination of motor vehicle hand-operated controls (steering wheel, horn, ignition, etc.), foot-operated controls (service brake, accelerator, clutch, etc.), and displays (speedometer, turn signal, gear position indicator, etc.). The purpose of this standard is to ensure the accessibility and visibility of motor vehicle controls and displays and to facilitate their selection under daylight and nighttime conditions. The intent of the standard is to reduce the safety hazards caused by the diversion of the driver's attention from the driving task and by mistakes in selecting controls. Furthermore, drivers can more easily operate an unfamiliar vehicle if the controls and displays are in somewhat uniform locations with uniform labels. FMVSS No. 101 does not require uniform locations for all controls and displays but does require uniform symbols and labels for most controls and displays. This standard applies to passenger cars, MPVs, trucks, and buses. Thus, it applies to all LTVs.

Most motor vehicles had some form of controls and displays prior to the standard. The requirements resulted in relocating and changing the visual appearance of the displays. While there may have been a one-time engineering development cost, there is little long-term cost associated with complying with the standard. No cost studies have been performed, and none are planned by the agency.

FMVSS No. 102, Transmission shift lever sequence, starter interlock, and transmission braking effect

FMVSS No. 102 became effective on January 1, 1968, and specifies the requirements for the transmission shift lever sequence, a starter interlock, and a braking effect of automatic transmissions. The purpose of this standard is to prevent shifting errors in unfamiliar vehicles, or when drivers change from one vehicle to another. It requires a starter interlock to prevent drivers from engaging the starter with the vehicle in a driving gear. It also requires automatic transmissions to have a low gear selection to provide a supplemental braking effect at speeds below 25 mph. This standard applies to passenger cars, MPVs, trucks, and buses. Thus, it applies to all LTVs.

The standard requires that all shift levers for automatic transmissions have the same clockwise sequence: park, reverse, neutral, drive, and low gears. This will reduce the likelihood of shifting errors when drivers change from one vehicle to another. Effective September 23, 1991, the identification of shift lever positions shall be displayed in view of the driver in a single location. Identification of the shift lever pattern for manual transmissions shall always be displayed in view of the driver when a driver is present in the driver's seating position. Vehicles with a 3-

speed manual transmission that has the standard H pattern shift sequence are not required to have a shift pattern display.

While there may have been a one-time development cost in some cases, there is little long-term cost associated with complying with the standard. No cost studies have been performed, and none are planned by the agency.

FMVSS No. 103, Windshield defrosting and defogging systems

FMVSS No. 103 became effective on January 1, 1968, and specifies requirements for windshield defrosting and defogging systems. The purpose of this standard is to establish minimum capability for all vehicles to assure that windshields will remain clear under conditions in which moisture could adhere to the inside or outside of the windshield. It is based on passenger cars meeting the requirements of the Society of Automotive Engineers (SAE) recommended practices established in 1964. The other vehicle classes under this standard are required to have windshield defrosting and defogging systems; however, no performance requirements are specified. The defrosting and defogging system includes the necessary ducts, baffles, cables, levers, and grilles to direct heated or dehumidified air onto the windshield. This standard applies to passenger cars, MPVs, trucks, and buses. Thus, it applies to all LTVs.

A study of seven pre-standard make-model passenger cars, and their corresponding post-standard systems, revealed minimal design changes resulting in a reduction of average weight and a slight increase of average consumer cost. However, NHTSA has no evidence that these changes were specifically made to meet performance requirements in the standard (Gilmour, 1982). Table 13 shows the sales-weighted average for the weight and consumer cost of windshield defrosting and defogging systems in pre- and post-standard passenger cars.

Table 13. FMVSS No. 103: Average weight and consumer cost of windshield defrosting and defogging systems in passenger cars

Model Year	Weight (lb)	Consumer Cost (2019$)
1965 (Pre-Standard)	1.23	$12.49
1969 (Post-Standard)	1.01	$13.51

A study of seven 1969 make-model LTVs indicated that the sales-weighted average weight and consumer cost of the defrosting and defogging systems was 3.05 lb and $13.63 in 2019 dollars (Gladstone et al., 1982, pp. 2-1–2-6). Although not studied, earlier model LTVs were also equipped with these systems.

The final rule for passenger cars and LTVs was published in the Federal Register on April 27, 1968, (33 FR 6465), and the NPRM on December 28, 1967, (32 FR 20865) making the baseline date September 1, 1967, or MY 1968. Since 100 percent of both the passenger car and LTV fleet had windshield defrosting and defogging systems by MY 1965, and there are no indications that the minimal design changes between 1965 and 1969 were made to meet the performance tests of the standard, there are no incremental costs. Thus, the safety equipment used for FMVSS No. 103 Windshield Defrosting and Defogging Systems is considered Safety1965. The cost of the equipment that was already there will not be considered as voluntarily provided before the NPRM and will not be attributed to the FMVSS. As discussed above, the cost of Safety1965 equipment that were standard on every passenger car and LTV by MY 1965 are not included in this analysis.

FMVSS No. 103 has never required or proposed to require rear-window defrosters and defoggers. Their development has been voluntary on the part of the industry, in response to customer demand. Drivers want a clear rear window, and they like a device that clears it for them automatically, so they do not have to wipe or scrape it repeatedly. NHTSA has evaluated rear-window defrosters and defoggers and was unable to conclude that they reduce police reported crashes (Morgan, 2004). NHTSA has no cost and weight teardown studies of rear-window defrosters and defoggers and has no plans to study them. Thus, while rear-window defrosters and defoggers are standard equipment on most light vehicles, they are not included in this analysis since they were never proposed by NHTSA and have not been shown by a NHTSA evaluation to have a safety benefit and are not linked to FMVSS No. 103.

FMVSS No. 104, Windshield wiping and washing systems

FMVSS No. 104 became effective on January 1, 1968, for passenger cars and January 1, 1969, for LTVs and specifies requirements for windshield wiping and washing systems. The standard requires that each vehicle have a power-driven windshield wiping system with two speeds, with the speed of the wiping system independent of the vehicle engine speed and engine load. It essentially mandated electric-powered wiper motors and precluded the early design of wiper systems that were driven by the vehicle’s engine vacuum. In addition, each vehicle shall have a windshield washing system that meets the requirements based on SAE recommended practices established in 1965. This standard applies to passenger cars, MPVs, trucks, and buses. Thus, it applies to all LTVs.

The final rule for passenger cars was published in the Federal Register on February 3, 1967**,** (32 FR 2410) and the NPRM on December 3, 1966**,** (31 FR 15212) making the baseline date for passenger cars September 1, 1966**,** or MY 1967. On April 27, 1968**,** (33 FR 6465), the standard was extended to LTVs with the NPRM on December 28, 1967**,** (32 FR 20865) making the baseline date for LTVs September 1, 1967**,** or MY 1968.

While all passenger cars complied with FMVSS No. 104 by MY 1965, not all LTVs complied by MY 1965. MY 1965 LTVs had one-speed wiper motors and did not have washing systems at all. Thus, all passenger cars and LTVs had single-speed wiping systems and that is considered the Safety1965 equipment. Thus, incremental cost for FMVSS No. 104 Windshield Wiping and Washing Systems is the difference in cost between the multi-speed wiping system and the single-speed wiping system plus the washing system.

Passenger Car Studies

In MY 1965 all passenger cars had both windshield wiping and washing systems. After studying seven pre-standard 1965 make-model passenger cars, the contractor concluded that the vehicles already complied with the standard (Gilmour, 1982). While parts, material, and weight were analyzed for MY 1965 and 1969 passenger cars, costs were not estimated. The contractor determined that no changes were attributable to the standard and did not estimate costs. Every passenger car that came under the standard had a windshield wiping and washing system by MY 1965, and there are no indications that the countermeasures were upgraded due to the standard. As a result, we will use the costs provided for LTVs as a proxy measure of the costs for passenger cars. The difference in cost between the multi-speed wiping system and the single-speed wiping system plus the washing system is the incremental cost for passenger cars and is considered voluntary.

LTV Studies

The windshield wiping and washing systems for seven MY 1969 make-model LTVs were also studied (Gladstone et al., 1982, pp. 3-1–3-23). They were compared to MY 1965 LTVs which had one-speed wiper motors and did not have washing systems at all. The cost of implementing the windshield wiper requirements was determined by comparing the single and multi-speed motors, an additional wire from the switch to the motor, and a switch that was changed from two positions to three positions. In the case of the variable speed motors, a variable switch was substituted for the two-position switch. Table 14 shows the sales-weighted average weight and consumer cost of each system, with the difference being the cost of implementing the windshield wiper requirements.

Table 14. FMVSS No. 104: Average weight and consumer cost of windshield wiper systems in LTVs

Motor Type	Weight (lb)	Consumer Cost (2019$)
Single Speed	2.23	$26.90
Multi-Speed	2.72	$32.48
Difference	0.49	$ 5.58

For the washing systems analysis, the MY 1965 LTVs were without the system and needed the following components (reservoir, pump, hoses, switch, and knob assembly). The sales-weighted average weight and consumer cost for the washing system was 1.65 lb and $15.43 in 2019 dollars.

Table 15 shows the total weight (2.14 lb) and additional consumer cost ($21.01) for FMVSS No. 104 comparing MY 1969 to 1965 LTVs. This same weight and costs were applied to passenger cars.

Table 15. FMVSS No. 104: Average weight and consumer cost of windshield wiping and washing systems in LTVs

System	Weight (lb)	Consumer Cost (2019$)
Windshield Wiping	0.49	$ 5.58
Windshield Washing	1.65	$15.43
Total	2.14	$21.01

Windshield wiping and washing systems that met FMVSS No. 104 were available in 100 percent of passenger cars by MY 1965 and 100 percent of LTVs in MY 1968. Since they were installed before the baseline date for passenger cars and on the baseline date for LTVs, the incremental costs are all considered voluntary for both passenger cars and LTVs.

Since the weights and costs are the same for passenger cars and LTVs, Table 16 shows the results for both after applying the learning curve to consumer costs. Weight stays the same, since we do not have a learning curve for weight, but consumer costs decrease as manufacturers find ways to reduce costs over time. We use a progress rate in the learning curve of 0.93.

Intermittent windshield wipers were never required or proposed by NHTSA. NHTSA has never attempted to evaluate whether these systems improve safety, nor estimated their costs with a teardown study, and there are no plans to study them. Thus, while intermittent windshield wipers are standard equipment on most light vehicles, they are not linked to FMVSS No. 104 and are not included in this analysis.

Table 16. FMVSS No. 104: Windshield wiping and washing – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	2.1	0	2.1	$21.33	0	$21.33
1969	2.1	0	2.1	$21.01	0	$21.01
1970	2.1	0	2.1	$20.77	0	$20.77
1971	2.1	0	2.1	$20.53	0	$20.53
1972	2.1	0	2.1	$20.30	0	$20.30
1973	2.1	0	2.1	$20.07	0	$20.07
1974	2.1	0	2.1	$19.90	0	$19.90
1975	2.1	0	2.1	$19.75	0	$19.75
1976	2.1	0	2.1	$19.59	0	$19.59
1977	2.1	0	2.1	$19.42	0	$19.42
1978	2.1	0	2.1	$19.27	0	$19.27
1979	2.1	0	2.1	$19.13	0	$19.13
1980	2.1	0	2.1	$19.03	0	$19.03
1981	2.1	0	2.1	$18.94	0	$18.94
1982	2.1	0	2.1	$18.85	0	$18.85
1983	2.1	0	2.1	$18.76	0	$18.76
1984	2.1	0	2.1	$18.65	0	$18.65
1985	2.1	0	2.1	$18.55	0	$18.55
1986	2.1	0	2.1	$18.44	0	$18.44
1987	2.1	0	2.1	$18.35	0	$18.35
1988	2.1	0	2.1	$18.26	0	$18.26
1989	2.1	0	2.1	$18.18	0	$18.18
1990	2.1	0	2.1	$18.10	0	$18.10

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1991	2.1	0	2.1	$18.04	0	$18.04
1992	2.1	0	2.1	$17.98	0	$17.98
1993	2.1	0	2.1	$17.91	0	$17.91
1994	2.1	0	2.1	$17.84	0	$17.84
1995	2.1	0	2.1	$17.78	0	$17.78
1996	2.1	0	2.1	$17.72	0	$17.72
1997	2.1	0	2.1	$17.65	0	$17.65
1998	2.1	0	2.1	$17.59	0	$17.59
1999	2.1	0	2.1	$17.53	0	$17.53
2000	2.1	0	2.1	$17.47	0	$17.47
2001	2.1	0	2.1	$17.41	0	$17.41
2002	2.1	0	2.1	$17.35	0	$17.35
2003	2.1	0	2.1	$17.30	0	$17.30
2004	2.1	0	2.1	$17.24	0	$17.24
2005	2.1	0	2.1	$17.19	0	$17.19
2006	2.1	0	2.1	$17.14	0	$17.14
2007	2.1	0	2.1	$17.09	0	$17.09
2008	2.1	0	2.1	$17.05	0	$17.05
2009	2.1	0	2.1	$17.02	0	$17.02
2010	2.1	0	2.1	$16.99	0	$16.99
2011	2.1	0	2.1	$16.95	0	$16.95
2012	2.1	0	2.1	$16.91	0	$16.91
2013	2.1	0	2.1	$16.87	0	$16.87
2014	2.1	0	2.1	$16.82	0	$16.82
2015	2.1	0	2.1	$16.78	0	$16.78
2016	2.1	0	2.1	$16.74	0	$16.74
2017	2.1	0	2.1	$16.70	0	$16.70
2018	2.1	0	2.1	$16.66	0	$16.66
2019	2.1	0	2.1	$16.63	0	$16.63

FMVSS No. 105, Hydraulic and electric brake systems

FMVSS No. 105 became effective on January 1, 1968, and specifies requirements for vehicles with hydraulic and electric service brake systems, and associated parking brake systems. The purpose of this standard is to ensure safe braking performance under normal and emergency conditions. This standard applies to:

- Hydraulically braked passenger cars manufactured before September 1, 2000;
- Hydraulically braked MPVs, trucks, and buses with a GVWR of 7,716 lb or less that were manufactured before September 1, 2002; and
- Hydraulically braked vehicles with a GVWR greater than 7,716 lb.

All hydraulically braked passenger cars manufactured after September 1, 2000, and hydraulically braked MPVs, trucks, and buses with a GVWR of 7,716 lb or less that were manufactured after September 1, 2002, are part of FMVSS No. 135 Light Vehicle Brake Systems. In the following tables, FMVSS No. 105 and FMVSS No. 135 are combined since safety countermeasures (like dual master cylinders, power boosters, disc brakes and ABS) used to meet the standards are discussed and there were no other new costs added to passenger cars and LTVs as a direct result of FMVSS No. 135.

Passenger Car Studies

Brake System Components

The brake system components specifically required by FMVSS No. 105 are a dual or split hydraulic service brake system, parking brake system, and brake system indicator lamp. Design characteristics of these components are also governed by this standard. The performance requirements for brake systems consist of a series of stopping tests simulating normal and emergency braking, fade and recovery, water recovery, and partial system failure.

The most important indication of brake performance is the distance in which a brake system can stop a vehicle from a given speed. The performance requirements for the service brake system are expressed in terms of stopping distance and deceleration rates from specific vehicle speeds using a specific range of brake pedal apply forces by the vehicle driver. Brake pedal apply force is measured in lb per foot and is an indication of how hard the vehicle driver's leg pushes against the brake pedal.

Fade and recovery requirements are also included in the standard to assure that a vehicle's braking performance is satisfactory when exposed to the high brake temperatures caused by prolonged or severe use or during the time that the brakes are cooling off after severe use. Fade is the inability of friction material to maintain its normal effectiveness when it is forced to work at elevated temperatures. Recovery is the rate at which the lining returns to its original friction level after having been exposed to a fade condition. Light fade occurs in vehicles even in low speed applications such as in heavy traffic. Moderate to severe fade is a condition that may occur when vehicles are used on hilly or mountainous roads, especially when heavy loads are carried. In addition, water recovery requirements are included in the standard to assure that a vehicle's braking system performs adequately after immersion in water. Finally, partial system failure requirements are included to ensure that a vehicle's brakes are capable of bringing the vehicle to a controlled stop in a reasonable distance if a part of the service brake system should fail.

Each vehicle shall be capable of completing all performance requirements without:

- detachment or fracture of any component of the braking system, and
- any visible brake fluid or lubricant on the friction surface of the brake or leakage at the master cylinder or brake power unit reservoir cover, seal, and filler openings.

FMVSS No. 105, effective in January 1968, represented the initial Federal effort to specify braking requirements for motor vehicles and required that passenger cars have a split service brake system and have stopping ability based upon deceleration rates specified in the SAE Recommended Practice J937, June 1966. Requirements for fade and recovery, water recovery, and stability while braking were also included in this standard. These requirements did not represent the full capabilities of modern braking technology; therefore, a new standard (105a) was established in September 1972 specifying requirements for motor vehicle hydraulic brake systems and parking brake systems.

FMVSS No. 105 is a performance standard, specifying stopping distances or deceleration rates for a series of stopping tests under various conditions. It does not prescribe technologies. However, dual master cylinders satisfied the FMVSS No. 105 requirement for a dual or split braking system. The goal of dual master cylinders is to provide dual hydraulic circuits, so that a fault in one hydraulic system will not lead to a catastrophic loss of all braking power.

The NPRM for the initial FMVSS, including FMVSS No. 105 was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. The baseline date is the model year that occurs prior to the NPRM being published in the Federal Register. The basic brake systems with a single master cylinder were installed in all passenger cars and LTVs before MY 1965 and thus, basic brake systems with a single master cylinder are considered Safety1965. Dual master cylinders were installed in all passenger cars in MY 1967. Thus, dual master cylinders are not considered part of Safety1965. Dual master cylinders were in all passenger cars by the baseline and are considered voluntarily supplied by manufacturers.

The principal difference between the 1968 and 1976 standards is that the new regulation specifies the straight-line stopping distances within which a car must stop under good conditions. The older rule merely specified the deceleration rate a car had to attain at some point during braking. Moreover, the stopping distances were set at a level that only half of the 1972 models appeared to be capable of meeting, according to consumer information data submitted to NHTSA by the manufacturers. In other words, it was felt that the new regulation would significantly improve stopping distances over 1972 levels in a large portion of the vehicle fleet. The new regulation requires more stringent partial failure, fade recovery, and water recovery tests than the older rule. In addition, the following requirements for improved handling and stability are added:

- wheel lockup is permitted at a speed below 10 mph, and
- lockup of only one wheel, not controlled by an antilock system, is permissible at speeds in excess of 10 mph.

It is difficult to determine what costs should be attributed to FMVSS No. 105 because changes in vehicle size, customer preferences, and development of superior materials and designs have all enhanced or changed braking performance, cost, and weight over the years. The four major changes to the braking systems that have occurred since 1965 are dual master cylinders, front disc brakes, brake power assist units (power boosters), and ABS. None of them are part of Safety1965 equipment. Each of these will be discussed separately. Table 17 shows the estimated percentage of passenger cars with these technologies by model year. The percentage of the passenger car fleet with power boosters for MYs 1969, 1970, and 1971 could not be found in the literature and was assumed to linearly increase between the years with known data of MYs 1968 and 1972. In addition, in the years before 1985 most of the known data are for domestic vehicles. In the years that data were not available for import passenger cars, we assumed the same percentage of braking countermeasures were installed in import passenger cars as could be found in the literature for domestic passenger cars.

Manufacturers had extensive advance knowledge of the upgrade to establish FMVSS No. 105a for passenger cars because an NPRM was issued November 11, 1970, (35 FR 17345) making the baseline date September 1, 1970, or MY 1971. FMVSS No. 105a was redesignated to FMVSS No. 105-75 in February 1974, and with only minor changes in the portion applicable to passenger cars, evolved into the January 1976 requirements. Power boosters were used to help meet the stopping distance requirements. Power boosters were not available in all passenger cars by the baseline date of MY 1971. Front disc brakes helped vehicles pass the fade and water-recovery tests.

Table 17. FMVSS No. 105: Percent of passenger cars with dual master cylinders, front disc brakes, power boosters, and ABS by MY

Model Year	Dual Master Cylinder	Front Disc Brakes	Power Boosters	Four-Wheel ABS	Rear-Wheel ABS
1968	100	13	41	0	0
1969	100	28	44	0	0
1970	100	41	47	0	0
1971	100	63	50	0	0
1972	100	74	68	0	0
1973	100	86	67	0	0
1974	100	84	67	0	0
1975	100	93	74	0	0
1976	100	99	81	0	0
1977	100	100	85	0	0
1978	100	100	88	0	0
1979	100	100	88	0	0
1980	100	100	89	0	0
1981	100	100	89	0	0
1982	100	100	90	0	0
1983	100	100	93	0	0

Model Year	Dual Master Cylinder	Front Disc Brakes	Power Boosters	Four-Wheel ABS	Rear-Wheel ABS
1984	100	100	96	0	0
1985	100	100	97	0	0
1986	100	100	99	1.7	0
1987	100	100	99	4.5	0.18
1988	100	100	100	5.1	0.08
1989	100	100	100	6.4	0.05
1990	100	100	100	11.1	0
1991	100	100	100	17	0
1992	100	100	100	32.2	0
1993	100	100	100	41.2	0
1994	100	100	100	55.5	0
1995	100	100	100	55.9	0
1996	100	100	100	58	0
1997	100	100	100	57.3	0
1998	100	100	100	60.7	0
1999	100	100	100	65.4	0
2000	100	100	100	63.1	0
2001	100	100	100	61.8	0
2002	100	100	100	62.5	0
2003	100	100	100	57.7	0
2004	100	100	100	61.3	0
2005	100	100	100	62.7	0
2006	100	100	100	71.5	0
2007	100	100	100	76.9	0
2008	100	100	100	79.9	0
2009	100	100	100	85.5	0
2010	100	100	100	97.4	0
2011	100	100	100	98.8	0
2012	100	100	100	100	0
2013	100	100	100	100	0

Model Year	Dual Master Cylinder	Front Disc Brakes	Power Boosters	Four-Wheel ABS	Rear-Wheel ABS
2014	100	100	100	100	0
2015	100	100	100	100	0
2016	100	100	100	100	0
2017	100	100	100	100	0
2018	100	100	100	100	0
2019	100	100	100	100	0

Dual Master Cylinders. Dual master cylinders were explicitly required by FMVSS No. 105 beginning on January 1, 1968, and were already implemented in all 1967 passenger cars. Dual master cylinders are the chief component of a split or dual brake system. A typical passenger car or LTV has a friction brake at each of its four wheels. These brakes are actuated through hydraulic pressure provided by the master cylinder as the brake pedal is depressed. A single brake system provides hydraulic fluid from one reservoir source to all four wheels. A typical split or dual brake system has two separate hydraulic circuits with a reservoir for the front brakes and one for the rear brakes. There are other dual braking systems that use a diagonal arrangement that has two circuits, each with one front wheel and one rear wheel on the opposite side of the vehicle. Without dual master cylinders, a failure in the brake hydraulic system can lead to a complete loss of braking capability. With dual brakes, however, if one of the circuits fails, the vehicle will retain braking capability with the other circuit. FMVSS No. 105 requires that vehicles must be able to stop within a specified distance from 60 mph when one of the brake hydraulic circuits is disabled. Furthermore, a brake warning light is required to illuminate whenever there is a gross loss of hydraulic pressure in one of the circuits.

NHTSA has done a teardown analysis of dual master cylinders. Forty-one make-model passenger cars representing pre-standard, post-standard, and trend systems were studied (Harvey et al., 1979), along with thirteen downsized make-model passenger cars (Gladstone et al., 1982d, pp. 2-1-2-19). Table 18 shows the sales-weighted average for the weight and consumer cost of master cylinders in 2019 dollars.

Table 18. FMVSS No. 105: Average weight and consumer cost of master cylinders in passenger cars

Category	Weight (lb)	Consumer Cost (2019$)
Single (Pre-Standard)	4.38	$36.77
Dual (Post-Standard)	6.12	$53.60
Dual (Trend)	7.97	$49.83
Dual (Downsized)	3.33	$48.04

Table 18 suggests that master cylinders decreased significantly in weight in the downsized passenger cars. The decrease was the result of a new, smaller cast-iron design and a new two-piece master cylinder unit with an aluminum-alloy bore and either a stamped steel or plastic reservoir.

To accurately allocate the average weight and consumer cost attributable to the standard in any given model year, it is necessary to separate the master cylinders into three time periods. Two conditions exist for the calculations. First, we assume that the average weight and consumer cost decreased at a linear rate from 1976 to 1982 and leveled off after that. Second, it is necessary to calculate what the weight and cost of master cylinders would have been if they had remained single instead of dual (because, presumably, the weight-saving technologies described above could also have been applied to a single master cylinder). The weight and cost figures are calculated using the following formulas.

1. Average Cost of Master Cylinders (1966-1976) =

   Cost of Post-Standard Dual Master Cylinders – Cost of Pre-Standard (Safety1965) Single Master Cylinders = $53.60 - $36.77 = $16.83

2. Average Cost of Master Cylinders (if they had remained single) =

   (Cost of Downsized Dual Master Cylinders/Cost of Post-Standard Dual Master Cylinders) * Cost of Pre-Standard Single Master Cylinders = ($48.04/$53.60) * $36.77 = $32.96

3. Average Cost of Master Cylinders (1982-2002) =

   Cost of Downsized Dual Master Cylinders – Cost of Master Cylinders (if they had remained single) = $48.04 – $32.96 = $15.08

4. Average Cost of Master Cylinders (CY), where 1977 ≤ CY ≤ 1981, =

   Costs in this time period are distributed by 83.33/16.67%, 66.67/33.33%, 50/50%, 33.33/66.67%, and 16.67/83.33% for the 5 model years respectively with the first percentage * $16.83 + the second percentage * $15.08. Thus, 1977 is 0.8333*$16.83 + 0.1667*$15.08.

   The learning curve is applied starting in 1982 if the average cost of $15.08 applies to MY 1982 models.

5. Average Weight of Master Cylinders (1966-1976) =

   Weight of Post-Standard Dual Master Cylinders – Weight of Pre-Standard (Safety1965) Single Master Cylinders = 6.12 – 4.38 = 1.74

6. Average Weight of Master Cylinders (if they had remained single) =

   (Weight of Downsized Dual Master Cylinders/Weight of Post-Standard Dual Master

   Cylinders) * Weight of Pre-Standard Single Master Cylinders = (3.33/6.12) * 4.38 = 2.38

7. Average Weight of Master Cylinders (1982-2002) =

   Weight of Downsized Dual Master Cylinders – Weight of Master Cylinders (if they had remained single) = 3.33 – 2.38 = 0.95

8. Average Weight of Master Cylinders (CY), where 1977 ≤ CY ≤ 1981, =

Weights are distributed by 83.33/16.67, 66.67/33.33, 50/50, 33.33/66.67, and 16.67/83.33% for the 5 model years respectively with the first percentage * 1.74 + the second percentage * 0.95. Thus, 1977 is 0.8333*1.74 + 0.1667*0.95.

Table 19 shows the average incremental weight and consumer cost of dual master cylinders, after subtracting the cost of single master cylinders (which are part of Safety1965), in passenger cars by model year after applying the learning curve. Because dual master cylinders were installed in 100 percent of passenger cars in the baseline year for this standard (MY 1967) these costs are considered voluntary costs.

Table 19. FMVSS No. 105: Incremental cost of dual master cylinders – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	1.7	0	1.7	$16.83	0	$16.83
1969	1.7	0	1.7	$16.83	0	$16.83
1970	1.7	0	1.7	$16.83	0	$16.83
1971	1.7	0	1.7	$16.83	0	$16.83
1972	1.7	0	1.7	$16.83	0	$16.83
1973	1.7	0	1.7	$16.83	0	$16.83
1974	1.7	0	1.7	$16.83	0	$16.83
1975	1.7	0	1.7	$16.83	0	$16.83
1976	1.7	0	1.7	$16.83	0	$16.83
1977	1.6	0	1.6	$16.54	0	$16.54
1978	1.5	0	1.5	$16.25	0	$16.25
1979	1.3	0	1.3	$15.95	0	$15.95
1980	1.2	0	1.2	$15.66	0	$15.66
1981	1.1	0	1.1	$15.37	0	$15.37
1982	1.0	0	1.0	$15.08	0	$15.08
1983	1.0	0	1.0	$15.02	0	$15.02
1984	1.0	0	1.0	$14.94	0	$14.94
1985	1.0	0	1.0	$14.87	0	$14.87
1986	1.0	0	1.0	$14.80	0	$14.80
1987	1.0	0	1.0	$14.74	0	$14.74
1988	1.0	0	1.0	$14.68	0	$14.68

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1989	1.0	0	1.0	$14.63	0	$14.63
1990	1.0	0	1.0	$14.58	0	$14.58
1991	1.0	0	1.0	$14.54	0	$14.54
1992	1.0	0	1.0	$14.50	0	$14.50
1993	1.0	0	1.0	$14.45	0	$14.45
1994	1.0	0	1.0	$14.41	0	$14.41
1995	1.0	0	1.0	$14.37	0	$14.37
1996	1.0	0	1.0	$14.33	0	$14.33
1997	1.0	0	1.0	$14.29	0	$14.29
1998	1.0	0	1.0	$14.25	0	$14.25
1999	1.0	0	1.0	$14.21	0	$14.21
2000	1.0	0	1.0	$14.17	0	$14.17
2001	1.0	0	1.0	$14.13	0	$14.13
2002	1.0	0	1.0	$14.10	0	$14.10
2003	1.0	0	1.0	$14.07	0	$14.07
2004	1.0	0	1.0	$14.03	0	$14.03
2005	1.0	0	1.0	$14.00	0	$14.00
2006	1.0	0	1.0	$13.97	0	$13.97
2007	1.0	0	1.0	$13.94	0	$13.94
2008	1.0	0	1.0	$13.91	0	$13.91
2009	1.0	0	1.0	$13.89	0	$13.89
2010	1.0	0	1.0	$13.87	0	$13.87
2011	1.0	0	1.0	$13.85	0	$13.85
2012	1.0	0	1.0	$13.82	0	$13.82
2013	1.0	0	1.0	$13.80	0	$13.80
2014	1.0	0	1.0	$13.77	0	$13.77
2015	1.0	0	1.0	$13.74	0	$13.74
2016	1.0	0	1.0	$13.72	0	$13.72
2017	1.0	0	1.0	$13.69	0	$13.69

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2018	1.0	0	1.0	$13.67	0	$13.67
2019	1.0	0	1.0	$13.65	0	$13.65

Front Disc Brakes. A change in the brake systems that was encouraged, although not required because of FMVSS No. 105, was the conversion of front brakes from a drum to a disc design. The basic brakes in Safety1965 include drum brakes. Disc brakes require less time to recover braking ability after being partially or fully submerged in water, plus they dissipate heat faster and are less likely to fade after repeated applications (e.g., on a long downhill grade). Furthermore, consumers prefer the superior feel of the car's braking power. Disc brakes experience linear relationships between brake pedal apply force and vehicle deceleration, without the tendency to grab like drum brakes. Manufacturers were encouraged by the capability of front disc brakes to meet the fade and recovery and water recovery requirements contained in FMVSS No. 105.

Front disc brakes began to appear on domestic passenger cars in MY 1965. They were not installed on all passenger cars and LTVs in MY 1965, thus they are not considered part of Safety1965. Consumers welcomed the new technology. The installation rate for disc brakes jumped from 13 percent of new cars in 1968 to 86 percent by 1973. The NPRM proposing FMVSS No. 105a was issued November 11, 1970, (35 FR 17345) making the baseline date September 1, 1970, or MY 1971. Although some cars with four-wheel drum brakes could and did pass the new tests, it was easier to meet them with front disc brakes. Furthermore, the superior self-adjusting characteristics of disc brakes allowed for increased vehicle stability during the high-speed stopping tests in FMVSS No. 105. By MY 1978, most cars and LTVs produced for sale in the United States had front disc brakes. (FMVSS No. 105 and 135 have never explicitly required disc brakes.)

The test for fade and recovery involved a repeated series of brake stops from a specific speed where the vehicle had to slow at a specific rate each time falling within minimum and maximum limits for brake pedal apply force. The test for water recovery ability involved driving a vehicle in any combination of forward and reverse directions through a trough having a water depth of 6 inches and then immediately performing a series of stops from 30 mph at a specified deceleration rate.

The sales-weighted average for the weight and consumer cost of front drum brakes from a sample of 1966 and 1968 MY vehicles was 57.47 lb and $224.56 in 2019 dollars. The front drum brake system included the brake drum, brake shoes with lining material, hydraulic wheel cylinder, brake adjuster, backing plate, springs, and miscellaneous hardware pieces. Early front disc brake systems (MY 1968 and 1976 passenger cars) weighed 70.99 lb and cost $204.09 in 2019 dollars. In other words, the early disc brake systems weighed more but cost less than drum brakes. The front disc brake system included the brake disc rotor, caliper, mounting bracket and bolts, backing plate, and brake pads with friction lining material. By 1977 to 1982, various cost- and weight-reducing technological improvements had significantly lowered the cost of disc brakes. Downsizing of the entire vehicle, resulting in opportunities to use less massive braking systems, also contributed to the cost and weight reduction for brakes. The weight dropped to an average of 50.36 lb, while the consumer cost dropped to an average of $104.51 in 2019 dollars. The role of FMVSS No. 105 in the shift to disc brakes is somewhat uncertain, but is a moot point since disc brakes, in the long term, had lower weight and cost than drum brakes. No weight and costs were included in the analysis for disc brakes since they eventually weighed less and costs less than drums brakes, which are the Safety1965 brakes.

Table 20 shows the overall weight and consumer cost of front brakes for the 1966/1968, 1968/1976, and 1977 to1982 make-model years.

Table 20. FMVSS No. 105: Average weight and consumer cost of front brakes in passenger cars

Category	Weight (lb)	Consumer Cost (2019$)
Drum (1966/68)	57.47	$224.56
Disc (1968/76)	70.99	$204.09
Disc (1977-1982)	50.36	$104.51

Power Boosters. As shown in Table 17, not all passenger cars in MY 1965 had power boosters, thus, power boosters are not part of Safety1965. While power boosters are not explicitly required to meet FMVSS No. 105, power boosters do help vehicles to stop quickly, especially under high speed or hazardous conditions. The stopping distance requirements, in conjunction with the brake pedal apply force requirements of FMVSS No. 105, encouraged manufacturers to use power boosters. Although some cars without power boosters could and did pass the stopping distance tests, it was easier to meet them with power boosters. It was difficult to stop cars within the distance and at the pedal pressure specified in FMVSS No. 105 unless they had power boosters. Furthermore, consumers like power boosters because they amplify the force applied by the driver to the brake pedal and allow even small drivers and older drivers to achieve high levels of vehicle braking on all sizes of vehicles. We decided power boosters are linked to FMVSS No. 105 because NHTSA proposed and later required a performance standard on stopping distance that resulted in the power boosters being used.

Table 21 shows the sales-weighted average weight and consumer cost (before applying the learning curve) of power boosters for the 1966, 1968, 1976, and downsized 1977 to1982 make-model passenger cars. For this analysis we assumed a linear increase in both cost and weight between 1968 and 1976, and then the learning curve was applied to costs starting in 1977. There was a significant reduction in weight and cost with downsizing in 1977.

Table 21. FMVSS No. 105: Average weight and consumer cost of power boosters in passenger cars

Model Year	Weight (lb)	Consumer Cost (2019$)	% of Cars with Power Brakes	Consumer Cost (2019$) Per Car
1966	7.61	$62.76	35.31	$22.16
1968	9.27	$63.01	31.50	$19.85
1976	11.60	$75.93	80.90	$61.43
1977-1982	7.86	$55.68	84.24	$46.90

The NPRM proposing FMVSS No. 105a was issued November 11, 1970, (35 FR 17345) making the baseline date September 1, 1970, or MY 1971. Thus, the percentage of passenger cars with power boosters in MY 1971 and earlier MYs are considered voluntary, the installation rate of the MY 1971 baseline year (50% installation) is considered voluntary for all MY 1972 and later passenger cars, and the difference between the percentage of the fleet with power boosters and 50 percent for all MY 1972 passenger cars and later are considered attributable.

Table 22 shows the resulting voluntary and attributable estimated weights and costs for the average passenger car after applying the percentage of the passenger cars with power boosters found in Table 17. In this case there is no need to show a separate table with weights and costs after applying the learning curve and before the baseline, voluntary, and attributable decisions, because the total columns shows the same information.

Table 22. FMVSS No. 105: Power boosters for passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	3.8	0	3.8	$25.83	0	$25.83
1969	4.2	0	4.2	$28.44	0	$28.44
1970	4.6	0	4.6	$31.13	0	$31.13
1971	5.1	0	5.1	$33.93	0	$33.93
1972	5.2	1.9	7.1	$34.74	$12.50	$47.24
1973	5.4	1.8	7.2	$35.54	$12.08	$47.63
1974	5.5	1.9	7.4	$36.35	$12.36	$48.71
1975	5.7	2.7	8.4	$37.16	$17.84	$54.99
1976	5.8	3.6	9.4	$37.96	$23.54	$61.50
1977	3.9	2.8	6.7	$27.84	$19.49	$47.33
1978	3.9	3.0	6.9	$27.47	$20.88	$48.34
1979	3.9	3.0	6.9	$27.17	$20.65	$47.81
1980	3.9	3.1	7.0	$26.94	$21.02	$47.96
1981	3.9	3.1	7.0	$26.75	$20.87	$47.62
1982	3.9	3.1	7.1	$26.57	$21.26	$47.83
1983	3.9	3.4	7.3	$26.38	$22.68	$49.06
1984	3.9	3.6	7.5	$26.15	$24.06	$50.22
1985	3.9	3.7	7.6	$25.93	$24.37	$50.30
1986	3.9	3.9	7.8	$25.71	$25.20	$50.91
1987	3.9	3.9	7.8	$25.52	$25.01	$50.54

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1988	3.9	3.9	7.9	$25.35	$25.35	$50.69
1989	3.9	3.9	7.9	$25.19	$25.19	$50.38
1990	3.9	3.9	7.9	$25.05	$25.05	$50.10
1991	3.9	3.9	7.9	$24.93	$24.93	$49.86
1992	3.9	3.9	7.9	$24.82	$24.82	$49.63
1993	3.9	3.9	7.9	$24.69	$24.69	$49.39
1994	3.9	3.9	7.9	$24.57	$24.57	$49.14
1995	3.9	3.9	7.9	$24.46	$24.46	$48.91
1996	3.9	3.9	7.9	$24.34	$24.34	$48.69
1997	3.9	3.9	7.9	$24.24	$24.24	$48.47
1998	3.9	3.9	7.9	$24.13	$24.13	$48.26
1999	3.9	3.9	7.9	$24.02	$24.02	$48.05
2000	3.9	3.9	7.9	$23.92	$23.92	$47.83
2001	3.9	3.9	7.9	$23.82	$23.82	$47.63
2002	3.9	3.9	7.9	$23.72	$23.72	$47.44
2003	3.9	3.9	7.9	$23.63	$23.63	$47.26
2004	3.9	3.9	7.9	$23.54	$23.54	$47.09
2005	3.9	3.9	7.9	$23.46	$23.46	$46.92
2006	3.9	3.9	7.9	$23.38	$23.38	$46.76
2007	3.9	3.9	7.9	$23.30	$23.30	$46.60
2008	3.9	3.9	7.9	$23.23	$23.23	$46.45
2009	3.9	3.9	7.9	$23.18	$23.18	$46.36
2010	3.9	3.9	7.9	$23.13	$23.13	$46.25
2011	3.9	3.9	7.9	$23.07	$23.07	$46.14
2012	3.9	3.9	7.9	$23.00	$23.00	$46.01
2013	3.9	3.9	7.9	$22.94	$22.94	$45.87
2014	3.9	3.9	7.9	$22.87	$22.87	$45.74
2015	3.9	3.9	7.9	$22.80	$22.80	$45.59
2016	3.9	3.9	7.9	$22.74	$22.74	$45.47

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2017	3.9	3.9	7.9	$22.68	$22.68	$45.35
2018	3.9	3.9	7.9	$22.62	$22.62	$45.24
2019	3.9	3.9	7.9	$22.56	$22.56	$45.13

Total Brake System. The total brake system (before ABS) includes the front- and rear-brake assembly, master cylinder, foot pedal and linkage, power booster, warning light, proportional valve, and parking brake system. For informational purposes Table 23 shows the sales-weighted average weight and consumer cost of the total brake system for the 1966, 1968, 1976, and 1977 to 1982 make-models. These costs are not included in the analysis. Again, the substantial drop in the weight and consumer cost of 1977 to 1982 brake systems is the result of specific new weight- and cost-saving brake technologies as well as the downsizing of the overall vehicle. Except for the cost impact of dual master cylinders in 1967 and power boosters, there is little evidence that any of the other major cost changes over the years are directly related to FMVSS No. 105 or that these costs would have been different in the absence of the standard.

Table 23. FMVSS No. 105: Average weight and consumer cost of the total brake system in passenger cars

Model Year	Weight (lb)	Consumer Cost (2019$)
1966	132.60	$657.93
1968	147.33	$699.56
1976	166.69	$728.04
1977-1982	117.21	$489.62

Antilock Brake Systems. ABSs were developed by the motor vehicle industry and voluntarily installed by manufacturers beginning in the mid-1980s on passenger cars and LTVs. Two different types of ABS systems were installed (rear-wheel ABS and four-wheel ABS). ABS was developed to prevent wheel lockup during hard braking on wet roads and during combination turning and braking maneuvers. When wheels lock up, the vehicle cannot respond correctly to steering maneuvers. When braking on low friction surfaces, standard brakes are not as effective in stopping the vehicle because the braking force is uniform to all wheels, even the ones that have little or no traction. ABS works by constantly measuring wheel speed; and, when it senses that a wheel is locking up, it decreases the braking force to that wheel. Rear-wheel ABS only controls the back two wheels. Four-wheel ABS also enables the driver to steer the vehicle in a controlled manner while stopping. Rear-wheel ABS was used on very few passenger cars. Many LTVs had rear-wheel ABS, and then all LTVs were changed to four-wheel ABS by MY 2004.

No type of ABS has ever been required for passenger vehicles with GVWR of 10,000 lb or less. However, the Highway Safety Act of 1991, Section 2507 instructed NHTSA to consider requiring ABS in passenger vehicles. NHTSA published an ANPRM at the beginning of 1994 asking for information about the effectiveness and potential benefits of ABS technologies.[7] Based on responses to the 1994 ANPRM, including statistical studies by NHTSA and others that failed to show significant net benefits for voluntarily installed ABS, NHTSA issued a second ANPRM in 1996 deferring indefinitely the ABS requirement (Kahane, 1993, 1994).[8] These studies concluded that ABS had mixed effectiveness results, and the agency subsequently decided not to go forth with rulemaking to require ABS for passenger vehicles.

Rear-wheel ABS was only installed on a small number of passenger cars. The only passenger cars with rear-wheel ABS are MYs 1987 to 1989 Chrysler Conquest (100% have rear-wheel ABS), MY 1987 Mitsubishi Starion (72% with rear-wheel ABS) and MY 1989 Mitsubishi Starion (100% with rear-wheel ABS). The estimated sales of the Chrysler Conquest were 13,975 in MY 1987; 8,605 in MY 1988; and 4,502 in MY 1989. The estimated sales of the Mitsubishi Starion were 6,264 in MY 1987 (of which 4,510 had rear-wheel ABS) and 130 vehicles in MY 1989. Combined these vehicles with rear-wheel ABS comprised 0.18 percent of MY 1987 passenger car sales, 0.08 percent in MY 1988, and 0.05 percent in MY 1989.

Four-wheel ABS was installed on an increasing number of passenger cars. Table 17 shows the percentage of passenger cars with four-wheel and rear-wheel ABS by model year (Kahane & Dang, 2009).[9]

The major ABS components are the wheel speed sensors and rings, the control unit, the modulator unit, and the wiring harness. The wheel speed sensors and rings provide an electrical signal to the ABS controller that is proportional to the wheel speed. The ABS controller is a computer that interprets and compares the signal from all the wheel speed sensors and sends control signals to the ABS modulator. The ABS modulator controls the hydraulic brake fluid pressure for each wheel. When the ABS controller interprets a signal from a wheel speed sensor as a wheel lock-up condition, a signal is sent to the modulator to rapidly pulse the hydraulic pressure at that particular wheel releasing the brake until the proper wheel speed has been restored. The wiring harness provides electrical power to the ABS controller and connects the speed sensors and the modulator to the controller.

The agency has estimated the weight and cost of four-wheel ABS in three different teardown studies. We will present the weight and costs for four-wheel passenger cars and LTVs together under the assumption that the weights and costs are similar between passenger cars and LTVs. The agency also has one teardown estimate for the weight and cost of a rear-wheel ABS system.

In 1991, NHTSA analyzed the cost of seven different four-wheel ABS systems in 5 passenger cars and two LTVs from MY 1988 to 1990 (Fladmark & Khadilkar, 1991, 1991a). Table 24 shows the sales-weighted average weight and consumer cost of ABS in these seven models. These are the incremental weights and costs of ABS, above and beyond the pre-ABS hydraulic brake system.

In 1994, NHTSA looked at the four-wheel ABS systems in one 1992 and one 1993 passenger car and a 1994 SUV (Fladmark & Khadilkar, 1994a).

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[7] *Federal Register* 59 (January 4, 1994): 281.

[8] *Federal Register* 61 (July 12, 1996): 36698.

[9] The ABS data for passenger cars and LTVs is from a spreadsheet that created Figures 1 and 2.

In 2006, NHTSA examined four-wheel ABS in 11 vehicles (5 passenger cars and 6 LTVs), 9 of which were MY 2005 vehicles, one from MY 2004 and one from MY 2006 (Ludtke & Associates, 2006). The estimates were summarized in the Final Regulatory Impact Analysis that accompanied the final rule on ESC (NHTSA, 2007). Based on the teardowns of a variety of vehicles of Asian, European, and domestic passenger cars and LTVs, it was assumed that the same cost would apply for both passenger cars and LTVs. The estimates were incremental to the hydraulic brake systems already on the vehicles. Table 24 shows these estimates and Table 25 shows details for the 2004 to 2006 models. Antilock brakes was one of the technologies used to set the learning curve progress rates. The learning curve for four-wheel ABS was applied to the $472.75 (2019$) estimate based in 2005 for all years from 1986 to 2019 with a progress rate of 0.87.

Since the rear-wheel ABS systems and the four-wheel ABS systems were essentially the same (only differing in the teardown study by the two front wheel speed sensors), we have combined the cumulative sales from both the rear-wheel and four-wheel ABS systems when using the learning curve for both the rear-wheel and four-wheel ABS systems.

Weight estimates for four-wheel ABS for passenger cars were taken from Table 24 using 35.29 lb for MY 1986 to 1990, 23.51 lb for MY 1992 to 1994, 10.70 lb from MY 2004 to 2019, and interpolations with linearly decreasing weights for the years in between.

Table 24. FMVSS No. 105: Average weights and costs for antilock brake systems – four-wheel passenger cars and LTVs

Model Years	Weight (lb)	Consumer Cost (2019$)
1989 - 1990	35.29	$848.89
1992 - 1994	23.51	$754.34
2004 - 2006	10.70	$472.75

Table 25. FMVSS No. 105: MY 2004-2006 components of four-wheel ABS passenger cars and LTVs

Components	Weight (lb)	Consumer Cost (2019$)
Speed sensors	3.22	$77.52
Integrated Control Unit/ Hydraulic Control Unit	6.78	$372.72
Wires/Telltale/Hardware	0.7	$22.52
Total	10.70	$472.75

Costs and weights for rear-wheel ABS systems were taken from the same Ludtke (2006) study. Vehicles #9 and #10 in that teardown study were the same make/model one year apart, one with a rear-wheel ABS system (MY 2004) and one with a four-wheel ABS system. The estimated costs (2019$) were $481.00 for the rear-wheel system and $514.03 for the four-wheel system. All the difference in costs was made up by the additional 2-wheel speed sensors for the front wheels of the four-wheel system. The weights were essentially identical, with the weight for the four-wheel system being slightly less (0.27 lb), probably because it is one model year later and some weight was taken out. The electronic control system in both models were identical.

Since our average cost for the four-wheel ABS system is $472.75 (different than the cost of the particular make/model used in the rear-wheel ABS teardown study), we'll use the ratio of the rear-wheel system cost to the four-wheel system cost ($481.00/$514.03) = 0.9357 times the average cost of the four-wheel system to estimate the cost of the rear-wheel ABS system or $442.38 ($472.75*0.9357). This cost will be put into the learning curve for rear-wheel ABS systems based on a MY 2005 vehicle. We'll assume the same weights as assumed for the four-wheel system which change based on model years as described above.

ABS became attributable when ESC in FMVSS No. 126 was proposed because it provides the basic elements necessary for ESC to function properly. On September 18, 2006, NHTSA proposed FMVSS No. 126[10] and the baseline date is September 1, 2006, or MY 2007. Thus, the percentage of passenger cars and LTVs equipped with ABS in MY 2007 and earlier model years are considered voluntary, the MY 2007 baseline year installation rate (76.9% installation for passenger cars) is considered voluntary for all MY 2008 and later passenger cars, and the difference between the percentage of the fleet with ABS and 76.9 percent for passenger cars for MY 2008 and later are considered attributable.

On April 6, 2007, NHTSA issued FMVSS No. 126 to require ESC on passenger cars, multipurpose vehicles, trucks, and buses with a GVWR of 10,000 lb or less: all new vehicles by MY 2012, with a phase-in comprising 55 percent of MY 2009 sales, 75 percent of MY 2010, and 95 percent of MY 2011, and 10 percent of MY 2012.

Table 26 shows the resulting weight and cost estimates for voluntarily and attributable provided ABS by model year for passenger cars. This table includes both the four-wheel and rear-wheel systems. The few rear-wheel systems added to the average passenger car $2.08 and 0.06 lb in MY 1987, $0.80 and 0.03 lb in MY 1988, and $0.41 and 0.02 lb in MY 1988. There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Table 26. As noted, ABS provided basic components that ESC needed to function properly. One could thus consider the attributable costs of ABS in MY 2008 and later to be associated with FMVSS No. 126 rather than with FMVSS No. 105/135. We account for them here since we are separately analyzing this specific technology, but a full accounting of ESC costs would add the attributable portion of ABS to the ESC sensor costs, which are discussed later in this report.

[10] 71 FR 54712, Docket No. 2006-25801. The abbreviation used to find articles published in the Federal Register (71 FR 54712) means the 71st Volume of the Federal Register starting on page 54712.

Table 26. FMVSS No. 105/135: ABS for passenger cars – four-wheel and rear-wheel systems combined

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1985	0.0	0.0	0.0	$0.00	$0.00	$0.00
1986	0.6	0.0	0.6	$31.49	$0.00	$31.49
1987	1.7	0.0	1.7	$57.83	$0.00	$57.83
1988	1.8	0.0	1.8	$54.11	$0.00	$54.11
1989	2.3	0.0	2.3	$59.01	$0.00	$59.01
1990	3.9	0.0	3.9	$91.76	$0.00	$91.76
1991	5.0	0.0	5.0	$130.85	$0.00	$130.85
1992	7.6	0.0	7.6	$231.20	$0.00	$231.20
1993	9.7	0.0	9.7	$277.85	$0.00	$277.85
1994	13.0	0.0	13.0	$352.95	$0.00	$352.95
1995	12.4	0.0	12.4	$339.46	$0.00	$339.46
1996	12.1	0.0	12.1	$338.58	$0.00	$338.58
1997	11.3	0.0	11.3	$323.54	$0.00	$323.54
1998	11.2	0.0	11.2	$332.58	$0.00	$332.58
1999	11.2	0.0	11.2	$348.03	$0.00	$348.03
2000	10.0	0.0	10.0	$327.27	$0.00	$327.27
2001	9.0	0.0	9.0	$313.45	$0.00	$313.45
2002	8.3	0.0	8.3	$310.76	$0.00	$310.76
2003	6.9	0.0	6.9	$281.80	$0.00	$281.80
2004	6.6	0.0	6.6	$294.41	$0.00	$294.41
2005	6.7	0.0	6.7	$296.41	$0.00	$296.41
2006	7.7	0.0	7.7	$332.87	$0.00	$332.87
2007	8.2	0.0	8.2	$352.68	$0.00	$352.68
2008	8.2	0.3	8.6	$347.83	$13.69	$361.53
2009	8.2	0.9	9.2	$344.86	$38.68	$383.54
2010	8.2	2.2	10.4	$341.25	$90.86	$432.11
2011	8.2	2.3	10.6	$337.33	$95.87	$433.20
2012	8.2	2.5	10.7	$333.26	$100.11	$433.37

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2013	8.2	2.5	10.7	$329.14	$98.87	$428.00
2014	8.2	2.5	10.7	$325.19	$97.68	$422.87
2015	8.2	2.5	10.7	$321.12	$96.46	$417.59
2016	8.2	2.5	10.7	$317.86	$95.48	$413.34
2017	8.2	2.5	10.7	$314.68	$94.53	$409.21
2018	8.2	2.5	10.7	$311.76	$93.65	$405.41
2019	8.2	2.5	10.7	$309.09	$92.85	$401.94

LTV Studies

Brake System Components. NHTSA extended FMVSS No. 105 (January 2, 1981, 46 FR 55), effective in September 1983, for the 1984 MY pickup trucks, vans, SUVs, and other vehicle classes with hydraulic brake systems. The NPRM was published on October 18, 1979, (44 FR 60113) making the baseline date MY 1980. Essentially the same types of requirements that applied to passenger cars and school buses were now required for LTVs with hydraulic brake systems. Table 27 shows the percentages of LTVs with the four countermeasures considered in this analysis, dual master cylinders, front disc brakes, power boosters, and ABS.

Table 27. FMVSS No. 105: Percentages of LTVs with dual master cylinders, front disk brakes, power boosters, and ABS by model year

Model Year	Dual Master Cylinder	Front Disc Brakes	Power Boosters	Four-wheel ABS	Rear-wheel ABS
1968	100	30	70	0	0
1969	100	30	70	0	0
1970	100	30	70	0	0
1971	100	30	70	0	0
1972	100	46	70	0	0
1973	100	64	70	0	0
1974	100	61	70	0	0
1975	100	75	70	0	0
1976	100	82	70	0	0
1977	100	87	70	0	0
1978	100	89	70	0	0
1979	100	89	70	0	0

Model Year	Dual Master Cylinder	Front Disc Brakes	Power Boosters	Four-wheel ABS	Rear-wheel ABS
1980	100	90	70	0	0
1981	100	85	70	0	0
1982	100	89	70	0	0
1983	100	93	70	0	0
1984	100	94	100	0	0
1985	100	97	100	0	0
1986	100	99	100	0	0
1987	100	99	100	0	15.5
1988	100	100	100	0	27.9
1989	100	100	100	0.2	52.4
1990	100	100	100	1.9	69.9
1991	100	100	100	5.4	72.4
1992	100	100	100	10.4	69.7
1993	100	100	100	29.7	53.3
1994	100	100	100	30.8	53.5
1995	100	100	100	53.3	36.3
1996	100	100	100	61.0	29.3
1997	100	100	100	59.8	31.5
1998	100	100	100	67.6	22.7
1999	100	100	100	71.5	18.4
2000	100	100	100	73.8	15.8
2001	100	100	100	81.3	7.3
2002	100	100	100	82.3	6.2
2003	100	100	100	87.2	4.3
2004	100	100	100	88.5	0
2005	100	100	100	90.3	0
2006	100	100	100	92.4	0
2007	100	100	100	94.6	0
2008	100	100	100	95.9	0
2009	100	100	100	99.4	0

Model Year	Dual Master Cylinder	Front Disc Brakes	Power Boosters	Four-wheel ABS	Rear-wheel ABS
2010	100	100	100	99.8	0
2011	100	100	100	100	0
2012	100	100	100	100	0
2013	100	100	100	100	0
2014	100	100	100	100	0
2015	100	100	100	100	0
2016	100	100	100	100	0
2017	100	100	100	100	0
2018	100	100	100	100	0
2019	100	100	100	100	0

Dual Master Cylinders. FMVSS No. 105 explicitly requires a dual braking system (i.e., dual master cylinders) in all vehicles it regulates, including LTVs. Dual master cylinders were not installed in all MY 1965 LTVs and are not considered part of Safety1965. Because dual master cylinders were installed in 100 percent of LTVs in MY 1967, long before the MY 1980 baseline date for LTVs these costs are included as voluntary costs of the FMVSS.

Since NHTSA has not performed any teardowns of LTVs master cylinders, we will assume the same cost for dual master cylinders in LTVs as in passenger cars (although it is conceivable that truck systems could cost more to the extent that LTVs are usually heavier vehicles than passenger cars). Table 19 shows the average weight and consumer cost after applying the learning curve of dual master cylinders compared to single master cylinders for passenger cars (which we believe would be the same cost for LTVs). Table 28 shows the incremental weight and cost of dual master cylinders for LTVs.

Table 28. FMVSS No. 105: Incremental cost of dual master cylinders – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	1.7	0	1.7	$16.83	0	$16.83
1969	1.7	0	1.7	$16.83	0	$16.83
1970	1.7	0	1.7	$16.83	0	$16.83
1971	1.7	0	1.7	$16.83	0	$16.83
1972	1.7	0	1.7	$16.83	0	$16.83
1973	1.7	0	1.7	$16.83	0	$16.83
1974	1.7	0	1.7	$16.83	0	$16.83

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1975	1.7	0	1.7	$16.83	0	$16.83
1976	1.7	0	1.7	$16.83	0	$16.83
1977	1.5	0	1.5	$16.54	0	$16.54
1978	1.3	0	1.3	$16.25	0	$16.25
1979	1.2	0	1.2	$15.95	0	$15.95
1980	1.1	0	1.1	$15.66	0	$15.66
1981	1.0	0	1.0	$15.37	0	$15.37
1982	1.0	0	1.0	$15.08	0	$15.08
1983	1.0	0	1.0	$15.02	0	$15.02
1984	1.0	0	1.0	$14.94	0	$14.94
1985	1.0	0	1.0	$14.87	0	$14.87
1986	1.0	0	1.0	$14.80	0	$14.80
1987	1.0	0	1.0	$14.74	0	$14.74
1988	1.0	0	1.0	$14.68	0	$14.68
1989	1.0	0	1.0	$14.63	0	$14.63
1990	1.0	0	1.0	$14.58	0	$14.58
1991	1.0	0	1.0	$14.54	0	$14.54
1992	1.0	0	1.0	$14.50	0	$14.50
1993	1.0	0	1.0	$14.45	0	$14.45
1994	1.0	0	1.0	$14.41	0	$14.41
1995	1.0	0	1.0	$14.37	0	$14.37
1996	1.0	0	1.0	$14.33	0	$14.33
1997	1.0	0	1.0	$14.29	0	$14.29
1998	1.0	0	1.0	$14.25	0	$14.25
1999	1.0	0	1.0	$14.21	0	$14.21
2000	1.0	0	1.0	$14.17	0	$14.17
2001	1.0	0	1.0	$14.13	0	$14.13
2002	1.0	0	1.0	$14.10	0	$14.10
2003	1.0	0	1.0	$14.07	0	$14.07

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2004	1.0	0	1.0	$14.03	0	$14.03
2005	1.0	0	1.0	$14.00	0	$14.00
2006	1.0	0	1.0	$13.97	0	$13.97
2007	1.0	0	1.0	$13.94	0	$13.94
2008	1.0	0	1.0	$13.91	0	$13.91
2009	1.0	0	1.0	$13.89	0	$13.89
2010	1.0	0	1.0	$13.87	0	$13.87
2011	1.0	0	1.0	$13.85	0	$13.85
2012	1.0	0	1.0	$13.82	0	$13.82
2013	1.0	0	1.0	$13.80	0	$13.80
2014	1.0	0	1.0	$13.77	0	$13.77
2015	1.0	0	1.0	$13.74	0	$13.74
2016	1.0	0	1.0	$13.72	0	$13.72
2017	1.0	0	1.0	$13.69	0	$13.69
2018	1.0	0	1.0	$13.67	0	$13.67
2019	1.0	0	1.0	$13.65	0	$13.65

Disc Brakes. As discussed in passenger cars above, since front disc brakes, in the long term, had lower weight and cost than drum brakes (see Table 20), no cost is added to this analysis for front disc brakes for LTVs.

Power Boosters. While power boosters are not explicitly required to meet FMVSS No. 105, power boosters do help vehicles to stop quickly, especially under high speed or hazardous conditions. The stopping distance requirements, in conjunction with the brake pedal apply force requirements of FMVSS No. 105, encouraged manufacturers to use power boosters. Although some LTVs without power boosters did pass the stopping distance tests, it was easier to meet them with power boosters. We decided power boosters are linked to FMVSS No. 105 because NHTSA proposed and later required a performance standard on stopping distance that resulted in the power boosters being used.

Table 29 shows the voluntary and attributable costs for power boosters for LTVs by year. There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Table 29. The final rule requiring FMVSS No. 105a for passenger cars and LTVs was published September 2, 1972, (37 FR 17970). The NPRM proposing FMVSS No. 105a was issued November 11, 1970, (35 FR 17345) making the baseline date September 1, 1970, or MY 1971. Since power boosters were installed in 30 percent of all LTVs in MY 1971, the 30 percent are considered voluntary for all MY 1971 and later LTVs, and the difference between the percentage of the fleet with power boosters and 30 percent for LTVs for MY 1972 and later are considered attributable.

Table 29. FMVSS No. 105: Power boosters for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	2.8	0	2.8	$18.90	0	$18.90
1969	2.9	0	2.9	$19.39	0	$19.39
1970	3.0	0	3.0	$19.87	0	$19.87
1971	3.0	0	3.0	$20.36	0	$20.36
1972	3.1	1.7	4.8	$20.84	$11.12	$31.96
1973	3.2	3.6	6.9	$21.33	$24.17	$45.49
1974	3.3	3.4	6.7	$21.81	$22.54	$44.35
1975	3.4	5.1	8.5	$22.29	$33.44	$55.74
1976	3.5	6.0	9.5	$22.78	$39.48	$62.26
1977	2.4	4.5	6.8	$16.70	$31.74	$48.44
1978	2.4	4.6	7.0	$16.48	$32.41	$48.89
1979	2.4	4.6	7.0	$16.30	$32.06	$48.36
1980	2.4	4.7	7.1	$16.17	$32.33	$48.50
1981	2.4	4.3	6.7	$16.05	$29.43	$45.48
1982	2.4	4.6	7.0	$15.94	$31.36	$47.30
1983	2.4	5.0	7.3	$15.83	$33.23	$49.06
1984	2.4	5.0	7.4	$15.69	$33.48	$49.17
1985	2.4	5.3	7.6	$15.56	$34.75	$50.30
1986	2.4	5.4	7.8	$15.43	$35.48	$50.91
1987	2.4	5.4	7.8	$15.31	$35.22	$50.54
1988	2.4	5.5	7.9	$15.21	$35.48	$50.69
1989	2.4	5.5	7.9	$15.11	$35.27	$50.38
1990	2.4	5.5	7.9	$15.03	$35.07	$50.10
1991	2.4	5.5	7.9	$14.96	$34.90	$49.86
1992	2.4	5.5	7.9	$14.89	$34.74	$49.63
1993	2.4	5.5	7.9	$14.82	$34.57	$49.39
1994	2.4	5.5	7.9	$14.74	$34.40	$49.14

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1995	2.4	5.5	7.9	$14.67	$34.24	$48.91
1996	2.4	5.5	7.9	$14.61	$34.08	$48.69
1997	2.4	5.5	7.9	$14.54	$33.93	$48.47
1998	2.4	5.5	7.9	$14.48	$33.78	$48.26
1999	2.4	5.5	7.9	$14.41	$33.63	$48.05
2000	2.4	5.5	7.9	$14.35	$33.48	$47.83
2001	2.4	5.5	7.9	$14.29	$33.34	$47.63
2002	2.4	5.5	7.9	$14.23	$33.21	$47.44
2003	2.4	5.5	7.9	$14.18	$33.08	$47.26
2004	2.4	5.5	7.9	$14.13	$32.96	$47.09
2005	2.4	5.5	7.9	$14.08	$32.84	$46.92
2006	2.4	5.5	7.9	$14.03	$32.73	$46.76
2007	2.4	5.5	7.9	$13.98	$32.62	$46.60
2008	2.4	5.5	7.9	$13.94	$32.52	$46.45
2009	2.4	5.5	7.9	$13.91	$32.45	$46.36
2010	2.4	5.5	7.9	$13.88	$32.38	$46.25
2011	2.4	5.5	7.9	$13.84	$32.30	$46.14
2012	2.4	5.5	7.9	$13.80	$32.21	$46.01
2013	2.4	5.5	7.9	$13.76	$32.11	$45.87
2014	2.4	5.5	7.9	$13.72	$32.02	$45.74
2015	2.4	5.5	7.9	$13.68	$31.92	$45.59
2016	2.4	5.5	7.9	$13.64	$31.83	$45.47
2017	2.4	5.5	7.9	$13.61	$31.75	$45.35
2018	2.4	5.5	7.9	$13.57	$31.67	$45.24
2019	2.4	5.5	7.9	$13.54	$31.59	$45.13

Other Brake Subsystem Components. A study was conducted on eight pre-standard (1983), and their corresponding post-standard (1984), make-model LTVs from the three-major U.S. Manufacturers (Adams et al., 1985). Costs were estimated only for those subsystems of the brake systems of LTVs that were a new or changed design in 1984. The front brake pads, rear brake systems, brake power boosters, emergency brake warning switch, and variable proportioning valve subsystems of Dodge, Ford, and GM trucks were studied.

The front brake pads and rear brake shoes on the pre-standard and post-standard LTV make-models were compared. The major change was in the brake pad, shoe lining material, and size. Pre-standard pads or linings were often made from asbestos-based or inorganic materials, whereas post-standard pads or linings are made of non-asbestos or semi-metallic materials. The elimination of the asbestos-based materials in the post-standard pads or linings was a result of the health hazards associated with its use in the manufacture of friction brake lining material and the maintenance of the brake systems. It was not a requirement of FMVSS No. 105. The semi-metallic materials were used to improve brake system fade performance and durability characteristics.

An emergency brake warning switch was added to the Ford trucks to comply with the brake system indicator lamp requirements. Vehicle height-sensitive variable rate proportioning valves were employed on the rear brakes to perhaps improve stopping distance performance when the LTVs were tested in a lightly loaded condition.

Table 30 shows the sales-weighted average weight and consumer cost of front brake pads, rear brakes, rear shoes, proportioning valves, and emergency brake warning switch for the 1983 and 1984 make-model LTVs.

Table 30. FMVSS No. 105: Average weight and consumer cost of brake system components in LTVs

Make-Model	Component	Model Year	Weight in Pounds	Consumer Cost ($2019)
Dodge 150	Front Pads	1983	1.21	$18.67
		1984	2.10	$28.00
	Rear Brakes	1983	50.29	$118.01
		1984	64.51	$134.19
Dodge 350	Front Pads	1983	1.63	$25.03
		1984	2.81	$37.55
Dodge MPV	Variable Valve	1984	1.50	$39.43
Ford – All Trucks	Warning Light Emergency Brake	1984	0.03	$ 0.55
Ford F-150	Rear Shoes	1983	1.48	$22.81
		1984	1.77	$25.10

Make-Model	Component	Model Year	Weight in Pounds	Consumer Cost ($2019)
Ford F-250	Front Pads	1983	1.03	$15.91
		1984	1.23	$17.49
	Rear Shoes	1983	1.75	$26.96
		1984	1.80	$27.71
	Variable Valve	1984	2.90	$15.48
Ford F-350	Front Pads	1983	2.44	$37.90
		1984	2.91	$41.69
GMC 1500	Front Pads	1983	1.14	$17.49
		1984	1.36	$26.24
GMC 2500	Front Pads	1983	1.14	$17.49
		1984	1.36	$26.24
	Variable Valve	1984	3.04	$21.05
GMC 3500	Front Pads	1983	1.37	$21.15
		1984	1.64	$31.73
	Variable Valve	1984	3.04	$17.34

Except for the emergency brake warning switch in Ford trucks, NHTSA does not have strong evidence that any of these changes were directly motivated by FMVSS No. 105 or actually needed to assure compliance with the standard. Therefore, only the cost and weight of the warning light emergency brake switch is attributed to FMVSS No. 105 (0.03 lb and $0.55). Although we don’t have data to verify this, we assume that other manufacturers provided a warning light brake switch starting in MY 1968. Since Ford accounted for 30 percent of truck sales in 1984, we assume voluntary compliance for 70 percent of the fleet from MY 1968 and 30 percent attributable to the standard from MY 1984 to 2019. Table 31 shows the average weight and consumer cost of brake system warning lights after applying the learning curve for FMVSS No. 105 in LTVs.

Table 31. FMVSS No. 105: Average weight and consumer cost warning light brake switch in LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.02	0	0.02	$0.52	0	$0.52
1969	0.02	0	0.02	$0.48	0	$0.48
1970	0.02	0	0.02	$0.46	0	$0.46
1971	0.02	0	0.02	$0.45	0	$0.45
1972	0.02	0	0.02	$0.44	0	$0.44
1973	0.02	0	0.02	$0.43	0	$0.43
1974	0.02	0	0.02	$0.42	0	$0.42
1975	0.02	0	0.02	$0.42	0	$0.42
1976	0.02	0	0.02	$0.41	0	$0.41
1977	0.02	0	0.02	$0.41	0	$0.41
1978	0.02	0	0.02	$0.40	0	$0.40
1979	0.02	0	0.02	$0.40	0	$0.40
1980	0.02	0	0.02	$0.40	0	$0.40
1981	0.02	0	0.02	$0.39	0	$0.39
1982	0.02	0	0.02	$0.39	0	$0.39
1983	0.02	0	0.02	$0.39	0	$0.39
1984	0.02	0.01	0.03	$0.38	$0.16	$0.55
1985	0.02	0.01	0.03	$0.38	$0.16	$0.55
1986	0.02	0.01	0.03	$0.38	$0.16	$0.54
1987	0.02	0.01	0.03	$0.38	$0.16	$0.54
1988	0.02	0.01	0.03	$0.37	$0.16	$0.53
1989	0.02	0.01	0.03	$0.37	$0.16	$0.53
1990	0.02	0.01	0.03	$0.37	$0.16	$0.53
1991	0.02	0.01	0.03	$0.37	$0.16	$0.53
1992	0.02	0.01	0.03	$0.37	$0.16	$0.52
1993	0.02	0.01	0.03	$0.36	$0.16	$0.52
1994	0.02	0.01	0.03	$0.36	$0.16	$0.52
1995	0.02	0.01	0.03	$0.36	$0.15	$0.52

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	0.02	0.01	0.03	$0.36	$0.15	$0.51
1997	0.02	0.01	0.03	$0.36	$0.15	$0.51
1998	0.02	0.01	0.03	$0.36	$0.15	$0.51
1999	0.02	0.01	0.03	$0.36	$0.15	$0.51
2000	0.02	0.01	0.03	$0.35	$0.15	$0.51
2001	0.02	0.01	0.03	$0.35	$0.15	$0.50
2002	0.02	0.01	0.03	$0.35	$0.15	$0.50
2003	0.02	0.01	0.03	$0.35	$0.15	$0.50
2004	0.02	0.01	0.03	$0.35	$0.15	$0.50
2005	0.02	0.01	0.03	$0.35	$0.15	$0.50
2006	0.02	0.01	0.03	$0.35	$0.15	$0.49
2007	0.02	0.01	0.03	$0.35	$0.15	$0.49
2008	0.02	0.01	0.03	$0.34	$0.15	$0.49
2009	0.02	0.01	0.03	$0.34	$0.15	$0.49
2010	0.02	0.01	0.03	$0.34	$0.15	$0.49
2011	0.02	0.01	0.03	$0.34	$0.15	$0.49
2012	0.02	0.01	0.03	$0.34	$0.15	$0.49
2013	0.02	0.01	0.03	$0.34	$0.15	$0.49
2014	0.02	0.01	0.03	$0.34	$0.15	$0.48
2015	0.02	0.01	0.03	$0.34	$0.14	$0.48
2016	0.02	0.01	0.03	$0.34	$0.14	$0.48
2017	0.02	0.01	0.03	$0.34	$0.14	$0.48
2018	0.02	0.01	0.03	$0.34	$0.14	$0.48
2019	0.02	0.01	0.03	$0.33	$0.14	$0.48

Antilock Brake Systems. Starting in MY 1987, ABS systems controlling only the rear wheels were installed on a growing percentage of LTVs rising to 72 percent in MY 1991. Rear-wheel ABS was intended to reduce rear wheel lockup and yawing. Many light truck crashes involved loss of directional control during braking, and rear-wheel ABS reduced loss of control on straight line braking tests. Rear-wheel ABS was an important first step for light trucks, culminating with large safety benefits from ESC. A study by NHTSA found that rear-wheel ABS significantly reduced the rate of non-fatal run-off-road crashes for all types of LTVs (Kahane, 1993). The accident reductions mostly did not carry over to fatal run-off-road crashes and little or no reduction could be found for multi-vehicle crashes. Since MY 1993, it became increasingly common for ABS systems to control all four wheels on LTVs, like passenger cars. In 2009, NHTSA issued an evaluation based on General Estimates System data (a national sample) from 1995 to 2007 and comprising a list of LTV make-models that had rear-wheel only ABS at some point. The follow-up study shows negligible effect for rear-wheel ABS overall, and it no longer shows a statistically significant effect in run-off-road crashes or in any specific type of crashes, such as rollovers (Kahane & Dang, 2009). For this analysis, we consider rear-wheel ABS as a voluntary safety measure. NHTSA never proposed it; however, it did appear to provide safety for drivers of LTVs.

ABS provided basic components that were needed by ESC in FMVSS No. 126 to function properly. Even though ABS is not a requirement for FMVSS No. 105/135 it is discussed and analyzed here. On September 18, 2006, NHTSA proposed FMVSS No. 126.[11] Thus, the baseline date is September 1, 2006, or MY 2007. The percentage of LTVs with ABS in MY 2007 and earlier are considered voluntary, the MY 2007 baseline year (94.6% installation for LTVs) is considered voluntary for all MY 2008 and later LTVs, and the difference between the percentage of the fleet with ABS and 94.6 percent for LTVs for MY 2008 and later are considered attributable.

On April 6, 2007, NHTSA issued FMVSS No. 126 to require ESC on passenger cars, multipurpose vehicles, trucks, and buses with a GVWR of 10,000 lb or less: all new vehicles by MY 2012, with a phase-in comprising 55 percent of MY 2009 sales, 75 percent of MY 2010, and 95 percent of MY 2011.

The costs and weights per vehicle are the same for passenger cars and LTVs for both the four-wheel ABS systems and the rear-wheel ABS systems (see the discussion in the passenger car ABS section). For LTVs we will present separate tables for four-wheel ABS systems and for rear-wheel ABS systems. Table 32 shows the resulting weight and cost estimates for voluntarily and attributable provided four-wheel ABS by MY for LTVs and Table 33 shows the results for rear-wheel ABS systems. There is no need for a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Tables 32 and 33. As noted, ABS provided basic components necessary for ESC to function properly. One could thus consider the attributable costs of ABS in MY 2008 and later to be associated with FMVSS No. 126 rather than with FMVSS No. 105/135. We account for them here since we are separately analyzing this specific technology, but a full accounting of ESC costs would add the attributable portion of ABS to the ESC sensor costs, which are discussed later in this report.

[11] 71 FR 54712, Docket No. 2006-25801.

Table 32. FMVSS No. 105/135: Four-wheel ABS for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1988	0.0	0.0	0.0	$0.00	$0.00	$0.00
1989	0.1	0.0	0.1	$1.83	$0.00	$1.83
1990	0.7	0.0	0.7	$15.71	$0.00	$15.71
1991	1.6	0.0	1.6	$41.56	$0.00	$41.56
1992	2.4	0.0	2.4	$74.67	$0.00	$74.67
1993	7.0	0.0	7.0	$200.30	$0.00	$200.30
1994	7.2	0.0	7.2	$195.87	$0.00	$195.87
1995	11.8	0.0	11.8	$323.68	$0.00	$323.68
1996	12.8	0.0	12.8	$356.09	$0.00	$356.09
1997	11.8	0.0	11.8	$337.65	$0.00	$337.65
1998	12.4	0.0	12.4	$370.39	$0.00	$370.39
1999	12.2	0.0	12.2	$380.50	$0.00	$380.50
2000	11.7	0.0	11.7	$382.76	$0.00	$382.76
2001	11.8	0.0	11.8	$412.35	$0.00	$412.35
2002	10.9	0.0	10.9	$409.21	$0.00	$409.21
2003	10.4	0.0	10.4	$425.87	$0.00	$425.87
2004	9.5	0.0	9.5	$425.05	$0.00	$425.05
2005	9.7	0.0	9.7	$426.89	$0.00	$426.89
2006	9.9	0.0	9.9	$430.17	$0.00	$430.17
2007	10.1	0.0	10.1	$433.86	$0.00	$433.86
2008	10.1	0.1	10.3	$427.89	$6.10	$433.99
2009	10.1	0.5	10.6	$424.23	$21.52	$445.75
2010	10.1	0.6	10.7	$419.79	$23.29	$443.08
2011	10.1	0.6	10.7	$414.98	$23.69	$438.66
2012	10.1	0.6	10.7	$409.97	$23.40	$433.37
2013	10.1	0.6	10.7	$404.89	$23.11	$428.00
2014	10.1	0.6	10.7	$400.04	$22.84	$422.87
2015	10.1	0.6	10.7	$395.04	$22.55	$417.59

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2016	10.1	0.6	10.7	$391.02	$22.32	$413.34
2017	10.1	0.6	10.7	$387.11	$22.10	$409.21
2018	10.1	0.6	10.7	$383.51	$21.89	$405.41
2019	10.1	0.6	10.7	$380.23	$21.70	$401.94

Table 33. FMVSS No. 105/135: Rear-wheel ABS for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1986	0.0	0.0	0.0	$0.00	$0.00	$0.00
1987	5.5	0.0	5.5	$179.69	$0.00	$179.69
1988	9.8	0.0	9.8	$272.89	$0.00	$272.89
1989	18.5	0.0	18.5	$449.00	$0.00	$449.00
1990	24.7	0.0	24.7	$540.71	$0.00	$540.71
1991	21.3	0.0	21.3	$521.46	$0.00	$521.46
1992	16.4	0.0	16.4	$468.30	$0.00	$468.30
1993	12.5	0.0	12.5	$336.36	$0.00	$336.36
1994	12.6	0.0	12.6	$318.37	$0.00	$318.37
1995	8.1	0.0	8.1	$206.28	$0.00	$206.28
1996	6.1	0.0	6.1	$160.05	$0.00	$160.05
1997	6.2	0.0	6.2	$166.43	$0.00	$166.43
1998	4.2	0.0	4.2	$116.38	$0.00	$116.38
1999	3.1	0.0	3.1	$91.63	$0.00	$91.63
2000	2.5	0.0	2.5	$76.68	$0.00	$76.68
2001	1.1	0.0	1.1	$34.65	$0.00	$34.65
2002	0.8	0.0	0.8	$28.85	$0.00	$28.85
2003	0.5	0.0	0.5	$19.65	$0.00	$19.65
2004-19	0.0	0.0	0.0	$0.00	$0.00	$0.00

FMVSS No. 106, Brake hoses

FMVSS No. 106 became effective on January 1, 1968, and specifies labeling and performance requirements for motor vehicle brake hoses, brake hose assemblies, and brake hose end fittings. The purpose of this standard is to reduce deaths and injuries occurring because of brake system failure from pressure or vacuum loss due to hose or hose assembly rupture. The standard applies to passenger cars, MPVs, trucks, (all LTVs), buses, trailers, and motorcycles and to hydraulic, air, and vacuum brake hoses, brake hose assemblies, and brake hose end fittings for use in those vehicles. Brake hoses are part of Safety1965. Minor amendments to FMVSS No. 106 Brake Hoses have taken place over the years. However, no cost studies of brake hoses have been performed, and none are planned by the agency.

FMVSS No. 107 – [Does not currently exist]

FMVSS No. 108, Lamps, reflective devices, and associated equipment

FMVSS No. 108 became effective on January 1, 1968, for vehicles with 80 or more inches of overall width and January 1, 1969, for all other vehicles. It specifies the requirements for original and replacement lamps, reflective devices, and associated equipment. The purpose of this standard is to reduce traffic accidents, deaths, and injuries by providing adequate illumination of the roadway and by enhancing the conspicuity of motor vehicles on the public roads so that their presence is perceived and their signals understood in daylight, darkness, or other conditions of reduced visibility. The standard applies to:

- passenger cars, MPVs, trucks, buses, trailers, and motorcycles;
- retro reflective sheeting and reflex reflectors; and
- lamps, reflective devices, and associated equipment for replacement of like equipment on vehicles to which this standard applies.

FMVSS No. 108 has been amended many times; however, the most important regulations have been the: (1) original standard, (2) side marker lamp requirement, (3) center high-mounted stop lamp requirement, and (4) retroreflective tape requirement for heavy trailers. While this standard covers all types of lighting and reflective devices, side marker lamps and CHMSL are the only lighting developments whose cost may be attributable to FMVSS No. 108 for passenger cars and LTVs. The original standard essentially required the basic lights that had been on vehicles for many years and are equipment included in Safety1965.

Daytime running lights are not included in this analysis. In 1990, GM petitioned NHTSA to allow daytime running lights on new cars and LTVs sold in the United States. On January 11, 1993, NHTSA amended FMVSS No. 108 to allow DRL on new vehicles. They began to appear on some GM vehicles in MY 1995 and on all of them by MY 1997. During MY 1997 to 2005, 25 to 30 percent of new cars and LTVs were DRL-equipped. GM again petitioned in 2001, this time to mandate rather than merely allow DRL on new vehicles. In 2008, NHTSA evaluated the crash-reducing effectiveness of DRL based on 2000-to-2005 data from FARS and from nine State crash files. None of the analyses showed a statistically significant effect for DRL; the observed overall effect was a non-significant 0.1 percent reduction of daytime involvements in two-vehicle crashes. On June 29, 2009, the agency denied the GM petition to mandate DRL in the United States (Wang, 2008). NHTSA has not performed a cost teardown study on DRL.

Since DRL have not been shown to be effective safety equipment, they are not considered voluntary equipment in this analysis.

Side Marker Lamps. Prior to MY 1964, passenger cars and LTVs did not have side marker lamps. That made it very difficult to see them from the side at night, especially when they crossed into intersections or pulled out of a driveway. Beginning with MY 1970 , FMVSS No. 108 required a red lamp (as far to the rear of the vehicle as practicable) and an amber lamp (as far to the front of the vehicle as practicable) on each side of the vehicle. Thus, four lamp/reflectors were required for all passenger cars and LTVs.

The final rule that included side marker lamps was published in the Federal Register on February 3, 1967, (32 FR 2414) and was applicable to side marker lamps for both passenger cars and LTVs. The NPRM was published December 3, 1966, (35 FR 15212) making the baseline date September 1, 1966, or MY 1967. The percentages of passenger cars and LTVs with side marker lamps was estimated in the NHTSA evaluation (Kahane, 1983) and is shown in Table 34. The same percentage is assumed for passenger cars and LTVs. Voluntary compliance is assumed at 13 percent for all years from MY 1967 and later since 13 percent of passenger cars and LTVs had them in the baseline year of MY 1967.

Table 34. FMVSS No. 108: Percentages of passenger cars and LTVs with side marker lamps by model year

Model Year	**Percentage**
1964	5
1965	8
1966	15
1967	13
1968	88
1969	85
1970 and later	100

A study of the cost and weight of side marker lamps or reflectors was conducted on 26 make-model passenger cars representing pre-standard (MY 1969), post-standard (MY 1970), and later-model systems (MY 1979 to 1981) (Harvey et al., 1979a; Gladstone et al., 1982a). Side marker lamps evolved over time. The sales-weighted average for the weight and consumer cost of the pre-standard MY 1969 passenger cars was calculated at 1.46 lb and $28.97 in 2019 dollars, which is attributed to the standard for MYs 1968 and 1969. Implementation of the side marker lamps in the post-standard MY 1970 passenger cars increased the weight to 1.95 lb and the consumer cost to $40.71 in 2019 dollars, which is attributed to the standard for MYs 1970 to 1978. The later model (1979 to 1981) side marker lamps in passenger cars decreased in weight to 1.30 lb and increased in consumer cost to $43.15 in 2019 dollars. The last cost estimate from the teardown study was for 1981 models. The learning curve was thus applied to all costs from 1982 to 2019.

NHTSA has no cost teardown studies of side marker lamps for LTVs, but assumes they are the same weight and cost as estimated for passenger cars.

Table 35 shows the average weight and consumer cost of side marker lamps attributable to FMVSS No. 108 in passenger cars and LTVs. There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Table 35.

Table 35. FMVSS No. 108: Side marker lamps for passenger cars and LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.2	1.1	1.3	$3.77	$21.73	$25.49
1969	0.2	1.1	1.2	$3.77	$20.86	$24.62
1970	0.3	1.7	2.0	$5.29	$35.42	$40.71
1971	0.3	1.7	2.0	$5.29	$35.42	$40.71
1972	0.3	1.7	2.0	$5.29	$35.42	$40.71
1973	0.3	1.7	2.0	$5.29	$35.42	$40.71
1974	0.3	1.7	2.0	$5.29	$35.42	$40.71
1975	0.3	1.7	2.0	$5.29	$35.42	$40.71
1976	0.3	1.7	2.0	$5.29	$35.42	$40.71
1977	0.3	1.7	2.0	$5.29	$35.42	$40.71
1978	0.3	1.7	2.0	$5.29	$35.42	$40.71
1979	0.2	1.1	1.3	$5.61	$37.54	$43.15
1980	0.2	1.1	1.3	$5.61	$37.54	$43.15
1981	0.2	1.1	1.3	$5.61	$37.54	$43.15
1982	0.2	1.1	1.3	$5.54	$37.07	$42.60
1983	0.2	1.1	1.3	$5.50	$36.82	$42.32
1984	0.2	1.1	1.3	$5.46	$36.55	$42.01
1985	0.2	1.1	1.3	$5.42	$36.28	$41.70
1986	0.2	1.1	1.3	$5.38	$36.01	$41.40
1987	0.2	1.1	1.3	$5.35	$35.79	$41.13
1988	0.2	1.1	1.3	$5.32	$35.57	$40.88
1989	0.2	1.1	1.3	$5.29	$35.38	$40.66
1990	0.2	1.1	1.3	$5.26	$35.20	$40.46
1991	0.2	1.1	1.3	$5.24	$35.06	$40.30

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1992	0.2	1.1	1.3	$5.22	$34.91	$40.13
1993	0.2	1.1	1.3	$5.19	$34.76	$39.95
1994	0.2	1.1	1.3	$5.17	$34.60	$39.77
1995	0.2	1.1	1.3	$5.15	$34.46	$39.61
1996	0.2	1.1	1.3	$5.13	$34.31	$39.44
1997	0.2	1.1	1.3	$5.11	$34.18	$39.28
1998	0.2	1.1	1.3	$5.09	$34.04	$39.13
1999	0.2	1.1	1.3	$5.07	$33.90	$38.96
2000	0.2	1.1	1.3	$5.04	$33.76	$38.80
2001	0.2	1.1	1.3	$5.02	$33.63	$38.65
2002	0.2	1.1	1.3	$5.01	$33.50	$38.51
2003	0.2	1.1	1.3	$4.99	$33.39	$38.38
2004	0.2	1.1	1.3	$4.97	$33.27	$38.24
2005	0.2	1.1	1.3	$4.95	$33.16	$38.11
2006	0.2	1.1	1.3	$4.94	$33.05	$37.99
2007	0.2	1.1	1.3	$4.92	$32.95	$37.87
2008	0.2	1.1	1.3	$4.91	$32.85	$37.76
2009	0.2	1.1	1.3	$4.90	$32.79	$37.69
2010	0.2	1.1	1.3	$4.89	$32.72	$37.61
2011	0.2	1.1	1.3	$4.88	$32.64	$37.52
2012	0.2	1.1	1.3	$4.86	$32.56	$37.42
2013	0.2	1.1	1.3	$4.85	$32.47	$37.32
2014	0.2	1.1	1.3	$4.84	$32.37	$37.21
2015	0.2	1.1	1.3	$4.82	$32.28	$37.10
2016	0.2	1.1	1.3	$4.81	$32.20	$37.01
2017	0.2	1.1	1.3	$4.80	$32.11	$36.91
2018	0.2	1.1	1.3	$4.79	$32.04	$36.82
2019	0.2	1.1	1.3	$4.78	$31.96	$36.74

Center High Mounted Stop Lamps. NHTSA amended FMVSS No. 108 on October 18, 1983, (48 FR 48235) to require CHMSL on new passenger cars, effective September 1, 1985. CHMSL were standard equipment on all MY 1986 cars; also on 1985 Cadillac models comprising 2.7 percent of the passenger car fleet.[12] The purpose of CHMSL is to reduce the chances of a vehicle from being struck in the rear by another vehicle. When the brakes are applied, the CHMSL sends a conspicuous signal to drivers of following vehicles that they must slow down. Since nearly two-thirds of all rear impact crashes involve pre-impact braking by the lead vehicle, the CHMSL can be a significant countermeasure to deter rear-impact crashes of all types.

A study was conducted on 30 passenger cars of MYs 1986 and 1987 to determine the weight and consumer cost of CHMSL (Carlson & Leonard, 1986; Khadilkar & Fladmark, 1988). The sales-weighted average for the weight and consumer cost for the 1986 and 1987 MY passenger cars were calculated at 0.85 lb and $13.50 in 2019 dollars. Because NHTSA has not performed teardown analyses for these systems on LTVs, and because they are like the systems on passenger cars, we will assume the same costs on LTVs as on passenger cars.

The NPRM for passenger cars CHMSL was published in the Federal Register on January 8, 1981, (46 FR 2132) making the baseline date September 1, 1980, or MY 1981. Since no passenger cars had CHMSL in MY 1981, all MY 1985 and later CHMSL are attributable to the standard.

An evaluation of CHMSL provided make/model information of LTVs that had CHMSL for MYs 1991 to 1993 (Kahane & Hertz, 1998). This data was combined with Ward's Automotive Yearbook (Ferris, 1991-1993) sales data to determine the percentage of MYs 1991 to 1993 LTVs with CHMSL. All LTVs had CHMSL in MY 1994.

The final rule extending CHMSL to LTVs was published on April 19, 1991 (56 FR 16015) and became effective on September 1, 1993. The NPRM was published in the Federal Register on May 31, 1990 (55 FR 22039) making the baseline date September 1, 1989, or MY 1990. Since no LTVs had CHMSL in MY 1990, all MY 1991 and later CHMSL in LTVs are considered attributable to the standard.

Table 36 shows the average weight and consumer cost of CHMSL attributable to FMVSS No. 108 in both passenger cars and LTVs. The cost per vehicle per model year is the same; however, the percentage of the fleet with CHMSL is different before the effective dates of the standard (MY 1985 for passenger cars and MYs 1991 to 1993 for LTVs). There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Table 36 for passenger cars.

[12] Based on *MVMA Motor Vehicles Facts and Figures '87*, Page 15, (298,762 Cadillac sales/11,042,115 passenger car sales).

Table 36. FMVSS No. 108: Average weight and cost of CHMSL attributable to passenger cars and LTVs

Model Year	PC % of fleet	LTV % of fleet	PC Weight	PC Cost 2019$	LTV Weight	LTV Cost 2019$
1984	0	0	0	$0.00	0	$0.00
1985	2.7	0	0.02	$0.54	0	$0.00
1986	100	0	0.85	$13.50	0	$0.00
1987	100	0	0.85	$12.64	0	$0.00
1988	100	0	0.85	$12.13	0	$0.00
1989	100	0	0.85	$11.81	0	$0.00
1990	100	0	0.85	$11.56	0	$0.00
1991	100	15.6	0.85	$11.37	0.13	$1.77
1992	100	32.7	0.85	$11.20	0.28	$3.66
1993	100	42.3	0.85	$11.03	0.36	$4.67
1994	100	100	0.85	$10.84	0.85	$10.84
1995	100	100	0.85	$10.67	0.85	$10.67
1996	100	100	0.85	$10.53	0.85	$10.53
1997	100	100	0.85	$10.41	0.85	$10.41
1998	100	100	0.85	$10.30	0.85	$10.30
1999	100	100	0.85	$10.19	0.85	$10.19
2000	100	100	0.85	$10.08	0.85	$10.08
2001	100	100	0.85	$9.99	0.85	$9.99
2002	100	100	0.85	$9.91	0.85	$9.91
2003	100	100	0.85	$9.84	0.85	$9.84
2004	100	100	0.85	$9.77	0.85	$9.77
2005	100	100	0.85	$9.70	0.85	$9.70
2006	100	100	0.85	$9.64	0.85	$9.65
2007	100	100	0.85	$9.59	0.85	$9.59
2008	100	100	0.85	$9.54	0.85	$9.55
2009	100	100	0.85	$9.50	0.85	$9.52
2010	100	100	0.85	$9.47	0.85	$9.48
2011	100	100	0.85	$9.43	0.85	$9.45

Model Year	PC % of fleet	LTV % of fleet	PC Weight	PC Cost 2019$	LTV Weight	LTV Cost 2019$
2012	100	100	0.85	$9.39	0.85	$9.41
2013	100	100	0.85	$9.34	0.85	$9.36
2014	100	100	0.85	$9.30	0.85	$9.32
2015	100	100	0.85	$9.26	0.85	$9.27
2016	100	100	0.85	$9.22	0.85	$9.24
2017	100	100	0.85	$9.18	0.85	$9.20
2018	100	100	0.85	$9.15	0.85	$9.16
2019	100	100	0.85	$9.12	0.85	$9.12

Headlamp Concealment Devices. Headlamp concealment devices were a popular design feature for passenger cars during the 1960s. Headlamp concealment devices were never installed on LTVs. These devices were primarily cosmetic; however, an unsafe driving situation could arise if the concealment devices were frozen shut when headlamps were needed. FMVSS No. 112 became effective on January 1, 1969, and required that the devices remain fully open when there is a power loss or system failure, or that they be manually operable without the use of tools. In addition, the device could not be involved in either the mounting or the aiming of the headlamps. FMVSS No. 112 was canceled on October 24, 1996, and the requirements were incorporated into FMVSS No. 108 (Lamps, Reflective Devices, and Associated Equipment under Section 12).

A study conducted on four make-model passenger cars, representing pre-standard and post-standard systems, indicated that the headlamp concealment devices met the requirements of the standard before its effective date (Adams et al., 1983). While there were minor changes in the headlamp concealment devices from 1966 to 1969, none of the changes were related to the standard. The arithmetic average for the weight and consumer cost of headlamp concealment devices for the pre-standard MY 1966 passenger cars was calculated at 12.20 lb and $158.60 in 2019 dollars. By 1969 the average weight for the post-standard passenger cars had increased to 14.01 lb while the consumer cost decreased to $136.65 in 2019 dollars. The main reason for the decreased cost was the change in operating system from an electrical system to a vacuum system for reasons unrelated to the regulation.

The final rule on headlamp concealment devices (FMVSS No. 112) was published in the Federal Register on April 27, 1968, (33 FR 6465) for passenger cars and LTVs. The NPRM was published on December 28, 1967, (32 FR 20865) making the baseline date September 1, 1967, or MY 1968. No cost is attributed to FMVSS No, 108 because all headlamp concealment devices met the requirements of the standard by MY 1965 and are considered Safety1965 equipment, and the changes made did not appear to relate to the standard.

Red/Amber Rear Turn Signals. Rear turn signals on passenger vehicles in the United States are permitted to be either amber or red, according to FMVSS No. 108. In Europe and many other countries, rear turn signals are required to be amber. Currently, manufacturers who produce vehicles for both the European and North American markets choose whether to produce all vehicles with amber rear turn signals or to equip the North American products with red rear turn signals. Thus, amber rear turn signals are provided voluntarily by the automobile manufacturers. All passenger cars and LTVs in MY 1965 had rear turn signals, most were red. We have assigned red rear turn signals as part of Safety1965. Thus, the incremental cost we address in this report is the difference in cost between amber and red rear turn signals.

A NHTSA evaluation by Allen (2009) found that amber turn signals were safer than red turn signals. The principal finding of the report is that amber signals show a 5.3 percent effectiveness in reducing involvement in two-vehicle crashes where a lead vehicle is rear-struck in the act of turning left, turning right, merging into traffic, changing lanes, or entering/leaving a parking space.

While amber rear turn signals are not required by NHTSA, and have never been proposed by NHTSA, they are included in this study because they are linked to the FMVSS. Amber rear turn signals are linked to the FMVSS, based on definitions set forth in the Introduction section, since NHTSA has evaluated amber rear turn signals and found the safety countermeasure effective at reducing crashes. In addition, NHTSA has completed a cost teardown study of amber rear turn signals compared to red rear turn signals.

A cost estimate was made of 6 passenger cars that changed from red to amber or from amber to red rear turn signals with no other changes (Khadilkar & Fladmark, 1988, Table 3-2). These matching switchover pairs included the 1979 Buick Skylark (red) and the 1980 Buick Skylark (amber), the 1978 Buick Le Sabre (red) and the 1979 Buick Le Sabre (amber), the 1982 Ford Mustang (red) and the 1983 Ford Mustang (amber), the 1979 Chevy Chevette (amber) and the 1980 Chevy Chevette (red), the 1983 Buick Century (amber) and the 1984 Buick Century (red), and the 1983 Olds Delta 88 (red) and the 1984 Olds Delta 88 (amber).

The average cost added by having two amber rear turn signals rather than two red turn signals was $1.45 in 2019 dollars, and the average weight increase per vehicle was 0.10 lb. Four of the six models in the study had higher costs for amber rear turn signals and two of the six had lower costs. Included in the cost teardown study were the light bulbs, sockets, lens, housing assembly and molding, attachment hardware, and the wiring harness that goes to the brake pedal.

The challenge for this analysis was determining the percentage of the fleet that has amber versus red rear turn signals. No data source that we could find addresses red versus amber rear turn signals. Since NHTSA never required amber rear turn signals, it has never collected comprehensive data on amber rear turn signals. Since the 1970s, a substantial proportion of passenger cars, and a smaller proportion of LTVs have had amber rear turn signals. But red rear turn signals have also remained common, perhaps because they allow sharing of components between the stop lamp and the turn signal or because they are perceived by some as a styling feature. In fact, many make-models have switched back and forth between amber and red rear turn signals over the years.

Data was collected for the Allen (2009) study from 14 State files (Alabama, Florida, Georgia, Illinois, Indiana, Kentucky, Maryland, Michigan, Missouri, North Carolina, Nebraska, Pennsylvania, Texas, and Utah) for CYs 1989 to 2006, or a subset of those years, depending on the State. Table 14 of the Allen evaluation shows the number of struck vehicles by age at the time of the crash by amber versus red rear turn signal. Given that the State crash data is from 1989 to 2005, we assumed that the data for 1- to 9-year-old passenger cars roughly represents

MYs 1996 to 2005 vehicles and the data for 10- to 20-year-old passenger cars roughly represents MYs 1985 to 1995. The percentage of passenger cars with amber rear turn signals doesn't change dramatically over time but increases from around 45 percent for MYs 1985 to 1995 to 50 percent for MYs 1996 to 2005.

Data was collected from Edmunds.com, Cars.com, Sylvania-automotive.com, and other internet sites to find the percentage of the passenger car and LTV fleet with amber rear turn signals for MYs 1970 and 1980 to supplement the data found in the Allen evaluation. These searches were conducted by viewing color photographs of the rear of every make/model sold in the model year and determining whether the vehicle had a red or amber rear turn signal and then weighting those findings by make/model sales for the model year in question from the *Ward's Automotive Yearbooks* (Stark & Powers, 1965-1974; Ferris, 1991-1993; Binder, 2002-2017; Norris, 2018-2020). In MYs 1970 and 1980, clear light bulbs were used, and the color of the lens determined whether the signal was amber or red. For MY 1970, every domestic vehicle used a red lens, and every import vehicle used an amber lens. Thus, we assumed the percent of amber rear turn signals was the same as the sales of import vehicles for MYs 1968 to 1975. MYs 1976 to 1980 were interpolated between the import sales in MY 1975 and the amber percentages found for MY 1980.

For MY 1980, we have additional sources of data, notably a list by Bill Rauch from IIHS of the make/models of passenger cars that consistently had red or consistently had amber rear turn signals from MY 1980 to 1987 and letters from GM, Ford, and Chrysler providing information on each passenger car make/model in the early 1980s and whether they had red or amber rear turn signals. By MY 1980, some of the imports (Audi, Porsche, and Mazda) had changed to red and some of the domestic make/models (Dodge Omni, Plymouth Horizon, American Motors Corporation Concord, AMC Eagle, and Ford Mustang) changed to amber. Since then, many make/models have changed from red to amber or amber to red. For this analysis, we use a linear interpolation to fill in data between years with known information.

We also collected red/amber data for every passenger car and LTV in MYs 2012, 2016, and 2019. As time progressed, there was a shift in design from a clear bulb with a red or amber lens to a clear bulb with a red lens or an amber bulb with a clear lens. By MY 2019, only 3 passenger cars and two LTVs models still had a clear bulb and amber lens. In addition, some make/models used a group of small light-emitting diode bulbs and without seeing the bulbs lit up, there was no way of knowing whether red or amber LED bulbs were deployed. Thus, a multi-step process was necessary for determining whether MYs 2012, 2016, or 2019 vehicles had red or amber turn signals. First, Edmunds.com or thecarconnection.com was searched to determine whether an amber rear turn signal lens was employed by looking at pictures of the rear of the make/model. If no amber lens was found, then a search of Sylvania-automotive.com or the Phillips bulb lookup was conducted to determine the color of the replacement bulb. Using these sources, the color of the rear turn signal bulb could not be found for all make/models. In addition, these sources almost never provided information on the color of the rear turn signal in the case of LED lights. We tried to find information on the internet for the LED lights, but in some cases this information was not clear as to whether the make/model was a European vehicle, or one sold in the United States. When we couldn't find conclusive information online, we went to a dealership and had someone step on the brakes while we looked at the rear brake light display. For MY 2019, we had to go to a dealership to determine the correct information for about 50 make/models including both passenger cars and LTVs. Finally, all the make/model information was sales-weighted using Wards automotive sales figures. To fill in data for the MYs in between those for which we collected data, we assumed a linear increase or decrease in amber percentages.

No amber rear turn signals were used on MY 1970 LTVs. It appears that Toyota and Datsun, but not Mazda, started using amber rear turn signals on LTVs in MY 1972. Because Wards Automotive did not consistently report import LTVs sales in the early 1970s, data on import versus domestic sales was taken from bea.gov. Import sales, excluding Mazda, were assumed to be a proxy measure for amber rear turn signal sales until 1987. Every LTV make/model was examined for MY 1980 and with the exception of Mazda, almost every foreign make/model (including captive imports) had an amber rear turn signal and every domestic make/model had a red rear turn signal.

An examination of rear turn signals using the same multi-step process described above for passenger cars was conducted for LTVs for MYs 2012, 2016, and 2019.

Table 37 shows the estimated percentages of the passenger car and LTV fleet with amber rear turn signals and the weight added and incremental cost per vehicle with amber rear turn signals after considering the learning curve. Table 38 and 39 show the incremental cost for the average passenger car and LTV, when considering the percentage of the fleet with amber rear turn signals. All costs and weight are considered voluntary.

Table 37. FMVSS No. 108: Amber rear turn signals – passenger cars and LTVs

Model Year	**PC % of fleet**	**LTV % of fleet**	**After Learning**	
			Weight	**Cost $2019**
1968	10.7	0.0	0.102	$2.10
1969	11.7	0.0	0.102	$1.95
1970	12.1	0.0	0.102	$1.87
1971	15.3	0.0	0.102	$1.80
1972	14.9	5.8	0.102	$1.75
1973	15.5	6.3	0.102	$1.70
1974	16.1	6.8	0.102	$1.67
1975	18.6	7.2	0.102	$1.64
1976	22.9	7.7	0.102	$1.61
1977	27.2	9.1	0.102	$1.57
1978	31.5	8.5	0.102	$1.54
1979	35.8	16.5	0.102	$1.51
1980	40.1	16.9	0.102	$1.49
1981	41.0	22.1	0.102	$1.47
1982	42.0	17.3	0.102	$1.45

Model Year	PC % of fleet	LTV % of fleet	After Learning	
			Weight	Cost $2019
1983	43.0	15.8	0.102	$1.44
1984	44.0	15.9	0.102	$1.42
1985	45.0	18.6	0.102	$1.40
1986	45.0	20.9	0.102	$1.39
1987	45.0	19.4	0.102	$1.37
1988	45.0	20.0	0.102	$1.36
1989	45.0	20.6	0.102	$1.35
1990	45.0	21.2	0.102	$1.34
1991	45.0	21.8	0.102	$1.33
1992	45.0	22.3	0.102	$1.33
1993	45.0	22.9	0.102	$1.32
1994	45.0	23.5	0.102	$1.31
1995	45.0	24.1	0.102	$1.30
1996	50.0	24.7	0.102	$1.30
1997	50.0	25.3	0.102	$1.29
1998	50.0	25.9	0.102	$1.28
1999	50.0	26.5	0.102	$1.28
2000	50.0	27.1	0.102	$1.27
2001	50.0	27.7	0.102	$1.26
2002	50.0	28.3	0.102	$1.26
2003	50.0	28.8	0.102	$1.25
2004	50.0	29.4	0.102	$1.25
2005	50.0	30.0	0.102	$1.24
2006	49.4	30.6	0.102	$1.24
2007	48.7	31.2	0.102	$1.23
2008	48.1	31.8	0.102	$1.23
2009	47.5	32.4	0.102	$1.22
2010	46.8	33.0	0.102	$1.22
2011	46.2	35.5	0.102	$1.22

Model Year	PC % of fleet	LTV % of fleet	After Learning	
			Weight	Cost $2019
2012	45.6	38.0	0.102	$1.21
2013	48.6	40.4	0.102	$1.21
2014	51.7	42.9	0.102	$1.20
2015	54.8	45.4	0.102	$1.20
2016	57.8	47.9	0.102	$1.19
2017	61.7	47.2	0.102	$1.19
2018	65.6	46.4	0.102	$1.19
2019	69.5	45.7	0.102	$1.18

Table 38. FMVSS No. 108: Amber rear turn signals – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.01	0.00	0.01	$0.22	$0.00	$0.22
1969	0.01	0.00	0.01	$0.23	$0.00	$0.23
1970	0.01	0.00	0.01	$0.23	$0.00	$0.23
1971	0.02	0.00	0.02	$0.28	$0.00	$0.28
1972	0.02	0.00	0.02	$0.26	$0.00	$0.26
1973	0.02	0.00	0.02	$0.26	$0.00	$0.26
1974	0.02	0.00	0.02	$0.27	$0.00	$0.27
1975	0.02	0.00	0.02	$0.30	$0.00	$0.30
1976	0.02	0.00	0.02	$0.37	$0.00	$0.37
1977	0.03	0.00	0.03	$0.43	$0.00	$0.43
1978	0.03	0.00	0.03	$0.48	$0.00	$0.48
1979	0.04	0.00	0.04	$0.54	$0.00	$0.54
1980	0.04	0.00	0.04	$0.60	$0.00	$0.60
1981	0.04	0.00	0.04	$0.60	$0.00	$0.60
1982	0.04	0.00	0.04	$0.61	$0.00	$0.61
1983	0.04	0.00	0.04	$0.62	$0.00	$0.62
1984	0.04	0.00	0.04	$0.62	$0.00	$0.62

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1985	0.05	0.00	0.05	$0.63	$0.00	$0.63
1986	0.05	0.00	0.05	$0.62	$0.00	$0.62
1987	0.05	0.00	0.05	$0.62	$0.00	$0.62
1988	0.05	0.00	0.05	$0.61	$0.00	$0.61
1989	0.05	0.00	0.05	$0.61	$0.00	$0.61
1990	0.05	0.00	0.05	$0.60	$0.00	$0.60
1991	0.05	0.00	0.05	$0.60	$0.00	$0.60
1992	0.05	0.00	0.05	$0.60	$0.00	$0.60
1993	0.05	0.00	0.05	$0.59	$0.00	$0.59
1994	0.05	0.00	0.05	$0.59	$0.00	$0.59
1995	0.05	0.00	0.05	$0.59	$0.00	$0.59
1996	0.05	0.00	0.05	$0.65	$0.00	$0.65
1997	0.05	0.00	0.05	$0.64	$0.00	$0.64
1998	0.05	0.00	0.05	$0.64	$0.00	$0.64
1999	0.05	0.00	0.05	$0.64	$0.00	$0.64
2000	0.05	0.00	0.05	$0.63	$0.00	$0.63
2001	0.05	0.00	0.05	$0.63	$0.00	$0.63
2002	0.05	0.00	0.05	$0.63	$0.00	$0.63
2003	0.05	0.00	0.05	$0.63	$0.00	$0.63
2004	0.05	0.00	0.05	$0.62	$0.00	$0.62
2005	0.05	0.00	0.05	$0.62	$0.00	$0.62
2006	0.05	0.00	0.05	$0.61	$0.00	$0.61
2007	0.05	0.00	0.05	$0.60	$0.00	$0.60
2008	0.05	0.00	0.05	$0.59	$0.00	$0.59
2009	0.05	0.00	0.05	$0.58	$0.00	$0.58
2010	0.05	0.00	0.05	$0.57	$0.00	$0.57
2011	0.05	0.00	0.05	$0.56	$0.00	$0.56
2012	0.05	0.00	0.05	$0.55	$0.00	$0.55
2013	0.05	0.00	0.05	$0.59	$0.00	$0.59

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2014	0.05	0.00	0.05	$0.62	$0.00	$0.62
2015	0.06	0.00	0.06	$0.66	$0.00	$0.66
2016	0.06	0.00	0.06	$0.69	$0.00	$0.69
2017	0.06	0.00	0.06	$0.73	$0.00	$0.73
2018	0.07	0.00	0.07	$0.78	$0.00	$0.78
2019	0.07	0.00	0.07	$0.82	$0.00	$0.82

Table 39. FMVSS No. 108: Amber rear turn signals – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00
1971	0.00	0.00	0.00	$0.00	$0.00	$0.00
1972	0.01	0.00	0.01	$0.10	$0.00	$0.10
1973	0.01	0.00	0.01	$0.11	$0.00	$0.11
1974	0.01	0.00	0.01	$0.11	$0.00	$0.11
1975	0.01	0.00	0.01	$0.12	$0.00	$0.12
1976	0.01	0.00	0.01	$0.12	$0.00	$0.12
1977	0.01	0.00	0.01	$0.14	$0.00	$0.14
1978	0.01	0.00	0.01	$0.13	$0.00	$0.13
1979	0.02	0.00	0.02	$0.25	$0.00	$0.25
1980	0.02	0.00	0.02	$0.25	$0.00	$0.25
1981	0.02	0.00	0.02	$0.32	$0.00	$0.32
1982	0.02	0.00	0.02	$0.25	$0.00	$0.25
1983	0.02	0.00	0.02	$0.23	$0.00	$0.23
1984	0.02	0.00	0.02	$0.23	$0.00	$0.23
1985	0.02	0.00	0.02	$0.26	$0.00	$0.26
1986	0.02	0.00	0.02	$0.29	$0.00	$0.29

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1987	0.02	0.00	0.02	$0.27	$0.00	$0.27
1988	0.02	0.00	0.02	$0.27	$0.00	$0.27
1989	0.02	0.00	0.02	$0.28	$0.00	$0.28
1990	0.02	0.00	0.02	$0.28	$0.00	$0.28
1991	0.02	0.00	0.02	$0.29	$0.00	$0.29
1992	0.02	0.00	0.02	$0.30	$0.00	$0.30
1993	0.02	0.00	0.02	$0.30	$0.00	$0.30
1994	0.02	0.00	0.02	$0.31	$0.00	$0.31
1995	0.02	0.00	0.02	$0.31	$0.00	$0.31
1996	0.03	0.00	0.03	$0.32	$0.00	$0.32
1997	0.03	0.00	0.03	$0.33	$0.00	$0.33
1998	0.03	0.00	0.03	$0.33	$0.00	$0.33
1999	0.03	0.00	0.03	$0.34	$0.00	$0.34
2000	0.03	0.00	0.03	$0.34	$0.00	$0.34
2001	0.03	0.00	0.03	$0.35	$0.00	$0.35
2002	0.03	0.00	0.03	$0.36	$0.00	$0.36
2003	0.03	0.00	0.03	$0.36	$0.00	$0.36
2004	0.03	0.00	0.03	$0.37	$0.00	$0.37
2005	0.03	0.00	0.03	$0.37	$0.00	$0.37
2006	0.03	0.00	0.03	$0.38	$0.00	$0.38
2007	0.03	0.00	0.03	$0.38	$0.00	$0.38
2008	0.03	0.00	0.03	$0.39	$0.00	$0.39
2009	0.03	0.00	0.03	$0.40	$0.00	$0.40
2010	0.03	0.00	0.03	$0.40	$0.00	$0.40
2011	0.04	0.00	0.04	$0.43	$0.00	$0.43
2012	0.04	0.00	0.04	$0.46	$0.00	$0.46
2013	0.04	0.00	0.04	$0.49	$0.00	$0.49
2014	0.04	0.00	0.04	$0.52	$0.00	$0.52
2015	0.05	0.00	0.05	$0.54	$0.00	$0.54

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2016	0.05	0.00	0.05	$0.57	$0.00	$0.57
2017	0.05	0.00	0.05	$0.56	$0.00	$0.56
2018	0.05	0.00	0.05	$0.55	$0.00	$0.55
2019	0.05	0.00	0.05	$0.54	$0.00	$0.54

Other Lighting System Developments. Technological advances have resulted in changes to vehicle lighting systems. Manufacturers are offering quartz-halogen headlamps, composite headlamps with replaceable bulbs, high intensity discharge lights, LED lights, and DRL. Since FMVSS No. 108 did not require these changes, no cost studies have been performed, and none are planned by this agency.

LED stop lamps and LED CHMSL were not included in this analysis because NHTSA's evaluation of them could not prove a benefit (Greenwell, 2013). The evaluation is based on 17 switch groups: make-models that switched from incandescent stop lamps and CHMSL to LED stop lamps and CHMSL, or vice-versa sometime from MYs 2000 to 2008. It uses crash data from 12 State files (Alabama, Florida, Georgia, Illinois, Kentucky, Maryland, Michigan, Missouri, Nebraska, New Jersey, North Carolina, and Pennsylvania) for CYs that were available at NHTSA: from 1998 to 2009, or a subset of those years, depending on the State.

FMVSS No. 109, New pneumatic and certain specialty tires

FMVSS No. 109 became effective on January 1, 1968, and specifies tire dimensions and laboratory test requirements for bead unseating resistance, strength, endurance, and high-speed performance; defines tire load rating; and specifies labeling requirements for passenger car tires. This standard applies to new pneumatic radial tires for use on passenger cars manufactured after 1948 and before 1975, new pneumatic bias ply tires, T-type spare tires, ST, FI, and 8-12 rim diameter and below tires for use on passenger cars manufactured after 1948. For new light vehicles (since they all use radial tires), FMVSS No. 109 was superseded by FMVSS No. 139. FMVSS No. 139 applies to new pneumatic radial tires for use on motor vehicles (other than motorcycles and low speed vehicles) that have a GVWR of 10,000 lb or less and that were manufactured after 1975. Thus, FMVSS No. 139 applies to passenger car and LTV tires. No cost studies of new pneumatic tires related to FMVSS No. 109 have been performed, and none are planned by this agency.

FMVSS No. 110, Tire selection and rims and motor home/recreation vehicle trailer load carrying capacity information for motor vehicles with a GVWR of 4,536 kilograms (10,000 lb) or less

FMVSS No. 110 became effective on April 1, 1968, and specifies requirements for original equipment tire and rim selection on new passenger cars to prevent tire overloading. These include placard requirements relating to load distribution as well as rim performance requirements under conditions of rapid tire deflation. This standard also applies to non-pneumatic spare tire assemblies for use on passenger cars. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 111, Rear visibility

Mirrors

FMVSS No. 111 became effective on January 1, 1968, and specifies requirements for the performance and location of inside and outside rearview mirrors. The purpose of this standard is to reduce the number of deaths and injuries that occur when the driver of a motor vehicle does not have a clear and reasonably unobstructed view to the rear. This standard applies to passenger cars, MPVs, trucks, (all LTVs), buses, school buses, and motorcycles. Furthermore, FMVSS No. 111 requires passenger cars to have a mounting system for the inside rearview mirror that would break away upon impact, and an outside rearview mirror. The purpose of breakaway mirrors is to reduce fatalities and injuries in frontal collisions to front seat occupants who contact the rearview mirror.

The final rule for passenger cars was published in the Federal Register on February 3, 1967, (32 FR 2410) and the NPRM on December 3, 1966, (31 FR 15212) making the baseline date for passenger cars September 1, 1966, or MY 1967. All passenger cars had an inside rearview mirror and an estimated 95 percent of passenger cars had a driver side outside rearview mirror by MY 1967. Thus, 95 percent of the outside rearview mirror costs are considered voluntary and 5 percent are considered attributable. On April 27, 1968, (33 FR 6465), the standard was extended to LTVs with the NPRM on December 28, 1967, (32 FR 20865) making the baseline date for LTVs September 1, 1967, or MY 1968. All LTVs had an inside rearview mirror, and it is believed that all LTVs had an outside rearview mirror by MY 1968. Thus, the cost of outsider rearview mirrors for LTVs is considered voluntary. Because all passenger cars and LTVs had an inside rearview mirror by MY 1965, an inside rearview mirror is considered part of Safety1965.

A weight and cost study of inside rearview mirrors was conducted on 16 pre-standard make-model passenger cars and their corresponding post-standard and trend systems (Adams et al., 1983). The sales-weighted average for the weight and consumer cost of the pre-standard MY 1966 passenger cars inside rearview mirror was calculated at 0.97 lb and $10.63 in 2019 dollars. Implementation of the inside rearview mirrors in the post-standard MY 1968 passenger cars increased the weight to 1.12 lb and the consumer cost to $14.98. An estimation of the weight and consumer price in the MY 1982 passenger cars indicated a decrease in weight to 0.71 lb and in consumer cost to $9.29 in 2019 dollars. However, inside rearview mirrors are not included in the analysis since they are considered part of Safety1965.

Because most States required outside rearview mirrors before the implementation of FMVSS No. 111 (effective 2/26/67), outside rearview mirrors were not analyzed in the Adams (1983) cost teardown study. However, for this analysis, where Safety1965 determines whether costs are included or not, it is important to determine whether outside rearview mirrors were standard equipment on all MY 1965 passenger cars and LTVs. An examination of many cars for sale on the internet show that some MY 1965 cars and LTVs did not have outside rearview mirrors. Apparently, an outside rearview mirror may have been an option because the same make model was found with and without an outside rearview mirror (for example, Oldsmobile Cutlass, Mercedes 230 SL, and Dodge pickups).

To get weight and cost estimates of driver side outside rearview mirrors, estimates were taken from two NHTSA contractor reports that did a teardown of every part of the passenger car (Gladstone et al., 1982b, pg. A-21, 1982c, p. 45). Two vehicles were studied, a 1980 Chevrolet Citation and a 1981 Plymouth Reliant. These costs were inflated to 2019 dollars and averaged. Table 40 shows the estimates before the learning curve.

Table 40. FMVSS No. 111: Outside rearview mirrors

	Weight (lb)	**Consumer Cost (2019$)**
MY 1980 Citation	1.70	$10.04
MY 1981 Reliant	1.83	$21.68
Average	1.77	$15.86

Table 41 for passenger cars and Table 42 for LTVs show the weight and cost after the learning curve for each MY for driver side outside rearview mirrors.

Table 41. FMVSS No. 111: Driver side outside rearview mirror – passenger cars

Model Year	**Weight (lb)**			**Consumer Cost (2019$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	1.68	0.09	1.77	$16.94	$0.89	$17.83
1969	1.68	0.09	1.77	$16.70	$0.88	$17.57
1970	1.68	0.09	1.77	$16.51	$0.87	$17.38
1971	1.68	0.09	1.77	$16.32	$0.86	$17.18
1972	1.68	0.09	1.77	$16.14	$0.85	$16.99
1973	1.68	0.09	1.77	$15.95	$0.84	$16.79
1974	1.68	0.09	1.77	$15.82	$0.83	$16.66
1975	1.68	0.09	1.77	$15.71	$0.83	$16.54
1976	1.68	0.09	1.77	$15.58	$0.82	$16.40
1977	1.68	0.09	1.77	$15.45	$0.81	$16.26
1978	1.68	0.09	1.77	$15.32	$0.81	$16.13
1979	1.68	0.09	1.77	$15.22	$0.80	$16.02
1980	1.68	0.09	1.77	$15.14	$0.80	$15.93
1981	1.68	0.09	1.77	$15.06	$0.79	$15.86
1982	1.68	0.09	1.77	$15.00	$0.79	$15.79
1983	1.68	0.09	1.77	$14.92	$0.79	$15.71
1984	1.68	0.09	1.77	$14.84	$0.78	$15.62

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1985	1.68	0.09	1.77	$14.75	$0.78	$15.53
1986	1.68	0.09	1.77	$14.67	$0.77	$15.44
1987	1.68	0.09	1.77	$14.60	$0.77	$15.37
1988	1.68	0.09	1.77	$14.53	$0.76	$15.29
1989	1.68	0.09	1.77	$14.46	$0.76	$15.22
1990	1.68	0.09	1.77	$14.40	$0.76	$15.16
1991	1.68	0.09	1.77	$14.35	$0.76	$15.11
1992	1.68	0.09	1.77	$14.30	$0.75	$15.06
1993	1.68	0.09	1.77	$14.25	$0.75	$15.00
1994	1.68	0.09	1.77	$14.20	$0.75	$14.95
1995	1.68	0.09	1.77	$14.15	$0.74	$14.89
1996	1.68	0.09	1.77	$14.10	$0.74	$14.84
1997	1.68	0.09	1.77	$14.05	$0.74	$14.79
1998	1.68	0.09	1.77	$14.00	$0.74	$14.74
1999	1.68	0.09	1.77	$13.95	$0.73	$14.68
2000	1.68	0.09	1.77	$13.90	$0.73	$14.63
2001	1.68	0.09	1.77	$13.85	$0.73	$14.58
2002	1.68	0.09	1.77	$13.81	$0.73	$14.53
2003	1.68	0.09	1.77	$13.76	$0.72	$14.49
2004	1.68	0.09	1.77	$13.72	$0.72	$14.44
2005	1.68	0.09	1.77	$13.68	$0.72	$14.40
2006	1.68	0.09	1.77	$13.64	$0.72	$14.36
2007	1.68	0.09	1.77	$13.60	$0.72	$14.32
2008	1.68	0.09	1.77	$13.57	$0.71	$14.28
2009	1.68	0.09	1.77	$13.54	$0.71	$14.26
2010	1.68	0.09	1.77	$13.52	$0.71	$14.23
2011	1.68	0.09	1.77	$13.49	$0.71	$14.20
2012	1.68	0.09	1.77	$13.46	$0.71	$14.17
2013	1.68	0.09	1.77	$13.42	$0.71	$14.13

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2014	1.68	0.09	1.77	$13.39	$0.70	$14.09
2015	1.68	0.09	1.77	$13.35	$0.70	$14.05
2016	1.68	0.09	1.77	$13.32	$0.70	$14.02
2017	1.68	0.09	1.77	$13.29	$0.70	$13.99
2018	1.68	0.09	1.77	$13.26	$0.70	$13.96
2019	1.68	0.09	1.77	$13.23	$0.70	$13.93

Table 42. FMVSS No. 111: Driver side outside rearview mirror – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	1.77	0.00	1.77	$17.83	$0.00	$17.83
1969	1.77	0.00	1.77	$17.57	$0.00	$17.57
1970	1.77	0.00	1.77	$17.38	$0.00	$17.38
1971	1.77	0.00	1.77	$17.18	$0.00	$17.18
1972	1.77	0.00	1.77	$16.99	$0.00	$16.99
1973	1.77	0.00	1.77	$16.79	$0.00	$16.79
1974	1.77	0.00	1.77	$16.66	$0.00	$16.66
1975	1.77	0.00	1.77	$16.54	$0.00	$16.54
1976	1.77	0.00	1.77	$16.40	$0.00	$16.40
1977	1.77	0.00	1.77	$16.26	$0.00	$16.26
1978	1.77	0.00	1.77	$16.13	$0.00	$16.13
1979	1.77	0.00	1.77	$16.02	$0.00	$16.02
1980	1.77	0.00	1.77	$15.93	$0.00	$15.93
1981	1.77	0.00	1.77	$15.86	$0.00	$15.86
1982	1.77	0.00	1.77	$15.79	$0.00	$15.79
1983	1.77	0.00	1.77	$15.71	$0.00	$15.71
1984	1.77	0.00	1.77	$15.62	$0.00	$15.62
1985	1.77	0.00	1.77	$15.53	$0.00	$15.53
1986	1.77	0.00	1.77	$15.44	$0.00	$15.44

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1987	1.77	0.00	1.77	$15.37	$0.00	$15.37
1988	1.77	0.00	1.77	$15.29	$0.00	$15.29
1989	1.77	0.00	1.77	$15.22	$0.00	$15.22
1990	1.77	0.00	1.77	$15.16	$0.00	$15.16
1991	1.77	0.00	1.77	$15.11	$0.00	$15.11
1992	1.77	0.00	1.77	$15.06	$0.00	$15.06
1993	1.77	0.00	1.77	$15.00	$0.00	$15.00
1994	1.77	0.00	1.77	$14.95	$0.00	$14.95
1995	1.77	0.00	1.77	$14.89	$0.00	$14.89
1996	1.77	0.00	1.77	$14.84	$0.00	$14.84
1997	1.77	0.00	1.77	$14.79	$0.00	$14.79
1998	1.77	0.00	1.77	$14.74	$0.00	$14.74
1999	1.77	0.00	1.77	$14.68	$0.00	$14.68
2000	1.77	0.00	1.77	$14.63	$0.00	$14.63
2001	1.77	0.00	1.77	$14.58	$0.00	$14.58
2002	1.77	0.00	1.77	$14.53	$0.00	$14.53
2003	1.77	0.00	1.77	$14.49	$0.00	$14.49
2004	1.77	0.00	1.77	$14.44	$0.00	$14.44
2005	1.77	0.00	1.77	$14.40	$0.00	$14.40
2006	1.77	0.00	1.77	$14.36	$0.00	$14.36
2007	1.77	0.00	1.77	$14.32	$0.00	$14.32
2008	1.77	0.00	1.77	$14.28	$0.00	$14.28
2009	1.77	0.00	1.77	$14.26	$0.00	$14.26
2010	1.77	0.00	1.77	$14.23	$0.00	$14.23
2011	1.77	0.00	1.77	$14.20	$0.00	$14.20
2012	1.77	0.00	1.77	$14.17	$0.00	$14.17
2013	1.77	0.00	1.77	$14.13	$0.00	$14.13
2014	1.77	0.00	1.77	$14.09	$0.00	$14.09
2015	1.77	0.00	1.77	$14.05	$0.00	$14.05

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2016	1.77	0.00	1.77	$14.02	$0.00	$14.02
2017	1.77	0.00	1.77	$13.99	$0.00	$13.99
2018	1.77	0.00	1.77	$13.96	$0.00	$13.96
2019	1.77	0.00	1.77	$13.93	$0.00	$13.93

There have been many improvements to mirror systems since the 1968 requirements that are not required by FMVSS No. 111. There was a day/night feature which allowed the driver to tilt the inside mirror to reduce glare from vehicles approaching from the rear. This has been replaced by an automatic dimming feature to achieve a reduction in glare. Many outside mirrors can now be adjusted from the inside of the vehicle by the driver to adjust the height and angle of the view to the rear. In addition, passenger side rearview mirrors have been added to most passenger cars and LTVs. None of these features are linked to FMVSS No. 111 because none of them have ever been proposed and none of them have ever been evaluated by NHTSA.

Cameras and Rear Visibility Requirements

To reduce the risk of backover crashes involving children, the elderly, and other pedestrians, NHTSA issued a final rule on April 7, 2014, (79 FR 19178) to expand the rear field of view for all passenger cars, LTVs, buses, and low speed vehicles with a gross vehicle weight of 10,000 lb or less.[13] The rule expands the rear field of view to detect a 10-foot-wide by 20-foot-long zone directly behind the vehicle. The effective date began on May 1, 2016, requiring 10 percent of vehicles manufactured from May 1, 2016, to before May 1, 2017, to comply, 40 percent of vehicles manufactured from May 1, 2017, to before May 1, 2018, to comply and 100% compliance for vehicles manufactured on or after May 1, 2018. Because of the effective date for full compliance being May 1, 2018, not all MY 2018 vehicles had a camera system. The current technology being used is a camera system with a video screen that displays an image to the driver of what is directly behind the vehicle when the vehicle is put into reverse.

The NPRM was published on December 7, 2010 (75 FR 76186), making the baseline date September 1, 2010, or MY 2011. Thus, the percentage of passenger cars and LTVs equipped with a rear visibility camera in MY 2011 and earlier MYs is considered voluntary, the MY 2011 baseline year installation rate is considered voluntary for MY 2012 and later, and the difference between the percentage of the fleet with rear visibility cameras and the percentage with rear visibility cameras in the baseline year of MY 2011 is considered attributable for MYs 2012 to MY 2019.

The navigation systems that manufacturers installed in some vehicles for consumer convenience, which had no safety function other than to reduce vehicle miles traveled by keeping drivers from getting lost or making the wrong turns, had a video screen that could be used for rear visibility cameras. Since this analysis estimates the incremental costs linked to the FMVSS that would not have occurred without the FMVSS, the cost of the video screen which was provided with a

[13] See Docket No. 2010-0162-0256.

navigation system is considered zero for this analysis up to and including the baseline year. Thus, the cost of a video screen which was provided with a navigation system before or during the baseline year is considered a baseline cost that is not linked to safety and is not considered a voluntary nor attributable cost.

The Ludtke & Associates (2010) cost teardown study included costs of 5 ultrasonic sensor systems and 3 MY 2010 camera systems. Based on research and cost benefit analysis, the agency determined that ultrasonic sensor systems were not good enough at detecting pedestrians and that MY 2010 camera systems had the basic components that could be slightly altered to meet the final rule's requirements. Some camera systems did not meet the time requirements for how quickly the screen must show the image after putting the vehicle in reverse. This is a software change that given time will be a no-cost item. However, these vehicles had all the essential cost items, camera, video screen, computer, wiring, etc., and for this analysis we assumed that these costs were provided either voluntarily if they were by the baseline year or attributable if they were after the baseline year.

For this analysis, we do not consider ultrasonic sensors as a baseline system that was replaced by a camera system or as a safety system that was voluntarily supplied. Both ultrasonic systems and camera systems were being marketed at the same time, with the ultrasonic sensor system being marketed as more of a parking aid than as a safety system. The ultrasonic sensor systems have not been evaluated by NHTSA to determine if they provided a safety benefit.[14]

There would be a lower cost ($60.67 in 2019$) and weight (0.26 lb) for a make-model that already had a navigation system (thus including the video screen) before adding the camera, computer, and wiring. For this analysis, the MY 2011 baseline year installations of cameras and navigation systems were examined to determine a baseline cost. Table 43 shows the percentages of the fleets with camera and navigation systems used in this analysis.

Table 43 is based on data collected for NHTSA's (2014) Final Regulatory Impact Analysis: Backover Crash Avoidance Technologies, FMVSS No. 111 and updated through MY 2016 using data collected from the *Ward's Automotive Yearbook* (Binder, 2002-2017) Factory Installed Equipment tables. Starting in MY 2017, cameras sales were provided in a different table in the *Ward's Automotive Yearbook* in the Electronic Equipment Installation Rates.

Starting in MY 2006, there were more navigation systems than camera systems for passenger cars and less navigation systems than camera systems for LTVs. By the baseline year of MY 2011, the percent of the fleet with camera systems was very close to the percent of the fleet with navigation systems. There was no need to collect data on or estimate the percentage of the fleet with navigation systems after MY 2011, since those percentages would not be used in the analysis.

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[14] For the interested reader, the cost of 5 ultrasonic sensors from the cost teardown study (Docket No. 2011-0066-0010) were summarized in the FRIA (Docket No. 2010-0162-0255, Table VI-1) as ranging from $103.38 to $186.44 in 2019 dollars. Ultrasonic sensors were installed in an estimated 9.2% of passenger cars and 25.7% of LTVs in MY 2011, the baseline year (see Table IV-2 of the FRIA).

Table 43. FMVSS No. 111: Percentages of fleets equipped with cameras

Model Year	Cameras		Navigation System	
	Passenger Cars	**LTVs**	**Passenger Cars**	**LTVs**
2006	0	0	7	8
2007	0	0	7	13
2008	1.45	17.01	8	16
2009	1.37	19.28	8	16
2010	3.27	25.00	9	18
2011	11.58	24.97	11	23
2012	18.02	25.53		
2013	31.45	33.85		
2014	44.26	63.39		
2015	64.81	78.27		
2016	87.31	86.60		
2017	92.38	91.28		
2018	98.23	98.84		
2019	100.00	100.00		

Based on a MY 2010 camera system with a 130° lens, computer, a display on the dash or in the mirror, and wiring to the system the estimated consumer cost is $186.44 in 2019 dollars and the added weight is 4.46 lb.[15] NHTSA believes that the weight and cost for a camera system are the same for both passenger cars and LTVs.

The initial cost was derived using MY 2010 vehicles, Table 44 shows the consumer cost per vehicle after applying the learning curve. Table 44 also shows the factors derived that are multiplied by the average weight and average cost per vehicle to deduct the value of the video screens that were available in the navigation systems during the applicable MY.[16] The factors are derived by comparing the weight of the video system already available (0.26 lb to the weight of the whole rear visibility camera system (4.46 lb) for the percent of the fleet with cameras or

[15] Ibid, pg. 73, Table VI-4, $159.50 in 2010$ brought up to $186.44 in 2019$. Weight is derived from the same table, in some cases averaging the weights shown as follows (in pounds): camera 0.111, wiring 0.028, circuit board 0.117, display 1.268, hardware 2.935 = 4.46 pounds. Optical drives were assumed to be unnecessary for a rear visibility system without a navigation system.

[16] A sample calculation for passenger cars costs for MY 2011 is: $177.40 cost per vehicle after learning x 0.1158 (percent of passenger cars with cameras) x 0.926 navigation system factor = $19.02 the average incremental cost added for rear visibility cameras for passenger cars in MY 2011.

navigation systems, whichever is less, and using the same methodology for costs of the video system ($60.67) compared to the pre-learning cost of $186.44.

Table 45 shows the distribution between voluntary and attributable costs for passenger cars by MY. Table 46 shows the distribution between voluntary and attributable costs for LTVs by MY. In the final analysis, LTVs have lower average costs for MY 2019 ($111.80) than passenger cars ($122.51) because LTVs had a higher baseline of navigation systems (23%) than passenger cars (11%) with a free (for this analysis) video display.

Table 44. FMVSS No. 111: Cost after learning and factors applied for navigation systems rear visibility cameras for passenger cars and LTVs

Model Year	PC + LTV Learning Cost	Factors Applied for Navigation Systems			
		PC Weight	PC Cost	LTV Weight	LTV Cost
2008	$211.05	0.989	0.992	0.849	0.892
2009	$197.65	0.987	0.991	0.849	0.892
2010	$186.44	0.972	0.980	0.830	0.879
2011	$177.40	0.896	0.926	0.783	0.845
2012	$170.00	0.896	0.926	0.783	0.845
2013	$161.85	0.896	0.926	0.783	0.845
2014	$153.63	0.896	0.926	0.783	0.845
2015	$146.47	0.896	0.926	0.783	0.845
2016	$141.66	0.896	0.926	0.783	0.845
2017	$137.84	0.896	0.926	0.783	0.845
2018	$134.76	0.896	0.926	0.783	0.845
2019	$132.34	0.896	0.926	0.783	0.845

Table 45. FMVSS No. 111: Cost for rear visibility cameras for passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2007	0.0	0.0	0.0	$0.00	$0.00	$0.00
2008	0.1	0.0	0.1	$2.44	$0.00	$2.44
2009	0.1	0.0	0.1	$2.65	$0.00	$2.65
2010	0.1	0.0	0.1	$5.36	$0.00	$5.36
2011	0.4	0.0	0.4	$18.23	$0.00	$18.23
2012	0.4	0.3	0.7	$17.47	$10.19	$27.66

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2013	0.4	0.8	1.3	$16.63	$30.50	$47.13
2014	0.4	1.3	1.8	$15.78	$47.16	$62.94
2015	0.4	2.1	2.6	$15.05	$72.83	$87.88
2016	0.4	3.0	3.5	$14.55	$99.96	$114.51
2017	0.4	3.2	3.7	$14.16	$103.73	$117.89
2018	0.4	3.5	3.9	$13.85	$108.71	$122.55
2019	0.4	3.6	4.0	$13.60	$108.92	$122.52

Table 46. FMVSS No. 111: Rear visibility cameras for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2007	0.0	0.0	0.0	$0.00	$0.00	$0.00
2008	0.6	0.0	0.6	$31.54	$0.00	$31.54
2009	0.7	0.0	0.7	$33.88	$0.00	$33.88
2010	0.9	0.0	0.9	$40.94	$0.00	$40.94
2011	0.9	0.0	0.9	$37.35	$0.00	$37.35
2012	0.9	0.0	0.9	$35.79	$0.81	$36.61
2013	0.9	0.3	1.2	$34.21	$12.17	$46.37
2014	0.9	1.3	2.2	$32.55	$50.10	$82.65
2015	0.9	1.9	2.7	$31.08	$66.37	$97.45
2016	0.9	2.2	3.0	$30.08	$74.27	$104.35
2017	0.9	2.3	3.2	$29.29	$77.78	$107.07
2018	0.9	2.6	3.5	$28.64	$84.74	$113.38
2019	0.9	2.6	3.5	$28.13	$84.54	$112.67

FMVSS No. 112

[Does not currently exist, FMVSS No. 112 was Headlamp Concealment Devices standard which has been moved and is analyzed as part of FMVSS No. 108.]

FMVSS No. 113, Hood latch system

FMVSS No. 113 became effective on January 1, 1969, and specifies the requirement for providing a hood latch system or hood latch systems. Each hood must be provided with a hood latch system, and a hood that opens from the front must be provided with a second latch position on the hood latch system or with a second hood latch system. The purpose of the standard is to prevent the incidence of hoods flying open and partially or completely obstructing the driver's view through the windshield while the vehicle is moving. This standard applies to passenger cars, MPVs, trucks, (all LTVs), and buses.

The final rule was published in the Federal Register on April 27, 1968, (33 FR 6465) for passenger cars and LTVs. The NPRM was published in the Federal Register on December 28, 1967, (32 FR 20865) making the baseline date September 1, 1967, or MY 1968.

A study of 37 make-model passenger cars representing pre-standard, post-standard, and trend systems was conducted (McVetty et al., 1982).[17] The sales-weighted average weight and consumer cost of the pre-standard MY 1968 passenger car total hood latch system was calculated at 3.28 lb and $23.74 in 2019 dollars. In MY 1970, the weight and consumer cost in the post-standard MY passenger cars had decreased to 3.07 lb and $22.71 in 2019 dollars. By MY 1971, the weight and consumer cost for the trend systems had increased slightly to 3.74 lb and $24.03 in 2019 dollars for the total hood latch system. The cost teardown study was analyzed and the weight and cost of only the safety latch in MY 1968 was sales weighted and estimated to be 0.81 lb and $4.91 in 2019 dollars. In MY 1970, the weight and consumer cost in the post-standard MY passenger cars had decreased to 0.71 lb and $4.47 in 2019 dollars. By MY 1971, the weight and consumer cost for the trend systems increased slightly to 0.75 lb and $4.58 in 2019 dollars before the learning curve for only the safety latch.

It was determined that there were three major reasons for hood latch design changes between MY 1968 and 1971 among the sample:

- the hood lock environment changed due to styling changes or other modifications,
- the trend to inside hood releases, as either an option or standard feature, required a change from a safety catch integral with the latch mechanism to a separate safety catch, and
- the designs were revised for cost reduction and simplification.

In MY 1965, every passenger car and LTV had at least a single latch design and a single latch design is considered the Safety1965 equipment. The Volkswagen Beetle was the only vehicle found that added a safety catch in MY 1968. There was a single latch operated by a cable from inside the vehicle. The MY 1968 design added a separate safety catch to the same basic latch

[17] In this cost teardown study, the contractor used a markup from variable cost to consumer cost of 1.63 for imports and 1.61 for domestic manufacturers. This markup was changed to 1.51 to make it consistent with the rest of the analysis.

used in MY 1965 and a push button was added to the front trunk lid handle to actuate the safety catch. Since the baseline date is MY 1968, and all passenger cars and LTVs, even the VW Beetle met the standard in MY 1968, these weight and cost impacts of the safety catch are considered voluntary.

Based on this information on passenger cars and a lack of any information to the contrary for LTVs, it is assumed that all LTVs met the hood latch requirements by MY 1968 and the cost and weight of the safety latch are considered voluntary for LTVs.

Table 47 shows the voluntary weight and cost impact for FMVSS No. 113 Hood Latch Systems passenger cars and LTVs.

Table 47. FMVSS No. 113: Voluntary weight and cost impact for hood latch system for passenger cars and LTVs

Model Year	**Weight (lb)**			**Consumer Cost (2019$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.81	0	0.81	$4.91	$0.00	$4.91
1969	0.81	0	0.81	$4.91	$0.00	$4.91
1970	0.71	0	0.71	$4.47	$0.00	$4.47
1971	0.75	0	0.75	$4.58	$0.00	$4.58
1972	0.75	0	0.75	$4.37	$0.00	$4.37
1973	0.75	0	0.75	$4.33	$0.00	$4.33
1974	0.75	0	0.75	$4.29	$0.00	$4.29
1975	0.75	0	0.75	$4.26	$0.00	$4.26
1976	0.75	0	0.75	$4.23	$0.00	$4.23
1977	0.75	0	0.75	$4.19	$0.00	$4.19
1978	0.75	0	0.75	$4.16	$0.00	$4.16
1979	0.75	0	0.75	$4.13	$0.00	$4.13
1980	0.75	0	0.75	$4.11	$0.00	$4.11
1981	0.75	0	0.75	$4.09	$0.00	$4.09
1982	0.75	0	0.75	$4.07	$0.00	$4.07
1983	0.75	0	0.75	$4.05	$0.00	$4.05
1984	0.75	0	0.75	$4.03	$0.00	$4.03
1985	0.75	0	0.75	$4.01	$0.00	$4.01
1986	0.75	0	0.75	$3.99	$0.00	$3.99
1987	0.75	0	0.75	$3.97	$0.00	$3.97
1988	0.75	0	0.75	$3.95	$0.00	$3.95

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1989	0.75	0	0.75	$3.93	$0.00	$3.93
1990	0.75	0	0.75	$3.92	$0.00	$3.92
1991	0.75	0	0.75	$3.90	$0.00	$3.90
1992	0.75	0	0.75	$3.89	$0.00	$3.89
1993	0.75	0	0.75	$3.88	$0.00	$3.88
1994	0.75	0	0.75	$3.86	$0.00	$3.86
1995	0.75	0	0.75	$3.85	$0.00	$3.85
1996	0.75	0	0.75	$3.83	$0.00	$3.83
1997	0.75	0	0.75	$3.82	$0.00	$3.82
1998	0.75	0	0.75	$3.81	$0.00	$3.81
1999	0.75	0	0.75	$3.79	$0.00	$3.79
2000	0.75	0	0.75	$3.78	$0.00	$3.78
2001	0.75	0	0.75	$3.77	$0.00	$3.77
2002	0.75	0	0.75	$3.76	$0.00	$3.76
2003	0.75	0	0.75	$3.74	$0.00	$3.74
2004	0.75	0	0.75	$3.73	$0.00	$3.73
2005	0.75	0	0.75	$3.72	$0.00	$3.72
2006	0.75	0	0.75	$3.71	$0.00	$3.71
2007	0.75	0	0.75	$3.70	$0.00	$3.70
2008	0.75	0	0.75	$3.69	$0.00	$3.69
2009	0.75	0	0.75	$3.69	$0.00	$3.69
2010	0.75	0	0.75	$3.68	$0.00	$3.68
2011	0.75	0	0.75	$3.67	$0.00	$3.67
2012	0.75	0	0.75	$3.66	$0.00	$3.66
2013	0.75	0	0.75	$3.65	$0.00	$3.65
2014	0.75	0	0.75	$3.64	$0.00	$3.64
2015	0.75	0	0.75	$3.63	$0.00	$3.63
2016	0.75	0	0.75	$3.62	$0.00	$3.62
2017	0.75	0	0.75	$3.62	$0.00	$3.62

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2018	0.75	0	0.75	$3.61	$0.00	$3.61
2019	0.75	0	0.75	$3.60	$0.00	$3.60

FMVSS No. 114, Theft protection and rollaway prevention

FMVSS No. 114 became effective on January 1, 1970, and specifies the requirements for a lock system that prevents the activation of the engine ignition and starting systems, movement of the steering wheel, and movement of the automatic transmission gear selector out of the park position when the key is removed. The purpose of this standard is to:

- reduce thefts and enhance safety by reducing the incidence of crashes resulting from unauthorized operation of a motor vehicle, and
- prevent the rollaway of parked vehicles because of children moving the automatic shift mechanism out of the park position.

This standard applies to passenger cars and to trucks and MPVs (almost all LTVs) having a GVWR of 10,000 lb or less. It does not apply, however, to walk-in van-type vehicles. Although this standard would initially have had some cost implications, no cost studies have been performed, and none are planned by this agency.

On March 30, 2010, NHTSA issued a final rule on brake transmission shift interlock that required a vehicle that has a park position to not be allowed to be shifted out of park without the brake pedal being depressed in any starting system key position.[18] The final rule was effective September 1, 2010, for passenger cars, trucks, and MPVs (all LTVs) with a GVWR of 10,000 lb or less. The final rule was based on a voluntary agreement signed in August 2006 by the Alliance of Automobile Manufacturers and the Association of International Automobile Manufacturers and only resulted in relatively simple mechanical or electrical modifications. No cost studies related to a brake transmission shift interlock for FMVSS No. 114 have been performed, and none are planned by this agency.

FMVSS No. 115 – [Does not currently exist]

FMVSS No. 116, Motor vehicle brake fluids

FMVSS No. 116 became effective on January 1, 1968, and specifies requirements for fluids for use in hydraulic brake systems of motor vehicles, containers for these fluids, and labeling of the container. The purpose of this standard is to reduce failures in the hydraulic braking systems of motor vehicles that may occur because of the manufacture or use of improper or contaminated fluid. Each passenger car, MPV, truck, (all LTVs), bus, trailer, and motorcycle that has a hydraulic brake system shall have fluid that has been manufactured and packaged in conformity with the requirements of this standard. FMVSS No. 116 could initially have had some minor cost

[18] Final Rule issued on March 30, 2010, 79 FR 15621, Docket No. 2010-0043.

implications, along with possibly each time it was updated; however, no cost studies have been performed, and none are planned by this agency.

FMVSS No. 117, Retreaded pneumatic tires

FMVSS No. 117 became effective January 1, 1972, and specifies performance, labeling, and certification requirements for retreaded pneumatic passenger car tires. The purpose of this standard is to require retreaded pneumatic passenger car tires to meet safety criteria like those for new pneumatic passenger car tires. This standard applies to retreaded pneumatic tires for use on passenger cars manufactured after 1948. Since FMVSS No. 117 does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 118, Power-operated window, partition, and roof panel systems

FMVSS No. 118 applies to passenger cars, MPVs, and trucks with a GVWR of 10,000 lb or less. This standard specifies requirements for power-operated window, partition, and roof panel systems to minimize the likelihood of death or injury from their accidental operation.

Originally, this standard did not allow the power windows to be operational unless a vehicle's ignition or electrical accessory system was energized via the ignition key. In other words, the opening and closing of the power windows in a parked vehicle without the ignition turned on (potential safety hazard to children or other unsuspecting people) would not be possible under the standard. In 1975, the standard was amended to add restrictions on the operation of power windows while the passenger doors were ajar.

A final rule was published in the Federal Register on July 23, 1970, (35 FR 11797) for passenger cars and MPVs. The NPRM was published in the Federal Register on August 23, 1969, (34 FR 13608) making the baseline date September 1, 1968, or MY 1969.

A final rule was published in the Federal Register on June 24, 1988, (53 FR 23766) extending the requirements to LTVs. The NPRM was published in the Federal Register on October 16, 1987, (52 FR 38488) making the baseline date September 1, 1986. Or MY 1987.

Based on information in the *Ward's Automotive Yearbook* (Stark & Powers, 1965-1974), approximately 11 percent of the baseline 1969 MY passenger cars had power windows. We don't know whether the MY 1969 passenger cars met FMVSS No. 118 or not. We assume they did not. Thus, we start adding attributable weight and costs for power windows with MY 1971 passenger cars, which were required to meet the standard, when an estimated 16.63 percent of passenger cars had power windows.

The standard's requirements for power-operated roof panel systems need not be met for vehicles manufactured before September 1, 1993. No cost estimates have been made for power-operated roof panel systems for the original standard and none are planned. Power-operated roof panels with an automatic reversal system are analyzed later in the analysis.

FMVSS No. 118 was effective for MPVs, which are passenger vans and sport utility vehicles, on February 1, 1971, although none of the MPVs had power windows at that time. Based on Ward's yearbooks (Stark & Powers, 1965-1974), no LTVs had power windows in 1975 and installations of the power windows were appearing in LTVs in 1978. FMVSS No. 118 was extended to light trucks (pickups and cargo vans) effective July 25, 1988. In this case, we assume power operated windows installed in LTVs in 1978 and later met FMVSS No. 118, since the manufacturers knew what the standards were for passenger cars and MPVs. All power windows in LTVs, other than in MPVs will be considered voluntary through MY 1987 and the voluntary percentage will be held at that MY 1987 baseline level through MY 2019. Attributable costs will be the difference between the installation rates from MY 1988 to 2019 minus the voluntary baseline level of MY 1987. These assumptions require us to separate LTVs into MPV's and light trucks. This was performed on a make/model basis for those vehicles with power windows only, with all pickups and cargo vans considered light trucks and all SUVs and passenger vans considered MPVs.

Power window installations were taken from every third year of the Ward's yearbooks and interpolated in between years. Ward's yearbooks did not provide information on power windows for MY 2017, 2018, or 2019. Data were taken from the factory installed equipment pages of domestic passenger cars, domestic LTVs, imported passenger cars and imported LTVs and combined into passenger cars and LTVs. LTVs with power windows were divided into MPVs and light trucks and assigned voluntary and attributable weights and costs as described above. This distribution was:

- In MY 1978, the LTVs with power windows were 45 percent MPVs and 55 percent trucks.
- In MY 1981, the LTVs with power windows were 46.9 percent MPVs and 53.1 percent trucks.
- In MY 1984, the LTVs with power windows were 40.4 percent MPVs and 59.6 percent trucks.
- In MY 1987, the LTVs with power windows were 61.3 percent MPVs and 38.7 percent trucks.

While the percent of the LTV fleet with power windows kept increasing, this distribution between MPVs and trucks with power windows changed rather dramatically because of the models that power windows were introduced in and because MPV sales were rising dramatically in the mid-1980s.

Unfortunately, the Ward's yearbooks did not report power windows installations for domestic LTVs for a long period (from MY 1987 to 2003). For these years, we took a ratio between domestic LTVs and domestic passenger cars and applied it at an increasing rate to close the gap in knowledge between MY 1987 (when 44.7% of domestic passenger cars and 33.8% of domestic LTVs had power windows) to MY 2003 (when 87.6% of domestic passenger cars and 83.0% of domestic LTVs had power windows). Table 118-03 shows the resulting estimated percent of passenger cars and LTVs with power windows, the average added weight and the average added cost after applying the learning curve.

A cost teardown study was conducted on six make-model passenger cars from two major domestic manufacturers that represented pre-standard, post-standard (MY 1982), and trend systems (Adams et al., 1983). The small sample was due to the limited number of vehicles and the MYs affected by the standard for these specialty items.

Implementation of the standard involved moving the window system supply wire to a different location and adding a circuit breaker. Since the block fuse mounting was part of the pre-standard make-models, it was decided to base the weight and consumer cost on the addition of the circuit breaker to the post-standard and trend systems. Due to the small sample size, the simple arithmetic average was used instead of the sales-weighted average.

Because NHTSA has not performed teardown analyses of the power window components on LTVs, and because they are like the components on passenger cars, we will assume the same costs on LTVs as on passenger cars. The costs don't match in Table 49 because of the different percent installation rates for passenger cars and LTVs. Costs generally increase over time, despite the learning curve decreasing costs over time, since the percent installation rates increase over time.

Table 48 shows the average weight and consumer cost of power window components linked to FMVSS No. 118 in passenger cars and LTVs. Table 49 shows the weight and consumer cost by MY after applying the learning curve, but before applying the percentage of the fleet with power windows to determine average vehicle costs.

Table 48. FMVSS No. 118: Average weight and consumer cost of power window components in passenger cars and LTVs

Component	Weight (lb)	Consumer Cost (2019$)
Circuit Breaker	0.04	$1.28

Table 49. FMVSS No. 118: Power windows percent of fleet with power windows weight and costs after learning passenger cars and LTVs

Model Year	% PC Install	% LTV Install	Added Weight (lb)	Learned Consumer Cost (2019$)
1971	16.6	0.0	0.04	$1.71
1972	22.6	0.0	0.04	$1.56
1973	21.7	0.0	0.04	$1.48
1974	20.8	0.0	0.04	$1.44
1975	19.9	0.0	0.04	$1.42
1976	21.2	0.0	0.04	$1.39
1977	22.5	0.0	0.04	$1.36
1978	23.8	2.1	0.04	$1.34
1979	23.7	3.5	0.04	$1.32
1980	23.5	4.9	0.04	$1.30
1981	23.4	6.3	0.04	$1.29
1982	29.0	10.5	0.04	$1.28
1983	34.7	14.8	0.04	$1.26

Model Year	% PC Install	% LTV Install	Added Weight (lb)	Learned Consumer Cost (2019$)
1984	40.3	19.0	0.04	$1.24
1985	41.0	21.8	0.04	$1.22
1986	41.7	24.6	0.04	$1.20
1987	42.5	27.4	0.04	$1.19
1988	45.6	31.3	0.04	$1.18
1989	48.7	35.2	0.04	$1.16
1990	51.8	39.1	0.04	$1.15
1991	54.9	43.0	0.04	$1.14
1992	59.2	47.2	0.04	$1.13
1993	63.5	51.4	0.04	$1.12
1994	67.8	55.6	0.04	$1.11
1995	70.6	58.6	0.04	$1.10
1996	73.4	61.7	0.04	$1.09
1997	76.3	64.8	0.04	$1.08
1998	78.3	68.3	0.04	$1.07
1999	80.4	71.8	0.04	$1.06
2000	82.5	75.2	0.04	$1.05
2001	84.2	78.4	0.04	$1.04
2002	86.0	81.6	0.04	$1.04
2003	87.7	84.8	0.04	$1.03
2004	93.2	87.4	0.04	$1.02
2005	92.1	83.8	0.04	$1.01
2006	94.0	87.0	0.04	$1.01
2007	95.8	90.2	0.04	$1.00
2008	95.7	90.9	0.04	$1.00
2009	95.6	91.6	0.04	$0.99
2010	96.4	91.8	0.04	$0.99
2011	97.2	92.0	0.04	$0.98
2012	98.0	92.1	0.04	$0.98
2013	98.9	92.4	0.04	$0.97

Model Year	% PC Install	% LTV Install	Added Weight (lb)	Learned Consumer Cost (2019$)
2014	98.8	95.1	0.04	$0.97
2015	99.0	96.4	0.04	$0.96
2016	98.6	98.4	0.04	$0.96
2017	98.6	98.4	0.04	$0.96
2018	98.6	98.4	0.04	$0.95
2019	98.6	98.4	0.04	$0.95

Table 50. FMVSS No. 118: Power windows – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00
1971	0.00	0.01	0.01	$0.00	$0.28	$0.28
1972	0.00	0.01	0.01	$0.00	$0.35	$0.35
1973	0.00	0.01	0.01	$0.00	$0.32	$0.32
1974	0.00	0.01	0.01	$0.00	$0.30	$0.30
1975	0.00	0.01	0.01	$0.00	$0.28	$0.28
1976	0.00	0.01	0.01	$0.00	$0.29	$0.29
1977	0.00	0.01	0.01	$0.00	$0.31	$0.31
1978	0.00	0.01	0.01	$0.00	$0.32	$0.32
1979	0.00	0.01	0.01	$0.00	$0.31	$0.31
1980	0.00	0.01	0.01	$0.00	$0.31	$0.31
1981	0.00	0.01	0.01	$0.00	$0.30	$0.30
1982	0.00	0.01	0.01	$0.00	$0.37	$0.37
1983	0.00	0.01	0.01	$0.00	$0.44	$0.44
1984	0.00	0.02	0.02	$0.00	$0.50	$0.50
1985	0.00	0.02	0.02	$0.00	$0.50	$0.50
1986	0.00	0.02	0.02	$0.00	$0.50	$0.50

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1987	0.00	0.02	0.02	$0.00	$0.51	$0.51
1988	0.00	0.02	0.02	$0.00	$0.54	$0.54
1989	0.00	0.02	0.02	$0.00	$0.57	$0.57
1990	0.00	0.02	0.02	$0.00	$0.60	$0.60
1991	0.00	0.02	0.02	$0.00	$0.63	$0.63
1992	0.00	0.02	0.02	$0.00	$0.67	$0.67
1993	0.00	0.03	0.03	$0.00	$0.71	$0.71
1994	0.00	0.03	0.03	$0.00	$0.75	$0.75
1995	0.00	0.03	0.03	$0.00	$0.78	$0.78
1996	0.00	0.03	0.03	$0.00	$0.80	$0.80
1997	0.00	0.03	0.03	$0.00	$0.82	$0.82
1998	0.00	0.03	0.03	$0.00	$0.84	$0.84
1999	0.00	0.03	0.03	$0.00	$0.85	$0.85
2000	0.00	0.03	0.03	$0.00	$0.87	$0.87
2001	0.00	0.03	0.03	$0.00	$0.88	$0.88
2002	0.00	0.03	0.03	$0.00	$0.89	$0.89
2003	0.00	0.04	0.04	$0.00	$0.90	$0.90
2004	0.00	0.04	0.04	$0.00	$0.95	$0.95
2005	0.00	0.04	0.04	$0.00	$0.93	$0.93
2006	0.00	0.04	0.04	$0.00	$0.95	$0.95
2007	0.00	0.04	0.04	$0.00	$0.96	$0.96
2008	0.00	0.04	0.04	$0.00	$0.95	$0.95
2009	0.00	0.04	0.04	$0.00	$0.95	$0.95
2010	0.00	0.04	0.04	$0.00	$0.95	$0.95
2011	0.00	0.04	0.04	$0.00	$0.96	$0.96
2012	0.00	0.04	0.04	$0.00	$0.96	$0.96
2013	0.00	0.04	0.04	$0.00	$0.96	$0.96
2014	0.00	0.04	0.04	$0.00	$0.96	$0.96
2015	0.00	0.04	0.04	$0.00	$0.95	$0.95

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2016	0.00	0.04	0.04	$0.00	$0.95	$0.95
2017	0.00	0.04	0.04	$0.00	$0.94	$0.94
2018	0.00	0.04	0.04	$0.00	$0.94	$0.94
2019	0.00	0.04	0.04	$0.00	$0.94	$0.94

Table 51. FMVSS No. 118: Power window – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1977	0.00	0.00	0.00	$0.00	$0.00	$0.00
1978	0.00	0.00	0.00	$0.02	$0.01	$0.03
1979	0.00	0.00	0.00	$0.02	$0.02	$0.05
1980	0.00	0.00	0.00	$0.03	$0.03	$0.06
1981	0.00	0.00	0.00	$0.04	$0.04	$0.08
1982	0.00	0.00	0.00	$0.07	$0.06	$0.13
1983	0.00	0.00	0.01	$0.11	$0.08	$0.19
1984	0.00	0.00	0.01	$0.14	$0.10	$0.24
1985	0.00	0.00	0.01	$0.14	$0.13	$0.27
1986	0.00	0.01	0.01	$0.14	$0.16	$0.30
1987	0.01	0.01	0.01	$0.12	$0.21	$0.33
1988	0.01	0.00	0.01	$0.12	$0.25	$0.37
1989	0.01	0.00	0.01	$0.12	$0.29	$0.41
1990	0.01	0.00	0.02	$0.12	$0.33	$0.45
1991	0.01	0.01	0.02	$0.12	$0.37	$0.49
1992	0.01	0.01	0.02	$0.12	$0.41	$0.53
1993	0.01	0.01	0.02	$0.12	$0.46	$0.58
1994	0.01	0.01	0.02	$0.12	$0.50	$0.62
1995	0.01	0.01	0.02	$0.12	$0.52	$0.64
1996	0.01	0.01	0.02	$0.12	$0.55	$0.67
1997	0.01	0.01	0.03	$0.12	$0.58	$0.70

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1998	0.01	0.02	0.03	$0.12	$0.61	$0.73
1999	0.01	0.02	0.03	$0.12	$0.64	$0.76
2000	0.01	0.02	0.03	$0.12	$0.67	$0.79
2001	0.01	0.02	0.03	$0.12	$0.70	$0.82
2002	0.01	0.02	0.03	$0.12	$0.72	$0.84
2003	0.01	0.02	0.03	$0.12	$0.75	$0.87
2004	0.01	0.02	0.03	$0.12	$0.77	$0.89
2005	0.01	0.02	0.03	$0.12	$0.73	$0.85
2006	0.01	0.02	0.03	$0.12	$0.76	$0.88
2007	0.01	0.03	0.04	$0.12	$0.78	$0.90
2008	0.01	0.03	0.04	$0.12	$0.78	$0.91
2009	0.01	0.03	0.04	$0.12	$0.79	$0.91
2010	0.01	0.03	0.04	$0.12	$0.79	$0.91
2011	0.01	0.03	0.04	$0.12	$0.78	$0.90
2012	0.01	0.03	0.04	$0.12	$0.78	$0.90
2013	0.01	0.03	0.04	$0.12	$0.78	$0.90
2014	0.01	0.03	0.04	$0.12	$0.80	$0.92
2015	0.01	0.03	0.04	$0.12	$0.81	$0.93
2016	0.01	0.03	0.04	$0.12	$0.82	$0.95
2017	0.01	0.03	0.04	$0.12	$0.82	$0.94
2018	0.01	0.03	0.04	$0.12	$0.82	$0.94
2019	0.01	0.03	0.04	$0.12	$0.81	$0.93

Safer Switches and Automatic Reversal Systems

There are two safety strategies related to power-operated windows. The first strategy is called Safer Switches. FMVSS No. 118 requires as of October 1, 2008, or MY 2009 that power window switches must be operable with a pull-to-close mechanism.[19] This aspect was required to reduce inadvertent actuation of the power window switch. NHTSA data indicates that inadvertent actuation has been at the root cause of the most serious and tragic power window incidents. In these events, an occupant, typically a toddler, would kneel or stand on the seat or armrest with

[19] The final rule was published in the Federal Register on April 12, 2006, (71 FR 18673), (Docket No. 2006-24455).

his or her head or body outside the window. Then the occupant would activate a toggle or rocker switch with its foot or knee, inadvertently closing the window. The result could be asphyxiation or other serious injury to the child. It would be extremely unlikely that a child could inadvertently operate a pull-to-close mechanism, with his or her head out of the window. NHTSA believes there is almost no cost or weight differential between a pull-to-close switch and a toggle or rocker switch.

The second technology related to power-operated windows is an automatic reversal system (ARS). An ARS detects a strain on the motor with a force sensing technology when the window cannot close all the way and automatically reverses the window so that it goes back down. ARS was proposed as an option in an NPRM published in the Federal Register on September 1, 2009 (74 F.R., 2009). A target population, cost estimates and benefit estimates for power window incidents, and safer switches effectiveness estimate were provided in an August 2009 preliminary regulatory evaluation (PRE) (NHTSA, 2009). In March 2011 NHTSA decided to withdraw their NPRM on automatic reversal systems after further analysis, citing that NHTSA could not estimate the target population of minor injuries that occur on an annual basis and couldn't estimate effectiveness (NHTSA, 2009a). A Final Regulatory Evaluation was never published.

While the NPRM only proposed ARS for side windows, all manufacturers that have supplied power roof panels (for example power sunroofs) have used ARS. We have determined that ARS is linked to FMVSS No. 118 by virtue of the NPRM, including both the side windows and power roof panels.

Since ARS was never required, all ARS switches will be considered voluntary. It is estimated that about 80 percent of European and Japanese models of passenger cars and LTVs had ARS in MY 2000 in some of their side windows. Assuming no domestic manufacturers had ARS at the time, based on sales data, this results in 46.1 percent of passenger cars and 23.4 percent of LTVs having ARS in MY 2000.

Of the 49 million power windows sold in MY 2010, 24.1 million had ARS. Data provided by manufacturers to NHTSA indicated that 19.2 million met the Economic Commission for Europe (ECE) R21 requirements and 4.9 million had ARS switches but did not meet the ECE R21 requirements. Manufacturers supplied detailed data to NHTSA for MY 2012 to 2015, indicating for every make/model which specific windows had power windows and ARS, and which standards they met, including roof panels. During this time (MY 2012 to 2015) an average of 3.8 side windows per passenger car had power windows of which about 50 percent had ARS, and about 3.9 side windows per LTV had power windows of which about 36 percent had ARS. The Ward's yearbooks do not provide data on power windows for MYs 2017 to 2019, thus, we assumed the same MY 2016 data will apply to MYs 2017 to 2019.

Based on the 2009 PRE, in MY 2009 about 19 percent of light vehicles have power roofs with ARS. This estimate was used for both passenger cars and LTVs. It is believed that power roofs with ARS started production around 1997 and a linear increase in the percent of the fleet with power roofs is assumed through MY 2010. Manufacturers' data indicated that all roof panels produced from MY 2012 to 2016 have ARS, but the data does not tell NHTSA what percent of the make/models have roof panels. Thus, we relied on Ward's yearbook factory installed equipment data to determine what percent of the passenger cars and LTVs had roof panels.

Ward's yearbooks do provide data on sunroofs from MY 2013 to 2019 (Binder, 2002-2017; Norris, 2018-2020).

Table 52 shows the estimated average number of side windows with ARS and the average number of power roofs with ARS for passenger cars and LTVs. Another way of reading this information is that 7 percent of the fleet in MY 1997 had roof panels with ARS.

Table 52. FMVSS No. 118: Estimated average number of side windows and roof panels per vehicle with automatic reversal systems – passenger cars and LTVs

Model Year	Windows		Roof Panels	
	PC	LTV	PC	LTV
1994	0	0	0	0
1995	1.65	1.40	0	0
1996	1.65	1.40	0	0
1997	1.65	1.40	0.07	0.07
1998	1.65	1.40	0.08	0.08
1999	1.65	1.40	0.09	0.09
2000	1.65	1.40	0.10	0.10
2001	1.65	1.40	0.11	0.11
2002	1.65	1.40	0.12	0.12
2003	1.65	1.40	0.13	0.13
2004	1.65	1.40	0.14	0.14
2005	1.85	1.60	0.15	0.15
2006	1.85	1.60	0.16	0.16
2007	1.85	1.60	0.17	0.17
2008	1.85	1.60	0.18	0.18
2009	1.85	1.60	0.19	0.19
2010	1.85	1.60	0.20	0.20
2011	1.85	1.60	0.25	0.25
2012	1.85	1.60	0.29	0.29
2013	2.18	1.60	0.33	0.34
2014	2.33	1.63	0.32	0.35
2015	2.24	1.74	0.32	0.36
2016	2.29	1.74	0.32	0.44
2017	2.29	1.74	0.36	0.43
2018	2.29	1.74	0.41	0.43

Model Year	Windows		Roof Panels	
	PC	LTV	PC	LTV
2019	2.29	1.74	0.40	0.41

The August 2009 PRE estimated the cost of ARS at $7.29 (2019$) per window. Although the PRE did not estimate weight impacts, we assume a small weight per window (0.04 lb) as was found for the original FMVSS No. 118 standard. The PRE did not distinguish between ARS systems that met FMVSS No. 118, ECE R21 or did not meet ECE R21. All ARS systems were estimated to have the same cost and weight, although they wouldn't have the same benefit.

Table 53 and Table 54 show the resulting weight and costs for ARS, combining power windows and roof panels, which are supplied voluntarily by manufacturers.

Table 53. FMVSS No. 118: Power windows and roof panels automatic reversal system weight and cost – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1994	0.00	0.00	0.00	$0.00	$0.00	$0.00
1995	0.00	0.00	0.00	$1.04	$0.00	$1.04
1996	0.01	0.00	0.01	$1.83	$0.00	$1.83
1997	0.01	0.00	0.01	$3.48	$0.00	$3.48
1998	0.02	0.00	0.02	$4.91	$0.00	$4.91
1999	0.03	0.00	0.03	$6.24	$0.00	$6.24
2000	0.03	0.00	0.03	$6.94	$0.00	$6.94
2001	0.03	0.00	0.03	$6.78	$0.00	$6.78
2002	0.04	0.00	0.04	$7.49	$0.00	$7.49
2003	0.04	0.00	0.04	$8.20	$0.00	$8.20
2004	0.05	0.00	0.05	$8.90	$0.00	$8.90
2005	0.06	0.00	0.06	$10.62	$0.00	$10.62
2006	0.06	0.00	0.06	$11.35	$0.00	$11.35
2007	0.07	0.00	0.07	$12.07	$0.00	$12.07
2008	0.07	0.00	0.07	$12.79	$0.00	$12.79
2009	0.08	0.00	0.08	$13.45	$0.00	$13.45
2010	0.08	0.00	0.08	$14.08	$0.00	$14.08

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2011	0.08	0.00	0.08	$14.36	$0.00	$14.36
2012	0.08	0.00	0.08	$14.48	$0.00	$14.48
2013	0.10	0.00	0.10	$16.78	$0.00	$16.78
2014	0.10	0.00	0.10	$17.44	$0.00	$17.44
2015	0.10	0.00	0.10	$16.67	$0.00	$16.67
2016	0.10	0.00	0.10	$16.79	$0.00	$16.79
2017	0.10	0.00	0.10	$16.88	$0.00	$16.88
2018	0.11	0.00	0.11	$17.07	$0.00	$17.07
2019	0.11	0.00	0.11	$16.88	$0.00	$16.88

Table 54. FMVSS No. 118: Power windows and roof panels automatic reversal system weight and cost – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1994	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.06	0.00	0.06	0.18	0.00	0.18
1996	0.06	0.00	0.06	0.78	0.00	0.78
1997	0.06	0.00	0.06	1.49	0.00	1.49
1998	0.06	0.00	0.06	2.10	0.00	2.10
1999	0.06	0.00	0.06	2.67	0.00	2.67
2000	0.06	0.00	0.06	3.02	0.00	3.02
2001	0.06	0.00	0.06	2.96	0.00	2.96
2002	0.06	0.00	0.06	3.96	0.00	3.96
2003	0.06	0.00	0.06	4.98	0.00	4.98
2004	0.06	0.00	0.06	5.98	0.00	5.98
2005	0.07	0.00	0.07	7.84	0.00	7.84
2006	0.07	0.00	0.07	8.89	0.00	8.89
2007	0.07	0.00	0.07	9.93	0.00	9.93
2008	0.07	0.00	0.07	10.96	0.00	10.96
2009	0.07	0.00	0.07	11.67	0.00	11.67

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2010	0.07	0.00	0.07	11.62	0.00	11.62
2011	0.07	0.00	0.07	11.78	0.00	11.78
2012	0.08	0.00	0.08	11.93	0.00	11.93
2013	0.08	0.00	0.08	12.08	0.00	12.08
2014	0.08	0.00	0.08	12.59	0.00	12.59
2015	0.08	0.00	0.08	13.34	0.00	13.34
2016	0.09	0.00	0.09	13.98	0.00	13.98
2017	0.09	0.00	0.09	13.79	0.00	13.79
2018	0.09	0.00	0.09	13.67	0.00	13.67
2019	0.09	0.00	0.09	13.44	0.00	13.44

FMVSS No. 119, New pneumatic tires for motor vehicles with a GVWR of more than 4,536 kilograms (10,000 lb) and motorcycles

FMVSS No. 119 became effective on March 1, 1975, and establishes performance and marking requirements for tires for use on vehicles other than passenger cars. The purpose of this standard is to:

- provide safe operational levels for tires used on motor vehicles other than passenger cars, and
- place sufficient information on the tires to permit their proper selection and use.

This standard applies to new pneumatic tires designed for highway use on MPVs, trucks, buses, trailers, and motorcycles manufactured after 1948.

Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 120, Tire selection and rims and motor home/recreation vehicle trailer load carrying capacity information for motor vehicles with a GVWR of more than 4,536 kilograms (10,000 lb)

FMVSS No. 120 became effective on August 1, 1976, and specifies tire and rim selection requirements and rim marking requirements. The purpose of this standard is to provide safe operational performance by ensuring that vehicles to which it applies have tires of adequate size and load rating and with rims of appropriate size and type designation. This standard applies to tires, rims, and non-pneumatic spare tire assemblies on MPVs, trucks, buses, trailers, and motorcycles. Since this standard does not regulate components of new passenger cars or LTVs with a GVWR of 4,536 kilograms (10,000 lb) or less, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 121, Air brake systems

FMVSS No. 121 originally went into effect for trucks, buses, and trailers on January 1, 1975, specifying performance standards and tests for air brake systems. In 1996, NHTSA issued final rules amending FMVSS No. 121 (and FMVSS No. 105) to require ABS and a malfunction indicator lamp or lamps on all new vehicles with GVWR greater than 10,000 lb. The ABS requirement went into effect for air-brake truck tractors manufactured on or after March 1, 1997, for air-brake trailers and single-unit trucks manufactured on or after March 1, 1998, and for hydraulic-brake trucks manufactured on or after March 1, 1999. The requirement for the malfunction indicator lamp on the vehicle went into effect simultaneously with the ABS requirement; furthermore, starting March 1, 2001, the truck tractor was required to display, within the cab, a malfunction indicator lamp for each trailer attached to it (61 F.R., 1996). The purpose of this standard is to insure safe braking performance under normal and emergency conditions. Before the standard went into effect, the manufacturers of truck-tractors, trailers, and other heavy vehicles were offering ABS in different configurations as optional equipment.

Since FMVSS No. 121 does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. However, a study was conducted in 2000 and Table 55 shows the arithmetic average weight and consumer cost of two air-braked truck-tractor ABS, two air-braked trailer ABS, and one tractor-trailer connection (Khadilkar, 2001). The connections between the tractors and the trailers are standardized by industry practice and by applicable standards and guidelines, which allows for interchangeability between various trailers and the towing tractors. (Of course, none of the costs of FMVSS No. 121 apply to passenger cars or LTVs because they have hydraulic brakes, not air brakes.)

Table 55. FMVSS No. 121: Average weight and consumer cost of ABS in air-braked truck-tractors and trailers

ABS	Weight (lb)	Consumer Cost (2019$)
Truck-Tractor		
2000 Navistar International Class 7 Bendix ABS	31.71	$848.91
2000 Freightliner Class 8 Meritor/Wabco ABS	18.76	$688.00
Trailer		
2000 Great Dane Meritor/Wabco ABS	31.74	$685.90
2000 Utility International Haldex ABS	33.19	$548.97
Tractor-Trailer Connection		
	9.54	$134.16

FMVSS No. 122, Motorcycle brake systems

FMVSS No. 122 became effective on January 1, 1974, and specifies performance requirements for motorcycle brake systems. The purpose of the standard is to ensure safe motorcycle braking performance under normal and emergency conditions. This standard only applies to motorcycles. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency for basic motorcycle brake systems costs. However, a cost study has been performed on motorcycle ABSs (Ludtke & Associates, 2011). Motorcycle ABS systems are not required.

Table 56. FMVSS No. 122: Average weight and consumer cost of ABS in motorcycles

Model	Weight (lb)	Consumer Cost (2019$)
2011 Harley Davidson	6.35	$350.69
2011 Suzuki SV 650	6.24	$342.16

FMVSS No. 123, Motorcycle controls and displays

FMVSS No. 123 became effective on September 1, 1974, and specifies requirements for the location, operation, identification, and illumination of motorcycle controls and displays and requirements for motorcycle stands and footrests. The purpose of this standard is to minimize accidents caused by operator error in responding to the motoring environment by standardizing certain motorcycle controls and displays. This standard applies to motorcycles with handlebars, except for motorcycles that are designed and sold exclusively for use by law enforcement agencies. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 124, Accelerator control systems

FMVSS No. 124 became effective on September 1, 1973, and establishes requirements for the return of a vehicle’s throttle to the idle position when the driver removes his or her foot from the accelerator control or in the event of a severance or disconnection in the accelerator control system. The purpose of this standard is to reduce deaths and injuries resulting from engine over-speed when the accelerator fails to return to the up position. This standard applies to passenger cars, MPVs, trucks, (all LTVs), and buses.

The final rule was published in the Federal Register on April 8, 1972, (37 FR 7097) for passenger cars and LTVs. The NPRM was published in the Federal Register on September 30, 1970, (35 FR 15241) making the baseline date September 1, 1970, or MY 1971. The agency knows that all MY 1973 passenger cars and LTVs met the standard by the effective date but has no data that would indicate that any pre-standard systems complied. None of the 9 pre-standard make-models in the cost teardown, that were MYs 1971 or 1972, complied. Thus, 100 percent of the passenger cars and LTVs are considered attributable to the standard starting in MY 1973 and no voluntary compliance is assumed. We assume that the MY 1965 passenger cars and LTVs had the same non-complying systems as examined in MYs 1971 or 1972 and can be considered

Safety1965. Thus, the cost and weight we included in this analysis is the difference between the pre-standard (Safety1965) systems and the complying system.

Accelerator control systems were difficult to analyze because changes were being made to the carburetor systems to meet Environmental Protection Agency fuel conservation and emissions systems standards at the same time FMVSS No. 124 went into effect. However, the standard was met by having two energy sources, an inner and outer accelerator return spring, which could return the throttle to the idle position.

Adams et al. (1983) conducted a study on 6 make-model passenger cars from four major manufacturers, two LTVs and one bus that represented pre-standard, post-standard, and trend systems. Analysis of each system identified an increase in the weight and consumer cost from the pre-standard make-models to the post-standard make-models. While a comparison of the post-standard and trend systems indicated that 4 out of the 6 passenger car make-models decreased in cost, 3 out of those 4 make-models were from the same manufacturer (GM). Because of the lack of evidence to support a significant trend, we focused on the pre-standard compared to the post-standard estimates and ignored the trend data. Based on the teardown analysis, where the accelerator control systems on LTVs were like the systems on passenger cars, we averaged the costs together for passenger cars and LTVs and used the simple arithmetic average instead of the sales-weighted average for the weight and consumer cost. The arithmetic average for the weight and consumer cost of the pre-standard make-models was calculated at 0.02 lb and $0.62 in 2019 dollars; the post-standard (averaging MY 1982 vehicles) was calculated at 0.04 lb and $1.26; the trend systems were calculated at 0.03 lb and $1.03.

Table 57 shows the actual weight and cost increments of accelerator control systems for FMVSS No. 124 in passenger cars and LTVs.

Table 57. FMVSS No. 124: Average weight and consumer cost of accelerator control systems in passenger cars and LTVs

Category	**Weight (lb)**	**Consumer Cost (2019$)**
Pre-Standard	0.02	$0.62
Post-Standard	0.04	$1.26
Difference	0.02	$0.64

Table 58 shows the weight and cost attributable to passenger cars and LTVs for accelerator control systems after applying the learning curve to the estimates of the difference in costs between pre-standard and post-standard systems. The learning curve, and $0.64 cost, is centered on MY 1982 because that was the median MY in the sample of vehicles studied. After applying the learning curve, costs are higher before MY 1982 and lower after MY 1982.

Table 58. FMVSS No. 124: Average weight and cost of accelerator controls in passenger cars and LTVs

Model Year	Weight (lb.)	Cost (2019$)
1972	0.00	$0.00
1973	0.02	$0.80
1974	0.02	$0.75
1975	0.02	$0.73
1976	0.02	$0.70
1977	0.02	$0.68
1978	0.02	$0.67
1979	0.02	$0.66
1980	0.02	$0.65
1981	0.02	$0.64
1982	0.02	$0.64
1983	0.02	$0.63
1984	0.02	$0.62
1985	0.02	$0.62
1986	0.02	$0.61
1987	0.02	$0.61
1988	0.02	$0.60
1989	0.02	$0.60
1990	0.02	$0.59
1991	0.02	$0.59
1992	0.02	$0.59
1993	0.02	$0.59
1994	0.02	$0.58
1995	0.02	$0.58
1996	0.02	$0.58
1997	0.02	$0.57
1998	0.02	$0.57
1999	0.02	$0.57

Model Year	Weight (lb.)	Cost (2019$)
2000	0.02	$0.57
2001	0.02	$0.56
2002	0.02	$0.56
2003	0.02	$0.56
2004	0.02	$0.56
2005	0.02	$0.55
2006	0.02	$0.55
2007	0.02	$0.55
2008	0.02	$0.55
2009	0.02	$0.55
2010	0.02	$0.55
2011	0.02	$0.54
2012	0.02	$0.54
2013	0.02	$0.54
2014	0.02	$0.54
2015	0.02	$0.54
2016	0.02	$0.54
2017	0.02	$0.54
2018	0.02	$0.53
2019	0.02	$0.53

FMVSS No. 125, Warning devices

FMVSS No. 125 became effective on January 1, 1974, and establishes shape, size, and performance requirements for reusable day and night equilateral triangle warning devices that can be erected on or near the roadway to warn approaching motorists of the presence of a stopped vehicle. The purpose of this standard is to reduce deaths and injuries due to rear-end collisions between moving traffic and disabled vehicles. This standard applies to devices that do not have self-contained energy sources and are designed to be carried in buses and trucks that have a GVWR greater than 10,000 lb. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 126, Electronic stability control systems

On April 6, 2007, (72 FR 17236), NHTSA published in the Federal Register a final rule on FMVSS No. 126 to require ESC on passenger cars, MPVs, trucks, (all LTVs), and buses with a GVWR of 10,000 lb or less with a phase-in comprising 55 percent of MY 2009 sales, 75 percent of MY 2010, 95 percent of MY 2011, and all new vehicles by MY 2012. ESC was first offered on selected MY 1997 passenger cars.

On September 18, 2006, NHTSA proposed FMVSS No. 126 (71 FR 54712). Thus, the baseline date is September 1, 2006, or MY 2007. ESC weight and costs will be considered voluntary through MY 2007 and the voluntary percentage will be held at that MY 2007 baseline level through MY 2019. Attributable costs will be the difference between the installation rates for MYs 2008 to 2019 minus the voluntary baseline level of MY 2007.

ESC systems detect when a vehicle is about to lose traction and automatically apply the brakes to individual wheels and reduce engine torque to help the driver stay on course. They are a highly effective crash avoidance technology. ESC systems detect and automatically assist drivers in oversteer and understeer situations that lead to loss of control and occur especially in unfavorable conditions such as rain, snow, sleet, or ice. Oversteer is when the vehicle turns more than the driver wants and is called spinning out. Understeer is when the vehicle turns less than the driver intends and is called plowing out. Sensors monitor the speed of each wheel, the steering wheel angle, the lateral acceleration and the yaw rate and estimate the slip of the vehicle in order to brake individual wheels and reduce engine torque so that the driver can maintain directional control. The yaw rate is the rate of change of the vehicle's heading. The system compares the measured yaw rate of the vehicle to the driver's intended rate of change of heading (as evidenced by the steering wheel angle) consistent with the speed and lateral acceleration of the vehicle. For example, a yaw rate measurement greater than that consistent with the vehicle's heading angle and corresponding steering wheel angle indicates oversteer. ESC rapidly and automatically intervenes to correct the vehicle heading by applying the brakes to individual wheels and possibly reducing engine torque to help the driver stay on the road. If the vehicle was experiencing the onset of oversteer in a left curve, ESC would momentarily apply the brake to the right front wheel to counteract the excessive yaw rate and stabilize the vehicle. During an understeer scenario, if a driver was attempting to drive around a left curve, the ESC system momentarily applies the left rear brake, creating a clockwise rotational force, to turn the heading of the vehicle back to the correct path. It will also reduce engine power to gently slow the vehicle and, if necessary, apply additional brakes.

All current vehicles with ESC also have ABS and traction control systems; the ESC to a large extent builds on ABS technology and shares ABS components. All the ABS costs were accounted for in FMVSS No. 105. ESC (without ABS costs added in) is assumed to be voluntarily provided through the baseline year of MY 2007 and the voluntary percentage will be held at that MY 2007 baseline level through MY 2019. Attributable costs for ESC (without ABS costs added in) will be the difference between the installation rates for MYs 2008 to 2019 minus the voluntary baseline level of MY 2007. The same accounting assumptions are made for weight.

Mercedes-Benz first offered ESC in 1997 as standard equipment on top-of-the-line subseries or as an option on other subseries of its S and SL luxury cars. The next year, BMW was the first with ESC standard on an entire make-model, its 700-series. By 2000, it was standard on most BMW and Mercedes cars, Cadillac Seville and a few other GM luxury models, Lexus LS and

GS, and Acura RL. Among SUVs, ESC was standard on Mercedes ML in 1999, on Lexus LX in 2000, followed by Toyota 4Runner and Land Cruiser, and Lexus RX the next year.

Although traction control systems which automatically reduce output torque to certain drive wheels in certain driving conditions may use the same brake components as the ESC system, traction control systems are not required by FMVSS No. 126 and are not considered by the agency to be a safety system, but more of a convenience feature. Thus, traction control systems are not included in this report.

Teardown cost estimateswere provided on ESC, ABS, and traction control for 11 vehicles, 9 of which were MY 2005 vehicles, one from MY 2004 and one from MY 2006 (Ludtke & Associates, 2006, 2006a). The estimates were summarized in the Final Regulatory Impact Analysis (NHTSA, 2007). Based on the teardowns of a variety of vehicles of Asian, European, and domestic passenger cars and LTVs, it was assumed that the same cost would apply for both passenger cars and LTVs. The estimates were incremental to the hydraulic brake systems already on the vehicles. Tables 17 and 27 provide the percent of passenger cars and LTVs with ABS. Table 24, 25, 26, 32, and 33 provide the weight and cost estimates for ABS. Table 59 shows the individual components for ESC.

Table 59. FMVSS No. 125: Average weight and cost of electronic stability control components in passenger cars and LTVs

	Weight (lb)	**Cost (2019$)**
Yaw Rate/Lateral Acceleration Sensors	0.78	$77.41
Steering Wheel Sensor	0.35	$35.40
Integrated Control Unit (over ABS)	0.61	$22.59
Wires/Telltale Light	0.08	$7.09
Total	1.82	$142.51

Table 60 provides the estimated percent of the fleet with ESC and the cost per vehicle after applying the learning curve. The $142.51 cost (in 2019$) for ESC was based on a MY 2005 vehicle. After applying the learning curve the cost per vehicle is higher in the years prior to MY 2005 and lower in years after MY 2005.

Table 60. FMVSS No. 126: Percent of fleet installed and learned costs for ESC systems in passenger cars and LTVs

Model Year	PC Percent	LTV Percent	Learned Cost Per Vehicle
1998	0.26	0.00	$268.46
1999	1.91	0.60	$208.43
2000	4.98	0.67	$185.15
2001	7.20	3.08	$170.54

Model Year	PC Percent	LTV Percent	Learned Cost Per Vehicle
2002	8.01	4.89	$161.62
2003	11.77	8.39	$153.69
2004	12.52	11.92	$147.56
2005	12.50	16.82	$142.51
2006	19.75	30.89	$136.75
2007	20.17	49.44	$131.47
2008	30.04	62.01	$126.99
2009	36.05	81.55	$124.36
2010	74.89	88.16	$120.91
2011	88.72	94.44	$117.58
2012	100	100	$114.56
2013	100	100	$112.01
2014	100	100	$109.89
2015	100	100	$107.96
2016	100	100	$106.55
2017	100	100	$105.28
2018	100	100	$104.17
2019	100	100	$103.21

Tables 61 and 62 show the average voluntary and attributable weights and costs per vehicle for passenger cars and LTVs.

Table 61. FMVSS No. 126: Average voluntary and attributable weights and costs for ESC – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00
1998	0.00	0.00	0.00	$0.70	$0.00	$0.70
1999	0.03	0.00	0.03	$3.98	$0.00	$3.98
2000	0.09	0.00	0.09	$9.22	$0.00	$9.22
2001	0.13	0.00	0.13	$12.28	$0.00	$12.28
2002	0.15	0.00	0.15	$12.95	$0.00	$12.95

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2003	0.21	0.00	0.21	$18.09	$0.00	$18.09
2004	0.23	0.00	0.23	$18.47	$0.00	$18.47
2005	0.23	0.00	0.23	$17.81	$0.00	$17.81
2006	0.36	0.00	0.36	$27.01	$0.00	$27.01
2007	0.37	0.00	0.37	$26.52	$0.00	$26.52
2008	0.37	0.18	0.55	$25.61	$12.53	$38.15
2009	0.37	0.29	0.66	$25.08	$19.75	$44.83
2010	0.37	1.00	1.36	$24.39	$66.16	$90.55
2011	0.37	1.25	1.61	$23.72	$80.60	$104.32
2012	0.37	1.45	1.82	$23.11	$91.45	$114.56
2013	0.37	1.45	1.82	$22.59	$89.41	$112.01
2014	0.37	1.45	1.82	$22.17	$87.73	$109.89
2015	0.37	1.45	1.82	$21.78	$86.19	$107.96
2016	0.37	1.45	1.82	$21.49	$85.06	$106.55
2017	0.37	1.45	1.82	$21.23	$84.04	$105.28
2018	0.37	1.45	1.82	$21.01	$83.16	$104.17
2019	0.37	1.45	1.82	$20.82	$82.39	$103.21

Table 62. FMVSS No. 126: Average voluntary and attributable weights and costs for ESC – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1997	0.0	0.0	0.0	$0.00	$0.00	$0.00
1998	0.0	0.0	0.0	$0.00	$0.00	$0.00
1999	0.0	0.0	0.0	$1.25	$0.00	$1.25
2000	0.0	0.0	0.0	$1.24	$0.00	$1.24
2001	0.1	0.0	0.1	$5.25	$0.00	$5.25
2002	0.1	0.0	0.1	$7.90	$0.00	$7.90
2003	0.2	0.0	0.2	$12.89	$0.00	$12.89
2004	0.2	0.0	0.2	$17.59	$0.00	$17.59

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2005	0.3	0.0	0.3	$23.97	$0.00	$23.97
2006	0.6	0.0	0.6	$42.24	$0.00	$42.24
2007	0.9	0.0	0.9	$65.00	$0.00	$65.00
2008	0.9	0.2	1.1	$62.78	$15.96	$78.75
2009	0.9	0.6	1.5	$61.48	$39.93	$101.42
2010	0.9	0.7	1.6	$59.78	$46.82	$106.60
2011	0.9	0.8	1.7	$58.13	$52.91	$111.05
2012	0.9	0.9	1.8	$56.64	$57.92	$114.56
2013	0.9	0.9	1.8	$55.38	$56.63	$112.01
2014	0.9	0.9	1.8	$54.33	$55.56	$109.89
2015	0.9	0.9	1.8	$53.38	$54.59	$107.96
2016	0.9	0.9	1.8	$52.68	$53.87	$106.55
2017	0.9	0.9	1.8	$52.05	$53.23	$105.28
2018	0.9	0.9	1.8	$51.50	$52.67	$104.17
2019	0.9	0.9	1.8	$51.03	$52.18	$103.21

FMVSS No. 127 - [Does not currently exist]

FMVSS No. 128 - [Does not currently exist]

FMVSS No. 129, New non-pneumatic tires for passenger cars

FMVSS No. 129 became effective on August 20, 1990, and specifies tire dimensions and laboratory test requirements for lateral strength, endurance, and high-speed performance; defines the tire load rating; and defines labeling requirements for non-pneumatic spare tires. This standard applies to new temporary spare non-pneumatic tires for use on passenger cars. Since this standard does not require new passenger cars or LTVs to have the optional non-pneumatic tires, no cost studies have been performed, and none are planned by this agency.

FMVSS No. 130 - [Does not currently exist]

FMVSS No. 131, School bus pedestrian safety devices

FMVSS No. 131 became effective on May 3, 1991, and establishes requirements for devices (stop signal arms) that can be installed on school buses to improve the safety of pedestrians near stopped school buses. The purpose of this standard is to reduce deaths and injuries by minimizing the likelihood of vehicles passing a stopped school bus and striking pedestrians near the bus. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 132 - [Does not currently exist]

FMVSS No. 133 - [Does not currently exist]

FMVSS No. 134 - [Does not currently exist]

FMVSS No. 135, Light vehicle brake systems

This standard specifies requirements for vehicles with hydraulic and electric service brakes and parking brake systems. The purpose of the standard is to ensure safe braking performance under normal conditions and emergency conditions. This standard applies to passenger cars manufactured on or after September 1, 2000, and to MPVs, trucks, and buses with a GVWR of 7,716 lb or less, manufactured on or after September 1, 2002. In addition, at the option of the manufacturer, passenger cars manufactured before September 1, 2000, and MPVs, trucks, and buses with a GVWR of 7,716 lb or less manufactured before September 1, 2002, may meet the requirements of this standard instead of FMVSS No. 105. FMVSS No. 135 is an update to FMVSS No. 105, including harmonizing some of the test requirements with Europe. It is not believed to have significantly increased the weight or cost of brake systems. However, no cost studies have been performed.

FMVSS No. 136 - Electronic Stability Control Systems on Heavy Vehicles

The final rule requires ESC systems on truck tractors and certain buses with a GVWR of greater than 11,793 kilograms (26,000 lb). The final rule was published in the Federal Register on Oct 30, 2017, (82 F.R: 50089, 2017; Docket No. 2015-0056). Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies of this standard have been performed.

FMVSS No. 137 - [Does not currently exist]

FMVSS No. 138, Tire pressure monitoring systems

Section 13 of the Transportation Recall Enhancement, Accountability, and Documentation Act of 2000 directed NHTSA to upgrade tire performance, including a requirement for systems that warn the driver when a tire is significantly underinflated – a situation that poses a safety risk, increasing the chance of skidding, hydroplaning, longer stopping distances, and crashes due to flat tires and blowouts. On April 8, 2005, (49 FR 18136), NHTSA published in the Federal Register a new safety standard, FMVSS No. 138, Tire pressure monitoring systems, requiring TPMS in all new cars and LTVs with GVWR of 10,000 lb or less built after September 1, 2007, (MY 2008). The phase-in period required TPMS on 20 percent of MY 2006 vehicles and 70 percent of MY 2007. A vehicle's TPMS must warn the driver when one or more of the vehicle's tires is severely underinflated – i.e., has fallen to 25 percent or more below the nominal pressure to which the TPMS has been calibrated. Ordinarily, the TPMS should be calibrated to the placard pressure recommended by the manufacturer for that vehicle, which is usually on a label on the inside of the driver's door frame. The display, a warning light on the instrument panel, must activate within 20 minutes of underinflated travel at speeds of 50 to 100 kmh and must remain illuminated until the underinflation is remedied. The system must also have a malfunction lamp in addition to a low-pressure warning lamp that alerts the driver if the vehicle's TPMS is not functioning properly.

This standard applies to passenger cars, MPVs, trucks, (all LTVs), and buses with a GVWR of 10,000 lb or less, except those vehicles with dual wheels on an axle.

There are two distinct types of TPMS that have been installed on production vehicles at various times since 2000 – an indirect system and the direct system. And there are two types of indirect systems with different capabilities (the pre-standard indirect system and the post-standard indirect system). In vehicles with ABS, indirect TPMS relies on the ABS system, which has sensors that continually monitor the speed of the four wheels. The operating principle is that if a single wheel has a faster rotational speed than other wheels, then its radius or rolling circumference must be smaller and therefore the tire may be underinflated, triggering the warning light if the difference in speeds is large enough. Because the indirect systems of the early 2000s (pre-standard indirect systems) could only detect relative wheel speeds, they could not detect when two to four tires lost pressure at about the same rate and were all underinflated. Since tires lose about 1 psi of pressure per month, the natural progression without refilling the tires would be for all four tires to be underinflated at about the same time, which could not be detected by the pre-standard indirect systems. The pre-standard indirect systems could detect when one tire got a nail in it and lost pressure. Thus, the pre-standard indirect systems provided some measure of safety, just not as much safety as the final rule required. FMVSS No. 138 required the TPMS to be capable of detecting underinflation in one or more of the tires, up to a total of four tires. As a result, most manufacturers began exclusively installing direct systems after publication of the final rule. A small percentage of sales in the early 2000s had pre-standard indirect TPMS. We attempted to estimate the percent of the fleet with indirect TPMS from MYs 2000 to 2006. This is an inexact science since TPMS was optional on several models and we did not know the percent of those models sold with TPMS. Table 65 shows these estimates for passenger cars and LTVs. The percent of new vehicles sold with TPMS rose from year to year until MY 2004, when several models were changed from providing TPMS as standard equipment to providing TPMS as optional equipment. By MY 2006, sales of direct TPMS systems picked up dramatically for passenger cars and dropped dramatically for indirect TPMS systems.

In 2009, the Audi A6 was the first post-standard indirect system to certify compliance with FMVSS No. 138. Since that time several Audi and VW models, as well as models from Honda, Mazda, Toyota, and Volvo, have come with indirect systems. The percent of the post-standard MYs 2009-to-2019 fleet with indirect systems was determined by using compliance data supplied by the manufacturers to NHTSA and is shown in Table 65. There was a trend of slow increases from MYs 2015 to 2017 in the percentage of the fleet that came with indirect systems until MY 2018. In MY 2018 Mazda changed to an indirect system but Toyota changed many of their high selling models (e.g., Corolla, Camry, and Prius passenger cars and 4-Runner, RAV4, Highlander, and Tundra LTVs) back from indirect systems to direct TPMS systems and all the Toyotas were changed back to direct systems by MY 2019.

These post-standard indirect systems integrate data from the ABS and ESC systems along with information from other evolving technology sensors into a diagnostic model and compare that data to historical data.

Because there were two different types of indirect TPMS systems we have decided to handle them separately in terms of the voluntary versus attributable analysis. The NPRM was published in the Federal Register on July 26, 2001, (66 FR 38984) making the baseline date September 1, 2000, or MY 2001. For those indirect TPMS systems that were produced from MY 2000 to 2006, weight and costs will all be considered voluntary through MY 2001 and the voluntary percentage will be held at that MY 2001 baseline level through MY 2006. While these MYs 2000 to 2006 indirect TPMS systems didn't meet the final standards, they did provide some safety and resulted in costs. Attributable costs will be the difference between the installation rates for MYs 2002 to 2006 minus the voluntary baseline level of MY 2001. For the indirect post-standard systems produced from MYs 2009 to 2019, all weight and costs are considered attributable to the standard. They all met the standard and were all produced after the baseline of MY 2001. None of the post-standard indirect systems were produced during the baseline year, so none are considered voluntary.

NHTSA hired a contractor to perform a cost teardown estimate for these post-standard indirect systems (FEV North America, Inc., 2016). The study used one vehicle to estimate post-standard indirect TPMS cost and weight for a 2014 Honda Accord. The increased cost per vehicle was estimated to range from $6.80 to $12.74 in 2019 dollars, depending upon the period over which software and development costs were amortized. For this analysis we assumed the mid-point of this range of $9.77. It was assumed that the baseline vehicle had ABS and traction control as standard equipment before developing post-standard indirect TPMS cost estimates (the costs of ABS were already included in FMVSS No. 105/135). Incremental costs were computed on both the costs of software development and implementation and additional hardware. Software development costs consisted of algorithm development and bench testing (specification, algorithm implementation, telltale logic, diagnostics implementation, bench testing setup, bench validation), independent software validation (test plan development, test plan execution), vehicle testing and calibration, and cluster development (telltale design- hardware, software, diagnostics, and testing). The increased hardware weight was estimated to be 0.08 pound and was limited to the wiring harness and warning lamp. Table 63 shows the estimated increase and weight and costs for indirect systems. These estimates are used for both the pre-standard and post-standard indirect systems.

Table 63. FMVSS No. 138: Average weight and cost for indirect TPMS – passenger cars and LTVs

Weight (lb)	Cost (2019$)
0.08	$9.77

In theory there would be some reduction in cost in removing indirect TPMS systems from vehicles. Since indirect systems were based on the ABS system, they most likely would involve developing the software and computing power to determine when to give a warning along with the warning light itself. Since the software development was already spent and both the software development and computing power would have to be redeveloped for the direct system or a post-standard indirect system, the only tangible savings might be in the warning light. We examined the basic warning lights in the direct TPMS cost teardown discussed later and found the average cost to be $0.41 in 2019 dollars. When applied to the baseline percentage of the fleet of MY 2001 TPMS (7.23% of passenger cars and 4.47% of LTVs), the savings would amount to $0.03

for passenger cars and $0.02 for LTVs. Since this cost is so small, the agency is not assuming a baseline cost for indirect TPMS that would offset some of the cost of meeting the standard.

Direct TPMS uses a battery-powered pressure sensor and a radio transmitter inside each tire that periodically broadcasts the tire pressure to a central processing unit in the vehicle. The sensors are most often located on the interior end of a tire's valve stems. Some direct systems, in addition to the warning light, display the actual pressure of each tire on the dash, allowing the driver to diagnose over-inflation as well as underinflation. The batteries have a finite life, variously estimated to range from 6 to 12 years or from 50,000 to 100,000 miles. When a battery expires, the entire wheel sensor must be replaced or the TPMS system won't work.

The direct monitoring systems include the following components.

1. An air pressure sensor mounted inside each tire's inner air chamber. One vehicle had the monitor attached to a strap that encircled the wheel at a location inside the tire, but most contained the monitor within the tire air injection valve system.
2. A transmitter for each tire that sends the pressure read out to a receiver mounted on the car body.
3. A receiver mounted on the car body.
4. A computer component that converts the air pressure data into a readout format for display on the vehicle instrument panel.
5. A method of transmitting the data to a display unit on the instrument panel.
6. A display on the instrument panel. This display varies from a light that tells the driver that tire pressure is low, to a display that tells the driver the tire pressure in each identified tire at any time, accompanied by a light that indicates that the tire pressure is low.

The cost of direct TPMS was examined in a cost teardown study (Ludtke & Associates, n.d.). Six direct MY 2008 TPMS systems were examined (3 from passenger cars and 3 from LTVs, including 2 Japanese, 2 European, and 2 domestic models) from a variety of suppliers around the world, to provide a representation from the major world-wide auto manufacturing areas. There was no pattern indicating the passenger car TPMS systems were more or less expensive than LTV TPMS systems or that Japanese systems were any more or less expensive than European or domestic systems (see Table 64). In the small sample we examined, the difference lies mainly in the type of display on the instrument panel. Thus, we decided to use a simple average of all the TPMS weights and costs and use them for both passenger cars and LTVs.

Table 64. FMVSS No. 138: Average weight and cost of direct TPMS for passenger cars and LTVs

Cars	Weight (lb)	Cost (2019$)
Japanese	0.66	$121.47
European	0.84	$245.74
Domestic	2.37	$219.10
LTVs		
Japanese	4.05	$284.91
European	1.02	$195.24
Domestic	1.11	$164.74
Average	1.67	$205.20

The percent of the fleet during the phase-in period with direct TPMS was estimated based on determining which make-models had direct TPMS and using information reported by manufacturers to NHTSA's compliance office for MYs 2004 to 2008 (see Table 65). Some manufacturers relied heavily on carry-forward credits to meet the phase-in requirements as all complying vehicles manufactured after August 8, 2005, could be counted as carry-forward credits. As shown in Table 65, the manufacturers would not have met the 70 percent phase-in requirement for MY 2007 without carry-forward credits. There were some starts and stops to the FMVSS No. 138 rulemaking process, but we will use the baseline of MY 2001 for determining voluntary and attributable costs. Table 65 also shows the consumer costs after applying the learning curve by MY.

Tables 66 to 69 show the average weight and consumer cost of indirect and direct TPMS for passenger cars and LTVs on a MY basis.

Table 65. FMVSS No. 138: Percentages of new vehicle fleet with indirect TPMS or direct TPMS plus learned costs for passenger cars and LTVs

Model Year	Indirect TPMS			Direct TPMS		
	Passenger Cars	LTVs	Learned Costs	Passenger Cars	LTVs	Learned Costs
2000	4.5	1.0	$13.39	0.0	0.0	n.a.
2001	7.2	4.5	$11.91	2.1	0.4	$351.94
2002	8.7	4.6	$11.23	2.2	1.5	$320.64
2003	9.3	2.8	$10.87	2.6	1.0	$306.18
2004	7.7	2.6	$10.64	7.7	21.4	$263.39

Model Year	Indirect TPMS			Direct TPMS		
	Passenger Cars	LTVs	Learned Costs	Passenger Cars	LTVs	Learned Costs
2005	12.9	4.6	$10.33	7.8	30.0	$244.97
2006	0.4	0.8	$10.31	21.4	30.8	$232.40
2007	0.0	0.0	$10.31	44.7	61.3	$218.42
2008	0.0	0.0	$10.31	100.0	100.0	$205.20
2009	0.2	0.0	$10.31	99.8	100.0	$199.96
2010	1.0	0.0	$10.29	99.0	100.0	$195.15
2011	3.0	0.8	$10.25	97.0	99.2	$190.88
2012	5.8	1.6	$10.16	94.2	98.4	$187.15
2013	14.7	1.8	$9.96	85.3	98.2	$183.95
2014	14.6	5.4	$9.77	85.4	94.6	$181.22
2015	17.3	5.5	$9.58	82.7	94.5	$178.65
2016	19.8	8.0	$9.41	80.2	92.0	$176.76
2017	28.6	15.5	$9.19	71.4	84.5	$175.16
2018	19.7	7.3	$9.10	80.3	92.7	$173.57
2019	10.1	4.1	$9.05	89.9	95.9	$172.09

Table 66. FMVSS No. 138: Indirect TPMS for passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2000	0.00	0.00	0.00	0.61	0.00	0.61
2001	0.01	0.00	0.01	0.86	0.00	0.86
2002	0.01	0.00	0.01	0.86	0.12	0.98
2003	0.01	0.00	0.01	0.81	0.20	1.01
2004	0.01	0.00	0.01	0.79	0.03	0.81
2005	0.01	0.00	0.01	0.77	0.57	1.34
2006	0.00	0.00	0.00	0.04	0.00	0.04
2007	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.00	0.00	0.00	0.00
2009	0.00	0.00	0.00	0.00	0.02	0.02

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2010	0.00	0.00	0.00	0.00	0.10	0.10
2011	0.00	0.00	0.00	0.00	0.31	0.31
2012	0.00	0.00	0.00	0.00	0.59	0.59
2013	0.00	0.01	0.01	0.00	1.46	1.46
2014	0.00	0.01	0.01	0.00	1.43	1.43
2015	0.00	0.01	0.01	0.00	1.66	1.66
2016	0.00	0.02	0.02	0.00	1.86	1.86
2017	0.00	0.02	0.02	0.00	2.63	2.63
2018	0.00	0.02	0.02	0.00	1.79	1.79
2019	0.00	0.01	0.01	0.00	0.91	0.91

Table 67. FMVSS No. 138: Direct TPMS for passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2000	0.00	0.00	0.00	$0.00	$0.00	$0.00
2001	0.04	0.00	0.04	$7.41	$0.00	$7.41
2002	0.04	0.00	0.04	$6.75	$0.23	$6.98
2003	0.04	0.01	0.04	$6.45	$1.47	$7.92
2004	0.04	0.09	0.13	$5.55	$14.74	$20.29
2005	0.04	0.09	0.13	$5.16	$13.87	$19.03
2006	0.04	0.32	0.36	$4.90	$44.78	$49.68
2007	0.04	0.71	0.75	$4.60	$93.00	$97.60
2008	0.04	1.63	1.67	$4.32	$200.88	$205.20
2009	0.04	1.63	1.67	$4.21	$195.35	$199.56
2010	0.04	1.62	1.65	$4.11	$189.09	$193.20
2011	0.04	1.58	1.62	$4.02	$181.13	$185.16
2012	0.04	1.54	1.57	$3.94	$172.36	$176.30
2013	0.04	1.39	1.42	$3.87	$153.04	$156.91
2014	0.04	1.39	1.43	$3.82	$150.95	$154.76

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2015	0.04	1.35	1.38	$3.76	$143.98	$147.74
2016	0.04	1.30	1.34	$3.72	$138.04	$141.76
2017	0.04	1.16	1.19	$3.69	$121.41	$125.10
2018	0.04	1.31	1.34	$3.66	$135.67	$139.32
2019	0.04	1.47	1.50	$3.63	$151.08	$154.70

Table 68. FMVSS No. 138: Indirect TPMS for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2000	0.00	0.00	0.00	0.13	0.00	0.13
2001	0.00	0.00	0.00	0.53	0.00	0.53
2002	0.00	0.00	0.00	0.01	0.01	0.52
2003	0.00	0.00	0.00	0.30	0.00	0.30
2004	0.00	0.00	0.00	0.27	0.00	0.27
2005	0.00	0.00	0.00	0.46	0.02	0.48
2006	0.00	0.00	0.00	0.09	0.00	0.09
2007	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.00	0.00	0.00	0.00
2009	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.08	0.08
2012	0.00	0.00	0.00	0.00	0.16	0.16
2013	0.00	0.00	0.00	0.00	0.18	0.18
2014	0.00	0.00	0.00	0.00	0.53	0.53
2015	0.00	0.00	0.00	0.00	0.53	0.53
2016	0.00	0.01	0.01	0.00	0.75	0.75
2017	0.00	0.01	0.01	0.00	1.43	1.43
2018	0.00	0.01	0.01	0.00	0.66	0.66
2019	0.00	0.00	0.00	0.00	0.37	0.37

Table 69. FMVSS No. 138: Direct TPMS for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2000	0.00	0.00	0.00	$0.00	$0.00	$0.00
2001	0.01	0.00	0.01	$1.47	$0.00	$1.47
2002	0.01	0.02	0.02	$1.34	$3.40	$4.74
2003	0.01	0.01	0.02	$1.28	$1.79	$3.07
2004	0.01	0.35	0.36	$1.10	$55.20	$56.30
2005	0.01	0.49	0.50	$1.02	$72.46	$73.48
2006	0.01	0.51	0.51	$0.97	$70.66	$71.62
2007	0.01	1.02	1.02	$0.91	$133.04	$133.95
2008	0.01	1.66	1.67	$0.86	$204.35	$205.20
2009	0.01	1.66	1.67	$0.83	$199.13	$199.96
2010	0.01	1.66	1.67	$0.81	$194.34	$195.15
2011	0.01	1.65	1.66	$0.80	$188.56	$189.36
2012	0.01	1.64	1.64	$0.78	$183.38	$184.16
2013	0.01	1.63	1.64	$0.77	$179.88	$180.64
2014	0.01	1.57	1.58	$0.76	$170.68	$171.44
2015	0.01	1.57	1.58	$0.75	$168.08	$168.83
2016	0.01	1.53	1.54	$0.74	$161.88	$162.62
2017	0.01	1.40	1.41	$0.73	$147.26	$147.99
2018	0.01	1.54	1.55	$0.72	$160.25	$160.97
2019	0.01	1.59	1.60	$0.72	$164.29	$165.01

FMVSS No. 139, New pneumatic radial tires for light vehicles

FMVSS No. 139 was upgraded effective on June 1, 2007, and specifies tire dimensions, test requirements, labeling requirements, and defines load ratings. The purpose of the upgraded standard is to create more stringent tire performance requirements and require improved labeling of tires to aid consumers in identifying tires that may be the subject of a safety recall. The standard applies to new pneumatic tires for use on motor vehicles (other than motorcycles and low speed vehicles) that have a GVWR of 10,000 lb or less and that were manufactured after 1975. The new standard increased the stringency of the high-speed and endurance tests and added a new low-pressure test. No teardown cost studies have been performed. However, cost estimates were made in the Preliminary Economic Assessment (NHTSA, 2001) that accompanied the Notice of Proposed Rulemaking, and were open to comment, and then final estimates were made in the Final Regulatory Evaluation (NHTSA, 2003). NHTSA estimated between 5 and 11 percent of the pre-standard tires in 2002 would have failed if they had been tested to the FMVSS No. 139. For this analysis we assumed the midpoint that 8 percent of the tires would have failed in 2002. In the Final Regulatory Evaluation it was estimated that the average vehicle cost for a vehicle with non-complying tires would have increased by a range $1.42 to $5.65 in 2019 dollars per vehicle in 2003 if it had instead had complying tires (passenger car or LTV). There is no typical countermeasure or tire feature needed to make those 2002 tires that failed the proposed new standards be able to pass the test. NHTSA’s tire experts believed different fixes were necessary for almost every different tire that failed. For this analysis we assumed that the average cost per vehicle for those failing the tire test would be the mid-point of the range of estimates or $3.53. There was no information indicating that FMVSS No. 139 would increase the weight of tires for either passenger cars or LTVs.

The final rule on FMVSS No. 139 was published in the Federal Register on June 26, 2003, (68 FR 38116) for tires on passenger cars and LTVs. The NPRM was published in the Federal Register on March 5, 2002, (67 FR 10050) making the baseline date September 1, 2001, or MY 2002.

NHTSA tested 2002 tires and found 92 percent of them already met the requirements. The requirements went into effect on June 1, 2007. Thus, we will assume that 92 percent complied from 2002 to 2006, that 96 percent of 2007 tires met the standard and, of course, all tires from 2008 onwards had to comply. It is plausible that the 92-percent compliance in 2002 did not materialize suddenly, but that there was a long history of gradually improving tires before that. We will assume 80 percent of 2001 tires would have met the requirements, 70 percent in 2000, etc. back to 10 percent in 1994, but none in 1993 or earlier. We assume voluntary compliance through the baseline year of 2002 and keep that 92 percent voluntary compliance level through 2019.

The learning curve for FMVSS No. 139 had to be adjusted to consider the total number of tires sold in a year, rather than the total number of vehicles sold in a year, since replacement tires also had to meet the standard. The Final Regulatory Evaluation estimated that there are 287 million tires sold per year that would have to meet the standard. Table 70 for passenger cars and Table 71 for LTVs show the estimated increase in vehicle cost due to the tire upgrade.

Table 70. FMVSS No. 139: Estimated increase in cost due to tire upgrade – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1993	0	0	0	$0.00	$0.00	$0.00
1994	0	0	0	$0.53	$0.00	$0.53
1995	0	0	0	$0.99	$0.00	$0.99
1996	0	0	0	$1.42	$0.00	$1.42
1997	0	0	0	$1.83	$0.00	$1.83
1998	0	0	0	$2.11	$0.00	$2.11
1999	0	0	0	$2.40	$0.00	$2.40
2000	0	0	0	$2.68	$0.00	$2.68
2001	0	0	0	$2.97	$0.00	$2.97
2002	0	0	0	$3.32	$0.00	$3.32
2003	0	0	0	$3.25	$0.00	$3.25
2004	0	0	0	$3.19	$0.00	$3.19
2005	0	0	0	$3.14	$0.00	$3.14
2006	0	0	0	$3.10	$0.00	$3.10
2007	0	0	0	$3.06	$0.13	$3.19
2008	0	0	0	$3.03	$0.26	$3.29
2009	0	0	0	$2.99	$0.26	$3.25
2010	0	0	0	$2.97	$0.26	$3.22
2011	0	0	0	$2.94	$0.26	$3.20
2012	0	0	0	$2.92	$0.25	$3.17
2013	0	0	0	$2.89	$0.25	$3.15
2014	0	0	0	$2.87	$0.25	$3.12
2015	0	0	0	$2.86	$0.25	$3.10
2016	0	0	0	$2.84	$0.25	$3.09
2017	0	0	0	$2.82	$0.25	$3.07
2018	0	0	0	$2.81	$0.24	$3.05
2019	0	0	0	$2.79	$0.24	$3.04

Table 71. FMVSS No. 139: Estimated increase in cost due to tire upgrade – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1993	0	0	0	$0.00	$0.00	$0.00
1994	0	0	0	$0.53	$0.00	$0.53
1995	0	0	0	$0.99	$0.00	$0.99
1996	0	0	0	$1.42	$0.00	$1.42
1997	0	0	0	$1.83	$0.00	$1.83
1998	0	0	0	$2.11	$0.00	$2.11
1999	0	0	0	$2.40	$0.00	$2.40
2000	0	0	0	$2.68	$0.00	$2.68
2001	0	0	0	$2.97	$0.00	$2.97
2002	0	0	0	$3.32	$0.00	$3.32
2003	0	0	0	$3.25	$0.00	$3.25
2004	0	0	0	$3.19	$0.00	$3.19
2005	0	0	0	$3.14	$0.00	$3.14
2006	0	0	0	$3.10	$0.00	$3.10
2007	0	0	0	$3.06	$0.13	$3.19
2008	0	0	0	$3.03	$0.26	$3.29
2009	0	0	0	$2.99	$0.26	$3.25
2010	0	0	0	$2.97	$0.26	$3.22
2011	0	0	0	$2.94	$0.26	$3.20
2012	0	0	0	$2.92	$0.25	$3.17
2013	0	0	0	$2.89	$0.25	$3.15
2014	0	0	0	$2.87	$0.25	$3.12
2015	0	0	0	$2.86	$0.25	$3.10
2016	0	0	0	$2.84	$0.25	$3.09
2017	0	0	0	$2.82	$0.25	$3.07
2018	0	0	0	$2.81	$0.24	$3.05
2019	0	0	0	$2.79	$0.24	$3.04

FMVSS No. 141, Minimum sound requirements for hybrid and electric vehicles

Pursuant to the Pedestrian Safety Enhancement Act of 2010 (Public Law 111-373) NHTSA published in the Federal Register a final rule on December 14, 2016, (81 FR 90416), to create a new FMVSS setting minimum sound level requirements for low-speed operation of hybrid and electric light vehicles. The minimum sound requirements provide a means for blind and other pedestrians as well as bicyclists and other road users to detect the presence of these so-called quiet vehicles and thereby reduce the risk that these vehicles will be involved in low-speed pedestrian crashes.

The final rule applies to electric and hybrid-electric passenger cars, MPVs, light trucks, and buses (all LTVs) with a GVWR of 10,000 lb or less and to low-speed vehicles. The standard applies to these vehicles if they can be operated in an electric mode in the test conditions covered by the standard, without any internal combustion engine operation. We have included fuel cell vehicles along with electric and hybrid vehicles as being required to meet the standard. The final rule requires hybrid and electric vehicles to emit sound at minimum levels while the vehicle is stationary (although not when the vehicle is parked, i.e., when the transmission is in park), while in reverse, and while the vehicle is in forward motion up to 30 kmh. Based on a response to petitions saying that the supply chain has been disrupted due to the COVID-19 pandemic, in a 09/01/2020 notice (85 F.R: 54273, 2020; Docket ID NHTSA-2020-0086), the effective date of the final rule was changed. Compliance with FMVSS No. 141 is required for all hybrid and electric vehicles to which these regulations are applicable beginning on March 1, 2021, with a 50-percent phase-in for vehicles produced between March 1, 2020, and February 28, 2021.

Mild hybrid vehicles are defined for this analysis as vehicles that cannot be operated solely in an electric mode. Mild hybrid vehicles may provide an assist to the internal combustion engine during some driving modes or may have only start/stop features. This definition has not been used consistently by all parties. For example, Wikipedia calls these Honda hybrids (MYs 2014 to 2015 Honda Civic, up to MY 2014 Honda Insight, and MYs 2014 to 2016 Honda CRZ) as mild hybrids, but these vehicles apparently could be driven about a mile on electric power. Thus, we did not consider them mild hybrids. The vehicles we considered mild hybrids and weren't added into the hybrid sales totals include the GM E-assist hybrid vehicles (MYs 2014 to 2019 Buick Lacrosse, MYs 2014 to 2018 Buick Regal, MY 2014 Chevy Malibu, and MY 2014 Chevy Impala) and the MY 2019 Ram pickup trucks.

The NPRM was published in the Federal Register on January 14, 2013, (78 FR 2797), making the baseline date September 1, 2012, or MY 2013. The Nissan Leaf electric vehicle in MY 2011 and the Hyundai Sonata and Kia Optima hybrid vehicles in MY 2011 were the first U.S. vehicles with a speaker system to alert pedestrians. Sales of electric and hybrid make/model/MYs were taken from *Ward's Automotive Yearbooks* (Binder, 2002-2017; Norris, 2018-2020) tables relating to engine installations and data were collected on which make/model/MY vehicles provided a speaker system by examining owner's manuals.[20] These data were supplemented by

[20] Ward's data on the Toyota RAV4 were incorrect for MY 2016 to 2019. Ward's data showed 100% of all RAV4 sales were hybrids for MY 2016 to 2018 and then had a very low percentage in MY 2019. These data were corrected by using data from Toyota Motor North America Reports, December 2019, Year End Sales and previous years.

Polk data (n.d.) where the VIN was used to determine engine type, in years before the *Ward's Automotive Yearbook* identified the sales of electric or hybrid vehicles.

Manufacturers called their sound systems by various names, such as Vehicle Proximity Notification System, Virtual Engine Sound System, Vehicle Sound for Pedestrian, and Acoustical Vehicle Alerting System. We tracked the sales of 113 electric or hybrid make/model systems sold sometime during the MY 2011-to-2019 period of which 58 make/model systems had speakers at some point during MY 2011 to 2019. The make/models included 21 electric passenger cars, 45 hybrid passenger cars, 8 electric or fuel cell LTVs, and 39 hybrid LTVs. The make/models with speakers included 15 electric passenger cars, 22 hybrid passenger cars, 7 electric or fuel cell LTVs, and 14 hybrid LTVs. Tables 72 and 73 show the total sales of electric and hybrid systems broken up by MY, the number of vehicles with speaker systems to alert pedestrians, and the percentage of all passenger cars and LTVs with speaker systems. The MY 2011 to 2013 weights and costs for the speaker systems to alert pedestrians provided are considered voluntary and the MY 2013 baseline percentage of the fleet is considered voluntary for MYs 2014 to 2019. The MY 2013 baseline is 4.70 percent of passenger cars and 0.142 percent of LTVs with speaker systems to alert pedestrians.

Table 72. FMVSS No. 141: Electric and hybrid vehicle speaker sales in passenger cars and LTVs – MYs 2011 to 2014

Passenger Cars	**MY 2011**	**MY 2012**	**MY 2013**	**MY 2014**
Total PC Sales	6,355,567	7,422,937	8,164,923	7,923,499
Electric Vehicle Sales	8,485	31,173	46,011	70,950
EV Speaker Sales	8,485	12,796	17,572	13,923
Hybrid Veh. Sales	104,141	317,691	502,399	477,989
Hybrid Speaker Sales	15,291	267,672	365,920	363,574
Total EV and Hybrid Sales	112,626	348,864	548,410	548,939
Total EV and Hybrid Speaker Sales	23,776	280,468	383,492	377,497
% of all PC With Speakers	0.37	3.78	4.70	4.76
LTVs	MY 2011	MY 2012	MY 2013	MY 2014
Total LTV Sales	7,855,531	8,344,384	9,051,809	9,781,770
Electric Vehicle Sales	0	0	1,046	1,108
EV Speaker Sales	0	0	1,046	1,108

Passenger Cars	MY 2011	MY 2012	MY 2013	MY 2014
Hybrid Veh. Sales	80,080	71,754	21,191	24,924
Hybrid Speaker Sales	0	0	11,822	23,683
Total EV and Hybrid Sales	80,080	71,754	22,237	26,032
Total EV and Hybrid Speaker Sales	0	0	12,868	24,791
% of all LTVs With Speakers	0.00	0.00	0.14	0.25

Table 73. FMVSS No. 141: Electric and hybrid vehicle speaker sales for passenger cars and LTVs – MY 2015 to 2019

Passenger Cars	MY 2015	MY 2016	MY 2017	MY 2018	MY 2019
Total PC Sales	8,148,312	6,628,727	6,379,821	5,231,594	4,621,822
Electric Vehicle Sales	129,517	75,207	106,322	138,885	220,384
EV Speaker Sales	65,616	33,989	37,575	51,203	33,141
Hybrid Veh. Sales	382,832	290,916	298,954	247,545	303,162
Hybrid Speaker Sales	307,645	212,601	179,799	160,083	181,758
Total EV and Hybrid Sales	512,349	366,123	405,276	386,430	523,546
Total EV and Hybrid Speaker Sales	373,261	246,590	217,374	211,286	214,899
% of all PC With Speakers	4.58	3.72	3.41	4.04	4.65
LTVs	MY 2015	MY 2016	MY 2017	MY 2018	MY 2019
Total LTV Sales	11,497,605	10,255,302	11,075,353	11,785,575	11,762,461
Electric Vehicle Sales	72	10,398	35,256	28,600	44,703

Passenger Cars	MY 2015	MY 2016	MY 2017	MY 2018	MY 2019
EV Speaker Sales	72	112	88	2,500	24,020
Hybrid Veh. Sales	22,108	64,787	118,976	152,680	262,080
Hybrid Speaker Sales	21,171	63,131	87,054	102,304	156,964
Total EV and Hybrid Sales	22,180	75,185	157,918	187,636	306,783
Total EV and Hybrid Speaker Sales	21,243	63,243	109,451	116,058	180,984
% of all LTVs With Speakers	0.19	0.62	0.99	0.99	1.54

While NHTSA does not have data (in terms of compliance testing with the standard) on most of the hybrid and electric vehicles produced in MYs 2011 to 2019, this analysis assumes that none of these speaker systems to alert pedestrians met all of the requirements of the final rule (since the final rule was not published until December 2016 and was adjusted with petitions for reconsideration in February 2018, and then again in September 2020 based on COVID-19). We assume all electric or hybrid vehicles with a speaker system in MYs 2011 to 2019 provided what we call a basic speaker system.

No cost teardown studies have been performed on this standard. The agency's Final Regulatory Impact Analysis (FRIA) (NHTSA, 2016), based on informal discussions with suppliers and industry experts and confidential manufacturers' information, estimates the installation weight and cost of adding a speaker system to alert pedestrians in order to comply with the requirements of this rule at 1.5 lb and $135.97 per vehicle (2019$) for unequipped light vehicles (i.e., vehicles that did not previously have any alert system components installed). The cost estimate of $138.38 for the final rule includes the cost of a dynamic speaker system that is packaged for protection from the elements and that is attached with mounting hardware and wiring in order to power the speakers and receive signal inputs, and a digital signal processor that receives information from the vehicle regarding vehicle operating status (to produce sounds dependent upon vehicle speed, for example). The $138.38 cost includes noise insulation costs, which were not part of the basic speaker system. As far as NHTSA knows, no sound insulation was used in the MYs 2011 to 2019 vehicles.

The FRIA also estimated an incremental weight and cost of 0 lb[21] and $55.74 for light vehicles which already had a speaker system to alert pedestrians. Thus, the average weight and cost for a

[21] In the FRIA NHTSA did discuss a range of incremental weights possible for sound insulation. Since no manufacturer supplied an estimate of that weight and sound insulation weight is not believed to be part of the MY 2012 to 2019 speaker systems, it is not important to this analysis.

supplied basic speaker system during MY 2011 to 2019 that did not meet all the final rule requirements is estimated to be 1.5 lb and $82.64 ($138.38 to $55.74). The required system has a much more refined speaker system and digital processor than the ones used in the basic speaker system of MYs 2011 to 2019. After applying the learning curve, the cost (2019$) for a basic speaker system used in this analysis is estimated at $11.15 for MY 2011, $90.32 in MY 2012, $82.64 in MY 2013, $78.77 in MY 2014, $76.27 in MY 2015, $74.78 in MY 2016, $73.48 in MY 2017, $72.39 in MY 2018, and $71.26 in MY 2019.

Table 74 and 75 show the average weight and cost per passenger car and LTV. The average cost for passenger cars for voluntarily supplied speaker systems is much higher than the average for LTVs because speaker systems to alert pedestrians were included in a much higher percentage of passenger cars than LTVs during in MYs 2011-to-2019.

Table 74. FMVSS No. 141: Average weight and consumer cost of minimum sound requirement for passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2010	0.00	0.00	0.00	$0.00	$0.00	$0.00
2011	0.01	0.00	0.01	$0.44	$0.00	$0.44
2012	0.06	0.00	0.06	$3.41	$0.00	$3.41
2013	0.07	0.00	0.07	$3.88	$0.00	$3.88
2014	0.07	0.00	0.07	$3.70	$0.05	$3.75
2015	0.07	0.00	0.07	$3.50	$0.00	$3.50
2016	0.06	0.00	0.06	$2.78	$0.00	$2.78
2017	0.05	0.00	0.05	$2.51	$0.00	$2.51
2018	0.06	0.00	0.06	$2.93	$0.00	$2.93
2019	0.07	0.00	0.07	$3.32	$0.00	$3.32

Table 75. FMVSS No. 141: Average weight and consumer cost of minimum sound requirement for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2011	0.00	0.00	0.00	$0.00	$0.00	$0.00
2012	0.00	0.00	0.00	$0.00	$0.00	$0.00
2013	0.00	0.00	0.00	$0.12	$0.00	$0.12
2014	0.00	0.00	0.00	$0.11	$0.09	$0.20
2015	0.00	0.00	0.00	$0.11	$0.03	$0.14
2016	0.00	0.01	0.01	$0.11	$0.36	$0.46
2017	0.00	0.01	0.01	$0.10	$0.62	$0.73
2018	0.00	0.01	0.01	$0.10	$0.61	$0.71
2019	0.00	0.02	0.02	$0.10	$1.00	$1.10

Section 3 – FMVSS 200 Series

The FMVSS 200 series of crashworthiness standards specify performance requirements for motor vehicles intended to reduce the fatality risk or injury severity of people involved in crashes. Performance specifications are more easily related to specific hardware modifications than in the FMVSS 100 series of standards. Furthermore, most crashworthiness standards result in modification to equipment that requires no action by the driver or passenger. A noted exception of this condition is the use of seat belts that often requires the occupant to buckle up.

FMVSS No. 201, Occupant protection in interior impact

Original Standard. FMVSS No. 201 became effective on January 1, 1968, (passenger cars) and September 1, 1981 (MPVs, trucks, and buses with a GVWR of 10,000 lb or less – all LTVs) and specifies requirements on the design and performance of instrument panels, seat backs, interior compartment doors, sun visors, and armrests. The purpose of this standard is to afford interior impact protection for occupants. Therefore, to meet the requirements, certain parts of the vehicle interior must be padded, and no sharp or pointed parts can be placed in the vehicle interior that an occupant can come in contact with during a frontal crash.

FMVSS No. 201 established impact test requirements for various interior surfaces, which may or may not have required some degree of modification to meet the tests. As a result, the cost analysis for FMVSS No. 201 was sometimes exploratory in nature. Since we did not know in advance if anything was changed to meet FMVSS No. 201, we had to discover this during the cost teardown analysis.

Several pre- and post-standard specimens were compared for each of the various interior structures addressed by the standard. In some structures, costs might be consistently higher for the post-standard specimens, as evidenced by a statistically significant average cost increase for the study sample. That probably indicates they were modified because of the standard. In other structures, costs went up in some specimens and down in others, but the average change in cost was not statistically significant. That probably indicates the modifications were merely for styling or production efficiency, and not needed for meeting the standard. In those cases where a specific modification was already known to be associated with FMVSS No. 201 (e.g., the change from friction to mechanical latches on glove compartment doors), the exploratory approach was unnecessary, and we were able to cost those modifications directly.

In some structures, like the instrument panel of passenger cars, manufacturers began padding interior surfaces well before the rulemaking process, as early as 1956. Each original component covered by FMVSS No. 201 is discussed below.

One of the most important developments relating to benefits that could be associated with FMVSS No. 201 occurred from 1967 to 1971 (i.e., during and after the FMVSS No. 201 rulemaking period) was the reduction in the rigidity of the middle and lower instrument panels. The middle and lower panels were redesigned to deform at a controlled rate during an impact to reduce peak loads on an occupant’s chest and legs. The availability of plastics, coupled with the desire to substitute them for steel to lighten vehicles, also led to less rigid panels. These improvements significantly reduced fatality and injury risk of right-front passengers in crashes (Kahane, 1988). Since a reduction in rigidity to the middle and lower instrument panels was evaluated by NHTSA and shown to provide safety improvements, it is linked to FMVSS No. 201. However, their costs have never been studied by NHTSA, and it isn’t intuitively obvious whether costs would have increased or decreased. Therefore, no cost estimates have been included in this analysis for the reduction in rigidity of the middle and lower instrument panel.

Note that FMVSS No. 201 was significantly upgraded in 1995 to include upper interior components. This final rule had a phased-in effective date and required 100 percent of all passenger cars and LTVs to meet the upgrade by MY 2003. Costs for this upgrade are examined later in this report.

Passenger Car Studies

The final rule for passenger cars was published in the Federal Register on February 3, 1967, (32 FR 2414). The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967.

Thirty passenger cars representing 10 make/models of pre-standard (1967), standard (1968), and post-standard (1969) systems were studied to determine the weight and consumer cost impact of FMVSS No. 201 (Gladstone et al., 1982d, pp. 2-1-2-19). Based on this study it is not believed that any FMVSS No. 201 components that met the standard were available in every passenger car by MY 1965. In some cases, like glove box compartment doors, there was a basic latch system that did not meet the standard but was available on every passenger car and LTV and is part of Safety1965, and acts as a baseline cost. Each of the FMVSS No. 201 components is analyzed separately.

Glove Box Compartment Doors. Glove box compartment doors were required by FMVSS No. 201 to remain in the closed position when subjected to an inertial load of 10g in the lateral and vertical directions, 30g in the longitudinal direction, or a head-on vehicle impact into a fixed barrier at 30 mph. A mechanical latch and striker with a release knob/button and mechanism was employed by the vehicle manufacturers to keep the door closed. Based on the teardown study, most passenger cars (79%) were already in compliance in the pre-standard 1967 MY, and their glove compartment door locks were identical in design and manufacturing processing for the pre-standard, standard, and post-standard model years. Those vehicles not in compliance in MY 1967 used a friction latch, which was nothing more than a tab or tang mount to the inside of the door that pressed against an indentation on the inside of the glove compartment. The friction force was enough to keep the door closed during normal operation of the vehicle but not during a crash. Those vehicles with the friction latch in MY 1967 switched to a positive mechanical latch in MY 1968. All MY 1965 passenger cars and LTVs had at least a friction latch and even though one might not consider that a safety countermeasure, a friction latch is the Safety1965 countermeasure and incremental costs for a mechanical latch were measured above the cost of the friction latch. The arithmetic average weight and consumer cost increase from the pre-standard to the post-standard vehicles was 0.05 lb and $1.00 in 2019 dollars in the cars that changed from friction to mechanical latches. Costs would be considered voluntary through MY 1967 and the voluntary percentage will be held at that MY 1967 baseline level through MY 2019. Attributable costs will be the difference between the installation rates for MYs 1968 to 2019 minus the voluntary baseline level of MY 1967. When these amounts are averaged with the rest of the fleet (unchanged), the average weight and consumer cost increases for the entire fleet are 0.01 lb and $0.21 in 2019 dollars and are attributed to the standard. Voluntary compliance for MYs 1968 to 2019 is 0.04 lb and $0.79. Both estimates are before applying the learning curve. Table 76 shows the weight and cost increases for the glove box after applying the learning curve to costs. There is no need to provide a separate table to show the weight and cost after the learning curve for the glove box since it is the same as the totals shown in Table 76.

Table 76. FMVSS No. 201: Weight and cost increases for the glove box – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.04	0.01	0.05	$0.83	$0.22	$1.05
1969	0.04	0.01	0.05	$0.79	$0.21	$1.00
1970	0.04	0.01	0.05	$0.77	$0.20	$0.97
1971	0.04	0.01	0.05	$0.75	$0.20	$0.95
1972	0.04	0.01	0.05	$0.73	$0.19	$0.93
1973	0.04	0.01	0.05	$0.72	$0.19	$0.91
1974	0.04	0.01	0.05	$0.71	$0.19	$0.90
1975	0.04	0.01	0.05	$0.70	$0.19	$0.88
1976	0.04	0.01	0.05	$0.69	$0.18	$0.87
1977	0.04	0.01	0.05	$0.68	$0.18	$0.86
1978	0.04	0.01	0.05	$0.67	$0.18	$0.85
1979	0.04	0.01	0.05	$0.67	$0.18	$0.84
1980	0.04	0.01	0.05	$0.66	$0.18	$0.84
1981	0.04	0.01	0.05	$0.66	$0.17	$0.83
1982	0.04	0.01	0.05	$0.65	$0.17	$0.83
1983	0.04	0.01	0.05	$0.65	$0.17	$0.82
1984	0.04	0.01	0.05	$0.64	$0.17	$0.81
1985	0.04	0.01	0.05	$0.64	$0.17	$0.81
1986	0.04	0.01	0.05	$0.63	$0.17	$0.80
1987	0.04	0.01	0.05	$0.63	$0.17	$0.80
1988	0.04	0.01	0.05	$0.62	$0.17	$0.79
1989	0.04	0.01	0.05	$0.62	$0.17	$0.79
1990	0.04	0.01	0.05	$0.62	$0.16	$0.78
1991	0.04	0.01	0.05	$0.61	$0.16	$0.78
1992	0.04	0.01	0.05	$0.61	$0.16	$0.77
1993	0.04	0.01	0.05	$0.61	$0.16	$0.77
1994	0.04	0.01	0.05	$0.61	$0.16	$0.77

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1995	0.04	0.01	0.05	$0.60	$0.16	$0.76
1996	0.04	0.01	0.05	$0.60	$0.16	$0.76
1997	0.04	0.01	0.05	$0.60	$0.16	$0.76
1998	0.04	0.01	0.05	$0.60	$0.16	$0.75
1999	0.04	0.01	0.05	$0.59	$0.16	$0.75
2000	0.04	0.01	0.05	$0.59	$0.16	$0.75
2001	0.04	0.01	0.05	$0.59	$0.16	$0.74
2002	0.04	0.01	0.05	$0.59	$0.16	$0.74
2003	0.04	0.01	0.05	$0.58	$0.16	$0.74
2004	0.04	0.01	0.05	$0.58	$0.15	$0.74
2005	0.04	0.01	0.05	$0.58	$0.15	$0.73
2006	0.04	0.01	0.05	$0.58	$0.15	$0.73
2007	0.04	0.01	0.05	$0.58	$0.15	$0.73
2008	0.04	0.01	0.05	$0.57	$0.15	$0.73
2009	0.04	0.01	0.05	$0.57	$0.15	$0.73
2010	0.04	0.01	0.05	$0.57	$0.15	$0.72
2011	0.04	0.01	0.05	$0.57	$0.15	$0.72
2012	0.04	0.01	0.05	$0.57	$0.15	$0.72
2013	0.04	0.01	0.05	$0.57	$0.15	$0.72
2014	0.04	0.01	0.05	$0.57	$0.15	$0.72
2015	0.04	0.01	0.05	$0.56	$0.15	$0.71
2016	0.04	0.01	0.05	$0.56	$0.15	$0.71
2017	0.04	0.01	0.05	$0.56	$0.15	$0.71
2018	0.04	0.01	0.05	$0.56	$0.15	$0.71
2019	0.04	0.01	0.05	$0.56	$0.15	$0.71

Protruding Components (Interior Door Release Handles, Window Regulators, and Vent Window Locks and Regulators). These were considered protrusions according to the original proposed FMVSS No. 201. The underlying concept of the proposed requirement was to re-contour, soften (change material or add padding), recess, or move the interior items that protruded into possible head, knee, or leg impact areas. This requirement was later removed in an amendment in the summer of 1967. Even though the protrusion requirement was dropped, vehicle manufacturers made changes to comply with the proposed requirements. 1968 was a transitional stage that reflected some uncertainty on design changes. By 1969, the cost of these systems was, on the average, lower (but not significantly lower) than in 1965. Window regulators were re-contoured with larger radii, using more pliable plastic or rubber knobs in place of the smaller metal knobs. This resulted in a decrease in consumer cost of $2.02 in 2019 dollars. Interior door release handles were reshaped with fewer sharp edges and corners and built into either the armrest or flush with the door inner trim panel, which decreased the consumer cost by $1.15 in 2019 dollars. Vent window locks were either eliminated or reshaped to be smaller and rounder, with many vehicles eliminating the vent window on the 1968 and 1969 make-models. Since the changes to the protruding components were not required, the weight and consumer cost difference is not attributed to the standard. Even if FMVSS No. 201 had required this modification, this report would not have credited the cost reduction to the standard because the same cost-saving modifications could presumably have been implemented without it.

Armrests. Armrests were required to deflect or collapse laterally upon impact at least 2 inches without contacting any underlying rigid material or have no unpadded areas that a passenger could contact in a collision. All MY 1965 passenger cars and LTVs had armrests and Safety1965 includes these pre-standard armrests. Because of the standard, many armrests were redesigned to be longer and shallower to protrude less into the pelvic impact area. Additional padding, support structure, and softer cover materials were also employed for MYs 1968 and 1969. However, the cost of these additions was in some cases more than offset by the reduction in the overall size of the armrest. The average change in weight and consumer cost from the pre-standard to the post-standard vehicles was an increase of 0.06 lb and a decrease of $0.46 in 2019 dollars. These weight and cost changes were not statistically significant since half of the armrests studied increased and half decreased. Since no consistent trend was demonstrated, the changes in the weight and cost of armrests are not attributed to the standard.

Sun Visors. FMVSS No. 201 required two sun visors be provided that were constructed of, or covered with, energy absorbing materials. No rigid material edge radii less than 0.125 inches would be present on the sun visor mounting. All MY 1965 passenger cars and LTVs had sun visors and Safety1965 includes these pre-standard sun visors. The manufacturers made the required design and material changes, but these did not necessarily lead to increased costs. In fact, the average weight and consumer cost decreased from the pre-standard to the post-standard vehicles by 0.15 lb and $0.64 in 2019 dollars. Since approximately half of the sun visors studied decreased in weight and cost while the other half increased, the difference between the 1967 and 1969 MYs is not statistically significant. Since no consistent trend was demonstrated, the changes in the weight and cost of sun visors are not attributed to the standard.

Instrument Panels. Instrument panels were required to have adequate energy absorption capabilities in head impact areas (primarily the top surface and edges of the panel) so that when a 15-lb, 6.5-inch diameter head form is impacted at a velocity of 15 mph the deceleration rate does not exceed 80g continuously for more than 3 ms. Not all MY 1965 passenger cars and LTVs had padding or even covers on their instrument panels. For example, the MY 1967 VW Beetle had no padding or cover. Thus, instrument panel padding and covers are not part of Safety1965, but Safety1965 includes an instrument panel with a hard surface, typically steel. For this analysis we included the passenger car instrument panel padding, cover, and assembly costs for attaching the padding and cover to the instrument panel. We do not include the steel base support or other reinforcements that are made of cold rolled steel, or speakers, etc. as part of the instrument panel padding costs.

A 1963 statistical study by B. J. Campbell reported that padding first became available as an option in MY 1956 on GM, Ford, and Chrysler cars. By 1963, padding was standard or optional on most cars. SAE issued Recommended Practice J921 in 1965, which set performance requirements for padding (but did not necessarily require cars to have the padding). In the absence of more definitive information for cars, we will assume a linear introduction rate by MY, starting at zero in 1955 and ending at 100 percent in 1968.

Thirty instrument panels (10 MY 1967, 10 MY 1968, and 10 MY 1969) were in the Gladstone et al. (1982) teardown study. In this case we don't know which MY 1967 vehicles met the standard and which ones didn't, so we used the sales weighted average cost of all MY 1967 vehicles as the voluntary provided baseline costs to distribute costs between voluntary and attributable. Total costs compared to no cover and padding are the total sales weighted average cost for MYs 1968 and 1969. Since we have no estimates of cost and weight after the 1969 MYs, we assume that increase in 1969 weight and cost applies to all years from 1969 to 2019. Changes to the padding and the instrument panel cover were made for MYs 1968 and 1969 for passenger cars. Table 77 shows the estimated costs for all 3 MYs studied. In theory, the MY 1967 baseline weight and costs would be considered voluntary and the difference in the sales weighted average weight and cost between the MYs 1968 and 1969 passenger cars and the MY 1967 baseline would be considered attributable to the standard. This doesn't work for MY 1969 costs, which were less than the MY 1967 baseline. We assumed that the MY 1969 cost, for which all models had to comply with the standard, would be voluntary for both MYs 1968 and 1969 under the assumption that the manufacturers could have changed designs to a lower cost with or without the standard.

Table 77. FMVSS No. 201: Instrument panel padding weight and cost – passenger cars

	Weight (lb)			**Cost (2019$)**		
	MY 67	MY 68	MY 69	MY 67	MY 68	MY 69
	2.27	2.96	2.81	$27.49	$27.81	$26.54
Learned cost				$27.64	$27.02	$26.54
Voluntary		2.27	2.27		$26.54	$26.54
Attributable		0.69	0.54		$0.48	0.00

Table 78 shows the final estimates for instrument panels in passenger cars. The learning curve uses $26.54 for MY 1969 as its basis. The MY 1968 cost of $27.02 comes from the learning curve.

Table 78. FMVSS No. 201: Final estimates for instrument panels in passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	2.27	0.69	2.96	$26.54	$0.48	$27.02
1969	2.27	0.54	2.81	$26.54	$0.00	$26.54
1970	2.27	0.54	2.81	$26.20	$0.00	$26.20
1971	2.27	0.54	2.81	$25.84	$0.00	$25.84
1972	2.27	0.54	2.81	$25.51	$0.00	$25.51
1973	2.27	0.54	2.81	$25.20	$0.00	$25.20
1974	2.27	0.54	2.81	$24.97	$0.00	$24.97
1975	2.27	0.54	2.81	$24.77	$0.00	$24.77
1976	2.27	0.54	2.81	$24.55	$0.00	$24.55
1977	2.27	0.54	2.81	$24.33	$0.00	$24.33
1978	2.27	0.54	2.81	$24.12	$0.00	$24.12
1979	2.27	0.54	2.81	$23.94	$0.00	$23.94
1980	2.27	0.54	2.81	$23.79	$0.00	$23.79
1981	2.27	0.54	2.81	$23.66	$0.00	$23.66
1982	2.27	0.54	2.81	$23.53	$0.00	$23.53
1983	2.27	0.54	2.81	$23.39	$0.00	$23.39
1984	2.27	0.54	2.81	$23.23	$0.00	$23.23
1985	2.27	0.54	2.81	$23.07	$0.00	$23.07
1986	2.27	0.54	2.81	$22.91	$0.00	$22.91
1987	2.27	0.54	2.81	$22.78	$0.00	$22.78
1988	2.27	0.54	2.81	$22.65	$0.00	$22.65
1989	2.27	0.54	2.81	$22.53	$0.00	$22.53
1990	2.27	0.54	2.81	$22.43	$0.00	$22.43
1991	2.27	0.54	2.81	$22.34	$0.00	$22.34
1992	2.27	0.54	2.81	$22.25	$0.00	$22.25
1993	2.27	0.54	2.81	$22.16	$0.00	$22.16

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1994	2.27	0.54	2.81	$22.06	$0.00	$22.06
1995	2.27	0.54	2.81	$21.97	$0.00	$21.97
1996	2.27	0.54	2.81	$21.89	$0.00	$21.89
1997	2.27	0.54	2.81	$21.80	$0.00	$21.80
1998	2.27	0.54	2.81	$21.72	$0.00	$21.72
1999	2.27	0.54	2.81	$21.63	$0.00	$21.63
2000	2.27	0.54	2.81	$21.55	$0.00	$21.55
2001	2.27	0.54	2.81	$21.47	$0.00	$21.47
2002	2.27	0.54	2.81	$21.39	$0.00	$21.39
2003	2.27	0.54	2.81	$21.32	$0.00	$21.32
2004	2.27	0.54	2.81	$21.25	$0.00	$21.25
2005	2.27	0.54	2.81	$21.18	$0.00	$21.18
2006	2.27	0.54	2.81	$21.11	$0.00	$21.11
2007	2.27	0.54	2.81	$21.05	$0.00	$21.05
2008	2.27	0.54	2.81	$20.99	$0.00	$20.99
2009	2.27	0.54	2.81	$20.95	$0.00	$20.95
2010	2.27	0.54	2.81	$20.91	$0.00	$20.91
2011	2.27	0.54	2.81	$20.86	$0.00	$20.86
2012	2.27	0.54	2.81	$20.80	$0.00	$20.80
2013	2.27	0.54	2.81	$20.75	$0.00	$20.75
2014	2.27	0.54	2.81	$20.69	$0.00	$20.69
2015	2.27	0.54	2.81	$20.63	$0.00	$20.63
2016	2.27	0.54	2.81	$20.58	$0.00	$20.58
2017	2.27	0.54	2.81	$20.53	$0.00	$20.53
2018	2.27	0.54	2.81	$20.48	$0.00	$20.48
2019	2.27	0.54	2.81	$20.43	$0.00	$20.43

Seat Back Padding. Like instrument panels, the head impact areas of seat backs are required to pass a head form impact test. The requirement applies to the top and backside of the seat back, which are impact areas for a rear-seat occupant in a frontal crash. Any seat back that is in the head impact zone for a rear seating position must comply. Thus, for passenger cars excluding two seaters with no rear seat, the front seat back must comply. For some LTVs like cargo vans there are no seat backs that must comply, but if an LTV has two or more rows of seats, then all seat backs forward of the last row must comply with FMVSS No. 201. In this analysis the weight and cost of padding the top and back of head restraints has been included in the weight and cost estimates for FMVSS No. 202 Head Restraints and is not considered here in FMVSS No. 201 Interior Padding.

Safety1965 does not include seat back padding since all passenger cars and LTVs studied did not meet the requirements in MY 1965. For passenger cars the baseline is MY 1967. The same 30 passenger cars were studied for seat back padding as were studied for instrument panels. The top cap and upper six inches of the front seat back padding was studied. All 10 make/models inspected in the teardown study increased seat back padding between MYs 1967 and 1968. Six of the 10 vehicles decreased seat back padding weight and cost between MYs 1968 and 1969. We examined bucket seat back padding weight and cost versus bench seat padding weight and cost and found no significant difference. Thus, we make no changes in the weight and cost estimates as seating preference shifted over time toward more bucket seats.

Since the baseline year for passenger cars is MY 1967, we assume the voluntary weights and costs are those from MY 1967 and the attributable costs are the difference between MYs 1968 and 1969 vehicles and the MY 1967 baseline. The sales weighted average weight and consumer cost for both (driver and right-front passenger seat) front seat backs for MY 1969 is 2.57 lb and $15.76 in 2019 dollars. Table 79 shows these results.

Table 79. FMVSS No. 201: Seat back padding weight and cost – passenger cars

	Weight (lb)			**Cost (2019$)**		
	MY 67	MY 68	MY 69	MY 67	MY 68	MY 69
Total	1.86	3.01	2.57	$9.48	$17.03	$15.76
Voluntary		1.86	1.86		$9.48	$9.48
Attributable		1.14	0.71		$7.55	$6.28

An additional study was conducted in the 1980s to determine the cost effect (trend cost) that FMVSS No. 201 had on 1983 passenger cars plus the effect that downsizing, weight reduction, and front-wheel drive may have had on the cost of implementing the standard (Osen & Ludtke, 1985). The basis for the cost determinations was the teardown and analysis of system components from selected vehicles representing comparable make-models prior to and after the effective date of the standard. Since the trend-system sample did not measure the same items or car designs as the pre- and post-standard sample, the costs cannot be used for comparison.

Seat back padding is not needed for passenger cars with no rear seat. Costs and weights are not included for seat back padding for those vehicles with no rear seat. Over the years, the percentage of passenger cars with a rear seat has not changed very much. Table 80 shows the percent of the fleet with a rear seat for passenger cars.

Table 80 also shows the average consumer cost increases for passenger cars after applying the learning curve. These results do not include the adjustment made for the percent of the fleet with no rear seats. Table 81 shows the average weight and consumer cost increases for passenger cars for seat back padding after applying the learning curve, the percent of the fleet with no rear seat, and the distribution between voluntary and attributable weights and costs.

Table 80. FMVSS No. 201: Percent of the fleet with rear seats and learning curve costs for padding seat backs in passenger cars

Model Year	Rear Seat %	Learned Costs
1968	99.00	$16.74
1969	99.00	$15.60
1970	99.00	$15.04
1971	99.00	$14.58
1972	99.00	$14.22
1973	99.00	$13.92
1974	99.00	$13.72
1975	99.00	$13.56
1976	99.00	$13.38
1977	98.00	$13.09
1978	98.00	$12.94
1979	98.00	$12.82
1980	98.00	$12.72
1981	98.00	$12.64
1982	98.00	$12.56
1983	98.00	$12.47
1984	98.00	$12.37
1985	98.00	$12.28
1986	98.00	$12.19
1987	98.50	$12.17
1988	98.50	$12.09
1989	98.50	$12.02
1990	98.00	$11.89

Model Year	Rear Seat %	Learned Costs
1991	98.00	$11.84
1992	98.00	$11.79
1993	98.00	$11.73
1994	98.00	$11.68
1995	98.50	$11.68
1996	98.50	$11.62
1997	98.50	$11.56
1998	98.50	$11.50
1999	98.50	$11.44
2000	98.50	$11.39
2001	98.50	$11.33
2002	98.50	$11.28
2003	97.98	$11.18
2004	97.98	$11.13
2005	97.98	$11.08
2006	97.98	$11.04
2007	97.98	$11.00
2008	99.28	$11.11
2009	99.28	$11.08
2010	99.28	$11.06
2011	99.28	$11.02
2012	99.15	$10.98
2013	98.50	$10.87
2014	98.50	$10.83
2015	98.50	$10.79
2016	98.65	$10.78
2017	98.80	$10.76
2018	98.95	$10.75
2019	98.70	$10.69

Table 81. FMVSS No. 201: Average weight and consumer cost increases for seat back padding in passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	1.83	1.15	2.98	$9.39	$7.36	$16.74
1969	1.83	0.72	2.54	$9.39	$6.21	$15.60
1970	1.83	0.72	2.54	$9.05	$5.99	$15.04
1971	1.83	0.72	2.54	$8.77	$5.81	$14.58
1972	1.83	0.72	2.54	$8.56	$5.66	$14.22
1973	1.83	0.72	2.54	$8.37	$5.54	$13.92
1974	1.83	0.72	2.54	$8.26	$5.47	$13.72
1975	1.83	0.72	2.54	$8.16	$5.40	$13.56
1976	1.83	0.72	2.54	$8.05	$5.33	$13.38
1977	1.81	0.71	2.52	$7.87	$5.21	$13.09
1978	1.81	0.71	2.52	$7.79	$5.15	$12.94
1979	1.81	0.71	2.52	$7.71	$5.11	$12.82
1980	1.81	0.71	2.52	$7.66	$5.07	$12.72
1981	1.81	0.71	2.52	$7.61	$5.03	$12.64
1982	1.81	0.71	2.52	$7.56	$5.00	$12.56
1983	1.81	0.71	2.52	$7.50	$4.97	$12.47
1984	1.81	0.71	2.52	$7.45	$4.93	$12.37
1985	1.81	0.71	2.52	$7.39	$4.89	$12.28
1986	1.81	0.71	2.52	$7.33	$4.86	$12.19
1987	1.82	0.71	2.53	$7.32	$4.85	$12.17
1988	1.82	0.71	2.53	$7.27	$4.81	$12.09
1989	1.82	0.71	2.53	$7.23	$4.79	$12.02
1990	1.81	0.71	2.52	$7.16	$4.74	$11.89
1991	1.81	0.71	2.52	$7.12	$4.72	$11.84
1992	1.81	0.71	2.52	$7.09	$4.69	$11.79
1993	1.81	0.71	2.52	$7.06	$4.67	$11.73
1994	1.81	0.71	2.52	$7.03	$4.65	$11.68
1995	1.82	0.71	2.53	$7.03	$4.65	$11.68

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	1.82	0.71	2.53	$6.99	$4.63	$11.62
1997	1.82	0.71	2.53	$6.95	$4.60	$11.56
1998	1.82	0.71	2.53	$6.92	$4.58	$11.50
1999	1.82	0.71	2.53	$6.89	$4.56	$11.44
2000	1.82	0.71	2.53	$6.85	$4.54	$11.39
2001	1.82	0.71	2.53	$6.82	$4.51	$11.33
2002	1.82	0.71	2.53	$6.79	$4.49	$11.28
2003	1.81	0.71	2.52	$6.72	$4.45	$11.18
2004	1.81	0.71	2.52	$6.70	$4.43	$11.13
2005	1.81	0.71	2.52	$6.67	$4.41	$11.08
2006	1.81	0.71	2.52	$6.64	$4.40	$11.04
2007	1.81	0.71	2.52	$6.62	$4.38	$11.00
2008	1.83	0.72	2.55	$6.68	$4.42	$11.11
2009	1.83	0.72	2.55	$6.67	$4.41	$11.08
2010	1.83	0.72	2.55	$6.65	$4.40	$11.06
2011	1.83	0.72	2.55	$6.63	$4.39	$11.02
2012	1.83	0.72	2.55	$6.60	$4.37	$10.98
2013	1.82	0.71	2.53	$6.54	$4.33	$10.87
2014	1.82	0.71	2.53	$6.52	$4.31	$10.83
2015	1.82	0.71	2.53	$6.50	$4.30	$10.79
2016	1.82	0.71	2.54	$6.49	$4.29	$10.78
2017	1.82	0.72	2.54	$6.48	$4.29	$10.76
2018	1.83	0.72	2.54	$6.47	$4.28	$10.75
2019	1.82	0.71	2.54	$6.43	$4.26	$10.69

Table 82 shows the total average weight and consumer cost increase of occupant protection for FMVSS No. 201 in passenger cars before applying the learning curve. Three separate learning curves were analyzed for passenger cars and LTVs to analyze all the necessary improvements to FMVSS No. 201. These learning curves were for the glove box latch, instrument panel, and seat back padding.

Table 82. FMVSS No. 201: Average weight and consumer cost of occupant protection countermeasures for passenger cars

Component	Weight (lb)	Consumer Cost (2019$)
Glove Box Door Latch	0.05	$1.00
Instrument Panel	2.81	$26.54
Seat Back Padding	2.57	$15.76
Total	5.43	$43.30

LTV Studies

The final rule extending FMVSS No. 201 to LTVs was published in the Federal Register on November 29, 1979, (44 FR 68470). The effective date was September 1, 1981, or MY 1982. The first NPRM proposing to extend FMVSS No. 201 to MPVs, trucks, and buses with a GVWR of 10,000 lb or less (all LTVs) was published in the Federal Register on September 25, 1970, (35 FR 14936), making the baseline date September 1, 1970, or MY 1971. A subsequent NPRM was published in the Federal Register on November 9, 1978, (43 FR 52264).

A study was conducted in 1979 on MY 1979 LTVs to determine the effects of extending the passenger car requirements of FMVSS No. 201 to LTVs (McLean, 1979).[22] An estimate of the additional weight and consumer cost imposed by the standard on LTVs was calculated to support the regulatory analysis process; however, these estimates were not based on a teardown analysis. All MY 1979 U.S. LTVs and the Nissan and Toyota pickups were inspected to determine their state of compliance. Cost and weight estimates to bring the MY 1979 vehicles not in compliance were prepared for all vehicles to bring them into compliance. This McLean (1979) study is the basis for LTV cost estimates for glove box compartment doors, instrument panels, and seat backs.

Glove Box Compartment Doors. As with passenger cars, all MY 1965 LTVs had at least a friction latch. A friction latch is the Safety1965 countermeasure and incremental costs for a mechanical latch were measured above the cost of a friction latch. The teardown study of MY 1979 LTVs found that a sales weighted 50 percent of glove box doors met the standard. However, the agency has no information to help it determine the percent of voluntary compliance before MY 1979. Since the September 25, 1970, NPRM proposed extending the glove box compartment doors requirement to LTVs, we assume a slow buildup of complying glove box doors starting in MY 1971 (see Table 84), like what we assume for instrument panel compliance and then 100-percent compliance in MY 1982, the effective date of FMVSS No. 201 for LTVs. The average increase in cost of a mechanical latch compared to a friction latch for LTVs was $0.56 (in 2019 dollars) and the weight was not estimated. We will assume the same weight (0.05 pound) as found in the passenger car teardown study. Since we assume compliance

[22] The mark-up factor from variable costs to consumer costs in this study was 1.649 rather than the mark-up used for this analysis of 1.51. Thus, costs were adjusted by a factor of 0.916 to make the costs consistent with a 1.51 mark-up.

started at 5 percent in MY 1971, the baseline year, 5 percent is considered voluntary and the rest of the weights and costs are attributable to the standard.

Protruding Components (Interior Door Release Handles, Window Regulators, and Vent Window Locks and Regulators). These were not studied in the LTV cost report, since the passenger car study found them to be less costly after the standard.

Armrests. All MY 1965 passenger cars and LTVs had armrests and Safety1965 includes these pre-standard armrests. All but one of the armrests complied with the standard in MY 1979. The one armrest that did not comply could have been moved to a slightly different position on the door to make it comply with no cost or it could have added padding. For this analysis we are assuming the no cost option could have been taken. NHTSA did not analyze MY 1965 LTV armrests to determine the difference in costs between Safety1965 and armrests meeting FMVSS No. 201. The passenger car analysis of armrests found no consistent increase in weight or costs between pre-standard MY 1965 arm rests and post-standard MY 1968/1969 armrests. We assume the same no increase in weight or costs for LTVs.

Sun Visors. All MY 1965 passenger cars and LTVs had sun visors and Safety1965 includes these pre-standard sun visors. All the sun visors in the MY 1979 analysis complied with the standard. The passenger car analysis of sun visors above found no increase in weight or costs between pre-standard MY 1965 sun visors and post-standard MY 1969 sun visors. We assume the same no increase in weight or costs for LTVs.

Instrument Panels. Unlike passenger cars, most of the LTVs needed padding added to their instrument panel to comply with the standard. A sales weighted estimated 41.7 percent complied with the standard in MY 1979. For each of the non-complying make/models, the area that needed to be padded on the instrument panel was determined, and padding and a cover were assumed to cover this area, with resulting weight and cost estimates. We took the average cost per square inch and the average weight per square inch from two make/models, which changed from having no instrument panel padding to compliant instrument panel padding and applied that to the total square inches of the instrument panels of all make/models examined. Those weights and costs were sales weighted, and the average increase for LTVs compared to no instrument panel padding or cover was an average weight increase of 3.19 lb and an average consumer cost increase of $17.38 in 2019 dollars. Since it is likely that instrument panel padding would only change with a new model, unless required by a standard, and LTV models aren't updated as often as passenger cars, we assume a steady increase in the percentage of vehicles with compliant instrument panels from MY 1971 starting a few years after FMVSS No. 201 was effective for passenger cars, as shown in Table 84. Since we assume compliance started at 5 percent in MY 1971, the baseline year, 5 percent is considered voluntary and the rest of the weights and costs are attributable to the standard.

Seat Back Padding. None of the MY 1979 LTVs met the seat back padding requirements and additional padding was required on all applicable seat backs. Since no baseline vehicles had complying seat back padding by the baseline date of MY 1971, all seat back padding costs for LTVs are attributable to the standard. Pickups equipped to carry rear-seat passengers would require added seat back padding on the front seat. Passenger vans, and other LTVs fitted with one or more seats behind the front seats, would require all but the rearmost seat backs to be padded. A 4-inch-tall pad was assumed across the width of the seat for all bench seats and a 6-

inch-tall pad was assumed across the width of the seat for all bucket seats. Based on the McLean (1979) study estimates were made for four different seat backs. These are shown in Table 83.

Table 83. FMVSS No. 201: Seat back padding weight and cost

Seat back		Weight (lb)	Cost (2019$)
Front	Pickup or Large Utility Bucket	1.22	$6.71
Front	Pickup or Large Utility Bench	1.34	$7.35
Front	Van or Small Utility Bucket	1.15	$6.32
Rear	Van or Utility Bench	1.44	$7.88

Unlike passenger cars, where the difference in costs between a bucket seat and a bench seat were not significant, the costs were different for LTVs. The sales weighted average weight and consumer cost increase of padding for LTVs changes from year to year based on a variety of factors. First, the percentage of bench seats in the front seat of pickup trucks has decreased while the percentage of bucket seats has increased. Second, while the percent of the fleet with rear seats for passenger cars remained essentially the same over the period, the percent of the LTVs with rear seats changed dramatically over time. There are several reasons for these changes. In 1968 there were no minivans, no CUVs, few SUVs, many compact pickups with no rear seats, and most standard sized pickup trucks were regular cabs with no rear seats. The only vehicles that have not changed over time, in terms of having rear seats, are full-sized vans, which have remained mostly cargo vans. In 2019, there are minivans, the market for CUVs and SUVs is substantial, many compact pickups have disappeared and the regular cab standard pickups with no rear seat are less than 10 percent of all pickup trucks. Thus, the percent of LTVs with a rear seat has increased from 19 percent in 1968 to 96 percent in 2019. Likewise, the average cost for seat back padding for LTVs has increased. By 2019, the sales weighted average LTV needed to add 1.53 lb of padding at a cost of $8.38 in 2019 dollars before learning. The average weight and cost for seat back padding are lower for LTVs (see Table 85) than for passenger cars (see Table 82). We have no explanation for the difference other than they were estimated by two different contractors.

Table 84 shows the estimated percent of the LTV new vehicles that complied with the standard. Table 85 shows the weight and consumer cost increase for the glove box, instrument panel, and seatback padding for LTVs before applying learning. Table 86 shows the percent of LTVs that have rear seats and need seat back padding. Table 86 also shows the learning curve costs before considering the percent of the LTV fleet with rear seat.

Table 84. FMVSS No. 201: Estimated compliance with FMVSS No. 201 – LTVs by MY

Model Year	Glove Box	Instru. Panel	Seat Back
1970	0	0	0
1971	5	5	0
1972	10	10	0
1973	15	15	0
1974	20	20	0
1975	25	25	0
1976	30	30	0
1977	35	35	0
1978	40	40	0
1979	50	41.7	0
1980	50	50	10
1981	60	60	20
1982	100	100	100
post-1982	100	100	100

Table 85. FMVSS No. 201: Average weight and consumer cost of occupant protection countermeasures in LTVs

Component	Weight (lb)	Consumer Cost ($2019)
Glove Box Door Latch	0.05	$0.56
Instrument Panel Padding	3.19	$17.38
Seat Back Padding by 2019	1.53	$8.38
Total	4.77	$26.32

Table 86. FMVSS No. 201: Average number of seat backs per LTV and costs before learning for LTVs

Model Year	Avg. Number per LTV		Costs Before Learning
	Front seat Backs	Rear seat Backs	
1980	0.237	0.178	$3.01
1981	0.237	0.178	$3.01
1982	0.237	0.178	$3.01
1983	0.237	0.178	$3.01
1984	0.237	0.178	$2.98
1985	0.237	0.178	$2.98
1986	0.237	0.178	$2.98
1987	0.376	0.279	$4.67
1988	0.376	0.279	$4.67
1989	0.376	0.279	$4.67
1990	0.376	0.279	$4.67
1991	0.376	0.279	$4.67
1992	0.376	0.279	$4.67
1993	0.376	0.279	$4.67
1994	0.376	0.279	$4.67
1995	0.631	0.474	$7.88
1996	0.631	0.474	$7.94
1997	0.631	0.474	$7.94
1998	0.631	0.474	$7.94
1999	0.631	0.474	$7.89
2000	0.631	0.474	$7.89
2001	0.631	0.474	$7.89
2002	0.631	0.474	$7.88
2003	0.664	0.496	$8.27
2004	0.664	0.496	$8.27
2005	0.664	0.496	$8.26
2006	0.664	0.496	$8.27

Model Year	Avg. Number per LTV		Costs Before Learning
	Front seat Backs	**Rear seat Backs**	
2007	0.664	0.496	$8.27
2008	0.668	0.501	$8.31
2009	0.668	0.501	$8.31
2010	0.668	0.501	$8.31
2011	0.668	0.501	$8.29
2012	0.668	0.501	$8.23
2013	0.694	0.481	$8.22
2014	0.694	0.519	$8.59
2015	0.694	0.519	$8.55
2016	0.705	0.482	$8.34
2017	0.686	0.514	$8.49
2018	0.667	0.545	$8.63
2019	0.736	0.454	$8.38

A study of the interior components on seven 1982 MY LTVs was conducted to determine the consumer cost and weight of the glove box latches, dashboard padding, armrests, and sun visors (Gladstone et al., 1982d). No pre-standard make-models were studied to serve as a baseline. The 1982 specimen vehicles were leased for visual inspection, detailed measurements, and photographic documentation, but components were not removed and torn down. However, because some of the make-models were extensively redesigned in 1982, the contractor was unable to directly compare the components of pre- and post-standard LTVs and did not estimate the average cost increase.

Table 87 for LTVs glove box latch, Table 88 for LTVs instrument panel, and Table 89 for LTVs seat back padding present the weight and cost estimates after applying the learning curve and the distribution between voluntary and attributable weights and costs.

Table 87. FMVSS No. 201: Weight and cost estimates after applying the learning curve for the glove box latch – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1971	0.00	0.00	0.00	$0.00	$0.03	$0.03
1972	0.00	0.00	0.01	$0.00	$0.06	$0.06
1973	0.00	0.01	0.01	$0.00	$0.09	$0.09
1974	0.00	0.01	0.01	$0.01	$0.11	$0.12
1975	0.00	0.01	0.01	$0.01	$0.14	$0.15
1976	0.00	0.01	0.02	$0.01	$0.16	$0.17
1977	0.00	0.02	0.02	$0.01	$0.19	$0.20
1978	0.00	0.02	0.02	$0.01	$0.21	$0.23
1979	0.00	0.02	0.03	$0.01	$0.26	$0.28
1980	0.00	0.02	0.03	$0.01	$0.26	$0.28
1981	0.00	0.03	0.03	$0.02	$0.31	$0.33
1982	0.00	0.05	0.05	$0.03	$0.52	$0.55
1983	0.00	0.05	0.05	$0.03	$0.51	$0.54
1984	0.00	0.05	0.05	$0.03	$0.51	$0.54
1985	0.00	0.05	0.05	$0.03	$0.51	$0.53
1986	0.00	0.05	0.05	$0.03	$0.50	$0.53
1987	0.00	0.05	0.05	$0.03	$0.50	$0.52
1988	0.00	0.05	0.05	$0.03	$0.50	$0.52
1989	0.00	0.05	0.05	$0.03	$0.49	$0.52
1990	0.00	0.05	0.05	$0.03	$0.49	$0.52
1991	0.00	0.05	0.05	$0.03	$0.49	$0.51
1992	0.00	0.05	0.05	$0.03	$0.49	$0.51
1993	0.00	0.05	0.05	$0.03	$0.48	$0.51
1994	0.00	0.05	0.05	$0.03	$0.48	$0.51
1995	0.00	0.05	0.05	$0.03	$0.48	$0.50
1996	0.00	0.05	0.05	$0.03	$0.48	$0.50
1997	0.00	0.05	0.05	$0.02	$0.47	$0.50
1998	0.00	0.05	0.05	$0.02	$0.47	$0.50
1999	0.00	0.05	0.05	$0.02	$0.47	$0.50

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2000	0.00	0.05	0.05	$0.02	$0.47	$0.49
2001	0.00	0.05	0.05	$0.02	$0.47	$0.49
2002	0.00	0.05	0.05	$0.02	$0.47	$0.49
2003	0.00	0.05	0.05	$0.02	$0.46	$0.49
2004	0.00	0.05	0.05	$0.02	$0.46	$0.49
2005	0.00	0.05	0.05	$0.02	$0.46	$0.48
2006	0.00	0.05	0.05	$0.02	$0.46	$0.48
2007	0.00	0.05	0.05	$0.02	$0.46	$0.48
2008	0.00	0.05	0.05	$0.02	$0.46	$0.48
2009	0.00	0.05	0.05	$0.02	$0.45	$0.48
2010	0.00	0.05	0.05	$0.02	$0.45	$0.48
2011	0.00	0.05	0.05	$0.02	$0.45	$0.48
2012	0.00	0.05	0.05	$0.02	$0.45	$0.48
2013	0.00	0.05	0.05	$0.02	$0.45	$0.47
2014	0.00	0.05	0.05	$0.02	$0.45	$0.47
2015	0.00	0.05	0.05	$0.02	$0.45	$0.47
2016	0.00	0.05	0.05	$0.02	$0.45	$0.47
2017	0.00	0.05	0.05	$0.02	$0.45	$0.47
2018	0.00	0.05	0.05	$0.02	$0.44	$0.47
2019	0.00	0.05	0.05	$0.02	$0.44	$0.47

Table 88. FMVSS No. 201: Weight and cost estimates after applying the learning curve for the instrument panel in LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00
1971	0.01	0.15	0.16	$0.05	$0.89	$0.94
1972	0.02	0.30	0.32	$0.09	$1.76	$1.85

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1973	0.02	0.46	0.48	$0.14	$2.61	$2.74
1974	0.03	0.61	0.64	$0.18	$3.45	$3.63
1975	0.04	0.76	0.80	$0.22	$4.27	$4.50
1976	0.05	0.91	0.96	$0.27	$5.08	$5.35
1977	0.06	1.06	1.12	$0.31	$5.87	$6.18
1978	0.06	1.21	1.28	$0.35	$6.66	$7.01
1979	0.07	1.27	1.33	$0.36	$6.89	$7.25
1980	0.08	1.52	1.60	$0.43	$8.21	$8.64
1981	0.10	1.82	1.92	$0.52	$9.79	$10.31
1982	0.16	3.03	3.19	$0.85	$16.23	$17.09
1983	0.16	3.03	3.19	$0.85	$16.14	$16.98
1984	0.16	3.03	3.19	$0.84	$16.03	$16.87
1985	0.16	3.03	3.19	$0.84	$15.92	$16.75
1986	0.16	3.03	3.19	$0.83	$15.81	$16.64
1987	0.16	3.03	3.19	$0.83	$15.71	$16.54
1988	0.16	3.03	3.19	$0.82	$15.63	$16.45
1989	0.16	3.03	3.19	$0.82	$15.55	$16.36
1990	0.16	3.03	3.19	$0.81	$15.47	$16.29
1991	0.16	3.03	3.19	$0.81	$15.41	$16.22
1992	0.16	3.03	3.19	$0.81	$15.35	$16.16
1993	0.16	3.03	3.19	$0.80	$15.29	$16.09
1994	0.16	3.03	3.19	$0.80	$15.22	$16.02
1995	0.16	3.03	3.19	$0.80	$15.16	$15.96
1996	0.16	3.03	3.19	$0.79	$15.10	$15.90
1997	0.16	3.03	3.19	$0.79	$15.04	$15.83
1998	0.16	3.03	3.19	$0.79	$14.99	$15.77
1999	0.16	3.03	3.19	$0.79	$14.93	$15.71
2000	0.16	3.03	3.19	$0.78	$14.87	$15.65
2001	0.16	3.03	3.19	$0.78	$14.81	$15.59

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2002	0.16	3.03	3.19	$0.78	$14.76	$15.54
2003	0.16	3.03	3.19	$0.77	$14.71	$15.48
2004	0.16	3.03	3.19	$0.77	$14.66	$15.43
2005	0.16	3.03	3.19	$0.77	$14.61	$15.38
2006	0.16	3.03	3.19	$0.77	$14.57	$15.33
2007	0.16	3.03	3.19	$0.76	$14.52	$15.29
2008	0.16	3.03	3.19	$0.76	$14.48	$15.24
2009	0.16	3.03	3.19	$0.76	$14.45	$15.21
2010	0.16	3.03	3.19	$0.76	$14.42	$15.18
2011	0.16	3.03	3.19	$0.76	$14.39	$15.15
2012	0.16	3.03	3.19	$0.76	$14.35	$15.11
2013	0.16	3.03	3.19	$0.75	$14.31	$15.07
2014	0.16	3.03	3.19	$0.75	$14.28	$15.03
2015	0.16	3.03	3.19	$0.75	$14.23	$14.98
2016	0.16	3.03	3.19	$0.75	$14.20	$14.95
2017	0.16	3.03	3.19	$0.75	$14.16	$14.91
2018	0.16	3.03	3.19	$0.74	$14.13	$14.87
2019	0.16	3.03	3.19	$0.74	$14.10	$14.84

Table 89. FMVSS No. 201: Weight and cost estimates after applying the learning curve for the seat back padding in LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1979	0.00	0.00	0.00	$0.00	$0.00	$0.00
1980	0.00	0.05	0.05	$0.00	$0.25	$0.25
1981	0.00	0.11	0.11	$0.00	$0.49	$0.49
1982	0.00	0.55	0.55	$0.00	$2.45	$2.45
1983	0.00	0.55	0.55	$0.00	$2.43	$2.43
1984	0.00	0.54	0.54	$0.00	$2.39	$2.39
1985	0.00	0.54	0.54	$0.00	$2.37	$2.37

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1986	0.00	0.54	0.54	$0.00	$2.35	$2.35
1987	0.00	0.85	0.85	$0.00	$3.66	$3.66
1988	0.00	0.85	0.85	$0.00	$3.64	$3.64
1989	0.00	0.85	0.85	$0.00	$3.62	$3.62
1990	0.00	0.85	0.85	$0.00	$3.59	$3.59
1991	0.00	0.85	0.85	$0.00	$3.58	$3.58
1992	0.00	0.85	0.85	$0.00	$3.56	$3.56
1993	0.00	0.85	0.85	$0.00	$3.55	$3.55
1994	0.00	0.85	0.85	$0.00	$3.53	$3.53
1995	0.00	1.44	1.44	$0.00	$5.93	$5.93
1996	0.00	1.45	1.45	$0.00	$5.94	$5.94
1997	0.00	1.45	1.45	$0.00	$5.91	$5.91
1998	0.00	1.45	1.45	$0.00	$5.88	$5.88
1999	0.00	1.44	1.44	$0.00	$5.81	$5.81
2000	0.00	1.44	1.44	$0.00	$5.79	$5.79
2001	0.00	1.44	1.44	$0.00	$5.76	$5.76
2002	0.00	1.44	1.44	$0.00	$5.73	$5.73
2003	0.00	1.51	1.51	$0.00	$5.99	$5.99
2004	0.00	1.51	1.51	$0.00	$5.96	$5.96
2005	0.00	1.51	1.51	$0.00	$5.93	$5.93
2006	0.00	1.51	1.51	$0.00	$5.91	$5.91
2007	0.00	1.51	1.51	$0.00	$5.89	$5.89
2008	0.00	1.52	1.52	$0.00	$5.90	$5.90
2009	0.00	1.52	1.52	$0.00	$5.89	$5.89
2010	0.00	1.52	1.52	$0.00	$5.88	$5.88
2011	0.00	1.51	1.51	$0.00	$5.85	$5.85
2012	0.00	1.50	1.50	$0.00	$5.79	$5.79
2013	0.00	1.50	1.50	$0.00	$5.77	$5.77
2014	0.00	1.57	1.57	$0.00	$6.00	$6.00

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2015	0.00	1.56	1.56	$0.00	$5.95	$5.95
2016	0.00	1.52	1.52	$0.00	$5.79	$5.79
2017	0.00	1.55	1.55	$0.00	$5.87	$5.87
2018	0.00	1.57	1.57	$0.00	$5.96	$5.96
2019	0.00	1.53	1.53	$0.00	$5.77	$5.77

Head Impact Protection Upgrade.

FMVSS No. 201 was substantially upgraded in August 1995 (60 FR 43031). A final rule was issued requiring passenger cars and LTVs to provide protection when an occupant's head strikes upper interior components during a crash, including pillars, side rails, headers, and the roof. The rule significantly expanded the scope of the standard. On August 4, 1998, (63 FR 41451) the standard was amended to permit, but not require, the installation of dynamically deploying upper interior head protection systems (e.g., window curtain air bags) that provide added head protection in lateral crashes. Recognizing that the 15 mph headform test might be a problem in target areas where an un-deployed air bag is stored (and, furthermore, an inappropriate test if the window curtain usually deploys at that speed), NHTSA offered an alternative compliance procedure. Manufacturers have the option to reduce the speed of the headform test to 12 mph on target areas where the bag is stored, provided they can also meet an 18-mph lateral (90°) crash test for the full vehicle into a pole – with head injury criterion < 1000. The pole test simulates a head impact with the deployed bag.

Specific areas of the upper interior are required to absorb energy to protect the occupant's head in an impact. A free motion headform is propelled into target locations on the A-pillar, B-pillar, side headers, front windshield header, and other potential interior locations. The impact speed for the free motion headform impact test for the new areas is 15 mph, as in the original FMVSS No. 201, but for these new targets, head injury criterion may not exceed 1000 for any 36-millisecond period. Impacts could be directed from a range of vertical and horizontal angles, not just head-on. The additional upper interior protection requirements can be met with or without head air bags. The upper interior head protection requirements were phased-in starting with the 1999 MY and all vehicles had to meet the standard with the 2003 MY. Manufacturers were offered a choice of several alternative phase-in schedules from September 1, 1998, to September 1, 2002. For example, phase-in schedule #1 specified that they certify to the new requirements on at least 10 percent of cars and LTVs manufactured from September 1, 1998, to August 31, 1999; at least 25 percent of cars and LTVs manufactured from September 1, 1999, to August 31, 2000; at least 40 percent of cars and LTVs manufactured from September 1, 2000, to August 31, 2001; at least 70 percent of cars and LTVs manufactured from September 1, 2001, to August 31, 2002; and all cars and LTVs manufactured on or after September 1, 2002.

The NPRM was published in the Federal Register on February 8, 1993, (58 FR 7506) making the baseline date September 1, 1992, or MY 1993. Since none of the fleet passed all the requirements by MY 1994, we assume no voluntary compliance and all the costs are attributable to the final rule.

A study was conducted to determine the changes made by the automotive industry to meet the standard's criteria without window curtain air bags. Ten make-model pre-standard passenger vehicles (six passenger cars, one pickup, one SUV, and two vans), and their corresponding mostly MY 2001 post-standard systems, were studied to determine the weight and consumer cost impact of adding non air bag components (Ludtke et al., 2003). The type of approaches used to meet the standard consist of foam padding, ridges molded from composite materials, injection molded egg-crate or honeycomb parts, and injection molded ribs in parallel on the interior side of trim pieces. All these approaches are used in the A- and B-pillar trim, header, and headliner locations.

The principal modifications needed to meet FMVSS No. 201 were the addition of energy-absorbing padding in the target areas noted above and the addition of window curtain air bags. In most make-models of cars and LTVs, padding came first, window curtains usually came later. It is generally unknown to what extent the padding stayed the same in vehicles after the window curtains arrived. Some modification or even discontinuation of the padding may occur in components that house the window curtains, such as the roof side rails, or possibly in areas that may be protected by window curtains, such as pillars. NHTSA studied the pillar components in three make-models certified to the head-impact upgrade of FMVSS No. 201, before and after these models had window curtains; the average cost of the components was slightly higher in the vehicles with the window curtains, suggesting (although not proving) that energy-absorbing materials were not downgraded, at least on these three models, after window curtains became available (Kahane, 2011, p. 17; Ludtke et al., 2004, pp. 3-47–3-54, Appendix A).

Table 90 shows the sales-weighted average weight and consumer cost of the protection systems without window curtain air bags derived from Ludtke (2003), before applying the learning curve. The data for passenger cars and LTVs was combined to estimate a single average cost.

Table 90. FMVSS No. 201: Average weight and consumer cost increase of head impact protection systems without air bags in passenger cars and LTVs

System	Weight (lb)	Consumer Cost (2019$)
Without Air Bags	1.89	$16.62

This cost is inherently attributable to FMVSS No. 201. Table 91 shows the percent of the fleet that met the standard by MY based on NHTSA test data and compliance data supplied by the manufacturers to NHTSA during the phase-in years and Table 92 and Table 93 show the average increase in passenger car and LTV weight and consumer cost by model year. Costs start to decline after the new vehicle fleet is 100-percent equipped due to learning.

Table 91. FMVSS No. 201: Percent compliance with FMVSS No. 201 upper interior head protection – non-air bag passenger cars and LTVs

Model Year	Passenger Cars	LTVs
Pre 1999	0	0
1999	20.53	15
2000	47.54	28.22
2001	63.43	35.47
2002	71.55	75.6
After 2002	100	100

Table 92. FMVSS No. 201: Average weight and consumer cost of upper interior head protection – non-air bag passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1998	0	0	0	0	0	0
1999	0	0.39	0.39	0	$4.11	$4.11
2000	0	0.90	0.90	0	$8.44	$8.44
2001	0	1.20	1.20	0	$10.54	$10.54
2002	0	1.35	1.35	0	$11.26	$11.26
2003	0	1.89	1.89	0	$15.03	$15.03
2004	0	1.89	1.89	0	$14.56	$14.56
2005	0	1.89	1.89	0	$14.20	$14.20
2006	0	1.89	1.89	0	$13.92	$13.92
2007	0	1.89	1.89	0	$13.69	$13.69
2008	0	1.89	1.89	0	$13.50	$13.50
2009	0	1.89	1.89	0	$13.39	$13.39
2010	0	1.89	1.89	0	$13.28	$13.28
2011	0	1.89	1.89	0	$13.16	$13.16
2012	0	1.89	1.89	0	$13.03	$13.03
2013	0	1.89	1.89	0	$12.91	$12.91
2014	0	1.89	1.89	0	$12.80	$12.80

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2015	0	1.89	1.89	0	$12.68	$12.68
2016	0	1.89	1.89	0	$12.59	$12.59
2017	0	1.89	1.89	0	$12.50	$12.50
2018	0	1.89	1.89	0	$12.43	$12.43
2019	0	1.89	1.89	0	$12.35	$12.35

Table 93. FMVSS No. 201: Average weight and consumer cost of upper interior head protection – non-air bag LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1998	0	0	0	0	0	0
1999	0	0.28	0.28	0	$3.01	$3.01
2000	0	0.53	0.53	0	$5.01	$5.01
2001	0	0.67	0.67	0	$5.89	$5.89
2002	0	1.43	1.43	0	$11.89	$11.89
2003	0	1.89	1.89	0	$15.03	$15.03
2004	0	1.89	1.89	0	$14.56	$14.56
2005	0	1.89	1.89	0	$14.20	$14.20
2006	0	1.89	1.89	0	$13.92	$13.92
2007	0	1.89	1.89	0	$13.69	$13.69
2008	0	1.89	1.89	0	$13.50	$13.50
2009	0	1.89	1.89	0	$13.39	$13.39
2010	0	1.89	1.89	0	$13.28	$13.28
2011	0	1.89	1.89	0	$13.16	$13.16
2012	0	1.89	1.89	0	$13.03	$13.03
2013	0	1.89	1.89	0	$12.91	$12.91
2014	0	1.89	1.89	0	$12.80	$12.80
2015	0	1.89	1.89	0	$12.68	$12.68
2016	0	1.89	1.89	0	$12.59	$12.59
2017	0	1.89	1.89	0	$12.50	$12.50

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2018	0	1.89	1.89	0	$12.43	$12.43
2019	0	1.89	1.89	0	$12.35	$12.35

FMVSS No. 202, Head restraints

On February 14, 1968, (33 FR 2945) a final rule was published in the Federal Register requiring passenger car front outboard seat head restraints. On September 25, 1989, (54 FR 39183) a final rule extended the requirements to LTVs. FMVSS No. 202 became effective on January 1, 1969, (passenger cars) and September 1, 1991, (MPVs, trucks, all LTVs, and buses with a GVWR of 10,000 lb or less). The purpose of this standard is to reduce the frequency and severity of neck injuries in rear-end and other collisions, specifically whiplash, a painful and sometimes disabling syndrome that is all too common in these crashes.

The NPRM for passenger cars was published in the Federal Register on December 28, 1967, (32 FR 20865) making the baseline date September 1, 1967, or MY 1968. Front seat outboard head restraints were not available in all passenger cars and LTVs by MY 1965, thus the Safety1965 countermeasure for head restraints is a seat back with no head restraint that is 22 inches tall as measured by the methodology in FMVSS No. 202. An estimated 12 percent of the fleet had head restraints in passenger cars by the baseline date of MY 1968 and are considered voluntary from MYs 1968 to 2019. Since 100 percent of passenger cars had front outboard seat head restraints from MY 1969 to 2019, the increase in their costs above the 12 percent voluntary level are considered attributable.

The NPRM for LTVs was published in the Federal Register on December 13, 1988, (53 FR 50047) making the baseline date September 1, 1988, or MY 1989. An estimated 58.2 percent of the fleet had head restraints in LTVs in the front outboard seating positions by the baseline date of MY 1989. All LTV head restraints up through MY 1989 are considered voluntary as are 58.2 percent from MYs 1990 to 2019. LTV front seat head restraint installations above that 58.2 percent baseline level are considered attributable from MY 1990 to 2019.

Vehicle manufacturers installed adjustable or nonadjustable (some people call them integral, and others call them fixed; they are the same) head restraints in response to FMVSS No. 202. Adjustable head restraints can be added to bench as well as bucket seats. They can be shifted up and down through a finite range to suit the occupant, and some can also be rotated about their lateral axis to change the distance from the face of the restraint to the back of the occupant’s head. Integral head restraints are built into a bucket seat, or in rare cases, a bench seat. They are not adjustable. Essentially the seat back is raised high enough to act as a head restraint, and seats with integral head restraints are commonly referred to as high-back seats. They require additional framing, padding, and seat covering as compared to a pre-standard seat back without a head restraint. Integral head restraints are rigidly attached to the seat back, are not adjustable, and can be composed of a metal frame that is covered with padding that allows the vehicle operator to see through the open areas of the framework.

The advantage of adjustable restraints is that they can potentially be optimally adjusted to capture the center of gravity of the head more effectively in a rear impact for a range of occupant sizes. Drivers may also use the adjustability to avoid perceived vision obstructions, when turning to the rear. The disadvantage is that taller occupants may neglect to adjust them up to an adequate height. Integral restraints avoid the problem of improper adjustment; however, historically they were criticized because, depending on their width, they might obstruct a driver's vision or create a wall that makes rear-seat passengers feel isolated from the people in front of them. Fixed see-through restraints try to avoid the shortcomings of the adjustable and the integral types.

Head restraint standard upgrade

FMVSS No. 202 was upgraded in a final rule issued on December 14, 2004, (69 FR 74848).[23] The upgrade, called FMVSS No. 202a, raised the outboard front seat's height requirement in the head restraint's highest position from 700 mm (27.5 inches) to 800 mm (31.5 inches) and added a new requirement that the restraint must be at least 750 mm (29.5 inches) high in its lowest position; also that the restraint should stay locked in position and cannot be lowered simply by pushing down on it in one action. That final rule also set a requirement limiting the distance between the back of the occupant's head and the occupant's head restraint (termed backset). After petitions for reconsideration, the final rule was amended (72 F.R., 2007). The final rule requires a 55 mm backset limit, measured with the seat back at the manufacturer's designated seating position. The final rule also limits gaps between the head restraint and seat back and requires a height retention lock test. The final rule is effective for all front-seat-passenger cars, LTVs, MPVs, and buses with a GVWR of 4,536 kg or 10,000 lb or less.

The NPRM for passenger cars and LTVs was published in the Federal Register on January 4, 2001, (66 FR 968) making the baseline date September 1, 2000, or MY 2001. Since every vehicle had head restraints before the baseline date and the estimated costs of the upgrade are based on vehicles with head restraints, all these additional costs for front outboard seat head restraints starting in MY 2009 are attributable to the upgrade. The one exception is the locking mechanism, where we have data on voluntary use of a locking mechanism before the baseline, to be discussed later.

For rear outboard seats, the upgraded final rule applies to any voluntarily supplied rear head restraint, except school buses. A rear outboard head restraint is defined as one that has a height greater than or equal to 700 mm. FMVSS No. 202a does not require rear outboard head restraints; however, if the seat back is 700 mm or more in height, then it is defined as a rear head restraint and must then have a minimum height of at least 750 mm and meet the backset requirements. Any adjustable rear head restraint would meet this height and be required to meet the standard.

The effective dates of the upgraded requirements for passenger cars and LTVs are:

- Front seat outboard: 80 percent of vehicles manufactured on or after September 1, 2009, and before September 1, 2010, must comply. One hundred percent of vehicles manufactured on or after September 1, 2010, must comply.

[23] NHTSA Docket No. 2004-19807-0002.

- Rear outboard seat: 80 percent of vehicles manufactured on or after September 1, 2010, and before September 1, 2011, must comply. One hundred percent of vehicles manufactured on or after September 1, 2011, must comply.

All costs for passenger car and LTV rear outboard seats and rear center seats are considered voluntary. Manufacturers are not required to provide any head restraints for the rear seat, even though with the head restraint upgrade a certain height is required if a head restraint is provided. Not all vehicles have head restraints in every rear seat that has a designated seating position. This is particularly true for the rear center seats. The head restraints for the rear seats have been divided into two groups for ease of presentation and calculation. Tall head restraints that appear to be able to meet the upgraded height standard (although they are not required to) and small head restraints that are more typical of the designs available before the upgrade were considered. We chose these designations because the cost and weight impact depend on the size of the head restraints provided.

We have manufacturer compliance data with the upgrade requirements for MYs 2010 to 2012. However, compliance data does not tell us whether the head restraints were adjustable or nonadjustable. In addition, the upgrade requirements do not apply to the center rear seat, and many manufacturers did not provide any data on the center rear seat. Thus, we used Cars.com to examine whether the head restraints were adjustable or nonadjustable and the availability and size of rear outboard and rear center seat head restraints, by looking at photographs of cars for sale, to supplement data provided by the manufacturers, and to also examine MY 2009 head restraints. The manufacturers did provide certification information on MY 2009 head restraints, but since the upgrade wasn't effective yet, most of them just said they certified to meeting the original FMVSS No. 202, making that data not useful for determining the percent of MY 2009 passenger cars and light trucks that met the upgraded standard of FMVSS No. 202a. For those head restraints not certified as compliant by the manufacturer, we classified them as tall or small head restraints based on our subjective judgment. We did not measure any head restraints. We examined all MY 2016 passenger cars and LTVs using photographs from Edmunds.com to determine adjustable versus non-adjustable and tall and small head restraints and weighted these findings by MY 2016 sales as found in *Ward's Automotive Yearbook* 2017 (Binder, 2002-2017). We also examined all MY 2018 and 2019 passenger cars and LTVs using photographs from Edmunds.com or the internet to determine adjustable versus non-adjustable and tall and small head restraints and weighted these findings by MY 2018 or 2019 sales as found in *Ward's Automotive Yearbook 2019* or *Ward's Automotive Yearbook 2020* (Norris, 2018-2020).

There are cost and weight impacts associated with the original standard and with increases in head restraint heights. Cost teardown studies provide estimates of costs of the original standard. Cost and weight estimates after MY 1980 are based on the height of head restraints. Head restraints have increased in height over time, sometimes, but not always, because of NHTSA requirements. The baseline height of a seat back with no head restraint is assumed to be 22 inches as measured using the methodology in the standard, essentially from the H-point or hip point of the dummy to the top of the seat back or the top of the head restraint at the manufacturer's designated seat back angle. We believe that this 22-inch baseline applies to the front seat and rear seat for both passenger cars and LTVs. The 22-inch baseline seat back height with no head restraint for the front seat of passenger cars was found for pre-standard seats in the Kahane (1982) evaluation. After reviewing several photos of pre-standard passenger cars we determined that the rear seat and front seat of passenger cars with no head restraints had essentially the same seat back height and assumed a 22-inch baseline for the rear seat of passenger cars as well. We have direct measurements for MY 1989 pickup trucks without head restraints in the front seat in the Supplemental Final Regulatory Evaluation and it shows that the average pickup truck front seat height in MY 1989 was 21.5 inches (72 F.R., 2007, p. 25, Table IV-5). We assumed that the average height of seat backs with no head restraint for all LTVs, including pickups, starting in MY 1968 would be the same as for passenger cars at 22 inches for both the front and rear seats.

Head restraints are an addition to vehicles. For an adjustable head restraint, the addition is obvious (the metal poles and adjustment mechanism, along with the padding and cover of the head restraint attached to the metal poles). The head restraint portion of the integral high-back seat is not so obvious and was estimated by considering only the additional material and labor to provide the increase in seat back height necessary to meet the requirements for a head restraint compared to what was considered a standard seat back. For the purposes of analysis, head restraints were divided into adjustable and nonadjustable categories. The nonadjustable restraints include integral and fixed head restraints.

For passenger car and LTV front seat outboard head restraints, we have the following cost and weight impacts to follow. This discussion will follow the outline below.

Passenger car and LTV front outboard seats:

- the distribution of adjustable/nonadjustable head restraints by model year (Table 94 for passenger cars and Table 105 for LTVs),
- cost and weight of the original standard FMVSS No. 202 for adjustable and nonadjustable head restraints (Table 95 for passenger cars and Table 106 for LTVs),
- incremental cost and weight of the increases in height per inch, compared to the average height of head restraints meeting the original standard,
- percent of vehicles by model year affected by the locking mechanism requirement,
- the cost of the locking mechanism requirement,
- no weight is attributable to the locking mechanism requirement,
- estimates of the average height of adjustable and nonadjustable head restraints by model year (Table 96),
- average number of front outboard head restraints (Table 101 for passenger cars and LTVs), and
- combining all these factors into estimates of the cost and weight impacts by model year (Table 111 for front seat outboard passenger cars and Table 114 for front seat outboard LTVs).

LTV front center seat:

- the estimated percentage of LTVs with a front center seating position and the estimated percentage with front center seat head restraints (Table 102), and
- estimates of the cost and weight impacts by model year (Table 115 for the front center seat of LTVs).

Passenger car and LTV rear outboard seats and rear center seat:

- the distribution of adjustable/nonadjustable head restraints by model year (Table 97 for passenger cars and Table 108 for LTVs),
- the estimated distribution of small and tall head restraints per vehicle by model year for rear outboard and rear center seating positions (Table 98 for passenger cars and Table 109 for LTVs),
- MYs 2009 to 2019 data on rear seat head restraints for passenger cars and LTVs (Table 99),
- MY 2019 distribution of nonadjustable/adjustable and tall/short rear seat head restraints for rear outboard and rear center seats (Table 100 for passenger cars and Table 110 for LTVs),
- average number of rear outboard head restraints and rear center head restraints per vehicle by model year (Table 103 for passenger cars and Table 104 for LTVs),
- estimates of the average height of adjustable and nonadjustable head restraints by model year for rear outboard and rear center seating positions (Table 96),
- incremental cost and weight of the increases in height per inch,
- percent of vehicles by model year affected by the locking mechanism requirement,
- the cost of the locking mechanism requirement, and
- combining all these factors into estimates of the cost and weight impacts by model year (Table 112 for the rear outboard seats of passenger cars, Table 113 for the rear center seat of passenger cars, Table 116 for the rear outboard seats of LTVs, and Table 117 for the rear center seats of LTVs).

FMVSS No. 202 has never required the front center seat of a light vehicle to have a head restraint. There were no MY 2019 passenger cars with a front center seat position and we know of no passenger cars prior to MY 2019 with a head restraint in the front center seat. Starting in MY 2004, the Toyota Tacoma (MYs 2004 to 2014) and Toyota Tundra (MYs 2004 to 2019) had a small adjustable head restraint in the front center seat. Starting in MY 2016, the Ford F-150 and Ford Super-duty standard cab pickups started to provide an adjustable tall head restraint in the front center seat. In MY 2019, about 1 percent of all LTVs had a head restraint in the center front seat position.

Passenger Car Front Seat

Passenger Car Front Seat – Original Standard

An estimated 12 percent of MY 1968 passenger car front outboards seats had head restraints and 100 percent of MY 1969 and later had head restraints. The vast majority of American passenger cars were fitted with adjustable head restraints in every year (1968 to 2019). During the 1970s, nonadjustable head restraints reached their peak market share, averaging 31 percent. Starting in 1983, the percentage of nonadjustable head restraints started to drop dramatically. A sample of MY 1998 passenger cars representing 47 percent of passenger car sales found that 93 percent of head restraints were adjustable and only 7 percent were nonadjustable. An examination of

Cars.com weighted by sales found that 97.54 percent of MY 2005 and 99.07 percent of MY 2010 passenger cars had adjustable head restraints. An examination of Edmunds.com found that 95.5 percent of MY 2016, 98.1 percent of MY 2018, and 97.5 percent of MY 2019 front seat passenger cars had adjustable head restraints. Table 94 shows the estimated average percentages of nonadjustable and adjustable head restraints in the front outboard seats of passenger cars from 1968 to 2019.

Table 94. FMVSS No. 202: Average distribution of percentages of nonadjustable/adjustable head restraints in the front seat of passenger cars from 1968 to 2019

Model Year	% Nonadjustable	% Adjustable
Front Seat		
1968	4	8
1969-1981	31	69
1982-1997	13	87
1998-2002	7	93
2003-2007	2	98
2008-2012	1	99
2013-2016	4.5	95.5
2017	3.2	96.8
2018	1.9	98.1
2019	2.5	97.5

Three separate studies of nonadjustable and adjustable headrests were conducted to determine the weight and consumer cost of the head restraint systems in 1969 to 1981 MY passenger cars. (Harvey et al., 1979b; Gladstone et al., 1982a, 1982d). There were a total of eight nonadjustable (integral or fixed) head restraints in various MY passenger cars, eleven adjustable head restraints in 1969 MY passenger cars, and five adjustable head restraints in 1979 to 1981 MY passenger cars. The average MY of the nonadjustable and 1979 to 1981 adjustable head restraints was MY 1978. Table 95 shows the sales-weighted average weight and consumer cost per head restraint for passenger car front outboard seats in 2019 dollars.

Table 95. FMVSS No. 202: Average weight and consumer cost per head restraint in front outboard passenger car seats

Category	Model Year	Ave. Height In Inches	Weight (lb)	Consumer Cost ($2019)
Nonadj.	1968-81	27.5	3.09	$19.11
Adjustable	1969	25.5	4.97	$29.85
Adjustable	1979-81	25.5	2.78	$21.75

Table 95 shows that adjustable head restraints decreased significantly in weight and consumer cost in 1969 and 1979 to 1981. NHTSA believes the reductions are due to two factors:

- initial over design (extra wide and bulky head restraints), and
- vehicle downsizing that resulted in smaller and narrower seats.

Adjustable head restraints was one of the data sets used to determine the learning curve. When we used the change in price in the adjustable head restraints, we found a progress rate of 0.91, which is a little lower than the average safety standard progress rate of 0.93 that we use for all safety standards for which we have not determined a specific progress rate.

To estimate the cost and weight reduction, we assume that the average cost and weight for adjustable head restraints decreased at a linear rate from 1968 to 1979, since no further downsizing occurred after 1979, and then started to increase as head restraints height started to increase in 1982.

Table 101 shows the number of front outboard passenger car head restraints and Table 103 shows the number of rear seat head restraints in passenger cars. Table 111 shows the resulting weights and costs by voluntary and attributable by model year for the front outboard head restraints in passenger cars.

Passenger Car Front Seat – Upgrade

The consumer cost of the upgraded standard was estimated in the Final Regulatory Impact Analysis (NHTSA, 2004). A study of nine LTV head restraints was conducted to determine the weight and consumer cost of the head restraint systems in 1992 to 1994 make-model LTVs and vans (Fladmark & Khadilkar, 1994). Since head restraints are fairly similar between LTVs and passenger cars, and it was easy to determine height from this data, this information was used for both passenger cars and LTVs to determine the average cost and weight per inch of head restraints. The average cost per inch of a head restraint (excluding the adjustment hardware and assembly costs) was $2.29 (in 2019 dollars). This average cost applies to both adjustable and nonadjustable head restraints. The average cost per inch is important for the calculations, since we have estimated how the height of head restraints has changed over time and have estimated the consumer cost of head restraints based on the difference in height compared to the height of head restraints that met the original standard. The weight impacts of increasing head restraint height was determined using the same methodology. The average integral seat weighed 0.38 lb per inch and the average adjustable head restraints weighed 0.68 lb per inch.

There was also a cost to add a locking mechanism to those adjustable head restraints that didn’t have a locking mechanism. These are simple devices for height adjustment that were estimated to cost $0.22 per head restraint. Based on the survey of 14 MY 1999 vehicles, half of the adjustable head restraints had a locking mechanism. This would be voluntary compliance. We added $0.11 per adjustable head restraint for MY 1999 and later to the voluntary costs of head restraints to account for the 50 percent voluntary compliance and another $0.11 per adjustable head restraint as attributable costs starting in MY 2008.

Head Restraint Height

Since the height of head restraints has changed over time, and we are assuming that the cost and weight of head restraints changes directly with the increase in height (once the downsizing period was over), we collected all the information we had on the height of head restraints. Some of the height increase was a natural progression over time, while in MY 2009 and later they were affected by the upgrade (FMVSS No. 202a) in the standard that raised height.

As discussed earlier, based on the Kahane (1982) evaluation and other sources, we estimate that the baseline seat back height, with no head restraint, is 22 inches. Kahane also found that the average passenger car front outboard head restraint was 25.5[24] inches for adjustable head restraints and 27.5 inches for integral head restraints. We assumed these measurements were applicable to a range of MY 1968 to 1981 vehicles. The next group of measurements are from MY 1999 vehicles. Based on a sample of 14 (9 passenger cars and 5 LTVs) MY 1999 vehicles, the average height of front outboard seat head restraints (for adjustable head restraints in the low position and integral head restraints) for passenger cars and LTVs was 28.2 inches (NHTSA, 2004). The average height for adjustable head restraints in the low position in the rear seat was 25.8 inches and the average height for an integral head restraint in the rear seat was 25.6 inches. The difference in height between passenger cars and LTVs was small, and since the measurements were based on only a few vehicles, we assumed that the height for passenger cars and LTVs was the same.

Over the course of analyzing comments and suggestions for the head restraint upgrade final rule, the agency measured some 2004 to 2007 models and found similar estimates for the front outboard seats, but some different heights in the rear seat, compared to the MY 1999 survey (notably that the average integral head restraint height in the rear seat increased to 26.3 inches). For MYs 2009 to 2019, we assumed manufacturers would at least meet the upgraded requirements. Table 96 shows all our estimated heights. Our best estimate is a difference of 3.2 inches between a small and tall head restraint. For cost purposes, we rely on height of the adjustable head restraints in the lowest position. This gives us a better estimate of the padding used in the head restraint and is not reliant on the length of the adjustment mechanism, which would come into play if we considered the height of adjustable head restraints in the highest (up) position.

Table 96. FMVSS No. 202: Head restraint height passenger cars and LTVs [25]

Seat	Type	Position	1968-1981	1999-2003	2004-2009	2010-2019
front	adjust.	low	25.5	28.2	28.2	29.5
front	adjust.	high		30.35	30.35	31.5
front	integral		27.5	28.2	28.2	29.5

[24] The average height of adjustable head restraints in the Kahane (1982) evaluation was shown at 25.5 inches after considering usage of adjustable head restraints. This was based on the National Crash Severity Study data (which was collected in 1977 to 1979), about 75% of the adjustable head restraints were in the down position. Since the typical adjustable head restraint at that time was about 3.0 to 3.5 inches in height and the baseline seat back was 22 inches, we assumed that the height for adjustable head restraints in the down (low) position was 25.5 inches.

[25] We assume a linear increase in height from MY 1981 to 1999.

Seat	Type	Position	1968-1981	1999-2003	2004-2009	2010-2019
rear	adjust.	low	25.5	25.8	25.7	
rear	adjust.	high		28.5	28.4	
rear	adjust.	small/low				26.3
rear	adjust.	small/high				29.5
rear	adjust.	tall/low				29.5
rear	adjust.	tall/high				31
rear	integral		25.5	25.6	26.3	
rear	integral	small				26.3
rear	integral	tall				29.5
rear	no head restraint		22	22	25.6	25.6

Passenger Car Rear Seat

Neither the original standard nor the upgrade requires manufacturers to supply rear seat head restraints. Approximately 41 percent of the MY 1999 vehicles had head restraints in the outboard rear seats. These are all voluntary. This 41 percent estimate was for both passenger cars and LTVs and will be applied to both. The agency has not attempted to assemble an estimate of the percent of the fleet with rear head restraints that were voluntarily supplied in passenger cars by MY with the exception of the data we collected for MYs 2005, 2009 to 2012, 2016, 2018, and 2019. For this analysis we are assuming a gradual build-up of rear outboard head restraints starting at 5 percent in 1992 and increasing 5 percentage points per year to 41 percent for MY 1999 and then increasing more quickly to the 100 percent of those with an outboard rear seat found for MY 2005 (see Table 103). The percent of passenger cars that are 2-seaters and don't have a rear seat fluctuates from year to year between 1 and 4 percent of total passenger car sales. Where we have gaps in information, we assume a linear increase or decrease in values.

Based on the MY 2005 examination of Cars.com and weighting that data by MY 2005 Polk data (n.d.), we estimated 42.43 percent of the passenger car rear seat head restraints were nonadjustable and 57.57 percent were adjustable. By MY 2010, there was a big change in the distribution of adjustable versus nonadjustable head restraints in the rear seat of passenger cars and the percentage of passenger cars providing a head restraint for the rear center seat. Based on the MY 2010 examination of Cars.com and weighting that data by MY 2010 Polk data, we estimate that 18.57 percent of the passenger car rear seat head restraints were nonadjustable and 81.43 percent were adjustable. When we examined the MY 2016 head restraints in the rear seat of passenger cars, we again found a large increase in adjustable head restraints. The percentage of adjustable head restraints stayed at about the same level from MYs 2016 to 2019 with the exception being an increase in non-adjustable head restraints in the rear center seat in MY 2019. This is likely an increase in the seat back height to a level that it appears to us that the seat back is high enough to be considered a head restraint. This is a subjective judgment as no measurements were taken to substantiate this belief. Table 97 shows our estimates of the distribution of adjustable and non-adjustable rear seat head restraints for passenger cars.

Table 97. FMVSS No. 202: Average distribution of percentage of nonadjustable/adjustable head restraints in the rear seat of passenger cars from 1992 to 2019

Model Year	Rear Outboard		Rear Center	
	% Nonadj.	% Adj.	% Nonadj.	% Adj.
1992-2005	42.43	57.57	42.43	57.57
2006	37.66	62.34	37.66	62.34
2007	32.89	67.11	32.89	67.11
2008	28.12	71.88	28.12	71.88
2009	23.35	76.65	23.35	76.65
2010	18.57	81.43	18.57	81.43
2011	16.21	83.79	15.78	84.22
2012	13.86	86.14	12.98	87.02
2013	11.50	88.50	10.19	89.81
2014	9.15	90.85	7.40	92.60
2015	6.79	93.21	4.60	95.40
2016	4.43	95.57	1.81	98.19
2017	3.94	96.06	3.38	96.62
2018	3.46	96.54	4.95	95.05
2019	6.87	93.13	17.59	82.41

Table 98 gives the assumed distribution of small and tall head restraints by model year for the rear seat of passenger cars. This is based on our examination of pictures of cars from MYs 2005, 2009 to 2012, 2016, 2018, and 2019. In MY 2009, 36.2 percent of the passenger car rear outboard head restraints were small, by MY 2019 only 0.3 percent of the rear outboard head restraints were small. The percentage of small center head restraints increased from MY 2009 (59.1%) to 2016 (69.9%), but then decreased to 58.5 percent for MY 2019.

Table 98. FMVSS No. 202: Passenger car rear seat head restraints – small versus tall

Model Year	Rear Outboard		Rear Center	
	% Small	% Tall	% Small	% Tall
1992-2002	100	0	100	0
2003	91	9	94.2	5.8

Model Year	Rear Outboard		Rear Center	
	% Small	% Tall	% Small	% Tall
2004	82	18	88.3	11.7
2005	73	27	92.5	7.5
2006	64	36	76.6	23.4
2007	55	45	70.8	29.2
2008	46	54	65.0	35
2009	36.2	63.8	59.1	40.9
2010	32.5	67.5	57.2	42.8
2011	13.3	86.7	64.8	35.2
2012	0.6	99.4	57.3	42.7
2013	1.2	98.8	60.5	39.5
2014	1.9	98.2	63.6	36.4
2015	2.5	97.5	66.8	33.2
2016	3.1	96.9	69.9	30.1
2017	2.7	97.3	65.0	35.0
2018	2.3	97.7	60.2	39.8
2019	0.3	99.7	58.5	41.5

Table 99 shows a summary of the data collected related to the upgraded Standard 202a for rear seat head restraints. The important conclusions that can be drawn from this table are:

- Not every passenger car with rear seats had outboard rear head restraints. Even in 2019, under the upgraded standards, some passenger cars had limited head room and did not have what looked like a head restraint in the rear seat. There were an estimated 1.974 rear outboard seating positions with 1.918 rear outboard head restraints per average passenger car. Most LTVs with an outboard rear seat had head restraints. There were an estimated 2.431 rear outboard seating positions with 2.414 rear outboard head restraints per average LTV. Thus, 97 percent of passenger car rear outboard seats had head restraints, while 99 percent of LTV rear outboard seats had head restraints in MY 2019.
- While over 91 percent of passenger cars have a rear center seat position, 78 to 84 percent of passenger cars with a rear center seat had a head restraint. For LTVs, the percent of rear center seat positions that had a head restraint increased from 56 percent in MY 2009 to 81 percent in MY 2019.
- The average number of rear outboard seats per LTV is higher than 2.0. Several LTVs have three rows, while regular cab pickups and most cargo vans have no rear seat.

- Most rear outboard head restraints for both passenger cars and LTVs are tall. A large proportion of the rear center seat head restraints for passenger cars are small, while a growing percentage of the LTVs rear center seat head restraints were small.
- In general, amongst the LTVs, pickup trucks make up the majority of the vehicles that might not supply a head restraint for the rear center seat that has a designated seating position.

Table 99. FMVSS No. 202: Rear seat head restraints for MYs 2009 to 2019

Passenger Cars	Number of Rear Outboard Seats Per Vehicle	Number of Rear Outboard Head Restraints	Percent Small Outboard Head Restraints	Percent Tall Outboard Head Restraints	Number of Rear Center Seats Per Vehicle	Number of Rear Center Head Restraints	Percent Small Center Head Restraints	Percent Tall Center Head Restraints
MY 2009	1.986	1.983	0.362	0.638	0.927	0.722	0.591	0.409
MY 2010	1.986	1.980	0.325	0.675	0.927	0.730	0.572	0.428
MY 2011	1.986	1.977	0.133	0.867	0.927	0.738	0.648	0.352
MY 2012	1.983	1.971	0.006	0.994	0.927	0.747	0.573	0.427
MY 2013	1.970	1.956	0.012	0.988	0.923	0.752	0.605	0.396
MY 2014	1.970	1.953	0.019	0.982	0.919	0.757	0.636	0.364
MY 2015	1.970	1.950	0.025	0.975	0.915	0.761	0.668	0.333
MY 2016	1.973	1.950	0.031	0.969	0.914	0.769	0.699	0.301
MY 2017	1.976	1.940	0.027	0.973	0.930	0.770	0.650	0.351
MY 2018	1.979	1.931	0.023	0.977	0.946	0.770	0.602	0.398
MY 2019	1.974	1.918	0.003	0.997	0.930	0.733	0.585	0.415
LTVs								
MY 2009	2.337	2.401	0.305	0.695	0.972	0.541	0.573	0.427
MY 2010	2.337	2.258	0.205	0.795	0.972	0.547	0.551	0.449
MY 2011	2.337	2.272	0.106	0.894	0.972	0.553	0.493	0.507
MY 2012	2.337	2.120	0.002	0.998	0.972	0.559	0.550	0.450
MY 2013	2.349	2.196	0.002	0.998	0.968	0.562	0.640	0.360

Passenger Cars	Number of Rear Outboard Seats Per Vehicle	Number of Rear Outboard Head Restraints	Percent Small Outboard Head Restraints	Percent Tall Outboard Head Restraints	Number of Rear Center Seats Per Vehicle	Number of Rear Center Head Restraints	Percent Small Center Head Restraints	Percent Tall Center Head Restraints
MY 2014	2.361	2.272	0.001	0.999	0.965	0.567	0.730	0.270
MY 2015	2.373	2.348	0.001	0.999	0.962	0.571	0.820	0.180
MY 2016	2.387	2.376	0	1	0.959	0.574	0.915	0.085
MY 2017	2.428	2.418	0	1	0.988	0.661	0.9315	0.0685
MY 2018	2.468	2.460	0	1	1.017	0.752	0.948	0.052
MY 2019	2.431	2.414	0.011	0.989	1.037	0.842	0.928	0.072

For ease of calculation, we have split the rear seat head restraints into outboard seats and center seats, adjustable and nonadjustable, and small and tall head restraints (see Table 100 as an example for MY 2019).

Table 100. FMVSS No. 202: Number of adjustable and nonadjustable and small and tall head restraints per vehicle MY 2019 passenger cars

	Average Number of Seating Positions	**Number of Head Restraints per Vehicle**			
		Adjustable	**Adjustable**	**Non-Adj.**	**Non-Adj.**
		Tall	**Small**	**Tall**	**Small**
Front Outboard	2.0	1.95	0.00	0.05	0.00
Front Center	0	0.00	0.00	0.00	0.00
Second Outboard	1.974	1.78	0.00	0.13	0.00
Second Center	0.930	0.26	0.34	0.04	0.09
		tall	**small**		
rear seat outboard percent		0.997	0.003		
rear seat center percent		0.415	0.585		

Number of Head Restraints

Table 101, Table 102, Table 103, and Table 104 show the average number of seating positions per vehicle, the percent of those seating positions that have head restraints and the resulting average number of head restraints by MY. The average number of seating positions comes from this report for seat belts and MY 2016, 2018, and 2019 data collected for this head restraint analysis from Edmunds.com. The percent with head restraints and the number of resulting head restraints come from various sources. The front outboard seats are based on the FMVSS No. 202 requirements, with some of the pre-standard years being filled in by data collected from NHTSA accident files. MY 1999 data was collected for the November 2004 Final Regulatory Impact Analysis. The rear seat information for MYs 2005, 2009 to 2012, 2016, 2018, and 2019 are based on our analyses of compliance data and pictures of vehicle interiors weighted by sales. Intervening years are filled in by assuming linear increases or decreases.

For MY 2019 the average total number of seating positions per passenger car is 4.904, counting 2 for the front seat, 1.974 for rear outboard seats and 0.93 for rear center seats. There were no passenger cars in MY 2019 with a front center seat position. Not all seating positions in the rear seat have head restraints in MY 2019 and the average number of head restraints per passenger car is 4.651 with 2 head restraints in the front outboard position, 1.918 head restraints in the outboard second seat position, and 0.733 head restraints in the center second seat position.

For MY 2019 the average total number of seating positions per LTV is 5.584, counting 2 for the front outboard seats, 0.115 for the front center seat of mostly pickups, 2.431 for rear outboard seats and 1.037 for rear center seats. Vehicles with a head restraint in the front center seat for MY 2019 in LTVs include Ram pickups with a standard cab, Ford pickups with a standard cab, and Toyota Tundra pickups. Not all seating positions in the rear seat have head restraints in MY 2019. The average number of head restraints per LTV is 5.267 with 2 head restraints in the front outboard position, 0.01 head restraints in the front center seat, 2.414 head restraints in rear outboard positions, and 0.842 head restraints in the rear center seat positions. The average number of head restraints in the rear seat of LTVs is influenced by many different factors over the years. For example, there are no seats (and thus no head restraints) in the rear of regular pickups or cargo vans; however, there are several SUVs, CUVs, and minivans having rear head restraints for the outboard seats and center seats of the second and third Toyota Tundra row. The percent of all LTVs that are standard (or regular) pickups (i.e., they have no rear seats like crew cabs) has decreased dramatically from 1968 to 2019, while CUVs and minivans were not part of the LTV population in 1968. The sales of SUVs and CUVs has increased dramatically. The rear seating positions of some full-size passenger vans, which are included in this report if they are less than 10,000 lb GVWR, include the second, third, and fourth rows of seats. While there are 15-passenger vans that include 5 rows of seats, these 15-passenger vans are over 10,000 lb GVWR and are not part of the LTV population included in this report.

Table 101. FMVSS No. 202: Front seat outboard head restraints – passenger cars and LTVs

Model Year	Front Outboard Passenger Cars			Front Outboard LTVs		
	Number of Front Seating Positions	Percent with Head Restraints	Number of Head Restraints	Number of Front Seating Positions	Percent with Head Restraints	Number of Head Restraints
1968	2	12	0.24	2	10.34	0.21
1969	2	100	2.00	2	10.34	0.21
1970	2	100	2.00	2	10.34	0.21
1971	2	100	2.00	2	10.34	0.21
1972	2	100	2.00	2	10.34	0.21
1973	2	100	2.00	2	10.34	0.21
1974	2	100	2.00	2	24.07	0.48
1975	2	100	2.00	2	24.07	0.48
1976	2	100	2.00	2	24.07	0.48
1977	2	100	2.00	2	24.07	0.48
1978	2	100	2.00	2	24.07	0.48
1979	2	100	2.00	2	24.07	0.48
1980	2	100	2.00	2	24.07	0.48
1981	2	100	2.00	2	24.07	0.48
1982	2	100	2.00	2	24.07	0.48
1983	2	100	2.00	2	40.77	0.82

Model Year	Front Outboard Passenger Cars			Front Outboard LTVs		
	Number of Front Seating Positions	Percent with Head Restraints	Number of Head Restraints	Number of Front Seating Positions	Percent with Head Restraints	Number of Head Restraints
1984	2	100	2.00	2	47.24	0.94
1985	2	100	2.00	2	53.77	1.08
1986	2	100	2.00	2	55.26	1.11
1987	2	100	2.00	2	64.28	1.29
1988	2	100	2.00	2	60.87	1.22
1989	2	100	2.00	2	58.2	1.16
1990	2	100	2.00	2	69.44	1.39
1991	2	100	2.00	2	70.51	1.41
1992	2	100	2.00	2	100	2.00
1993	2	100	2.00	2	100	2.00
1994	2	100	2.00	2	100	2.00
1995	2	100	2.00	2	100	2.00
1996	2	100	2.00	2	100	2.00
1997	2	100	2.00	2	100	2.00
1998	2	100	2.00	2	100	2.00
1999	2	100	2.00	2	100	2.00
2000	2	100	2.00	2	100	2.00
2001	2	100	2.00	2	100	2.00
2002	2	100	2.00	2	100	2.00
2003	2	100	2.00	2	100	2.00
2004	2	100	2.00	2	100	2.00
2005	2	100	2.00	2	100	2.00
2006	2	100	2.00	2	100	2.00
2007	2	100	2.00	2	100	2.00
2008	2	100	2.00	2	100	2.00
2009	2	100	2.00	2	100	2.00
2010	2	100	2.00	2	100	2.00

Model Year	Front Outboard Passenger Cars			Front Outboard LTVs		
	Number of Front Seating Positions	Percent with Head Restraints	Number of Head Restraints	Number of Front Seating Positions	Percent with Head Restraints	Number of Head Restraints
2011	2	100	2.00	2	100	2.00
2012	2	100	2.00	2	100	2.00
2013	2	100	2.00	2	100	2.00
2014	2	100	2.00	2	100	2.00
2015	2	100	2.00	2	100	2.00
2016	2	100	2.00	2	100	2.00
2017	2	100	2.00	2	100	2.00
2018	2	100	2.00	2	100	2.00
2019	2	100	2.00	2	100	2.00

Table 102. FMVSS No. 202: Front center seat head restraints – LTVs

Model Year	Percent of All LTVs With Front Center Seating Position	Percent of all LTVs With Front Center Head Restraints
2003	33	0
2004	33	0.3598
2005	33	0.4767
2006	33	0.5227
2007	33	0.7577
2008	25	0.5985
2009	25	0.6087
2010	25	0.5470
2011	25	0.3871
2012	25	0.4501
2013	23	0.4617
2014	23	0.4427
2015	23	0.3102
2016	11.0	1.499

Model Year	Percent of All LTVs With Front Center Seating Position	Percent of all LTVs With Front Center Head Restraints
2017	10.6	1.357
2018	10.1	1.216
2019	11.5	1.003

Table 103. FMVSS No. 202: Passenger car rear seat head restraints

Model Year	Rear Outboard Pass. Cars			Rear Center Passenger Cars		
	Number of Rear Seating Positions	**Percent with Head Restraints**	**Number of Head Restraints**	**Number of Rear Seating Positions**	**Percent with Head Restraints**	**Number of Head Restraints**
1968	1.98	0.00	0	0.62	0.00	0
1969	1.98	0.00	0	0.62	0.00	0
1970	1.98	0.00	0	0.62	0.00	0
1971	1.98	0.00	0	0.62	0.00	0
1972	1.98	0.00	0	0.62	0.00	0
1973	1.98	0.00	0	0.62	0.00	0
1974	1.98	0.00	0	0.62	0.00	0
1975	1.98	0.00	0	0.62	0.00	0
1976	1.98	0.00	0	0.62	0.00	0
1977	1.96	0.00	0	0.62	0.00	0
1978	1.96	0.00	0	0.62	0.00	0
1979	1.96	0.00	0	0.62	0.00	0
1980	1.96	0.00	0	0.62	0.00	0
1981	1.96	0.00	0	0.62	0.00	0
1982	1.96	0.00	0	0.62	0.00	0
1983	1.96	0.00	0	0.62	0.00	0
1984	1.96	0.00	0	0.62	0.00	0
1985	1.96	0.00	0	0.62	0.00	0
1986	1.96	0.00	0	0.62	0.00	0
1987	1.97	0.00	0	0.86	0.00	0

Model Year	Rear Outboard Pass. Cars			Rear Center Passenger Cars		
	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints
1988	1.97	0.00	0	0.86	0.00	0
1989	1.97	0.00	0	0.86	0.00	0
1990	1.96	0.00	0	0.86	0.00	0
1991	1.96	0.00	0	0.86	0.00	0
1992	1.96	5.00	0.10	0.86	3.85	0.03
1993	1.96	10.00	0.20	0.86	7.70	0.07
1994	1.96	15.00	0.29	0.86	11.55	0.10
1995	1.97	20.00	0.39	0.90	15.40	0.14
1996	1.97	25.00	0.49	0.90	19.25	0.17
1997	1.97	30.00	0.59	0.90	23.10	0.21
1998	1.97	35.00	0.69	0.90	26.95	0.24
1999	1.97	41.00	0.81	0.90	31.57	0.28
2000	1.97	50.00	0.99	0.90	38.50	0.35
2001	1.97	60.00	1.18	0.90	46.20	0.42
2002	1.97	70.00	1.38	0.90	53.90	0.49
2003	1.96	80.00	1.57	0.92	61.60	0.57
2004	1.96	90.00	1.76	0.92	69.30	0.64
2005	1.96	100.00	1.96	0.92	77.00	0.71
2006	1.96	100.00	1.96	0.92	77.00	0.71
2007	1.96	100.00	1.96	0.92	77.00	0.71
2008	1.99	100.00	1.99	0.93	77.00	0.71
2009	1.99	99.85	1.98	0.93	77.89	0.72
2010	1.99	99.71	1.98	0.93	78.78	0.73
2011	1.99	99.56	1.98	0.93	79.67	0.74
2012	1.98	99.42	1.97	0.93	80.56	0.75
2013	1.97	99.27	1.96	0.92	81.45	0.75
2014	1.97	99.12	1.95	0.92	82.34	0.76

Model Year	Rear Outboard Pass. Cars			Rear Center Passenger Cars		
	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints
2015	1.97	98.98	1.95	0.91	83.23	0.76
2016	1.97	98.83	1.95	0.91	84.14	0.77
2017	1.98	98.20	1.94	0.93	82.75	0.77
2018	1.98	97.56	1.93	0.95	81.35	0.77
2019	1.97	97.16	1.92	0.93	78.81	0.73

Table 104. FMVSS No. 202: LTV rear seat head restraints

Model Year	Rear Outboard LTVs			Rear Center LTVs		
	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints
1968	0.39	0.00	0	0.09	0.00	0
1969	0.39	0.00	0	0.09	0.00	0
1970	0.39	0.00	0	0.09	0.00	0
1971	0.39	0.00	0	0.09	0.00	0
1972	0.39	0.00	0	0.09	0.00	0
1973	0.39	0.00	0	0.09	0.00	0
1974	0.39	0.00	0	0.09	0.00	0
1975	0.39	0.00	0	0.09	0.00	0
1976	0.39	0.00	0	0.09	0.00	0
1977	0.83	0.00	0	0.14	0.00	0
1978	0.83	0.00	0	0.14	0.00	0
1979	0.83	0.00	0	0.14	0.00	0
1980	0.83	0.00	0	0.14	0.00	0
1981	0.83	0.00	0	0.14	0.00	0
1982	0.83	0.00	0	0.14	0.00	0
1983	0.83	0.00	0	0.14	0.00	0

Model Year	Rear Outboard LTVs			Rear Center LTVs		
	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints
1984	0.83	0.00	0	0.14	0.00	0
1985	0.83	0.00	0	0.14	0.00	0
1986	0.83	0.00	0	0.14	0.00	0
1987	1.31	0.00	0	0.26	0.00	0
1988	1.31	0.00	0	0.26	0.00	0
1989	1.31	0.00	0	0.26	0.00	0
1990	1.31	0.00	0	0.26	0.00	0
1991	1.31	0.00	0	0.26	0.00	0
1992	1.31	5.00	0.07	0.26	2.75	0.01
1993	1.31	10.00	0.13	0.26	5.50	0.01
1994	1.31	15.00	0.20	0.26	8.25	0.02
1995	2.21	20.00	0.44	0.70	11.00	0.08
1996	2.21	25.00	0.55	0.70	13.75	0.10
1997	2.21	30.00	0.66	0.70	16.50	0.12
1998	2.21	35.00	0.77	0.70	19.25	0.13
1999	2.21	41.00	0.91	0.70	22.55	0.16
2000	2.21	50.00	1.11	0.70	27.50	0.19
2001	2.21	60.00	1.33	0.70	33.00	0.23
2002	2.21	70.00	1.55	0.70	38.50	0.27
2003	2.32	80.00	1.86	0.94	44.00	0.41
2004	2.32	90.00	2.09	0.94	49.50	0.46
2005	2.32	100.00	2.32	0.94	55.00	0.52
2006	2.32	100.00	2.32	0.94	55.00	0.52
2007	2.32	100.00	2.32	0.94	55.00	0.52
2008	2.34	100.00	2.34	0.97	55.00	0.53
2009	2.34	99.50	2.40	0.97	55.62	0.54
2010	2.34	99.50	2.26	0.97	56.24	0.55

Model Year	Rear Outboard LTVs			Rear Center LTVs		
	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints	Number of Rear Seating Positions	Percent with Head Restraints	Number of Head Restraints
2011	2.34	99.50	2.27	0.97	56.86	0.55
2012	2.34	99.50	2.12	0.97	57.48	0.56
2013	2.35	99.50	2.20	0.97	58.10	0.56
2014	2.36	99.50	2.27	0.97	58.72	0.57
2015	2.37	99.50	2.35	0.96	59.34	0.57
2016	2.39	99.54	2.38	0.96	59.89	0.57
2017	2.43	99.61	2.42	0.99	66.91	0.66
2018	2.47	99.68	2.46	1.02	73.92	0.75
2019	2.43	99.29	2.41	1.04	81.21	0.84

LTV Front Seat

Head restraints have been required since September 1, 1991, (MY1992) in pickup trucks, vans, and SUVs with a GVWR of 10,000 lb or less. Nevertheless, head restraints or other devices capable of meeting FMVSS No. 202 (e.g., high-backed captain's chairs) were already installed in some vans, SUVs, and pickup trucks well before 1992, even before the rulemaking process that extended the standard to LTVs. See Table 101 for the estimated percent of LTVs with head restraints in the front outboard seat by MY.

Table 105 shows the average percentage of nonadjustable and adjustable LTV head restraints by MY. In a sample of MY 1998 LTVs representing 72 percent of LTV sales, a sales weighted distribution found 80 percent nonadjustable and 20 percent adjustable. These percentages changed dramatically. An examination of Cars.com weighted by sales found that 78.38 percent of MY 2005 and 94.04 percent of MY 2010 LTVs had adjustable head restraints. An examination of Edmunds.com found every MYs 2016, 2018, and 2019 LTV had adjustable head restraints in the front outboard seats.

Table 105. FMVSS No. 202: Average percentage of nonadjustable/adjustable head restraints in LTVs front outboard seats by model year

Model Year	% Nonadjustable	% Adjustable
1968-1997	55	45
1998-2002	80	20
2003-2007	21.62	78.38
2008-2012	5.96	94.04
2013	4.5	95.5
2014	3.0	97.0
2015	1.5	98.5
2016-2019	0	100

A study of nine LTV head restraints was conducted to determine the weight and consumer cost of the head restraint systems in 1992 to 1994 make-model LTVs and vans (Fladmark & Khadilkar, 1994). Four of the head restraints were nonadjustable while five were adjustable. Table 106 shows the basic data from the cost teardown contract. As discussed earlier, we took the cost per inch and weight per inch from these MYs 1992 to 1994 LTVs and applied them to both passenger cars and LTVs.

Table 101 shows the number of front outboard LTV head restraints and Table 114 shows the resulting weights and costs by voluntary and attributable by model year for front seat outboard LTV head restraints.

Table 106. FMVSS No. 202: Average weight and consumer cost per head restraint in LTVs front outboard seat (original standard for LTVs [MYs 1992 to 94] was not used in this analysis)

Category	Weight (lb)	Consumer Cost ($2019)
Nonadjustable	3.72	$20.71
Adjustable	4.69	$22.47

LTV Front Seat – Upgrade

As discussed in the Passenger Car Front Seat – Upgrade section we used the LTV head restraint cost tear-down study to estimate that increasing the height of the average head restraint added $2.29 (2019 dollars) per inch. Similarly, increasing the average height of a head restraint increased the average weight of an integral seat by 0.38 lb per inch and the average adjustable head restraints by 0.68 lb per inch.

There was also a cost to add a locking mechanism to those adjustable head restraints that didn’t have a locking mechanism. These are simple devices for height adjustment that were estimated to cost $0.22 per head restraint. Based on the survey of 14 MY 1999 vehicles, half of the adjustable head restraints had locking mechanisms. This would be voluntary compliance. We added $0.11 per adjustable head restraint for MY 1999 and later to the voluntary costs of head restraints to account for the 50 percent voluntary compliance and another $0.11 per adjustable head restraint as attributable costs starting in MY 2008. These cost estimates are included in Table 114 for the front outboard seats of LTVs.

LTV Front Center Seat

In MYs 2004 and 2005 the Toyota Tundra were the first LTVs that supplied a head restraint in the front center seat. These were small adjustable head restraints. Since 2004 these Toyotas with front center seat head restraints made up a small percentage of the LTV fleet (0.3 to 0.8%). In MY 2016, Ford introduced a head restraint in the front center seat of the Ford F-150 and Ford Super Duty pickup trucks for those vehicles with regular cabs (regular cabs have no rear seat). These Ford pickups have a tall adjustable head restraint. In MY 2019, Ram pickup trucks with regular cabs introduced a small adjustable head restraint. Assuming the same weight and cost for a rear center seat head restraint for the center front seat head restraint results in the estimated weight and cost shown in Table 107. The average weight and cost consider that only 0.99 percent (see Table 102) of all LTVs had a head restraint in the front center seat in MY 2019.

Table 107. FMVSS No. 202: Average weight and consumer cost for head restraints in LTVs front center seat – MY 2019

Category	Weight (lb)	No Learning Consumer Cost ($2019)	After Learning Consumer Cost ($2019)
Per Adjustable Tall Head Restraint	5.50	$31.13	$24.64
Per Adjustable Small Head Restraint	3.32	$23.80	$18.84
Weighted Average	4.36	$27.28	$21.59
Average for the LTV fleet	0.04	$0.27	$0.21

LTV Rear Seat

Head restraints have never been required in the rear seat of LTVs. Some were voluntarily supplied as integral restraints in captain's chairs (which may be optional equipment) or as adjustable head restraints starting around MY 1992. In the Final Regulatory Impact Analysis,[26] 41 percent of the MY 1999 vehicles were estimated to have rear outboard head restraints. This estimate was for both passenger cars and LTVs and will be applied to both. The agency has not

[26] NHTSA. (2004, November). *Final Regulatory Impact Analysis, FMVSS No. 202 Head Restraints for Passenger Vehicles.* Docket No. 2004-19807-0001.

attempted to assemble an estimate of the percent of the fleet with rear head restraints that were voluntarily supplied in LTVs by MY except for MY 2005, the data collected for MYs 2009 to 2012, 2016, 2018 and 2019. For this analysis we are assuming a gradual build-up of rear outboard head restraints starting at 5 percent in 1992 and increasing 5 percentage points per year to 41 percent for MY 1999 and then increasing more quickly to the 100 percent of those vehicles with an outboard seating position found for MY 2005 (see Table 104). This percentage declined slightly to 99.29 percent in MY 2019 as a few new models were introduced that had outboard rear seats which did not have head restraints. The percent of LTVs with center rear head restraints was estimated to be 55 percent of LTV rear outboard head restraints (based on the percentage found in MY 2010 LTVs) until MY 2009, when data from cars.com and Edmunds.com were used to estimate the percent of LTVs with center rear head restraints (see Table 104).

Based on the MY 2005 examination of Cars.com and weighting that data by MY 2005 Polk data (n.d.) , we estimated 11.64 percent of the LTV rear seat head restraints were nonadjustable and 88.36 percent were adjustable. Based on the MY 2010 examination of Cars.com and weighting that data by MY 2010 Polk data, we estimate that 17.71 percent of the LTV rear seat head restraints were nonadjustable, and 82.29 percent were adjustable. Based on an examination of MY 2016 and MY 2018 LTVs using Edmunds.com, all LTVs with a rear seat head restraint had adjustable head restraints and we assumed a linear increase in adjustable head restraints from MY 2010 to 2016. In MY 2019, it appeared that some make/models had a high enough rear seat back to be considered a non-adjustable head restraint. Table 108 shows our estimated distribution of nonadjustable and adjustable head restraints in the rear seat of LTVs by seating position and MY.

Table 108. FMVSS No. 202: Average distribution of percentages of nonadjustable/adjustable head restraints in the rear seat of LTVs from 1992 to 2019

Model Year	**Rear Outboard**		**Rear Center**	
	% Nonadj.	**% Adj.**	**% Nonadj.**	**% Adj.**
1992-2005	11.64	88.36	11.64	88.36
2006	12.87	87.13	12.87	87.13
2007	14.08	85.92	14.08	85.92
2008	15.29	84.71	15.29	84.71
2009	16.50	83.50	16.50	83.50
2010	17.71	82.29	17.71	82.29
2011	14.76	85.24	14.76	85.24
2012	11.81	88.19	11.81	88.19
2013	8.86	91.14	8.86	91.14
2014	5.91	94.09	5.91	94.09
2015	2.96	97.04	2.96	97.04

Model Year	Rear Outboard		Rear Center	
	% Nonadj.	% Adj.	% Nonadj.	% Adj.
2016	0	100	0	100
2017	0	100	0	100
2018	0	100	0	100
2019	5.89	94.11	10.93	89.07

Table 109 shows our estimates of the percentages of LTV rear seat head restraints that are tall or small for MYs 2009 to 2019. We assumed that all LTV rear seat head restraints were small from MYs 1992 to 2002, from this point we assume a linear increase in the percentage of tall head restraints until our known estimate in MY 2009.

Table 109. FMVSS No. 202: LTV rear seat head restraints – small versus tall

Model Year	Rear Outboard		Rear Center	
	% Small	% Tall	% Small	% Tall
1992-2002	100	0	100	0
2003	90.1	9.9	93.9	6.1
2004	80.1	19.9	87.8	12.2
2005	70.2	29.8	81.7	18.3
2006	60.3	39.7	75.6	24.4
2007	50.4	49.6	69.5	30.5
2008	40.4	59.6	63.4	36.6
2009	30.5	69.5	57.3	42.7
2010	20.5	79.5	55.1	44.9
2011	10.6	89.4	49.3	50.7
2012	0.2	99.8	61.8	38.2
2013	0.2	99.8	69.1	30.9
2014	0.1	99.9	76.4	23.6
2015	0.1	99.9	83.7	16.3
2016	0.0	100.0	91.5	8.5
2017	0.0	100.0	93.2	6.8
2018	0.0	100.0	94.8	5.2
2019	1.1	98.9	92.8	7.2

We have split the rear head restraints into outboard seats and center seats, adjustable and nonadjustable, and small and tall head restraints. Table 110 shows the distribution of small and tall and adjustable and non-adjustable head restraints for LTVs for MY 2019. The rear seating positions include the second, third, fourth, and fifth rows of seats. Note that except for the front outboard seats, the total number of head restraints do not equal the average number of seat positions, since head restraints are only required at the front outboard seating positions.

Table 110. FMVSS No. 202: Distribution of small and tall and adjustable/non-adjustable head restraints for LTVs – MY 2019

	Average Number of Seating Positions	**Number of Head Restraints per Vehicle**			
		Adjustable	**Adjustable**	**Non-Adj.**	**Non-Adj.**
		Tall	**Small**	**Tall**	**Small**
Front Outboard	2	2.000	0.000	0.000	0.000
Front Center	0.115	0.005	0.005	0.000	0.000
Second, Third, Fourth, Fifth Outboard	2.431	2.255	0.017	0.134	0.009
Second, Third, Fourth, Fifth Center	1.037	0.061	0.689	0.000	0.092
		Tall	Small		
Rear seat outboard		98.95%	1.05%		
Rear seat center		7.24%	92.76%		

We provide two examples of cost calculations for MY 2019 to help the reader understand our methodology – passenger car front-outboard costs (Table 111) and LTV rear center seat costs (Table 117).

Passenger car front outboard seat head restraint costs are shown in Table 111 for MY 2019 as $6.09 for voluntary and $42.89 for attributable for a total of $48.98. How do we get those cost estimates? For adjustable head restraints we start with $21.75 for the original standard from Table 95, this is adjusted for an increase in height from 25.5 inches to 29.5 inches (4 inches x $2.29 per inch = $9.16. $21.75 + $9.16 = $30.91. Locking mechanisms add $0.22 for a total of $31.13 for adjustable head restraints. For nonadjustable head restraints we start with $19.11 for the original standard from Table 95, this is adjusted for an increase in height from 27.5 inches to 29.5 inches (2 inches x $2.29 per inch = $4.58. $19.11 + $4.58 = $23.69). These cost estimates are weighted by percent adjustable ($30.91 * 0.9741) and percent non-adjustable ($23.69 *

0.251) to get an average cost of $30.94, which is multiplied by a learning curve function of .7914 to get a learned cost of $24.49 * 2 head restraints per vehicle = $48.98. Voluntary costs are 12 percent from MY 1968 in Table 101, plus $0.11*2 seats = $0.22 for locking mechanisms in MY 2019 ($48.98 * 0.12 + $0.22 = $6.09; attributable costs are the remainder ($48.98 - $6.09 = $42.89).

LTV rear center head restraint costs are shown in Table 117 for MY 2019 as $15.61. All rear seat head restraints are considered voluntary. How do we get those cost estimates? We have small and tall adjustable head restraints to consider. There are no non-adjustable head restraints in the rear center seats head restraints. For small adjustable head restraints we start with $21.38 for the original standard from Table 95. This is adjusted for an increase in height from 25.5 inches to 26.3 inches (0.8 inches x $2.25 per inch = $1.80. $21.38 + $1.80 = $23.18). Added to this is a locking mechanism cost of $0.22 = $23.40. For tall adjustable head restraints we start with $21.38. This is adjusted for an increase in height from 25.5 inches to 29.5 inches (4 inches x $2.25 per inch = $9.00. $21.38 + $9.00 = $30.38). Added to this is a locking mechanism cost of $0.22 = $30.60. These cost estimates are weighted for the rear center seat of LTVs from Table 99 by 95.4 percent small ($23.40 * 0.954) and 4.6 percent tall ($30.60 * 0.046) to get an average cost of $23.73, which is multiplied by a learning curve function of .8038 to get a learned cost of $19.08 * .729 head restraints per vehicle = $13.90.

Table 111 to Table 117 show the estimated passenger car and LTV head restraint weight and cost results combining the original standard, the upgraded standard, voluntary, and attributable compliance.

In recent years, a limited number of models with dynamic or active head restraints (that move closer to the head when a crash occurs) were certified as complying with FMVSS No. 202 starting in MY 2012, and electric or power head restraints (that automatically move closer to the head after starting the vehicle) were certified as complying, starting in MY 2010. NHTSA has done no cost teardown studies of these newer systems and has not included whatever their increase in costs might be in this analysis.

Table 111. FMVSS No. 202: Head restraints front seat outboard – passenger cars

Model Year	**Weight (lb)**			**Consumer Cost (2019$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	1.04	0.00	1.04	$6.31	$0.00	$6.31
1969	1.02	7.48	8.50	$6.24	$45.78	$52.02
1970	0.99	7.24	8.22	$6.12	$44.88	$51.00
1971	0.95	7.00	7.95	$6.00	$43.99	$49.99
1972	0.92	6.75	7.67	$5.88	$43.10	$48.97
1973	0.89	6.51	7.40	$5.75	$42.20	$47.96
1974	0.86	6.27	7.13	$5.63	$41.31	$46.94
1975	0.82	6.03	6.85	$5.51	$40.41	$45.93

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1976	0.79	5.79	6.58	$5.39	$39.52	$44.91
1977	0.76	5.55	6.30	$5.27	$38.63	$43.89
1978	0.72	5.30	6.03	$5.15	$37.73	$42.88
1979	0.69	5.06	5.75	$5.02	$36.84	$41.86
1980	0.69	5.06	5.75	$5.02	$36.84	$41.86
1981	0.69	5.06	5.75	$5.02	$36.84	$41.86
1982	0.70	5.12	5.82	$5.17	$37.91	$43.08
1983	0.72	5.28	6.00	$5.19	$38.09	$43.28
1984	0.74	5.44	6.18	$5.21	$38.23	$43.44
1985	0.76	5.60	6.37	$5.23	$38.35	$43.59
1986	0.79	5.76	6.55	$5.25	$38.48	$43.73
1987	0.81	5.92	6.73	$5.27	$38.65	$43.92
1988	0.83	6.08	6.91	$5.30	$38.84	$44.13
1989	0.85	6.24	7.09	$5.33	$39.06	$44.38
1990	0.87	6.40	7.27	$5.36	$39.29	$44.64
1991	0.89	6.56	7.45	$5.39	$39.55	$44.95
1992	0.92	6.72	7.64	$5.43	$39.79	$45.22
1993	0.94	6.88	7.82	$5.46	$40.01	$45.47
1994	0.96	7.04	8.00	$5.49	$40.23	$45.71
1995	0.98	7.20	8.18	$5.52	$40.45	$45.97
1996	1.00	7.36	8.36	$5.55	$40.68	$46.22
1997	1.03	7.52	8.54	$5.58	$40.91	$46.49
1998	1.06	7.80	8.86	$5.70	$41.79	$47.49
1999	1.09	7.97	9.06	$5.97	$41.96	$47.93
2000	1.09	7.97	9.06	$5.94	$41.70	$47.64
2001	1.09	7.97	9.06	$5.90	$41.46	$47.36
2002	1.09	7.97	9.06	$5.87	$41.23	$47.10
2003	1.10	8.08	9.18	$5.92	$41.56	$47.48
2004	1.10	8.08	9.18	$5.89	$41.35	$47.23

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2005	1.10	8.08	9.18	$5.86	$41.14	$47.00
2006	1.10	8.08	9.18	$5.83	$40.94	$46.78
2007	1.10	8.08	9.18	$5.81	$40.75	$46.56
2008	1.10	8.10	9.21	$5.82	$40.84	$46.66
2009	1.10	8.10	9.21	$5.80	$40.73	$46.53
2010	1.32	9.65	10.97	$6.38	$44.93	$51.31
2011	1.32	9.65	10.97	$6.36	$44.77	$51.13
2012	1.32	9.65	10.97	$6.33	$44.60	$50.93
2013	1.30	9.56	10.87	$6.25	$44.06	$50.31
2014	1.30	9.56	10.87	$6.22	$43.88	$50.10
2015	1.30	9.56	10.87	$6.20	$43.69	$49.89
2016	1.30	9.56	10.87	$6.17	$43.53	$49.71
2017	1.31	9.59	10.90	$6.17	$43.51	$49.68
2018	1.31	9.62	10.93	$6.17	$43.49	$49.66
2019	1.31	9.61	10.92	$6.14	$43.28	$49.43

Table 112. FMVSS No. 202: Head restraints rear outboard seats – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1991	0.00	0.00	0.00	$0.00	$0.00	$0.00
1992	0.25	0.00	0.25	$1.67	$0.00	$1.67
1993	0.51	0.00	0.51	$3.31	$0.00	$3.31
1994	0.76	0.00	0.76	$4.94	$0.00	$4.94
1995	1.02	0.00	1.02	$6.57	$0.00	$6.57
1996	1.28	0.00	1.28	$8.16	$0.00	$8.16
1997	1.53	0.00	1.53	$9.73	$0.00	$9.73
1998	1.79	0.00	1.79	$11.29	$0.00	$11.29
1999	2.20	0.00	2.20	$13.35	$0.00	$13.35
2000	2.68	0.00	2.68	$16.17	$0.00	$16.17

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2001	3.22	0.00	3.22	$19.30	$0.00	$19.30
2002	3.75	0.00	3.75	$22.39	$0.00	$22.39
2003	4.27	0.00	4.27	$25.32	$0.00	$25.32
2004	4.93	0.00	4.93	$29.55	$0.00	$29.55
2005	5.48	0.00	5.48	$32.67	$0.00	$32.67
2006	5.51	0.00	5.51	$32.98	$0.00	$32.98
2007	5.53	0.00	5.53	$33.29	$0.00	$33.29
2008	5.63	0.00	5.63	$34.19	$0.00	$34.19
2009	5.65	0.00	5.65	$34.52	$0.00	$34.52
2010	9.00	0.00	9.00	$44.75	$0.00	$44.75
2011	9.81	0.00	9.81	$47.11	$0.00	$47.11
2012	10.37	0.00	10.37	$48.59	$0.00	$48.59
2013	10.34	0.00	10.34	$48.21	$0.00	$48.21
2014	10.37	0.00	10.37	$48.15	$0.00	$48.15
2015	10.40	0.00	10.40	$48.08	$0.00	$48.08
2016	10.45	0.00	10.45	$48.11	$0.00	$48.11
2017	10.43	0.00	10.43	$47.80	$0.00	$47.80
2018	10.41	0.00	10.41	$47.50	$0.00	$47.50
2019	10.32	0.00	10.32	$46.87	$0.00	$46.87

Table 113. FMVSS No. 202: Head restraints rear center seats – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1991	0.00	0.00	0.00	$0.00	$0.00	$0.00
1992	0.09	0.00	0.09	$0.56	$0.00	$0.56
1993	0.17	0.00	0.17	$1.12	$0.00	$1.12
1994	0.26	0.00	0.26	$1.66	$0.00	$1.66
1995	0.36	0.00	0.36	$2.31	$0.00	$2.31
1996	0.45	0.00	0.45	$2.87	$0.00	$2.87

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1997	0.54	0.00	0.54	$3.42	$0.00	$3.42
1998	0.63	0.00	0.63	$3.97	$0.00	$3.97
1999	0.77	0.00	0.77	$4.69	$0.00	$4.69
2000	0.94	0.00	0.94	$5.69	$0.00	$5.69
2001	1.13	0.00	1.13	$6.79	$0.00	$6.79
2002	1.32	0.00	1.32	$7.88	$0.00	$7.88
2003	1.54	0.00	1.54	$9.15	$0.00	$9.15
2004	1.78	0.00	1.78	$10.68	$0.00	$10.68
2005	1.98	0.00	1.98	$11.81	$0.00	$11.81
2006	1.99	0.00	1.99	$11.92	$0.00	$11.92
2007	2.00	0.00	2.00	$12.03	$0.00	$12.03
2008	2.02	0.00	2.02	$12.29	$0.00	$12.29
2009	2.06	0.00	2.06	$12.57	$0.00	$12.57
2010	2.96	0.00	2.96	$15.41	$0.00	$15.41
2011	2.90	0.00	2.90	$15.32	$0.00	$15.32
2012	3.07	0.00	3.07	$15.89	$0.00	$15.89
2013	3.06	0.00	3.06	$15.92	$0.00	$15.92
2014	3.06	0.00	3.06	$15.95	$0.00	$15.95
2015	3.05	0.00	3.05	$15.97	$0.00	$15.97
2016	3.05	0.00	3.05	$16.06	$0.00	$16.06
2017	3.12	0.00	3.12	$16.16	$0.00	$16.16
2018	3.18	0.00	3.18	$16.25	$0.00	$16.25
2019	2.96	0.00	2.96	$14.95	$0.00	$14.95

Table 114. FMVSS No. 202: Head restraints front seat outboard – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.81	0.00	0.81	$4.95	$0.00	$4.95
1969	0.80	0.00	0.80	$4.88	$0.00	$4.88
1970	0.78	0.00	0.78	$4.81	$0.00	$4.81
1971	0.76	0.00	0.76	$4.75	$0.00	$4.75
1972	0.74	0.00	0.74	$4.68	$0.00	$4.68
1973	0.72	0.00	0.72	$4.61	$0.00	$4.61
1974	1.64	0.00	1.64	$10.57	$0.00	$10.57
1975	1.59	0.00	1.59	$10.41	$0.00	$10.41
1976	1.55	0.00	1.55	$10.25	$0.00	$10.25
1977	1.51	0.00	1.51	$10.09	$0.00	$10.09
1978	1.46	0.00	1.46	$9.93	$0.00	$9.93
1979	1.42	0.00	1.42	$9.77	$0.00	$9.77
1980	1.42	0.00	1.42	$9.77	$0.00	$9.77
1981	1.42	0.00	1.42	$9.77	$0.00	$9.77
1982	1.45	0.00	1.45	$9.79	$0.00	$9.79
1983	2.49	0.00	2.49	$16.59	$0.00	$16.59
1984	2.94	0.00	2.94	$19.21	$0.00	$19.21
1985	3.41	0.00	3.41	$21.85	$0.00	$21.85
1986	3.56	0.00	3.56	$22.44	$0.00	$22.44
1987	4.21	0.00	4.21	$26.11	$0.00	$26.11
1988	4.05	0.00	4.05	$24.75	$0.00	$24.75
1989	3.94	0.00	3.94	$23.71	$0.00	$23.71
1990	4.00	0.77	4.77	$23.76	$4.59	$28.35
1991	4.06	0.86	4.92	$23.83	$5.04	$28.88
1992	4.13	2.96	7.09	$23.89	$17.16	$41.05
1993	4.19	3.01	7.20	$23.95	$17.20	$41.14
1994	4.25	3.05	7.31	$23.99	$17.23	$41.22
1995	4.31	3.10	7.41	$24.05	$17.27	$41.32

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	4.38	3.14	7.52	$24.10	$17.31	$41.41
1997	4.44	3.19	7.63	$24.17	$17.36	$41.52
1998	4.16	2.99	7.15	$22.45	$16.13	$38.58
1999	4.20	3.02	7.22	$22.52	$16.10	$38.62
2000	4.20	3.02	7.22	$22.38	$16.00	$38.38
2001	4.20	3.02	7.22	$22.25	$15.91	$38.16
2002	4.20	3.02	7.22	$22.12	$15.82	$37.95
2003	5.06	3.63	8.69	$26.38	$18.65	$45.03
2004	5.06	3.63	8.69	$26.24	$18.56	$44.80
2005	5.06	3.63	8.69	$26.11	$18.46	$44.58
2006	5.06	3.63	8.69	$25.99	$18.37	$44.36
2007	5.06	3.63	8.69	$25.87	$18.29	$44.16
2008	5.29	3.80	9.08	$27.01	$19.04	$46.04
2009	5.29	3.80	9.08	$26.94	$18.99	$45.92
2010	6.29	4.52	10.80	$29.71	$20.98	$50.70
2011	6.29	4.52	10.80	$29.61	$20.91	$50.52
2012	6.29	4.52	10.80	$29.50	$20.83	$50.33
2013	6.32	4.54	10.85	$29.49	$20.82	$50.30
2014	6.34	4.56	10.90	$29.47	$20.81	$50.28
2015	6.37	4.58	10.95	$29.46	$20.78	$50.25
2016	6.40	4.60	11.00	$29.46	$20.78	$50.24
2017	6.40	4.60	11.00	$29.35	$20.71	$50.06
2018	6.40	4.60	11.00	$29.25	$20.63	$49.89
2019	6.40	4.60	11.00	$29.16	$20.56	$49.72

Table 115. FMVSS No. 202: Head restraints front center seat – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2003	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.00	0.01	0.07	0.00	0.07
2005	0.01	0.00	0.01	0.09	0.00	0.09
2006	0.02	0.00	0.02	0.10	0.00	0.10
2007	0.02	0.00	0.02	0.14	0.00	0.14
2008	0.02	0.00	0.02	0.11	0.00	0.11
2009	0.02	0.00	0.02	0.11	0.00	0.11
2010	0.02	0.00	0.02	0.11	0.00	0.11
2011	0.01	0.00	0.01	0.08	0.00	0.08
2012	0.01	0.00	0.01	0.09	0.00	0.09
2013	0.02	0.00	0.02	0.09	0.00	0.09
2014	0.01	0.00	0.01	0.09	0.00	0.09
2015	0.01	0.00	0.01	0.06	0.00	0.06
2016	0.07	0.00	0.07	0.34	0.00	0.34
2017	0.07	0.00	0.07	0.31	0.00	0.31
2018	0.06	0.00	0.06	0.28	0.00	0.28
2019	0.04	0.00	0.04	0.22	0.00	0.22

Table 116. FMVSS No. 202: Head restraints rear seat outboard – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1991	0.00	0.00	0.00	$0.00	$0.00	$0.00
1992	0.18	0.00	0.18	$1.25	$0.00	$1.25
1993	0.36	0.00	0.36	$2.48	$0.00	$2.48
1994	0.54	0.00	0.54	$3.69	$0.00	$3.69
1995	1.21	0.00	1.21	$8.25	$0.00	$8.25
1996	1.51	0.00	1.51	$10.24	$0.00	$10.24
1997	1.81	0.00	1.81	$12.22	$0.00	$12.22

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1998	2.11	0.00	2.11	$14.17	$0.00	$14.17
1999	2.64	0.00	2.64	$16.75	$0.00	$16.75
2000	3.22	0.00	3.22	$20.30	$0.00	$20.30
2001	3.86	0.00	3.86	$24.22	$0.00	$24.22
2002	4.51	0.00	4.51	$28.10	$0.00	$28.10
2003	5.41	0.00	5.41	$33.55	$0.00	$33.55
2004	6.02	0.00	6.02	$38.23	$0.00	$38.23
2005	6.69	0.00	6.69	$42.27	$0.00	$42.27
2006	6.68	0.00	6.68	$41.93	$0.00	$41.93
2007	6.67	0.00	6.67	$41.59	$0.00	$41.59
2008	6.71	0.00	6.71	$41.75	$0.00	$41.75
2009	6.89	0.00	6.89	$42.62	$0.00	$42.62
2010	10.83	0.00	10.83	$52.79	$0.00	$52.79
2011	11.45	0.00	11.45	$54.71	$0.00	$54.71
2012	11.24	0.00	11.24	$52.56	$0.00	$52.56
2013	11.75	0.00	11.75	$54.63	$0.00	$54.63
2014	12.27	0.00	12.27	$56.70	$0.00	$56.70
2015	12.79	0.00	12.79	$58.77	$0.00	$58.77
2016	13.07	0.00	13.07	$59.69	$0.00	$59.69
2017	13.30	0.00	13.30	$60.52	$0.00	$60.52
2018	13.53	0.00	13.53	$61.36	$0.00	$61.36
2019	12.97	0.00	12.97	$59.02	$0.00	$59.02

Table 117. FMVSS No. 202: Head restraints rear seat center – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1991	0.00	0.00	0.00	$0.00	$0.00	$0.00
1992	0.02	0.00	0.02	$0.14	$0.00	$0.14
1993	0.04	0.00	0.04	$0.27	$0.00	$0.27
1994	0.06	0.00	0.06	$0.40	$0.00	$0.40
1995	0.21	0.00	0.21	$1.43	$0.00	$1.43
1996	0.26	0.00	0.26	$1.78	$0.00	$1.78
1997	0.31	0.00	0.31	$2.12	$0.00	$2.12
1998	0.37	0.00	0.37	$2.46	$0.00	$2.46
1999	0.46	0.00	0.46	$2.91	$0.00	$2.91
2000	0.56	0.00	0.56	$3.52	$0.00	$3.52
2001	0.67	0.00	0.67	$4.20	$0.00	$4.20
2002	0.78	0.00	0.78	$4.87	$0.00	$4.87
2003	1.20	0.00	1.20	$7.45	$0.00	$7.45
2004	1.34	0.00	1.34	$8.49	$0.00	$8.49
2005	1.49	0.00	1.49	$9.39	$0.00	$9.39
2006	1.48	0.00	1.48	$9.31	$0.00	$9.31
2007	1.48	0.00	1.48	$9.24	$0.00	$9.24
2008	1.54	0.00	1.54	$9.55	$0.00	$9.55
2009	1.55	0.00	1.55	$9.60	$0.00	$9.60
2010	2.24	0.00	2.24	$11.64	$0.00	$11.64
2011	2.35	0.00	2.35	$12.01	$0.00	$12.01
2012	2.25	0.00	2.25	$11.78	$0.00	$11.78
2013	2.20	0.00	2.20	$11.67	$0.00	$11.67
2014	2.14	0.00	2.14	$11.56	$0.00	$11.56
2015	2.09	0.00	2.09	$11.45	$0.00	$11.45
2016	2.02	0.00	2.02	$11.32	$0.00	$11.32
2017	2.30	0.00	2.30	$12.92	$0.00	$12.92
2018	2.58	0.00	2.58	$14.57	$0.00	$14.57
2019	2.86	0.00	2.86	$15.82	$0.00	$15.82

FMVSS No. 203, Impact protection for the driver from the steering control system

FMVSS No. 204, Steering control rearward displacement

Every passenger car and LTV in MY 1965 had a rigid steering column. This type of rigid column is considered Safety1965, even though the rigid steering column had no safety benefit. Incremental weights and costs are compared to a rigid steering column.

Passenger Car Studies

FMVSS No. 203/204 became effective on January 1, 1968, (passenger cars) and September 1, 1981, (MPVs, trucks, and buses). FMVSS No. 203 specifies requirements for steering control systems that yield forward, cushioning the impact of the driver's chest by absorbing much of his or her impact energy in front-end crashes. FMVSS No. 204 specifies requirements limiting the rearward displacement of the steering column into the passenger compartment. The purpose of these standards is to provide basic occupant protection for the driver in a frontal crash and minimize chest, neck, head, or facial injuries from an impact. This standard applies to passenger cars, MPVs, trucks, (all LTVs), and buses with a GVWR of 10,000 lb or less. Since the changes made to steering columns typically satisfied both standards, this analysis is combined into one section.

The final rule for passenger cars was published in the Federal Register on February 3, 1967, (32 FR 2414). The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212), making the baseline date September 1, 1966, or MY 1967. An estimated 63.37 percent of passenger cars had energy absorbing steering columns in MY 1967, and that level will be considered voluntary through MY 2019. Attributable costs will be the difference between the installation rate for MY 1968 at 100 percent and the voluntary baseline level of MY 1967, or 36.63 percent.

The requirements of FMVSS Nos. 203 and 204 address the hazards of a steering column in two different ways. FMVSS No. 203 requires that the impact force developed on the chest not to exceed a safe level of 2,500 lb from the steering column during an impact of 15 mph. This is accomplished by designing the column to collapse at a controlled rate upon impact. FMVSS No. 204 specifies a limit of 5 inches horizontal steering column intrusion toward the driver during a head-on crash into a fixed barrier at 30 mph. Essentially, FMVSS No. 203 addresses the driver impacting the steering wheel/column and FMVSS No. 204 is concerned with the steering column being driven into the interior as the front of the vehicle is crushed during a crash. A collapsible steering column typically satisfied both requirements. It should be noted that FMVSS No. 203 does not apply as a separate requirement to vehicles that conform to the barrier crash standards of FMVSS No. 208 by means of air bags. FMVSS No. 203 extends past the weight class covered by FMVSS No. 208. FMVSS No. 203 goes to 10,000 lb GVWR and the air bag requirement in FMVSS No. 208 goes to 5,500 lb unloaded and 8,500 lb GVWR. Nevertheless, today's vehicles with air bags still have collapsible steering columns since this device is an important component of the crush space and ride-down in the safety system that makes air bags effective.

Manufacturers replaced the rigid steering columns with different collapsible designs. American Motors, Chrysler, and GM had installed steering columns with the energy absorbing features on their 1967 models; whereas Ford, Toyota, VW, and, probably other foreign-based manufacturers introduced them in 1968. Three main components were modified to create a collapsible column: the outer jacket tube, the shift tube, and the steering shaft. The outer jacket is the visible external tube mounted to the firewall and instrument panel that contains the shift tube, the steering shaft, a wiring harness, and any internal energy absorbing components. The shift tube transfers the rotational input from the column mounted shift lever to the bottom of the steering column where linkage from the transmission is connected. The shift tube is oriented concentrically inside the outer jacket tube. The steering shaft transfers the rotational input from the steering wheel to the bottom of the steering column where it connects with the steering gearbox or an intermediate shaft. The steering shaft typically passes through the center of the column.

The outer jackets were weakened by cutting longitudinal slots in them (Ford), or by replacing a lower part of the jacket with a tube-shaped, basket-weave section of metal mesh (GM, Chrysler, AMC, VW, and Toyota). Later in 1969, AMC and GM started using an outer jacket composed of two concentric tubes, with the lower tube of a smaller diameter like a telescope. Between the outer diameter of the smaller tube and the inner diameter of the larger tube was a bearing sleeve that contained small hardened steel balls. During an impact, this outer jacket would collapse and absorb energy at a controlled rate as the steel balls cut grooves into the tubes. Chrysler maintained the basket-weave mesh design until the mid-1970s when they started placing a tapered collar/mandrel at the base of the outer jacket. As the column was loaded, the outer jacket would peel apart as it was pressed against the outer diameter of the collar and collapse at a controlled rate. Chrysler also introduced a wheel canister absorption device starting with the 1970 Dodge Challenger and Plymouth Barracuda in place of the energy-absorbing column. Volvo has also used wheel canisters. In 1973, Ford started installing an internally grooved column that uses friction between the column tubes to absorb energy.

The shift tube and the steering shaft were redesigned to collapse under impact. The shift tubes were designed to telescopically collapse with the outer jacket. The steering shaft was changed from a single rigid shaft to a two- or three-piece shaft. The lower section on the two-piece shaft and the middle section on the three-piece shaft were hollow to allow the upper shaft to collapse into it.

One modification that could be attributed to FMVSS No. 204 was the change to the steering gearbox’s intermediate shafts from a rigid to a collapsible design. These intermediate shafts span the distance from the lower end of the steering shaft to the steering gearbox mounted on the front sub-frame. Initially, a coaxial design where a smaller shaft slides into a larger hollow shaft was used to create a collapsible intermediate shaft. With the advent of rack and pinion steering, when the intermediate shaft usually became too short and too vertical to accommodate the coaxial design, two or more universal joints were used on the intermediate shaft to allow it to fold upon impact. The manufacturers of the vehicles studied made no major front structural changes to comply with FMVSS No. 204.

The shear capsule, which is a bracket designed to prevent rearward movement of the column but to allow forward movement, is a vital partner to the steering column energy-absorbing device. When the lower part of the column is forced backward due to vehicle damage, the shear capsule holds the upper column in place while the column EAD collapses. On the other hand, when the driver contacts the steering wheel, the shear capsule freely allows the upper part of the column to move forward while the EAD collapses (Kahane, 1981).

The steering assemblies and front structures of 1969 to 1976 post-standard passenger cars and their corresponding 1966 pre-standard make-models were examined to determine the weight and consumer cost of equipment changes in response to FMVSS Nos. 203/204 (McLean et al., 1980).[27] Examination of the front structures indicated that the post-standard structures and their pre-standard counterparts were identical; no structural changes were made in response to the standard. Therefore, the weight and consumer cost estimates were based on the steering column assemblies. Three of the make-model passenger cars in the study (Rambler American, VW Beetle, and Toyota Corona) were not included in these estimates because there were no corresponding pre-standard models by the same manufacturers, so the weight and consumer cost added by the standard could not be accurately estimated. Furthermore, the steering column assembly of the 1968 VW Beetle used a simple mesh design that was soon modified and not a typical mesh-type column.

The cost analysis is subdivided into two sections:

- the steering assembly within the passenger compartment, and
- the steering assembly within the engine compartment.

The best estimate of the weight and consumer cost changes within the passenger compartment are obtained by subtracting the weight and consumer cost of the corresponding pre-standard steering column assembly from the weight and consumer cost of the post-standard steering column assembly. This cost analysis is based on six make-models where teardowns were performed on the 1969 and 1966 steering assemblies. The average incremental weight and consumer cost attributed to within the passenger compartment is 1.89 lb and $31.20 in 2019 dollars.

Within the engine compartment, an intermediate shaft is used between the steering column assembly and the steering gearbox in some cars with a forward-mounted steering gearbox. The engine compartment telescoping device, which was installed for the purpose of complying with FMVSS No. 204, was sometimes located on the intermediate shaft. Telescoping post-standard and rigid pre-standard intermediate shafts were examined. The post-standard shaft was found to cost $11.50 more in 2019 dollars and weigh about the same as the pre-standard design. This device is used in 39 percent of all passenger cars, so the average cost per car is $4.49 in 2019 dollars (Kahane, 1981).

Table 118 shows the average incremental weight and consumer cost of steering assemblies attributable to FMVSS Nos. 203/204 in passenger cars.

Table 118. FMVSS Nos. 203 and 204: Average incremental weight and consumer cost of steering assemblies in passenger cars

Category	Weight (lb)	Consumer Cost (2019$)
Passenger	1.89	$31.20
Engine	0.00	$ 4.49
Total	1.89	$35.69

[27] The multiplier used in this report was 1.61 and was adjusted to 1.51 to be consistent with the rest of the report.

An additional study by Osen & Ludtke (1985a) was conducted on MY 1983 passenger cars to determine the trend in weight and consumer cost of their steering column systems.[28] The entire sample of passenger cars studied had made extensive changes since the original post-standard vehicles. Unlike the 1968 and 1969 vehicles studied, every 1983 MY passenger car studied used an intermediate steering shaft and two universal joints, which are necessary components of a rack and pinion steering system.

The design of the trend steering columns was affected in several ways by downsizing. Eight of the twelve 1983 vehicles studied used rack and pinion steering in place of the traditional worm and re-circulating ball gearbox type steering system. The downsized cars of 1983 were shorter in length from the windshield base to the front of the car; consequently, they had less room to package a steering system. Rack and pinion steering systems were mounted much closer to the firewall than the older systems with the steering gearbox located ahead of the front axle centerline. A steep angle resulted when the intermediate shaft was linked from the end of the steering column to the drive flange on the steering rack. This steep angle necessitated the use of universal joints on the ends of the intermediate shafts to allow the intermediate shaft to fold under impact. The universal joints added considerable cost to the intermediate shaft. A cheaper coaxial shaft would not function at these steep angles. The cost of the trend steering column was also affected by the increased use of floor shifts. Four of the vehicles studied used a floor shift for the transmission, eliminating the column shift tube altogether. The modest net overall decrease in weight and consumer cost of the trend steering columns, as compared to those of the standard year, are primarily the result of the trend steering columns being simpler and smaller. The various cost-increasing and cost-savings factors essentially cancelled each other out, resulting in about the same net cost as in earlier years.

Table 119 shows the sales-weighted average weight and consumer cost of steering column assemblies for the pre-standard, standard, post-standard, and trend system passenger cars. It is important to note that there has been relatively little change to the weight and consumer cost from 1967 to 1983. Unlike Table 118, Table 119 computes the average total weight and consumer cost for all specimen vehicles in each MY group rather than the average incremental weight and consumer cost for matching make-models only (because the 1983 specimens did not match the earlier make-models).

Table 119. FMVSS Nos. 203 and 204: Average total weight and consumer cost of steering column assemblies in passenger cars by MY

Model Year	Weight (lb)	Consumer Cost (2019$)
1966 (Pre-Standard)	9.94	$31.29
1967-1968 (Standard)	10.90	$55.84
1969-1976 (Post-Standard)	12.41	$60.56
1983 (Trend)	11.90	$57.04

[28] The multiplier used in this report was 1.63 and it was adjusted to 1.51 to make it consistent with the rest of the report.

Table 120 shows the breakout of the weight and consumer cost of the different steering column designs. All six major energy absorbing design types are represented, as were the three largest U.S. auto manufacturers (Chrysler, Ford, and GM). Furthermore, there are several data points for the three most common energy absorbing design types (mesh, ball, and slotted columns) (Kahane, 1981). Based on limited study samples, it appears that the costs of the various alternative collapsible column designs were similar.

Table 120. FMVSS Nos. 203 and 204: Average incremental weight and consumer cost by steering column design for passenger cars (increase relative to matching 1966 pre-standard assemblies)

Design Type	Weight (lb)	Consumer Cost (2019$)
Mesh	1.59	$29.88
Ball	1.06	$20.89
Slotted	1.30	$21.84
Grooved	0.53	$25.58
Slotted/Mandrel	0.62	$30.97
Wheel Canister	1.52	$27.27

Table 121 shows the resulting weight and consumer cost after applying the learning curve and the split between voluntary and attributable weight and cost. The MY 1969 cost used in the learning curve is based on Table 118 of $35.69.

Table 121. FMVSS Nos. 203 and 204: Weights and consumer costs of steering columns – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	1.20	0.69	1.89	$23.81	$13.76	$37.58
1969	1.20	0.69	1.89	$22.61	$13.07	$35.69
1970	1.20	0.69	1.89	$21.94	$12.68	$34.63
1971	1.20	0.69	1.89	$21.36	$12.35	$33.70
1972	1.20	0.69	1.89	$20.89	$12.08	$32.97
1973	1.20	0.69	1.89	$20.44	$11.82	$32.26
1974	1.20	0.69	1.89	$20.15	$11.65	$31.80
1975	1.20	0.69	1.89	$19.90	$11.50	$31.41
1976	1.20	0.69	1.89	$19.64	$11.35	$31.00
1977	1.20	0.69	1.89	$19.39	$11.21	$30.60

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1978	1.20	0.69	1.89	$19.17	$11.08	$30.24
1979	1.20	0.69	1.89	$18.97	$10.97	$29.94
1980	1.20	0.69	1.89	$18.82	$10.88	$29.71
1981	1.20	0.69	1.89	$18.69	$10.81	$29.50
1982	1.20	0.69	1.89	$18.57	$10.74	$29.31
1983	1.20	0.69	1.89	$18.44	$10.66	$29.10
1984	1.20	0.69	1.89	$18.29	$10.57	$28.87
1985	1.20	0.69	1.89	$18.15	$10.49	$28.64
1986	1.20	0.69	1.89	$18.01	$10.41	$28.42
1987	1.20	0.69	1.89	$17.89	$10.34	$28.22
1988	1.20	0.69	1.89	$17.77	$10.27	$28.04
1989	1.20	0.69	1.89	$17.67	$10.21	$27.88
1990	1.20	0.69	1.89	$17.58	$10.16	$27.74
1991	1.20	0.69	1.89	$17.50	$10.12	$27.62
1992	1.20	0.69	1.89	$17.43	$10.07	$27.50
1993	1.20	0.69	1.89	$17.35	$10.03	$27.37
1994	1.20	0.69	1.89	$17.27	$9.98	$27.25
1995	1.20	0.69	1.89	$17.19	$9.94	$27.13
1996	1.20	0.69	1.89	$17.12	$9.89	$27.01
1997	1.20	0.69	1.89	$17.04	$9.85	$26.90
1998	1.20	0.69	1.89	$16.97	$9.81	$26.79
1999	1.20	0.69	1.89	$16.90	$9.77	$26.67
2000	1.20	0.69	1.89	$16.83	$9.73	$26.56
2001	1.20	0.69	1.89	$16.76	$9.69	$26.45
2002	1.20	0.69	1.89	$16.70	$9.65	$26.35
2003	1.20	0.69	1.89	$16.64	$9.62	$26.25
2004	1.20	0.69	1.89	$16.58	$9.58	$26.16
2005	1.20	0.69	1.89	$16.52	$9.55	$26.07
2006	1.20	0.69	1.89	$16.47	$9.52	$25.98

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2007	1.20	0.69	1.89	$16.41	$9.49	$25.90
2008	1.20	0.69	1.89	$16.36	$9.46	$25.82
2009	1.20	0.69	1.89	$16.33	$9.44	$25.77
2010	1.20	0.69	1.89	$16.30	$9.42	$25.72
2011	1.20	0.69	1.89	$16.26	$9.40	$25.65
2012	1.20	0.69	1.89	$16.21	$9.37	$25.58
2013	1.20	0.69	1.89	$16.17	$9.34	$25.51
2014	1.20	0.69	1.89	$16.12	$9.32	$25.44
2015	1.20	0.69	1.89	$16.07	$9.29	$25.36
2016	1.20	0.69	1.89	$16.03	$9.27	$25.30
2017	1.20	0.69	1.89	$15.99	$9.24	$25.23
2018	1.20	0.69	1.89	$15.95	$9.22	$25.17
2019	1.20	0.69	1.89	$15.91	$9.20	$25.11

LTV Studies

FMVSS Nos. 203 and 204 were effective for LTVs on September 1, 1981. The final rule was published in the Federal Register on November 29, 1979, (44 FR 68470) extending the standard to LTVs. The NPRM was published in the Federal Register on November 9, 1978 (43 FR 52264), making the baseline date September 1, 1978, or MY 1979. The first LTVs with energy absorbing steering columns were the car-based pickups (e.g., the Chevy El Camino in MY 1967 and the Ford Ranchero in MY 1972). Almost all GM LTVs had an energy absorbing steering column by MY 1973. An estimated 62.07 percent of LTVs had an energy absorbing steering column by MY 1979 the baseline year. All energy absorbing columns will be considered voluntary up through MY 1979 and that level will be held constant as voluntary compliance through MY 2019. Attributable costs will be the difference between the installation rate for MY 1979 and installation rates from MYs 1980 to 2019. Table 123 shows the installation rates for energy absorbing steering columns estimated for passenger cars and LTVs.

Collapsible steering columns had already been installed in pickup trucks and MPVs from AMC, Chrysler, and GM before the standard was effective. Collapsible steering columns were lacking mostly in full-sized vans with forward control steering systems where the more vertical angle of the column made it difficult to implement an energy-absorbing system.

Unlike passenger cars, NHTSA has not performed teardowns of complete steering assemblies in post-standard and matching pre-standard make-models of LTVs. However, steering columns with intermediate shafts from seven 1982 post-standard make-model LTVs and vans were torn down to determine their weight and consumer cost (Gladstone et al., 1982d). The contractor also estimated (without actual teardown) how much these columns would have cost if they had been rigid one-piece designs typical of pre-standard vehicles.

Table 122 shows the sales-weighted average weight and consumer cost of a steering column without energy absorbing columns (hypothetical estimate) and one with energy absorbing columns (actual teardown). The figures include the complete steering column and intermediate shaft, but not the steering wheel.

Table 122. FMVSS Nos. 203 and 204: Estimated average weights and consumer costs of steering columns in LTVs

Category	Weight (lb)	Consumer Cost (2019$)
Without Energy Absorbing Columns	10.13	$34.46
With Energy Absorbing Columns	10.76	$48.86
Estimated Incremental Weight & Cost	0.63	$14.40

The incremental weight and cost estimates in Table 122 are lower than the estimates for passenger cars (1.89 lb and $35.69 in Table 118). The estimates for passenger cars are based on actual teardowns of matching pre- and post-standard specimens and consider the entire steering assembly; therefore, we believe them to be more reliable estimates than Table 122, and we shall use the passenger car estimates as our estimate for LTVs as well.

Table 124 shows the sales-weighted average weight and consumer cost of steering column assemblies attributable to FMVSS Nos. 203 and 204 in LTVs.

Table 123. FMVSS Nos. 203 and 204: Installation rates of energy absorbing columns in percent passenger cars and LTVs

Model Year	Passenger Cars	LTVs
1967	63.37	2.72
1968	100	2.57
1969	100	2.85
1970	100	6.38
1971	100	6.50
1972	100	6.66
1973	100	50.61
1974	100	50.05
1975	100	50.98

Model Year	Passenger Cars	LTVs
1976	100	54.34
1977	100	56.68
1978	100	55.53
1979	100	62.07
1980	100	78.22
1981	100	79.09
1982 - 2019	100	100

Table 124. FMVSS Nos. 203 and 204: Weights and consumer costs of steering columns – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.05	0.00	0.05	$0.97	$0.00	$0.97
1969	0.05	0.00	0.05	$1.02	$0.00	$1.02
1970	0.12	0.00	0.12	$2.21	$0.00	$2.21
1971	0.12	0.00	0.12	$2.19	$0.00	$2.19
1972	0.13	0.00	0.13	$2.20	$0.00	$2.20
1973	0.96	0.00	0.96	$16.33	$0.00	$16.33
1974	0.95	0.00	0.95	$15.91	$0.00	$15.91
1975	0.96	0.00	0.96	$16.01	$0.00	$16.01
1976	1.03	0.00	1.03	$16.84	$0.00	$16.84
1977	1.07	0.00	1.07	$17.35	$0.00	$17.35
1978	1.05	0.00	1.05	$16.80	$0.00	$16.80
1979	1.17	0.00	1.17	$18.59	$0.00	$18.59
1980	1.17	0.31	1.48	$18.44	$4.80	$23.24
1981	1.17	0.32	1.49	$18.31	$5.02	$23.33
1982	1.17	0.72	1.89	$18.19	$11.12	$29.31
1983	1.17	0.72	1.89	$18.06	$11.04	$29.10
1984	1.17	0.72	1.89	$17.92	$10.95	$28.87
1985	1.17	0.72	1.89	$17.78	$10.86	$28.64
1986	1.17	0.72	1.89	$17.64	$10.78	$28.42

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1987	1.17	0.72	1.89	$17.52	$10.70	$28.22
1988	1.17	0.72	1.89	$17.41	$10.64	$28.04
1989	1.17	0.72	1.89	$17.31	$10.58	$27.88
1990	1.17	0.72	1.89	$17.22	$10.52	$27.74
1991	1.17	0.72	1.89	$17.14	$10.48	$27.62
1992	1.17	0.72	1.89	$17.07	$10.43	$27.50
1993	1.17	0.72	1.89	$16.99	$10.38	$27.37
1994	1.17	0.72	1.89	$16.91	$10.33	$27.25
1995	1.17	0.72	1.89	$16.84	$10.29	$27.13
1996	1.17	0.72	1.89	$16.76	$10.24	$27.01
1997	1.17	0.72	1.89	$16.69	$10.20	$26.90
1998	1.17	0.72	1.89	$16.63	$10.16	$26.79
1999	1.17	0.72	1.89	$16.55	$10.12	$26.67
2000	1.17	0.72	1.89	$16.48	$10.07	$26.56
2001	1.17	0.72	1.89	$16.42	$10.03	$26.45
2002	1.17	0.72	1.89	$16.36	$9.99	$26.35
2003	1.17	0.72	1.89	$16.30	$9.96	$26.25
2004	1.17	0.72	1.89	$16.24	$9.92	$26.16
2005	1.17	0.72	1.89	$16.18	$9.89	$26.07
2006	1.17	0.72	1.89	$16.13	$9.86	$25.98
2007	1.17	0.72	1.89	$16.08	$9.82	$25.90
2008	1.17	0.72	1.89	$16.03	$9.79	$25.82
2009	1.17	0.72	1.89	$16.00	$9.78	$25.77
2010	1.17	0.72	1.89	$15.96	$9.75	$25.72
2011	1.17	0.72	1.89	$15.92	$9.73	$25.65
2012	1.17	0.72	1.89	$15.88	$9.70	$25.58
2013	1.17	0.72	1.89	$15.84	$9.68	$25.51
2014	1.17	0.72	1.89	$15.79	$9.65	$25.44
2015	1.17	0.72	1.89	$15.74	$9.62	$25.36

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2016	1.17	0.72	1.89	$15.70	$9.59	$25.30
2017	1.17	0.72	1.89	$15.66	$9.57	$25.23
2018	1.17	0.72	1.89	$15.62	$9.55	$25.17
2019	1.17	0.72	1.89	$15.59	$9.52	$25.11

FMVSS No. 205, Glazing materials

FMVSS No. 205 became effective on January 1, 1968, and specifies requirements for glazing materials for use in motor vehicles and motor vehicle equipment. The purpose of this standard is to:

- reduce injuries resulting from impact to glazing surfaces,
- ensure a necessary degree of transparency in motor vehicle windows for driver visibility, and
- minimize the possibility of occupants being thrown through the vehicle windows in collisions.

This standard applies to glazing materials for use in passenger cars, MPVs, trucks, all LTVs, buses, motorcycles, slide-in campers, and pickup covers designed to carry people while in motion.

Essentially, FMVSS No. 205 required that glazing materials used for windshields, windows, and interior partitions meet the requirements outlined in the industry's American National Standard Institute *Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways*, Z-26.1 as issued in 1966. (The requirements were subsequently revised in Z26.1-1977, January 26, 1977, as supplemented by Z26.1a, July 3, 1980). ANSI Z26.1 outlines the requirements for all vehicle safety glazing materials, which include safety glass, safety plastic, multiple glazed units (two or more sheets of glazing separated by an air space), and bullet-resistant glazing. The standard specifies which type of glazing material can be in vehicle locations where driving visibility is required and not required. For passenger cars and LTVs, the industry used tempered glass for side and rear windows and laminated glass for windshields, although the standard allowed the use of other glazing materials in these locations if they met the material test requirements described in the standard.

ANSI Z26.1 defines tempered glass as a single sheet of specially treated (heat or chemically treated) plate, sheet, or float glass. It cannot be cut, drilled, or polished after treatment. When it is broken at any point, the entire piece immediately breaks into innumerable small pieces, which may be described as granular, usually with no large, jagged edges. Tempered glass for use in locations other than windshields must pass tests for light stability, luminous transmittance, humidity, boil, ball impact, fracture, shot bag impact, and abrasion resistance. Tempered glass had been in use for many years before FMVSS No. 205, and the standard has not imposed any cost increases with its use.

ANSI Z26.1 defines laminated glass as two or more sheets of glass held together by a layer of plastic material. Under impact, laminated glass will crack or break but the pieces do not fly, and the edges of holes are less jagged than ordinary glass. In addition to the tests required of tempered glass, laminated glass must also pass tests for deviation/distortion and penetration resistance.

In MY 1965, the standard windshield for all passenger cars and LTVs was composed of a 0.015-inch layer of polyvinyl butyral tightly bonded between two 0.125-inch layers of plate glass. This windshield is considered Safety1965 and the incremental cost of HPR windshields over the MY 1965 windshields is included in this analysis. Tests in the industry indicated that the plastic interlayer did not stretch more than the glass before the tight bond between the plastic and the glass caused tearing. Consequently, the plastic interlayer was easily torn by broken glass, allowing an occupant's head to tear through the windshield in low-speed crashes causing disfiguring or disabling head injuries associated with windshield contact. In the early 1960s, it was discovered that a looser bond between the plastic and glass layers could be obtained by increasing the moisture content of the polyvinyl butyral, which set the stage for the development of improved windshields. In 1962, SAE requested glass companies develop a safer windshield, and the HPR windshield was the response to that request (Kahane, 1985). The penetration resistance requirement was SAE standard J938, and first published in October 1965. FMVSS No. 205, effective in January 1968, was based largely on earlier SAE and ANSI standards; the installation of HPR windshields was the primary vehicle modification associated with those standards.

The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. Since 100 percent of the passenger car and LTV fleet met the proposal by MY 1967, the baseline date, the incremental cost of HPR windshields over the MY 1965 windshield is considered voluntary. The Federal standard essentially codified existing industry practices, and these practices were developed before the Federal government began to regulate motor vehicle safety.

High Penetration Resistant Windshield. The HPR windshield had a 0.030-inch advanced plastic interlayer bonded between two pieces of glass by a special adhesive that permitted the plastic to slide along the glass and not delaminate or discolor. In 1965, the domestic manufacturers installed HPR windshields, on an experimental basis, in a few models. By 1966, every domestic automobile manufacturer adopted the HPR windshield and by MY 1967 all import vehicles also adopted the HPR windshield. These windshields remained unchanged until 1977 when thinner panes of glass (0.105-0.115 inch) were used to support vehicle downsizing (Gladstone et al., 1982d).

The same Gladstone study determined the weight and consumer cost differential between the pre-1965 and earlier glazing and the FMVSS No. 205 HPR windshield and tempered side and rear windows of MY 1969 passenger cars. The only variance in the windshield between the 1965 and the HPR windshield was the increase in thickness of the plastic interlayer from 0.015-inch to 0.030-inch and the use of an improved adhesive bonding material.[29] A representative sample of major domestic and foreign manufacturers was examined, and the sales-weighted average weight and consumer cost increase of an HPR windshield was calculated at 1.07 lb and $10.49 in 2019 dollars.

Table 125 shows the average incremental weight and cost, after applying the learning curve, for both passenger cars and LTVs.

Table 125. FMVSS No. 205: Average incremental weights and consumer costs of high penetration resistance windshields – passenger cars and LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	1.07	0.00	1.07	$10.84	$0.00	$10.84
1969	1.07	0.00	1.07	$10.49	$0.00	$10.49
1970	1.07	0.00	1.07	$10.27	$0.00	$10.27
1971	1.07	0.00	1.07	$10.05	$0.00	$10.05
1972	1.07	0.00	1.07	$9.87	$0.00	$9.87
1973	1.07	0.00	1.07	$9.70	$0.00	$9.70
1974	1.07	0.00	1.07	$9.59	$0.00	$9.59
1975	1.07	0.00	1.07	$9.49	$0.00	$9.49
1976	1.07	0.00	1.07	$9.38	$0.00	$9.38
1977	1.07	0.00	1.07	$9.27	$0.00	$9.27
1978	1.07	0.00	1.07	$9.18	$0.00	$9.18
1979	1.07	0.00	1.07	$9.09	$0.00	$9.09
1980	1.07	0.00	1.07	$9.03	$0.00	$9.03
1981	1.07	0.00	1.07	$8.98	$0.00	$8.98
1982	1.07	0.00	1.07	$8.93	$0.00	$8.93
1983	1.07	0.00	1.07	$8.88	$0.00	$8.88
1984	1.07	0.00	1.07	$8.82	$0.00	$8.82
1985	1.07	0.00	1.07	$8.76	$0.00	$8.76
1986	1.07	0.00	1.07	$8.70	$0.00	$8.70
1987	1.07	0.00	1.07	$8.65	$0.00	$8.65
1988	1.07	0.00	1.07	$8.60	$0.00	$8.60
1989	1.07	0.00	1.07	$8.55	$0.00	$8.55
1990	1.07	0.00	1.07	$8.51	$0.00	$8.51
1991	1.07	0.00	1.07	$8.48	$0.00	$8.48

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1992	1.07	0.00	1.07	$8.45	$0.00	$8.45
1993	1.07	0.00	1.07	$8.41	$0.00	$8.41
1994	1.07	0.00	1.07	$8.38	$0.00	$8.38
1995	1.07	0.00	1.07	$8.34	$0.00	$8.34
1996	1.07	0.00	1.07	$8.31	$0.00	$8.31
1997	1.07	0.00	1.07	$8.28	$0.00	$8.28
1998	1.07	0.00	1.07	$8.25	$0.00	$8.25
1999	1.07	0.00	1.07	$8.21	$0.00	$8.21
2000	1.07	0.00	1.07	$8.18	$0.00	$8.18
2001	1.07	0.00	1.07	$8.15	$0.00	$8.15
2002	1.07	0.00	1.07	$8.12	$0.00	$8.12
2003	1.07	0.00	1.07	$8.09	$0.00	$8.09
2004	1.07	0.00	1.07	$8.07	$0.00	$8.07
2005	1.07	0.00	1.07	$8.04	$0.00	$8.04
2006	1.07	0.00	1.07	$8.02	$0.00	$8.02
2007	1.07	0.00	1.07	$7.99	$0.00	$7.99
2008	1.07	0.00	1.07	$7.97	$0.00	$7.97
2009	1.07	0.00	1.07	$7.95	$0.00	$7.95
2010	1.07	0.00	1.07	$7.94	$0.00	$7.94
2011	1.07	0.00	1.07	$7.92	$0.00	$7.92
2012	1.07	0.00	1.07	$7.90	$0.00	$7.90
2013	1.07	0.00	1.07	$7.88	$0.00	$7.88
2014	1.07	0.00	1.07	$7.86	$0.00	$7.86
2015	1.07	0.00	1.07	$7.83	$0.00	$7.83
2016	1.07	0.00	1.07	$7.81	$0.00	$7.81
2017	1.07	0.00	1.07	$7.80	$0.00	$7.80
2018	1.07	0.00	1.07	$7.78	$0.00	$7.78
2019	1.07	0.00	1.07	$7.76	$0.00	$7.76

Glass-Plastic Windshields. FMVSS No. 205 was amended in 1983 to permit, but not require, the use of glass-plastic glazing material at the option of the motor vehicle manufacturer. Glass-plastic windshields were thought to further reduce (over HPR windshields) occupant lacerations from impact with the windshield. This new windshield was essentially an HPR windshield with a layer of polyurethane bonded to the glass surface that faces the vehicle interior. This layer would provide a barrier that would prevent an occupant from contacting the broken shards of glass during an impact (Parsons, 1993). At the time of the amendment, the potential drawbacks of a glass-plastic windshield were thought to be:

- The lower abrasion resistance of the inside plastic layer could lead to degraded visibility and a shorter windshield lifespan, which would increase vehicle operation cost.
- The windshield is stiffer (four plies) and could contribute to a higher incidence of blunt impact injuries.
- The additional cost of a glass-plastic windshield on a new vehicle was estimated to be between $52.67 and $62.37 in 2019 dollars as compared to an HPR windshield (NHTSA 1983, September).
- Attachment of the rearview mirror to the plastic with adhesive was not practical. Other mounting schemes were needed.
- Attachments and removal of decals to the inside of the windshield may result in localized scratches and haze.

In the early 1980s, Ford and GM installed glass-plastic windshields in rental vehicles for field-testing; however, the durability of these windshields in the real world was less than expected. The plastic inner liner was susceptible to damage (i.e., cuts, scratches) from the everyday operating environment. In 1984, GM installed the glass-plastic windshields as standard equipment in one of its luxury car models, the Cadillac Seville Elegante. By MYs 1986 and 1987, GM had made these windshields standard equipment on approximately 210,000 cars Parsons, 1993).

The actual cost of glass-plastic windshields in use was greater than estimated in the 1983 amendment. The estimated cost increase of a glass-plastic windshield in 1983 was between $87.32 and $103.96 in 2019 economics. This estimate was from the sole supplier of glass-plastic glazing at the time and was based on a production volume of 500,000 to 1,000,000 units annually. Much lower production volumes resulted in higher costs. After the 1987 MY, GM no longer installed glass-plastic windshields in any vehicles due to high warranty and replacement costs, and no other domestic or import automaker has used them in their U.S. market vehicles since.

A small percentage of new vehicles are being equipped with laminated glass in the side windows. NHTSA researched laminated glass as a countermeasure for occupant ejection through the side window, eventually deciding that the countermeasure of choice would be ejection mitigating window curtains. It appears that laminated glass is more likely to be selected for use in side windows as a security measure, rather than a safety measure.

No incremental weight or cost has been added to this analysis associated with glass plastic windshields, since they were only installed in a small percentage of the fleet for a few model years and didn’t turn out to be a practical safety countermeasure.

FMVSS No. 206, Door locks and door retention components

FMVSS No. 206 became effective on January 1, 1968, (passenger cars), January 1, 1970, (MPVs), and January 1, 1972, (trucks) and specifies requirements for door locks and door retention components including latches, hinges, and other supporting means. The purpose of this standard is to minimize the likelihood of occupants being thrown from the vehicle through a door as a result of an impact. This standard applies to passenger cars, MPVs, and trucks (all LTVs).

Side Door Components.

Door latches were required to have a fully latched position and a secondary latched position, which were required to withstand a 2,500-lb longitudinal load in the fully latched position and 1,000-lb load in the secondary latched position. In the transverse direction, the latch must withstand a 2,000-lb load when fully engaged and a 1,000-lb load in the secondary latched position. Door latches were also required not to move from the fully engaged position when a longitudinal or transverse inertial load of 30g was applied to the door latch system. Similarly, door hinges were required to sustain loads of 2,500 lb longitudinal and 2,000 lb transverse without failure.

FMVSS No. 206 had a history that began before NHTSA was founded. Specifically, it incorporated two SAE standards developed by the domestic auto industry. The standard gradually evolved and became stronger throughout 1962 to 1969. The manufacturers who often anticipated the regulations and steadily improved their door locks throughout 1956 to 1969 voluntarily implemented most of these improvements (Kahane, 1989).Unfortunately, NHTSA has no cost teardown studies that provide data on what was the strength of latches and hinges or their weights and costs in MY 1965 to develop a Safety1965 base, or how those latches and hinges changed in strength as a result of FMVSS No. 206. NHTSA does have crash data proving that door openings decreased significantly from 1956 to 1969, thus proving that improvements continuously were being made (see Kahane [1989]). But NHTSA has not performed any cost teardown studies on door latches, hinges, and other retention components for side doors of passenger cars or LTVs during the 1960s, and none are planned by the agency. Thus, we cannot estimate the weight and cost impacts compared to what would be Safety1965.

Back Door Components.

In September 28, 1995, (60 FR 50124), a final rule amending FMVSS No. 206 was published that extended the side door requirements to the back doors of passenger cars and MPVs. This ruling affected hatchbacks, stations wagons, SUVs, and passenger vans with a GVWR of 10,000 lb or less. The NPRM was published in the Federal Register on August 30, 1994, (59 FR 44691). Sixty percent of the affected vehicles were required to comply by September 1, 1997, with 100 percent by September 1, 1998. The intent of the amendment is to prevent occupant ejections from vehicles with back doors.

In March 1994, NHTSA published a press release warning owners of minivans and other vehicles with hatchbacks that these doors can open unexpectedly in a crash and unbelted occupants can be ejected. A cost and weight analysis was performed on latch/striker assemblies from the back doors of two 1993 (pre-standard) minivans (Rutland & Spinney, 1994). One of the assemblies met the side door latch strength requirements of FVMSS No. 206 while the other did not. The latch/striker assembly that passed the FVMSS No. 206 testing weighed 0.86 lb and cost an estimated $4.62 in 2019 dollars, while the latch/striker assembly that failed weighed 0.90 lb and cost an estimated $6.32 in 2019 dollars. A comparison of the test results and cost analysis leads to the conclusion that a latch/striker that meets the requirements of FMVSS No. 206 in this case did not cost more than a latch/striker that does not meet the standard. Therefore, an increase in the weight and consumer cost of back door latches has not been attributed to the standard. While a more detailed teardown analysis of a representative sample of pre- and post-standard make-models would be needed to confirm this initial no-cost estimate, NHTSA has no plans to perform such an analysis.

Sliding Door Components.

On February 6, 2007, (72 FR 53385), NHTSA issued a final rule which amended the safety standard on door locks and door retention components and updated the requirements and test procedures to harmonize with the world's first global technical regulation for motor vehicles. The final rule added new test requirements and test procedures for sliding doors, added secondary latch position requirements for doors other than hinged side doors and back doors and extended the application of the standard to buses with a GVWR of 10,000 lb or less, including 12-15 passenger vans. The effective date was September 1, 2009.

The NPRM was published in the Federal Register on December 15, 2004, (69 FR 75020), making the baseline date September 1, 2004, or MY 2005. Only vans and minivans have sliding doors currently. Costs will all be considered voluntary through MY 2005 and the voluntary percentage will be held at that MY 2005 baseline level (see Table 127, 10.8% of all LTVs had 1 complying sliding door in MY 2005) through MY 2019. Attributable costs will be the difference between the compliance rates for MYs 2006 to 2019 minus the voluntary baseline level of MY 2005. This standard presented an unusual situation. Every large van with sliding doors passed FMVSS No. 206 before the baseline date, but many minivans did not. Thus, the voluntary and attributable decision was analyzed for large vans and minivans separately and then combined.

The only cost and weight impact of the amendments was to sliding doors. The significant factor in passing the new requirements was whether the sliding door was attached by a latch on both sides of the door or by a latch on one side and a pin on the other. All sliding doors attached by two latches passed the test and none of those with a pin on one side passed, failing always on the side with the pin.

The Final Regulatory Evaluation estimated that the cost to add a second latch to a sliding door was $9.70 in 2019 economics (NHTSA, 2006). The latch in a sliding door is like the latch used in all passenger car and LTV doors. While the agency did not have a cost teardown of a sliding door latch, we had a cost teardown of several other door latches (Ludtke & Associates, 2001). The latch cost of the MY 1995 Ford F150, 1995 Dodge Ram, 1975 Chevy Malibu, 1976 Ford Escort, and an F100 Pickup were averaged at $10.34. The pin was estimated to cost $0.64, thus the incremental cost per latch was $9.70 in 2019 economics. Table 126 shows the costs per door before and after learning by MY.

Table 126. FMVSS No. 206: Cost per sliding door

Model Year	Costs Before Learning (2019$)	Costs After Learning (2019$)
1968	$9.70	$10.62
1969	$9.70	$10.46
1970	$9.70	$10.33
1971	$9.70	$10.20
1972	$9.70	$10.07
1973	$9.70	$9.92
1974	$9.70	$9.80
1975	$9.70	$9.70
1976	$9.70	$9.59
1977	$9.70	$9.47
1978	$9.70	$9.36
1979	$9.70	$9.27
1980	$9.70	$9.22
1981	$9.70	$9.17
1982	$9.70	$9.12
1983	$9.70	$9.06
1984	$9.70	$8.99
1985	$9.70	$8.91
1986	$9.70	$8.81
1987	$9.70	$8.71
1988	$9.70	$8.63
1989	$9.70	$8.56
1990	$9.70	$8.49
1991	$9.70	$8.44
1992	$9.70	$8.38
1993	$9.70	$8.31
1994	$9.70	$8.24
1995	$9.70	$8.17
1996	$9.70	$8.11

Model Year	Costs Before Learning (2019$)	Costs After Learning (2019$)
1997	$9.70	$8.05
1998	$9.70	$7.97
1999	$9.70	$7.90
2000	$9.70	$7.83
2001	$9.70	$7.77
2002	$9.70	$7.72
2003	$9.70	$7.68
2004	$9.70	$7.63
2005	$9.70	$7.59
2006	$9.70	$7.54
2007	$9.70	$7.50
2008	$9.70	$7.44
2009	$9.70	$7.41
2010	$9.70	$7.38
2011	$9.70	$7.34
2012	$9.70	$7.29
2013	$9.70	$7.25
2014	$9.70	$7.21
2015	$9.70	$7.18
2016	$9.70	$7.14
2017	$9.70	$7.12
2018	$9.70	$7.09
2019	$9.70	$7.07

The weight of the latch was taken from the report on the weight of the MY 1979 and 1980 Ford F-150 pickup truck (Ludtke & Associates, 1980, p. A-25). The weight of one latch was 1.16 lb and the weight of the striker was 0.21 lb. It is assumed that the weight of the pin would be close to the weight of the striker and that the net weight would be the weight of the latch or 1.16 lb.

All the full-size vans had 2 latches and would pass the test. However, not all full-size vans had sliding doors, some had cargo doors which were not affected by this amendment. We could find no data to help determine the distribution of sliding doors versus cargo doors in full-size vans and assumed 50 percent were sliding doors and 50 percent were cargo doors. The standard essentially did not change full-size vans. The cost of the equipment that was already there will be considered voluntary.

Some minivans had a pin attachment and needed a second latch to comply. Other minivans had a second latch, and we will consider all installations meeting the standard for minivans up to the baseline year of MY 2005 as voluntary. We will assume costs for minivans from MY 2006 on that are above the baseline levels to be attributed to the standard. Many of the minivans had two sliding doors installed (one on each side). A few of the full-size vans had two sliding doors, along with a small percentage (2.2% in MY 2019) of the Ram Promaster and a larger percentage (21.0% in MY 2019) of the Ford Transit.

For this part of FMVSS No. 206 we decided to base the learning curve on complying sliding door sales, which included large vans and complying minivans. We considered using all latches on side doors, but decided to only use complying sliding door sales, since the closing sliding door latch technology is a little different from a closing side door of a passenger car. If we had relied only on complying minivan sales, the learning curve would have been very steep resulting in very high costs for the early years because minivan sales in their early years (starting in MY 1984) were not large.

We examined the sales of large vans and minivans, the number of sliding doors per large van and per minivan, weighted compliance with FMVSS No. 206 over time, and determined the percentage of all LTVs with complying and non-complying sliding doors to determine the average cost for all LTVs for each MY. Table 127 shows the factors used in the interim steps in the calculations for minivans (sales, number of doors, and compliance by MY), which are added to similar calculations for large vans.

Table 128 shows the average weights and costs for LTVs. Column 5 (minivan complying doors) + Column 7 (full size van % with sliding door – all of which comply) = Column 8 (complying doors % LTVs). The result (7.2%) for MY 1968 means that 7.2 percent of all LTVs in MY 1968 have one sliding door that complies with FMVSS No. 206.

Table 127. FMVSS No. 206: Factors affecting costs for LTVs

Model Year	**Minivan % of LTV sales**	**Ave. # of Doors per Minivan**	**Ave. Percent of Complying Doors**	**Minivan Complying Doors**	**Full size van % of LTV sales**	**Full size van % with Sliding door**	**Average % of LTVs with 1 Complying Door**
1968					14.3	7.2	7.2
1969					14.3	7.2	7.2
1970					14.3	7.2	7.2
1971					14.3	7.2	7.2
1972					14.3	7.2	7.2
1973					14.3	7.2	7.2
1974					14.3	7.2	7.2

Model Year	Minivan % of LTV sales	Ave. # of Doors per Minivan	Ave. Percent of Complying Doors	Minivan Complying Doors	Full size van % of LTV sales	Full size van % with Sliding door	Average % of LTVs with 1 Complying Door
1975					14.3	7.2	7.2
1976					14.3	7.2	7.2
1977					14.3	7.2	7.2
1978					14.3	7.2	7.2
1979					14.3	7.2	7.2
1980					14.4	7.2	7.2
1981					14.1	7.1	7.1
1982					13.8	6.9	6.9
1983					13.5	6.8	6.8
1984	0	0	0	0.00	13.2	6.6	6.6
1985	9.58	1.00	19.94	1.91	11.1	5.5	7.4
1986	13.09	1.00	32.75	4.29	10.4	5.2	9.5
1987	14.98	1.00	32.52	4.87	9.6	4.8	9.7
1988	15.19	1.00	32.06	4.87	9.6	4.8	9.6
1989	17.71	1.00	25.12	4.45	9.5	4.8	9.2
1990	20.32	1.00	30.48	6.19	8.4	4.2	10.4
1991	21.18	1.00	28.16	5.97	7.4	3.7	9.7
1992	21.00	1.00	28.30	5.94	7.9	3.9	9.9
1993	21.19	1.00	33.80	7.16	8.1	4.0	11.2
1994	20.86	1.00	38.76	8.09	6.8	3.4	11.5
1995	20.46	1.02	39.51	8.25	6.5	3.3	11.5
1996	18.49	1.21	30.02	6.74	5.6	2.8	9.6
1997	17.98	1.37	38.33	9.46	5.6	2.8	12.2
1998	16.51	1.46	42.98	10.36	5.3	2.7	13.0
1999	16.36	1.52	45.11	11.19	5.1	2.6	13.8
2000	16.13	1.59	42.28	10.86	4.9	2.4	13.3
2001	13.63	1.78	38.57	9.35	4.0	2.0	11.4
2002	13.02	1.81	34.84	8.20	3.9	1.9	10.1

Model Year	Minivan % of LTV sales	Ave. # of Doors per Minivan	Ave. Percent of Complying Doors	Minivan Complying Doors	Full size van % of LTV sales	Full size van % with Sliding door	Average % of LTVs with 1 Complying Door
2003	11.90	1.84	35.82	7.86	3.6	1.8	9.6
2004	11.87	1.95	40.28	9.34	3.7	1.8	11.2
2005	11.91	1.94	38.22	8.85	3.9	2.0	10.8
2006	11.13	1.97	54.19	11.91	4.1	2.0	13.9
2007	9.37	1.99	54.94	10.22	3.8	1.9	12.1
2008	9.28	2.00	95.45	17.69	3.9	1.9	19.6
2009	8.48	1.99	93.50	15.77	3.1	1.6	17.3
2010	8.24	1.97	100	16.24	3.2	1.6	17.9
2011	7.60	1.97	100	14.96	3.4	1.7	16.7
2012	8.30	1.97	100	16.35	3.5	1.7	18.1
2013	7.40	1.95	100	14.44	3.3	1.6	16.1
2014	7.15	1.93	100	13.83	3.3	1.6	15.5
2015	6.24	1.93	100	12.01	3.3	1.7	13.7
2016	6.05	1.94	100	11.73	3.5	1.8	13.5
2017	5.35	1.91	100	10.22	2.7	1.5	11.7
2018	4.30	1.90	100	8.18	2.1	1.2	9.4
2019	4.37	1.88	100	8.23	2.9	1.7	9.9

Table 128. FMVSS No. 206: Weight and consumer cost of sliding doors – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.08	0.00	0.08	$0.76	$0.00	$0.76
1969	0.08	0.00	0.08	$0.75	$0.00	$0.75
1970	0.08	0.00	0.08	$0.74	$0.00	$0.74
1971	0.08	0.00	0.08	$0.73	$0.00	$0.73
1972	0.08	0.00	0.08	$0.72	$0.00	$0.72
1973	0.08	0.00	0.08	$0.71	$0.00	$0.71
1974	0.08	0.00	0.08	$0.70	$0.00	$0.70

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1975	0.08	0.00	0.08	$0.69	$0.00	$0.69
1976	0.08	0.00	0.08	$0.69	$0.00	$0.69
1977	0.08	0.00	0.08	$0.68	$0.00	$0.68
1978	0.08	0.00	0.08	$0.67	$0.00	$0.67
1979	0.08	0.00	0.08	$0.66	$0.00	$0.66
1980	0.08	0.00	0.08	$0.66	$0.00	$0.66
1981	0.08	0.00	0.08	$0.65	$0.00	$0.65
1982	0.08	0.00	0.08	$0.63	$0.00	$0.63
1983	0.08	0.00	0.08	$0.61	$0.00	$0.61
1984	0.08	0.00	0.08	$0.59	$0.00	$0.59
1985	0.09	0.00	0.09	$0.66	$0.00	$0.66
1986	0.11	0.00	0.11	$0.84	$0.00	$0.84
1987	0.11	0.00	0.11	$0.84	$0.00	$0.84
1988	0.11	0.00	0.11	$0.83	$0.00	$0.83
1989	0.11	0.00	0.11	$0.79	$0.00	$0.79
1990	0.12	0.00	0.12	$0.88	$0.00	$0.88
1991	0.11	0.00	0.11	$0.82	$0.00	$0.82
1992	0.11	0.00	0.11	$0.83	$0.00	$0.83
1993	0.13	0.00	0.13	$0.93	$0.00	$0.93
1994	0.13	0.00	0.13	$0.95	$0.00	$0.95
1995	0.13	0.00	0.13	$0.94	$0.00	$0.94
1996	0.11	0.00	0.11	$0.78	$0.00	$0.78
1997	0.14	0.00	0.14	$0.98	$0.00	$0.98
1998	0.15	0.00	0.15	$1.04	$0.00	$1.04
1999	0.16	0.00	0.16	$1.09	$0.00	$1.09
2000	0.15	0.00	0.15	$1.04	$0.00	$1.04
2001	0.13	0.00	0.13	$0.88	$0.00	$0.88
2002	0.12	0.00	0.12	$0.78	$0.00	$0.78
2003	0.11	0.00	0.11	$0.74	$0.00	$0.74

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2004	0.13	0.00	0.13	$0.85	$0.00	$0.85
2005	0.13	0.00	0.13	$0.82	$0.00	$0.82
2006	0.12	0.04	0.16	$0.79	$0.26	$1.05
2007	0.10	0.04	0.14	$0.68	$0.23	$0.91
2008	0.10	0.12	0.23	$0.67	$0.79	$1.46
2009	0.09	0.11	0.20	$0.59	$0.69	$1.28
2010	0.09	0.12	0.21	$0.58	$0.74	$1.32
2011	0.09	0.11	0.19	$0.55	$0.68	$1.22
2012	0.09	0.12	0.21	$0.58	$0.74	$1.32
2013	0.08	0.10	0.19	$0.52	$0.65	$1.17
2014	0.08	0.10	0.18	$0.50	$0.62	$1.12
2015	0.07	0.09	0.16	$0.45	$0.53	$0.98
2016	0.07	0.08	0.16	$0.45	$0.52	$0.96
2017	0.06	0.07	0.14	$0.39	$0.45	$0.84
2018	0.05	0.06	0.11	$0.31	$0.36	$0.67
2019	0.06	0.06	0.11	$0.34	$0.36	$0.70

FMVSS No. 207, Seating systems

FMVSS No. 207 became effective on January 1, 1968, (passenger cars) and January 1, 1972, (MPVs, trucks, (all LTVs), and buses) and specifies requirements for seats, their attachment assemblies, and their installation. The purpose of this standard is to minimize the possibility of their failure by forces acting on them because of vehicle impact.

The standard requires that each occupant seat installation, except for folding auxiliary jump seats and side-facing seats, shall withstand a load of twenty times the weight of the seat in a forward and rearward longitudinal direction and withstand a 3,300-inch pound moment about the seat's H point (location, when viewed from the side, where an occupant's hips would reside when sitting in the seat). Folding and hinged seats are required to have a self-locking restraining device for the seat back with a release control to allow the seat back to be folded forward. The restraining device must preclude inertial release when subjected to a 20g longitudinal load. Additionally, the restraining device must withstand a forward longitudinal load of twenty times the weight of the seat back applied to the center of gravity of the seat back without failing or releasing.

FMVSS No. 207 is essentially associated with one tangible vehicle modification: the introduction of seat back locks in the folding front seat backs of passenger cars with two doors. Folding and hinged seats were not necessary in 4-door vehicles. On a model year basis, the percentage of 2-door cars sold has decreased steadily from a high of 64 percent in MY 1974 to 8.5 percent in MY 2019.

On February 3, 1967, (32 FR 2414) a final rule requiring seat back locks was published in the Federal Register and it has only affected passenger cars. The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. Seat back lock costs are considered voluntary through MY 1967 and the voluntary percentage will be held at that MY 1967 baseline level through MY 2019. Attributable costs will be the difference between the installation rates for MYs 1968 to 2019 minus the voluntary baseline level of MY 1967. An estimated 29.5 percent of all passenger cars (57 percent of the 2-door passenger cars) had seat back locks in MY 1967 and all MY 1968 2-door passenger cars had seat back locks. Thus, voluntary compliance is 57 percent and attributable compliance is 43 percent of total compliance in MYs 1968 to 2019.

Seat mounting assemblies and floor panels on twelve 1969 MY U.S. manufactured passenger cars were examined to determine the impact of FMVSS No. 207. There were no apparent modifications to the seat mounting assemblies or the floor panels under the seats on any of the vehicles examined. The manual seat back locks from four 1969 MY 2-door passenger cars (Ford Mustang, Ford Thunderbird, Chevrolet Nova, and Pontiac Firebird) were examined to determine their cost and weight (Harvey et al., 1979, pp. 16–19).[30] The results of the first three cars were reasonable and consistent, especially since the Mustang had a simpler lever for operating the seat back lock than did the Thunderbird and Nova. The much lower results for the Firebird were anomalous, especially since the photographs suggested it had almost the same hardware as the Mustang. In addition, the report gave two conflicting values for added weight intimating that the cost estimates for the Firebird were incorrectly calculated or transcribed in several categories. Only the results for the first three vehicles were used for computing the average. Automatic (inertial) seat back locks from three MY 1986 passenger cars (Chevrolet Camaro, Dodge 400, and Ford Tempo) were also studied (Carlson & Leonard, 1986).

Seat back locks were implemented at GM in 1967 and at Ford and Chrysler in 1968. In addition, VW and Opel contained seat back locks by 1966 and Fiat, Renault, Datsun, and Sunbeam by 1967 (Costenoble & Northrop, 1978, pp. 49–50).

The percent of passenger cars that are 2-door cars which had seat back locks in MY 1967 is not easy to estimate. The 1975 Polk National Vehicle Population Profile (NVPP) (Polk & Co., n.d.) file (the earliest one we have) gives you an accurate estimate that 50.75 percent of MY 1967 GM cars (i.e., the 1967 GM cars that were still on the road on July 1, 1975) were 2-door. Although the 1975 Polk NVPP file has registrations for each of the import manufacturers listed above for MY 1967, the number of doors is unknown for all except VW, and there it is either unknown or 2-door. In the case of Sunbeam, it doesn’t matter, because Sunbeam was a sports car and all were 2-door. For most of these manufacturers, except VW, we did find a distribution of 2-door and 4-door for MY 1968 or 1969 vehicles and used that as a proxy measure for MY 1967, because there were many more vehicles here than in FARS.

For VW, we used the distribution of BODY_TYP for the vehicles that were in fatal crashes and thus in FARS. We used the first 6 years of FARS (1975 to 1980), because after that, given the shorter lifespans of cars in those days, there were probably few MY 1966 or 1967 models on the

[30] The multiplier in this report was 1.61 and was adjusted to 1.51 to make it consistent with the rest of the report.

road after 1980. FARS gives us useful distributions for VW (88.1% were 2-door passenger cars), Datsun, Fiat, and Opel. The 2-door distributions found in FARS for Datsun, Fiat, and Opel were very similar to the MY 1968 or 1969 distributions found in the 1975 Polk NVPP file (Polk & Co., n.d.). There are very few Renault vehicles in the FARS files and all were 4-doors. An examination of the models sold worldwide by Renault in 1967 shows several 4-door models and only one 2-door sports car that might not have been sold in the United States. Thus, we assume all Renaults are 4-door cars and would not have seat back locks. The result of this analysis is an estimate that 29.5 percent of the MY 1967 baseline passenger cars had seat back locks.

Initially all seat back locks were the manual type. Persons desiring to enter the rear seat of a 2-door car could not fold over the front seat back until they disengaged the lock by operating a lever or pressing a button. Around 1980, the domestic manufacturers switched to automatic inertial seat back locks, which operate much like inertial seat belt retractors. The front seat back folds over freely except during the moments when the car is subjected to decelerations by impacts, road bumps, or emergency braking. During a frontal crash, an inertial mechanism automatically locks the seat back in place.

Table 129 shows the arithmetic average weight and consumer cost of manual and automatic seat back locks for two seats in 2-door passenger cars. On average, the automatic seat back locks weighed more than, and cost about the same as, the manual locks. Since seat back locks were an addition to the seat, their weight and consumer cost is attributed to FMVSS No. 207 but only in 2-door passenger cars. The cost of manual seat back locks will be used for MYs 1968 to 1979 (without the use of the learning curve), while the cost of automatic applied using the cost of the automatic seat back locks in the equation).

Table 129. FMVSS No. 207: Average weight and consumer cost of seat back locks in 2-door passenger cars

Category	Weight (lb)	Consumer Cost (2019$)
Manual (1968-1979)	3.07	$21.49
Automatic (1980-2019)	3.96	$20.71

Table 130 provides the average weight and consumer cost per passenger car. Seat back locks were generally not used in LTVs.

Table 130. FMVSS No. 207: Weights and consumer costs of seat back locks – passenger cars

Model Year	Percent 2-doors	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	54.20	0.95	0.72	1.66	$6.64	$5.01	$11.65
1969	54.82	0.96	0.72	1.68	$6.71	$5.07	$11.78
1970	57.94	1.01	0.76	1.78	$7.10	$5.35	$12.45
1971	58.43	1.02	0.77	1.79	$7.16	$5.40	$12.56
1972	56.15	0.98	0.74	1.72	$6.88	$5.19	$12.07

Model Year	Percent 2-doors	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1973	57.79	1.01	0.76	1.77	$7.08	$5.34	$12.42
1974	64.32	1.13	0.85	1.97	$7.88	$5.94	$13.82
1975	61.32	1.07	0.81	1.88	$7.51	$5.67	$13.18
1976	60.91	1.07	0.80	1.87	$7.46	$5.63	$13.09
1977	59.15	1.04	0.78	1.82	$7.25	$5.47	$12.71
1978	58.51	1.02	0.77	1.80	$7.17	$5.41	$12.57
1979	59.96	1.05	0.79	1.84	$7.34	$5.54	$12.88
1980	58.06	1.31	0.99	2.30	$7.05	$5.32	$12.37
1981	49.72	1.12	0.85	1.97	$6.01	$4.53	$10.54
1982	45.83	1.03	0.78	1.81	$5.51	$4.16	$9.67
1983	41.07	0.93	0.70	1.63	$4.92	$3.71	$8.63
1984	41.56	0.94	0.71	1.65	$4.95	$3.73	$8.69
1985	38.59	0.87	0.66	1.53	$4.58	$3.45	$8.03
1986	37.42	0.84	0.64	1.48	$4.42	$3.33	$7.75
1987	34.93	0.79	0.59	1.38	$4.11	$3.10	$7.21
1988	37.78	0.85	0.64	1.50	$4.43	$3.34	$7.77
1989	38.32	0.86	0.65	1.52	$4.47	$3.38	$7.85
1990	32.97	0.74	0.56	1.31	$3.84	$2.90	$6.74
1991	31.77	0.72	0.54	1.26	$3.69	$2.78	$6.48
1992	27.78	0.63	0.47	1.10	$3.22	$2.43	$5.65
1993	28.35	0.64	0.48	1.12	$3.28	$2.48	$5.76
1994	27.95	0.63	0.48	1.11	$3.23	$2.44	$5.66
1995	26.03	0.59	0.44	1.03	$3.00	$2.26	$5.26
1996	23.50	0.53	0.40	0.93	$2.70	$2.04	$4.75
1997	21.57	0.49	0.37	0.85	$2.48	$1.87	$4.35
1998	19.61	0.44	0.33	0.78	$2.25	$1.70	$3.95
1999	19.73	0.45	0.34	0.78	$2.26	$1.71	$3.97
2000	19.08	0.43	0.32	0.76	$2.18	$1.65	$3.83
2001	18.66	0.42	0.32	0.74	$2.13	$1.61	$3.74

Model Year	Percent 2-doors	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2002	17.68	0.40	0.30	0.70	$2.02	$1.52	$3.54
2003	15.87	0.36	0.27	0.63	$1.81	$1.37	$3.18
2004	17.21	0.39	0.29	0.68	$1.96	$1.48	$3.44
2005	14.33	0.32	0.24	0.57	$1.63	$1.23	$2.86
2006	15.08	0.34	0.26	0.60	$1.72	$1.30	$3.01
2007	14.26	0.32	0.24	0.56	$1.62	$1.22	$2.85
2008	14.53	0.33	0.25	0.58	$1.65	$1.25	$2.90
2009	14.65	0.33	0.25	0.58	$1.66	$1.26	$2.92
2010	13.51	0.30	0.23	0.53	$1.53	$1.16	$2.69
2011	10.81	0.24	0.18	0.43	$1.23	$0.93	$2.15
2012	12.29	0.28	0.21	0.49	$1.39	$1.05	$2.44
2013	14.17	0.32	0.24	0.56	$1.61	$1.21	$2.82
2014	12.12	0.27	0.21	0.48	$1.37	$1.04	$2.41
2015	12.70	0.29	0.22	0.50	$1.44	$1.08	$2.52
2016	8.91	0.20	0.15	0.35	$1.01	$0.76	$1.77
2017	8.12	0.18	0.14	0.32	$0.92	$0.69	$1.61
2018	7.52	0.17	0.13	0.30	$0.85	$0.64	$1.49
2019	8.46	0.19	0.14	0.34	$0.96	$0.72	$1.68

FMVSS No. 208, Occupant crash protection

FMVSS No. 209, Seat belt assemblies

FMVSS No. 210, Seat belt assembly anchorages

FMVSS No. 208 was proposed on December 3, 1966, (31 FR 15212) with a group of initial FMVSS. The final rule was published on February 3, 1967, (32 FR 2414). The final rule for FMVSS No. 208 became effective on January 1, 1968, (passenger cars) and July 1, 1971, (MPVs, trucks, all LTVs, and buses). It was the basic crash protection standard and initially defined the requirements for the installation of seat belts in passenger cars. The standard was amended to specify performance requirements for anthropomorphic test dummies seated in the outboard front seats of passenger cars and certain MPVs, trucks, and buses for manual and automatic restraint systems. It subsequently required and set performance levels for automatic crash protection, especially air bags.

FMVSS No. 209 became effective on January 1, 1968, and specifies requirements for seat belt assemblies. It applies to the seat belt assembly itself and the vehicle. The requirements apply to:

- straps, webbing, or similar material,
- all necessary buckles and other fasteners,
- retractors,
- all hardware designed for installing the assembly in a motor vehicle, and
- installation, labeling, usage, and maintenance instructions for the assembly.

FMVSS No. 210 became effective on January 1, 1968, (passenger cars) and July 1, 1971, (MPVs, trucks, all LTVs, and buses) and establishes requirements for seat belt assembly anchorages. The purpose of this standard is to ensure proper location of anchorages for effective occupant restraint and to reduce the likelihood of failure. The requirements apply to any component, other than the webbing or straps, involved in transferring seat belt loads to the vehicle structure.

The purpose of FMVSS Nos. 208, 209, and 210 is to reduce the number of fatalities and the number and severity of injuries to occupants involved in crashes. Seat belts that meet these standards offer protection in crashes of all types, e.g., front, side, rollover. Many of the requirements of FMVSS No. 208 that pertain to frontal air bags are focused on frontal crash protection. These standards apply to passenger cars, MPVs, trucks, and buses. Since FMVSS Nos. 209 and 210 support the hardware requirements of FMVSS No. 208, these standards have been combined into this analysis with FMVSS No. 208. Not all the early cost teardown studies of seat belts included costs for anchorages. For this report, weight and cost estimates for anchorages meeting FMVSS No. 210 were added to the early cost teardown studies where necessary (Osen & Ludtke, 1985b). The anchorages for passenger cars were a little more expensive than the anchorages for LTVs. The later cost teardown studies of manual or automatic seat belts specifically included the weights and costs for anchorages meeting FMVSS No. 210.

This analysis of FMVSS No. 208 focuses on the safety countermeasures and seating positions for passenger cars and LTVs separately. We consider lap belts, lap/shoulder belts, automatic belts, driver air bags, passenger air bags, advanced air bags, pretensioners and load limiters, and manual on/off switches for right front passenger air bags for the following seating positions where applicable – front outboard seat, front center seat, rear outboard seat, and rear center seat. We focus on the installation rates of these safety features and the baseline year related to the most important NPRMs that resulted in these safety features being implemented. There were many stops and starts to automatic restraints and air bags with many NPRMs that did not materialize into a final rule. Thus, we focus on the NPRMs that led to final rules that resulted in the safety features becoming widely popular.

Before NHTSA was established, many states were requiring lap belts in motor vehicles (National Committee on Uniform Traffic Laws and Ordinances, 1972). Wisconsin was the first State to require lap belts in the front outboard seats of new automobiles, which included both passenger cars and LTVs, effective with MY1962 (as Wisconsin defines model year; see discussion in next paragraph).[31] As of December 31, 1963, 23 States had laws requiring lap belts that were effective

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[31] An automobile was a motor vehicle with a shipping weight of more than 1,000 lb and designed primarily for the

at various times; 16 of those State laws were effective by January 1, 1964. As of January 1, 1968, the effective date of NHTSA's requirements for lap belts in passenger cars, 34 States required lap belts for at least the front outboard seats of passenger cars. As the number of States requiring lap belts increased, manufacturers inevitably began installing them in all vehicles. It becomes impractical to maintain separate assembly and shipping operations for different States. State requirements resulted in all passenger cars, but not all LTVs being produced with lap belts in the front outboard seats by MY 1965. Thus, lap belts are not Safety1965 equipment in any seating position.

The first NPRM on FMVSS No. 208 was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. Since lap belts were provided for 100 percent of passenger cars for the front outboard seating position for MY 1965, the definitions developed for this analysis would mean that lap belts at the front outboard seating position for passenger cars were voluntarily provided safety equipment. However, it is hard to argue that lap belts were voluntarily provided when State laws were requiring the manufacturers to provide lap belts. Since many State laws were passed and effective before NHTSA was established, it did not seem appropriate to set a baseline date (that determines voluntary versus attributable) that was limited by when NHTSA was established. Thus, we decided to make an exception in the case of lap belts for the front outboard seats. The baseline for lap belts for the front outboard seats is based on the first State requirement and not a NHTSA NPRM. The Wisconsin rule was issued on September 25, 1961. And if this were an NPRM, under our definitions, the last September 1 before the NPRM would set the baseline at September 1, 1961, which would be MY 1962. However, since the Wisconsin rule says it is effective with the MY 1962 fleet, their definition of model year was not the same as ours, and their MY 1962 had to start January 1, 1962. It was not logical to require dealers to install seat belts (on September 1, 1961) before the rule was issued (on September 25, 1961), so under their definition MY 1962 cannot start on September 1, 1961, but presumably starts January 1, 1962. Our baseline model year is defined as the last model year in production as of September 1 before a NPRM was published in the Federal Register. Since Wisconsin had a different definition of model year than we do, and didn't have an NPRM, the last January 1 before the Wisconsin rule would be January 1, 1961, making the baseline model year for us 1961. In MY 1961 the front seat outboard lap belt installation rate was an estimated 35 percent for passenger cars and 20 percent for LTVs.[32]

Since lap belt anchorages were standard equipment on most MY 1961 vehicles, lap belts were easy to install and were often a dealer installed option until they became standard equipment. Lap/shoulder belts would eventually replace lap belts in all but the front center seat position. We consider lap belts at other seating positions and lap/shoulder belts like all other technologies in this analysis, with voluntary and attributable decisions based on the NPRM baseline. The initial State laws before NHTSA was established did not require lap/shoulder belts.

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purpose of transporting people rather than property but does not have a passenger carrying capacity sufficiently large to bring it within the definition of motor bus (10 or more people including the operator). Wisconsin statues 1961, Title XLIV Vehicle Code.

[32] The percentage of vehicles with lap belts are based directly on NCSS and NASS data, which included vehicles of all MYs and specified whether they were belt-equipped at the various occupied seating positions.

When considering the weights and costs of lap/shoulder belts and automatic belts for the front seat outboard positions, in terms of voluntary and attributable, we assume that the voluntary weights and costs of lap/shoulder belts and automatic belts include the voluntary weights and costs that would have been assigned to lap belts without retractors for 35 percent of passenger cars and 20 percent of LTVs.

While this first NPRM proposed lap belts at all seating positions in passenger cars, we address each group of seating positions separately (front outboard seats, front center seat, rear outboard seats, and rear center seats), since subsequent rules did not always cover the same seating positions with the same requirements at the same time.

Seat belts are effective for all occupants (except children in safety seats installed in the vehicle with lower anchors and tethers), in most types of crashes, designed to keep occupants within the vehicle and close to their original seating position, provide ride-down by gradually decelerating the occupant as the vehicle deforms and absorbs energy, and, if possible, prevent occupants from contacting harmful interior surfaces or one another. Lap belts for outboard front seat occupants were first offered as options in MY 1956 and have been standard on the outboard front seat of passenger cars since 1965. Shoulder harnesses were added in MY 1968 in passenger cars; modern 3-point lap-shoulder belts became standard in MY 1974. Automatic belts that require no action by the occupant were furnished on a small percentage of cars starting in MY 1975, increased to 6.6 percent in MY 1987 and to a high of 41.1 percent in MY 1991, but were phased out by MY 1997.

Overview of Regulatory History

FMVSS Nos. 208, 209, and 210 were among NHTSA's initial safety standards, with an NPRM in December 1966, a final rule in February 1967, and an effective date of January 1, 1968, for passenger cars. FMVSS No. 208 originally required lap belts at each designated seating position in passenger cars only, plus shoulder belts at the outboard front seats if lap belts alone could not prevent dummies from contacting the windshield header in static tests. Since lap belts alone could not prevent dummies from contacting the windshield in static tests, the final rule, in effect, required the front outboard seat of new passenger cars to have shoulder belts effective January 1, 1968.

NHTSA extended the original FMVSS No. 208 requirements to LTVs up to 10,000 lb GVWR, effective July 1, 1971. The extension did not result in much immediate change, because most LTV make-models had been equipped with lap belts by 1968 or earlier and continued to have only lap belts up to the mid-1970s (35 F.R., 1970).

Responding to (1) the inadequate restraint provided by lap belts alone for the head and torso, (2) the inadequate restraint provided by loosely worn belts, and (3) low belt use, NHTSA amended FMVSS No. 208, effective January 1, 1972, (36 F.R., 1971):

- To require shoulder belts at the outboard front seats of all passenger cars (dropping the test of contact with the windshield header). Shoulder belts at that time could still be separate or integral with the lap belt.

- To require lap belts to have emergency-locking or automatic-locking retractors at all outboard seating positions (front and rear) and lap/shoulder belts at front outboard seats to have manual or emergency locking retractors for both passenger cars and LTVs.
- To require a warning to sound when the lap belts at the outboard front seats were not buckled.
- To permit an automatic restraint system, such as air bags or automatic belts, as an alternative to the manual shoulder belt and the buzzer.
- To include, for the first time, a 30-mph frontal barrier test (in which manual belts must remain intact, and optional automatic systems must meet dummy injury criteria).

Responding to (1) very low use of the separate shoulder belt and (2) continued low use of lap belts, NHTSA amended FMVSS No. 208, effective September 1, 1973, to require (38 F.R., 1973):

- Integral, 3-point lap-shoulder belts at the outboard front seats of passenger cars (or, alternatively, automatic protection).
- Ignition interlocks whereby belts at the outboard front seats must be buckled before a car can be started.

NHTSA amended FMVSS No. 208, effective October 29, 1974, to delete the ignition-interlock requirement. Taking its place was a 4-to-8 second visible and audible warning if the driver was unbelted (39 F.R., 1974).

As part of its effort to bring safety requirements for LTVs up to the same level as cars, NHTSA amended FMVSS No. 208 to require integral, 3-point lap-shoulder belts (or, alternatively, automatic protection) at the outboard front seats of most LTVs effective January 1, 1976, and all LTVs with GVWR of 10,000 lb or less effective September 1, 1981 (40 F.R., 1975).

Low use of manual belts continued into the early 1980s. On July 17, 1984, NHTSA amended FMVSS No. 208 to phase-in automatic protection, such as air bags or automatic belts, into the outboard front seats of passenger cars between September 1, 1986, and September 1, 1989. To encourage the development of air bags, NHTSA exempted the right front seat from the automatic protection requirement until August 31, 1993, in cars with driver air bags. NHTSA, the manufacturers, and the safety community dedicated themselves to a successful effort to encourage buckle-up laws in the States. Comfort and convenience standards for belts were also added to FMVSS No. 208, effective September 1, 1986. During the implementation of automatic protection, automatic belts in passenger cars initially predominated, then driver air bags with manual 3-point belts, and, after September 1, 1993, dual air bags with manual 3-point belts (46 F.R., 1981).

The superior protection of lap-shoulder belts, as compared to lap belts alone, was extended to the outboard rear seats. Passenger cars had to have 3-point belts, effective December 11, 1989, and LTVs, starting September 1, 1991.[33] Lap-shoulder belts were extended to all rear designated

[33] From December 11, 1989, to August 31, 1990, cars were allowed separate lap and shoulder belts as an alternative to 3-point belts, but nobody exercised that option (F.R. 54, 1989). The requirement does not apply to some types of seats/vehicles.

seating positions for passenger cars and LTVs, including the rear middle seats, but excluding side-facing seats, effective September 1, 2005 (68 F.R., 2004). The center front seats may have lap belts or lap/shoulder belts.

Automatic protection was to be phased into the outboard front seats of LTVs with GVWR 8,500 lb or less from September 1, 1994, to September 1, 1997. Manufacturers used air bags with manual belts in LTVs; none had automatic belts after September 1, 1994, and very few LTVs had automatic belts before that date (56 F.R., 1991). On-the-road experience and consumer reaction soon demonstrated that the combination of manual 3-point belts with air bags was the most effective and desirable system. All passenger cars manufactured after September 1, 1997, and all LTVs after September 1, 1998, were required to have manual 3-point belts and air bags for the driver and the right front passenger. Automatic belts were phased out in the front outboard seats (58 F.R., 1993).

Air bags of the early 1990s presented risks to infants, children under the age of 12, and certain other people, particularly when they were too close to the air bag at the time of deployment. NHTSA urged that high-risk people travel in the rear seat when possible. The agency also amended FMVSS No. 208 with measures to reduce risk when these people must travel in the front seat:

- Effective June 22, 1995, NHTSA permitted manual on-off switches for the passenger air bag in pickup trucks without rear seats or other vehicles that cannot accommodate child safety seats in the rear seat. This provision was implemented with a provision to sunset by September 1, 2012. This facilitated the implementation of passenger air bags in pickup trucks. Effective January 19, 1998, NHTSA also enabled people who must transport high-risk people in the front seats of any vehicle to obtain aftermarket on-off switches at their own expense (60 F.R., 1995). Although this provision was also implemented with the same sunset date, NHTSA extended the date by 3 years to provide time for consideration of a rulemaking to permanently allow the aftermarket switches.
- Effective March 19, 1997, the agency temporarily relaxed some aspects of the frontal impact test to facilitate the introduction of redesigned air bags that deploy less forcefully (62 F.R., 1997).

From September 1, 2003, to September 1, 2006, advanced air bags were phased in that do not deploy at all (suppression) if a small child is present or deploy only at a low level of force (low-risk deployment) if a small child is present or if an older child/small adult is out-of-position and close to the air bag (65 F.R., 2000).

The following technologies have been employed over the years to meet the requirements of FMVSS No. 208:

- **Manual belts** are seat belts that will provide protection in a crash if occupants buckle up. Manual belts can be lap belts that fit around the pelvic region or combined/separate lap and shoulder belts. Manual lap/shoulder belts are now equipped with inertia reels that allow the belt webbing to play out so that the occupant can reach forward freely in the occupant compartment under normal conditions but lock the belt in place in a crash. To remind drivers to use their belts, FMVSS No. 208 requires the installation of a brief (4 to 8 seconds) audible and visible driver seat belt warning system. However, many manufacturers are now extending the duration of the audible and visible reminders and providing them for passenger seats to get more occupants to fasten their seat belt. The following are types of manual belts:

  - Manual lap belts with manual adjustment (airline style), simple retractors, or locking retractors;
  - Separate manual lap belts and shoulder harnesses, with manual adjustment or simple retractors on the lap belt, and manual adjustment on the shoulder harness; and
  - Manual 3-point belts, combining the lap belt and shoulder harness into a single integral device, with locking retractors.

- **Automatic belts** are similar in many respects to manual belts but differ in that they are attached at one end between the seats in a passenger car without a center front seat and at the other end to the interior of the door, or in the case of a belt with a motorized anchorage, to the doorframe. The belt moves out of the way when the door is opened and automatically moves into place around the occupant when the door is closed. Thus, the occupant need take no action to gain the protective benefits of the belt. The following are types of automatic belts:
  - Motorized torso belts with manual lap belts;
  - Non-motorized automatic torso belts with manual lap belts and/or knee bolsters; and
  - Door-mounted, automatic 3-point belts.
- **Frontal air bags** are fabric cushions that are very rapidly filled with gas to cushion the occupants against colliding with the vehicle interior when a crash occurs that has a frontal deceleration strong enough to register on a sensor device in the vehicle. When such a crash is sensed, there is rapid generation or release of gas to inflate the bag. After the crash, the bag quickly deflates to permit emergency egress. Beginning in 1996, other types of air bags such as side air bags or window curtains have been installed, but FMVSS No. 208 regulates only frontal air bags. Frontal air bags are broken down into two categories:
  - Driver air bags, and
  - Dual air bags (driver and right-front passenger).

The weight and consumer cost of the various seat belt systems, along with seat belt assembly anchorages, and frontal air bags in passenger cars were studied and are presented in the following sections.

Passenger Car Studies – Seat Belts

Manual Front Outboard Seat Belts Without Retractors. Passenger cars employed lap belts as the occupant protection system for many years prior to the implementation of FMVSS No. 208.

Seat belt systems prior to 1968 were manually adjusted, airline style. Manual lap belts were believed to be highly effective not only for preventing occupant ejection from the vehicle in crashes but also for preventing harmful occupant contacts with interior vehicle components. They were installed initially at the outboard front seating positions.

Crash investigation and biomechanics research demonstrated that a lap belt alone was insufficient for restraining an occupant's head and upper torso from injurious contact with the vehicle's interior, especially in frontal crashes, and might even result in a harmful concentration of force on the abdomen. A shoulder harness was needed in addition to the lap belt to limit the forward motion of the upper body.

The original FMVSS No. 208 required for passenger cars a lap (Type 1) seat belt at all designated seating positions and a lap and shoulder belt at the outboard front seating positions if the windshield header was a potential head impact area for a lap-belted dummy. Since it was uncertain that a lap belt could always keep the dummy from contacting the windshield header in the static test, this rule in effect led to the installation of lap and shoulder belts for the front outboard seat of passenger cars. The final rule was published in the Federal Register on February 3, 1967, (32 FR 2414). The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212), making the baseline date for lap belts at all positions (except the front outboard seats) and the baseline date for lap and shoulder belts for front outboard positions September 1, 1966, or MY 1967. As was discussed earlier, an exception was made for lap belts at the front outboard seats, where the baseline was chosen based on the first State (Wisconsin) to require passenger cars and LTVs to have lap belts. The lap belt installations from MY 1961 of 35 percent for the front outboard seats of passenger cars is considered voluntary, and the voluntary percentage is held at that baseline level through MY 2019. We consider the lap belt voluntary percentage, and the weights and costs that would have been spent on the voluntary lap belts, as voluntary for lap/shoulder belts and automatic belts that supplanted lap belts in the front outboard positions later.

By MY 1967, all passenger cars had either a lap belt (99.35%) or an integral lap/shoulder belt (0.65%) at the front outboard positions. We know of no models that had a lap and separate shoulder belt in MY 1967. The lap/shoulder belt installations from MY 1967 of 0.65 percent of passenger cars is considered voluntary, and the voluntary percentage is held at that MY 1967 baseline level through MY 2019. As discussed in the previous paragraph, the weights, and costs of voluntarily supplied lap belts were also included in the lap/shoulder belt voluntary estimates. FMVSS No. 208 in effect required lap and shoulder belts beginning January 1, 1968. Since the MY starts September 1, 1967, some models were delayed in the installation of the shoulder harness until January 1, 1968. Without any actual data on the split between lap belts and lap and shoulder belts, for this analysis we assume that 12.5 percent of all MY 1968 passenger cars had lap belts and 87.5 percent of all MY 1968 passenger cars had lap and shoulder belts for the front outboard seats.[34]

Crash data and observational surveys soon indicated that few occupants fastened both belts, and most did not bother using the shoulder harness. These seat belts were manually adjustable. This shortcoming was remedied with the development of integral 3-point (Type 2) belts, which were used at that time primarily by the European manufacturers. The integral 3-point belts became,

[34] Lap and shoulder belts were required January 1, 1968. Therefore, there are 3 months (October, November, and December) of unknown belt installations. We assumed for these 3 months that half of the passenger cars would have lap belts and half with lap and shoulder belts. Thus, lap belts are assumed to be installed in half the fleet for 1/4 of the year (1/4 * 0.5 = 1/8 of the year or 12.5%).

and are still today, the primary component of the occupant protection system. They are highly effective in saving lives and preventing serious injuries in rollovers, frontal crashes, and many types of side impacts.

A cost and weight analysis was performed on three lap belt systems and one separate lap/shoulder belt without retractors (McLean et al., 1978). NHTSA did not cost-analyze any of the early European integral 3-point belt systems, which were present in a small percentage of new cars in the United States. They are assumed to have approximately the same weight and consumer cost as

the early separate lap/shoulder belts. Since the lap belt systems studied ranged over several MYs, we took the arithmetic average of their weights and costs. With very little data on separate lap/shoulder belt systems and 3-point belt systems without retractors, we combined these estimates and used their average weight and cost for both systems.

A cost and weight analysis was also performed on seat belt assembly anchorages in passenger cars (Osen & Ludtke, 1985b). Table 131 shows the average weight and consumer cost per seat for the manual front outboard seat belts without retractors, plus the seat belt assembly anchorages. For front outboard lap/shoulder belts without retractors, $31.34 was used from MY 1968 to 1971, then costs for front outboard lap/shoulder belts with retractors started with MY 1972.

Table 131. FMVSS No. 208: Average weight and consumer cost per seat of manual front outboard seat belts without retractors in passenger cars

Belt Assemblies	Weight (lb)	Consumer Cost (2019$)
Lap Belt Only	2.38	$29.09
Separate Lap/Shoulder Belt	2.95	$31.34
3-Point Belt	2.95	$31.34

Manual Front Outboard Seat Belts With Retractors. Manually adjusting the belt systems was considered inconvenient, especially when people of different sizes took turns driving the same car. The belt was not adjusted to fit the size of the person driving, which in many cases resulted in a loose-fitting belt making it less effective. To eliminate the loose fit and the inconvenience of manual adjustment, retractors were added to the seat belt systems. Retractors are a device for storing part or all the webbing in a seat belt assembly. However, with automatic locking retractors the belts became uncomfortably tight and restricted the freedom of motion needed for driving. A major improvement was the inertia reel or emergency locking retractor. It allowed the belt to spool out freely and retract when an occupant moved forward and backward in the seat during normal vehicle operation, but it locked the belt in place upon sensing a crash by sensing rapid belt spool out or vehicle deceleration.

The final rule amending FMVSS No. 208 to require integral 3-point belts at front outboard seats in passenger cars was published in the Federal Register on June 20, 1973, (38 FR 16072). The NPRM was published in the Federal Register on April 30, 1973 (38 FR 9830), making the baseline date September 1, 1972, or MY 1973.

In terms of retractors, the NPRM proposing retractors for front outboard seating positions for both passenger cars and LTVs was published in the Federal Register on September 25, 1970, making the baseline date for retractors September 1, 1970, or MY 1971. The final rule was published in the Federal Register on March 10, 1971, (36 FR 4600) and became effective January 1, 1972. Since retractors first started to appear in MY 1972, all retractors are considered attributable to the standard. All passenger cars had a lap belt with a retractor and a separate shoulder belt or a lap/shoulder belt with a retractor by MY 1973.

To summarize the cost estimate methodology for lap/shoulder belts in the front outboard seats of passenger cars:

For MYs 1968 to 1971, lap/shoulder belts without retractors were installed in the front outboard seats of passenger cars. The cost can be subdivided into two components: (1) the cost of a lap belt alone and (2) the incremental costs for lap/shoulder belts over lap belts only. The lap belt is considered 35 percent voluntary and 65 percent attributable. The incremental cost of lap/shoulder belts over lap belts is voluntary for 0.65 percent of the fleet and attributable for 99.35 percent of the fleet.

For MY 1972 and later (lap/shoulder belts with retractors) the cost includes three components: (1) the cost of a lap belt alone, (2) the incremental costs for lap/shoulder belts over lap belts only, and (3) the incremental cost of retractors. The first component is considered 35 percent voluntary and 65 percent attributable. The second component is voluntary for 0.65 percent of the fleet and attributable for 99.35 percent of the fleet. The third component is always attributable because no passenger cars had retractors before the baseline year.[35] [36] The learning curve starts in MY 1992 for front seat outboard lap/shoulder belts in passenger cars.

Beginning in January 1972, FMVSS No. 208 offered three options to meet its requirements for an occupant restraint system (36 F.R: 47, 1971).

- **Option 1** – Meet the injury protection criteria of the standard by automatic means in frontal and front angular crash test or provide either (1) automatic crash protection in a lateral and rollover crash test or (2) manual lap belt or combination of a manual lap/shoulder belt at each seating position.

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[35] An example calculation for costs for MY 1980 for passenger cars for front outboard lap/shoulder belts that appears in Table 165c is: 2 seats * $50.59 * 0.9944 with manual belts = $100.62 for lap/shoulder belts. To estimate the voluntary costs, you start with the lap belt costs of 35 percent voluntary, minus the baseline percent with lap/shoulder belts (0.65%), times the last year of lap belt costs with no retractors 1971 at $29.09 times 2 seat positions = $19.98. Added to that are the lap/shoulder belt costs with no retractor for $31.34 times 2 seat positions times the voluntary percentage of 0.0065 = $0.41. Combining these voluntary costs of $19.98 + $0.41 = $20.39 times the percent of the fleet (0.9944) that has manual lap/shoulder belts = $20.28. Attributable costs were estimated to be the difference between total costs and voluntary costs.

[36] Several methods were examined to determine voluntary versus attributable accounting for lap/shoulder belts, given that the learning curve could affect lap belt costs differently than lap/shoulder belt costs. Holding lap belt costs constant through MY 2019 would not work because lap/shoulder belts costs were on a learning curve and eventually lap/shoulder belt costs would be less than lap belt costs. We considered developing a learning curve for lap belts, but the learning curve for lap belts would be different than the learning curve for lap/shoulder belts and eventually this would lead to unlikely results. The best solution was to relate the post-learning curve lap/shoulder belt costs to the pre-learning curve level of lap/shoulder belt costs. In this way when the lap/shoulder belt costs decreased for the learning curve, the voluntary and attributable lap/shoulder belt costs also decreased.

- **Option 2** – Meet the injury protection criteria of the standard by automatic means in a frontal crash test and provide a manual lap belt or a combination of a manual lap/shoulder belt for each seating position.
- **Option 3** – Provide, at each front outboard-designated seating position, a Type 2 belt (a lap and shoulder belt) and at other seating positions either a Type 1 (lap belt) or Type 2 belt.

In addition, each belt system must have a belt warning system that operates a continuous or flashing light and a buzzer for 4 to 8 seconds when the car is started, and the driver's belt is not used.[37] All belts must have an emergency release mechanism that is readily accessible to an occupant. Manual belts must have a push button release.

Vehicle manufacturers chose the third option by employing Type 2 belts in the front outboard positions and Type 1 belts in the other positions. The domestic and Japanese manufacturers kept the lap and separate shoulder belt for the front outboard positions and added retractors. The European manufacturers stayed with the integral lap/shoulder belts for the front outboard positions and added retractors.

The number of separate lap/shoulder belts and integral 3-point belts with and without retractors in MYs 1968 to 1973 are shown in Table 132 by model year.[38] Retractors were required January 1, 1972. Since the model year starts October 1, 1971, we don't know how many vehicles produced between October 1, 1971, and December 31, 1971, had retractors. For this analysis, we assumed that half of these vehicles in this 3-month period had retractors and half did not. Thus, the estimated percentage of MY 1972 passenger cars without retractors equals 1/4 of the fleet times 1/2 or 1/8 of the fleet or 12.5 percent. This means that an estimated 87.5 percent of the MY 1972 passenger cars had retractors in the lap/shoulder belts for front outboard seats.

Table 132. FMVSS No. 208: Percentages of lap/shoulder belts by belt type for outboard front seating positions in MYs 1968 to 1973 passenger cars

	MY 1968	**MY 1969**	**MY 1970**	**MY 1971**	**MY 1972**	**MY 1973**
Without Retractor						
Lap Belts	12.5					
Separate Lap/Sh.	73.3	72.3	72.9	72.3	9.3	
Integral 3-point	14.2	27.7	27.1	27.7	3.2	
With Retractor						

[37] From January 1, 1972, to August 31, 1973, a continuous light and buzzer were required. From September 1, 1973, to October 29, 1974, an ignition interlock system was required, whereby front outboard belts had to be buckled before a car could be started. The ignition interlock requirement was revoked on October 29, 1974, and the 4 to 8 second warning system replaced the persistent warning system. We did not obtain a cost estimate for the ignition interlock system.

[38] The percentages in Table 208-2 were derived from Appendix C of the Kahane (2015) report. The percentages in Table C-1 for passenger car front outboard lap belts, actually includes both lap belts and separate lap and shoulder belts, while the percentages for outboard front 3-point belts includes integral 3-point belts.

	MY 1968	MY 1969	MY 1970	MY 1971	MY 1972	MY 1973
Separate Lap/Sh.					65.2	74.2
Integral 3-point					22.3	25.8

Starting with MY 1974, the separate shoulder belt was no longer allowed for the front outboard seating positions under the third option. Only an integral lap/shoulder belt was allowed.[39] By MY 1978, features like dual retractors (one for the lap belt and one for the torso belt) were introduced to improve the ease-of-use and performance of front seat belts.

A series of cost and weight analyses were performed on two separate lap/shoulder belts and 20 integral 3-point seat belts used to satisfy the third option in FMVSS No. 208 (McLean et al., 1978, pp. 88–103; Fladmark & Khadilkar, 1992, 1992a, 1992b, 1992c, 1996, 1996a, 1997, 1997a; Gladstone et al., 1982a pp. 3-1–3-59).

Table 133 shows the arithmetic average weight and consumer cost per seat for the manual front outboard seat belts with retractors. The lap belt estimates were derived by subtracting 0.29 lb and $1.87 from the separate lap/shoulder belt estimates. A similar method was used for LTVs.

For front seat outboard lap/shoulder belts costs, $31.34 was used for 1968 to 1971, $44.15 was used for 1972 and 1973 for separate lap/shoulder belts, then for integral 3-point belts with retractors $50.73 is used for 1972 to 1978 (with 1972 and 1973 being distributed as shown in Table 132), $50.59 for 1979 to 1981, $43.91 for 1988 to 1991 and then the learning curve is applied for 1992 to 2019. Sales for the learning curve calculations were accumulated starting in 1974 with integral 3-point belts, and the learning curve costs were fit so that they pass through $43.91 in 1992, which was the average year of the 14 teardowns completed on MYs 1988 to 1996 passenger cars. Thus, we used the teardown data where available and the learning curve after that point.

[39] Under the first two options, a Type 1 belt was permissible if the vehicle could meet the frontal crash test requirement.

Table 133. FMVSS No. 208: Average weight and consumer cost per seat of manual front outboard seat belts with retractors in passenger cars

Model Year	Weight (lb)	Consumer Cost (2019$)
Lap Belt		
1972-1973	4.23	$43.07
Separate Lap/Shoulder Belt		
1972-1973	4.52	$44.94
Integral 3-Point Belt		
1972-1974	4.60	$50.73
1979-1981	5.82	$50.59
1988-1996	3.97	$43.91

The sample of integral 3-point seat belts represented different eras in passenger cars. This information ($50.73 for 1974 and $43.91 for 1992) was used to determine a progress rate for the learning curve.

The weight of lap/shoulder belts starts at 2.95 lb for 1968 to 1971 without retractors (Table 131), increases to 4.52 lb for separate lap/shoulder belts with retractors in 1972 to 1973, integral 3-point belts for front outboard seating positions in passenger cars is estimated based on the teardown studies, starting with 4.60 lb for MY 1974, increasing linearly to 5.82 lb in MY 1979, then decreasing starting in MY 1982 linearly to 3.97 lb in MY 1988 and staying at that level through MY 2019.

Rear Outboard Seat Belts. The February 3, 1967, (32 FR 2414) final rule required lap belts at all designated seating positions for passenger cars, including rear outboard seats. The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212), making the baseline September 1, 1966, or MY 1967. In MY 1967 all passenger cars had lap belts in the rear outboard seats and are considered voluntary from MY 1968 to 1989, after which all passenger cars were supplied with lap/shoulder belts.

From January 1, 1968, to December 10, 1989, FMVSS No. 208 only required Type 1 (lap) belts at the rear-outboard positions of passenger cars. In MYs 1966 to 1970, 100 percent of rear-outboard seats had Type 1 belts. Type 2 belts, which were integral 3-point belts, were voluntarily installed in a small number of European make-models starting in 1971, and subsequently in a gradually increasing list of models. Retractors were added in 1972.

Three-point belts are more effective than lap belts, particularly in frontal crashes, because they restrain the torso. Lap/shoulder belts are highly effective in saving lives and preventing serious injuries in rollovers, frontal crashes, and many types of side impacts. On June 14, 1989, (54 FR 25275), NHTSA published a final rule in the Federal Register amending FMVSS No. 208 to require 3-point belts at the rear outboard seats of passenger cars with emergency locking retractors. The NPRM was published in the Federal Register on November 29, 1988, (53 FR 47982), making the baseline date September 1, 1988, or MY 1989. All 3-point belts in the rear outboard seats of passenger cars are considered voluntary through MY 1989 and the voluntary percentage (67.67%) will be held at that MY 1989 baseline level through MY 2019. In addition, for the remaining 32.33 percent, lap belts would have been supplied voluntarily and the weight and costs of lap belts without retractors would have been added to the voluntary totals for MYs 1990 to 2019.40 The final rule mandating lap/shoulder belts for forward-facing rear outboard seating positions became effective December 11, 1989, in all passenger cars, other than convertibles, with a GVWR of 10,000 lb or less, and then it became effective for convertibles on September 1, 1991.

A series of cost and weight analyses were performed on rear outboard seat belts with and without retractors (McLean et al., 1978; Fladmark & Khadilkar, 1992, sec. 12–15). Table 134 shows the average weight and consumer cost per seat for the rear outboard seat belts. The last row comes from a later study to be discussed below.

Table 134. FMVSS No. 208: Average weight and consumer cost per seat of rear outboard seat belts in passenger cars

Belt Assemblies	**Weight (lb)**	**Consumer Cost (2019$)**
Without Retractors		
Lap Only (1968)	1.83	$22.80
3-Point Belt (1971)	1.83	$22.80
With Retractors		
Lap Only (1972-1974)	2.73	$25.35
Lap Only (1979-1981)	3.09	$36.68
Lap Only (1988-1989)	2.84	$26.90
Lap Only Average (1972-74 & 1988-89)	2.79	$25.74
3-Point Belt (1988-1992) (not used in analysis)	3.56	$30.49
3-Point Belt (1988-1992) (used in analysis)	2.58	$25.53

Note: In these small tables for FMVSS No. 208, the dates in the first column by the types of seat belts relate to the MYs of the vehicles in the teardown study, not the year that the data was applied in the analysis**.**

The sample of the lap-only seat belts represented three different eras in passenger cars. The average weight and consumer costs of the 1972 to 1974 samples and the 1988 and 1989 samples are nearly equal. There is no obvious explanation why the 1979 to 1981 costs are substantially

[40] Since the weight and cost in Table 134 without retractors is the same for lap belts and 3-point belts and the weight and cost for lap belts with retractors is more than for lap/shoulder belts with retractors, we show no attributable weight or cost for rear outboard seat lap/shoulder belts in Table 208-17c, except for the weight and cost of retractors.

higher, in fact, even higher than the cost estimate for 3-point belts. It is perhaps a consequence of the specific make-models selected. At all the other seat positions, the 1979 to 1981 estimates were consistent with the earlier and later estimates. For rear outboard lap belts, we use $22.80 and 1.83 lb from 1968 to 1971, then we assume for 1972 to 1989, an average cost derived across all lap belt with retractor studies for the average MY 1980 vehicle of $25.74 for the learning curve and 2.79 lb.

For rear outboard lap/shoulder belts, NHTSA did not cost analyze any of the early European integral 3-point belt systems in MY 1971 without retractors, which were present in fewer than 1 percent of new cars in the United States. They are assumed to have approximately the same weight and consumer cost as the lap belt only. For rear outboard lap/shoulder belts with retractors we took the results from the Fladmark (1992c) study of 4 belt systems from MYs 1988 to 1992 (average MY 1990) that averaged $25.53 and 2.58 lb. From MY 1972 to 2019 we applied the learning curve for costs with a base of $25.53 for the MY 1990 vehicles. This average cost for lap/shoulder belts for outboard rear seats with retractors is slightly more than the average cost estimate for rear seat outboard lap belts with retractors ($25.05) for MY 1990 after considering the learning curve.

Retractors were required in MY 1972 and were not installed in any rear outboard seats voluntarily in MY 1971. Thus, retractors are considered attributable to FMVSS No. 208. Before applying the learning curve, the difference between 3-point rear outboard seat belts with retractors versus 3-point rear outboard seat belts without retractors are 0.75 lb (2.58 - 1.83) and $2.73 ($25.53 - $22.80) per seat.

Front Center Seat Belts. FMVSS No. 208 has only required Type 1 (lap) belts at the front center seat position. The final rule published in the Federal Register on February 3, 1967, (32 FR 2414), required lap belts at all designated seating positions (which included the front center seat) for passenger cars. The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212), making the baseline date September 1, 1966, or MY 1967. Since 100 percent of all passenger cars that had a front center seat had lap belts in the front center seat by MY 1967, the weight and cost of front center lap belts are considered voluntary. There have been no passenger cars with a front center seat since MY 2011.

We examined the owner's manual of several passenger cars, that were essentially the last MYs to have a front center seat position, to determine whether any front center seat belts had a retractor or not. In all the following models, a lap belt was supplied at the front center seating position that did not have a retractor: MY 2009 Buick Lucerne, MY 2005 Pontiac Bonneville, 2009 Ford Crown Victoria, 2009 Lincoln Town Car, and 2010 Cadillac DTS. Thus, we assume that the front center seat in passenger cars have always had an airline-style lap belt without a retractor. As far as we know, no passenger cars have had lap/shoulder belts in the front center seat.

Rear Center Seat Belts.

From January 1, 1968, to MY 2005, FMVSS No. 208 has only required Type 1 (lap) belts at the rear center seat positions. The final rule was published in the Federal Register on February 3, 1967, (32 FR 2414), required lap belts at all designated seating positions (which included the rear center seat) for passenger cars. The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212), making the baseline date September 1, 1966, or MY 1967. An estimated 75 percent of MY 1967 passenger cars had lap belts at the rear center seat by the baseline date. Thus, this percentage is considered voluntary for lap belts, which were later supplanted by lap/shoulder belts in the rear center seat. Since all MY 1968 passenger cars were required to have lap belts at the rear center seat, 25 percent of their weight and cost is considered attributable. This 75 percent voluntary and 25 percent attributable weight and cost for lap belts is carried forward to the lap/shoulder belt calculations.

Rear center seat lap belts were examined to determine what percent of the new passenger cars had a retractor. Since rear center seats were required to have lap/shoulder belts starting with a phase-in in MY 2006, we examined owner's manuals from MY 2000. We limited the search to those make/models with lap belts and not lap/shoulder belts by using the data in Appendix A of the Kahane (2017) report. Every make/model had airline-style belts without a retractor. Thus, we assume that no make/models had a retractor in the rear center seat in passenger cars that had lap belts.

On December 8, 2004, (69 FR 70904), in response to Anton's Law, signed on December 4, 2002, the agency published a final rule mandating lap/shoulder belts for all forward-facing rear seating positions, including center seats, and all rear facing seating positions (the back of the station wagon style), in all motor vehicles with GVWR of less than 10,000 lb (all passenger cars and LTVs). The NPRM was published in the Federal Register on August 6, 2003, (68 FR 46546), making the baseline date September 1, 2002, or MY 2003.

The phase-in effective dates were:

- 50 percent of all vehicles manufactured from September 1, 2005, to August 31, 2006;
- 80 percent of all vehicles manufactured from September 1, 2006, to August 31, 2007; and
- 100 percent of all vehicles manufactured on or after September 1, 2007, must comply.

In the 1990s, manufacturers began voluntarily installing lap/shoulder belts in the rear center seating position. By MY 1999, over 30 percent of passenger cars had rear center lap/shoulder belts and this increased to 82 percent by the baseline date of MY 2003.

All 3-point belts in the rear center seats of passenger cars are considered voluntary through MY 2003 and the voluntary percentage (82.13%) is held at that MY 2003 baseline level through MY 2019 and is applied to the difference in weight and cost between the lap/shoulder belt and lap belt. The lap belt portion of the weight and costs, which has both attributable and voluntary portions were carried forward into the lap/shoulder belt calculations.

A series of cost and weight analyses were performed on front and rear center lap belts (McLean et al., 1978, pp. 88–103; Gladstone et al., 1982a, pp. 3-1–3-59; Khadilkar et al., 2001b). Based on the latest cost teardown analysis of rear center lap belts by Khadilkar (2001a), 5 center rear seat belt systems were examined. The 3 lap/shoulder systems, namely the 1999 Volvo S70, the 2000 Ford Focus, and the 2000 Honda Accord all had retractors. This is several years before the NPRM. Thus, we assume that all lap/shoulder systems for the rear center seat have retractors. The 2 lap-only systems, 1992 Honda Accord and 1993 Ford Escort did not have retractors. They were airline style.

Table 135 shows the average weight and consumer cost per seat for the front and rear center belts.

Table 135. FMVSS No. 208: Average weight and consumer cost per seat of front and rear center lap belts without retractors in passenger cars

Belt Assemblies	Weight (lb)	Consumer Cost (2019$)
Front Center		
Lap Only (1968-1974)	0.90	$19.99
Lap Only (1979-1981)	0.79	$18.50
Rear Center		
Lap Only (1968-1974)	1.02	$19.54
Lap Only (1979-1981)	0.75	$17.27
Lap Only (1992-1993)	1.09	$15.72

There is a decrease in cost over time in Table 135. The $18.50 for MY 1980 for the front center lap belt and $15.72 for MY 1992 for the rear center lap belt are used in the learning curve. The weights used for the front center lap belts were 0.90 lb from MY 1968 to 1974, decreasing by 0.02 lb per year from MY 1975 to 1978, and then 0.79 lb for MY 1979 and thereafter. The weights used for the rear center lap belts were 1.02 lb from MY 1968 to 1974, decreasing by 0.054 lb per year from MY 1975 to 1978, 0.75 lb for MY 1979 to 1981, increasing by 0.03 lb per year from MY 1982 to 1991, then 1.09 lb for MY 1992 and thereafter.

The cost teardown in FEV North America, Inc. (2016) and Khadilkar (2001b) estimate of rear center lap/shoulder belts of 4.69 lb and $38.11 in 2019 dollars was based on the teardown of 4 passenger cars in two studies (see Table 136). The $38.11 cost estimate was based on MY 2000 vehicles and learning was applied from MY 1994 to 2019. All four of these lap/shoulder belts included retractors. The structure added for 3 of the 4 passenger cars included only the anchorage at 0.11 lb and $1.25.

Table 136. FMVSS No. 209: Lap/shoulder belts in the rear center seat – passenger cars with retractors

Model Year	Make/Model	Belt		Structure		Total	
		Weight	Cost	Weight	Cost	Weight	Cost
2002	VW Passat	1.64	$28.00	7.72	$12.60	9.35	$40.60
2000	Ford Focus	3.36	$39.57	0.11	$1.25	3.47	$40.82
1999	Volvo S70	2.74	$34.01	0.11	$1.25	2.85	$35.26
2000	Honda Accord	2.99	$34.50	0.11	$1.25	3.10	$35.75
	Average	2.68	$34.02	2.01	$4.09	4.69	$38.11

Automatic Front Outboard Seat Belts With Retractors. On July 5, 1977, (42 FR 34289), a final rule was published in the Federal Register requiring automatic occupant protection at front outboard seats in passenger cars. The NPRM was published on June 14, 1976, (41 FR 24070). However, that final rule was rescinded in 1981 before its effective date. This analysis uses as a baseline the final rule that did result in automatic protection being implemented. The July 17, 1984, (49 FR 28962), final rule amended FMVSS No. 208 to require automatic occupant protection at front outboard seats in passenger cars. The NPRM was published in the Federal Register on October 14, 1983, (48 FR 48622), making the baseline date September 1, 1983, or MY 1984.

The requirements for automatic restraints in the front seating positions of passenger cars were issued in response to the persistent low use rate of manual belts. Two systems that qualified as automatic restraints were air cushion restraints (air bags) and automatic seat belts (belts that automatically move into place around the occupant when the door is closed).

The 1984 rule required that some type of automatic restraint be installed in passenger cars but provided the manufacturers the choice of a variety of methods of providing automatic protection, including automatic seat belts and air bags, as long as certain specified performance requirements were met. The final rule required automatic occupant protection in all passenger automobiles based on a phase-in schedule beginning September 1986, with full implementation being required by September 1989. The front center seat of passenger cars was exempt from, and rear seats were not covered by, the requirements.

The weight and cost of automatic belts in the front outboard seats is considered voluntary from MY 1975 when they were introduced through MY 1984 and the voluntary percentage (0.33%) is held at that MY 1984 baseline level through MY 2019. In addition, we assume that lap belts would have been voluntarily supplied for 35 percent of the automatic belts and the weight and cost of the basic lap belts without retractors was assumed to be voluntarily. Attributable weight and costs are based on the difference between the weight and costs estimated for automatic belts and the estimated voluntary weights and costs that would have accrued for lap belts.

Most vehicle manufacturers initially chose to comply with the requirements by installing automatic belts in many of their vehicles. The fact that the rule did not include design specifications gave them broad flexibility in selecting the design and performance characteristics of their automatic belts. For example, the motorized two-point torso belts required the occupant to manually fasten the lap belt for full protection, while the door-mounted non-motorized 3-point belts were often detached by occupants from their anchorage in the middle of the car and subsequently used in the same manner as a manual 3-point belt. And one of the non-motorized 2-point torso belt systems had an automatic shoulder belt used in combination with a knee bolster. This was the only shoulder belt system specifically designed for use without a lap belt because the knee bolster took the place of the lap belt.

A series of cost and weight analyses were performed on automatic motorized and non-motorized seat belts (McLean, 1978, pp. 88–103; Fladmark & Khadilkar, 1992a, sec. 8; Khadilkar et al., 1988, 1988a, 1988b, 1988c).[41] These cost teardown studies were examined and some of the results were amended to make them consistent with methods used in this analysis. The oldest study (for the VW Rabbit 2-point 1975 to 1982 models) used a methodology that included

[41] A multiplier of 1.64 was used in these studies and were adjusted to 1.51 to be consistent with this analysis.

tooling costs per vehicle as variable costs, while we consider tooling costs as part of fixed costs in this analysis. These tooling costs were taken out of the variable costs and estimated costs recalculated. Several of the cost teardowns used a multiplier of 1.64 from variable cost to consumer cost, which was adjusted to 1.51 to be consistent with the remainder of the analysis.

Five separate learning curves were used, one for each of the automatic belt types. The assumptions used for the learning curves are as follows. All belt parts (including retractors) would use a progress rate of 0.96, which is the progress rate used for all manual belts in this analysis. All non-belt parts (knee bolsters and door structure) would use a progress rate of 0.93, which is the progress rate used for all countermeasures for which we didn't have a calculated progress rate. A weighted progress rate was determined for each of the 5 automatic belt systems as shown in Table 137. One system (1991 Toyota Tercel) had only belt parts and a progress rate of 0.96. It had a manual lap belt and automatic non-motorized shoulder belt attached at the B-pillar, with no knee bolster.

Table 137 shows the average weight and consumer cost per seat for the automatic front outboard seat belts with retractors and anchors. Since these estimates are based on at most nine systems, arithmetic rather than sales-weighted averages of the costs and weights were used.

Table 137. FMVSS No. 208: Average weight, consumer cost, and progress rate per seat of automatic front outboard seat belts in passenger cars

Belt Type	Weight (lb)	Consumer Cost (2019$)	Progress Rate Used in Learning Curve
Non-Motorized			
2-point[1] (1975-1982)	11.05	$ 62.64	0.948
2-point[2] (1987-1990)	16.90	$161.17	0.955
2-point[3] (1991-1995)	4.51	$67.67	0.960
3-point[4] (1987-1996)	14.30	$207.68	0.955
Motorized			
2-point[5] (1981-1996)	15.18	$229.61	0.949

1. Passive lap belt with knee bolster.
2. Active non-motorized shoulder belt with knee bolster.
3. Separate passive lap belt and active non-motorized shoulder belt with no knee bolster.
4. Non-motorized 3-pt belt with no knee bolster.
5. Passive lap belt with motorized shoulder belt and knee bolster.

The estimate for 1987 to 1996 non-motorized 2-point belts is substantially higher than the estimates for the 1975 to 1982 and 1991 to 1995 systems primarily because structural modifications were made to the existing vehicle. The costs would probably be lower if the 2-point belts had been built in as an overall redesign of the vehicle like it was in the 1975 to 1982 and 1991 to 1995 systems. NHTSA does not know if these extra costs were characteristic of most of the systems in the first years of the automatic protection requirement, or only of the one system we analyzed. Similarly, we do not know if the costs for the non-motorized 3-point belts and the motorized 2-point belts, each based on analyses of three 1987 systems, were reduced in subsequent years. Since all automatic belts were phased out by the mid-1990s, NHTSA is not planning any further cost analyses.

Successful enactment of buckle-up laws in most of the states, and the demonstrated superior performance and customer preference for manual 3-point belts with air bags, soon eliminated interest in the various types of automatic belts. FMVSS No. 208 was subsequently modified to require dual air bags plus manual 3-point belts effective September 1, 1997, in passenger cars. In 1986 to 1996, vehicles with air bags usually had manual belts, but some had automatic belts at one or both front outboard positions.

The distribution of automatic belts used in the cost calculation is shown in Tables 138, 139, and 140. These tables show the average number of automatic belts by MY. Tables 138 and 139 show the average cost for each of the automatic belt types, while Table 140 shows the average weight by automatic belt types. These costs and weights are weighted by the distribution of the number of belts per car for each MY.

Table 138. FMVSS No. 208: Average consumer cost by type of belt and the number of seat belts by type in an average passenger car for MYs 1975 to 1987

Seat Belt Assembly	**Cost per Seat**	**"n" of Belts Per Car**						
		'75 to 81	**'82**	**'83**	**'84**	**'85**	**'86**	**'87**
Automatic								
2-Point Non-Motorized (1975-1982)	$62.64	0.01	0.005					
2-Point Non-Motorized (1987-1990)	$161.17							0.013
2-Point Non-Motorized (1991-1995)	$67.67							
3-Point Non-Motorized (1987-1996)	$207.68							0.052
2-Point Motorized (1981-1996)	$229.61	0.01	0.005	0.01	0.01	0.01	0.01	0.065

Table 139. FMVSS No. 208: Average consumer cost by type of belt and the number of seat belts by type in an average passenger car for MYs 1988 to 1994

Seat Belt Assembly	Cost per Seat	"n" of Belts Per Car						
		'88	'89	'90	'91	'92	'93	'94
Automatic								
2-Point Non-Motorized (1975-1982)	$62.64							
2-Point Non-Motorized (1987-1990)	$161.17	0.02	0.01	0.07				
2-Point Non-Motorized (1991-1995)	$67.67				0.09	0.09	0.03	0.03
3-Point Non-Motorized (1987-1996)	$207.68	0.12	0.18	0.37	0.32	0.24	0.23	0.19
2-Point Motorized (1981-1996)	$229.61	0.10	0.13	0.36	0.41	0.23	0.27	0.17

Table 140. FMVSS No. 208: Average weight by type of belt and the number of seat belts by type in an average passenger car for MYs 1995 to 2001

Seat Belt Assembly	Weight per Seat	"n" of Belts Per Car						
		'95	'96	'97	'98	'99	'00	'01
Automatic								
2-Point Non-Motorized (1975-1982)	11.05							
2-Point Non-Motorized (1987-1990)	16.90							
2-Point Non-Motorized (1991-1995)	4.51	0.00						
3-Point Non-Motorized (1987-1996)	14.30	0.08	0.03					
2-Point Motorized (1981-1996)	15.18	0.05	0.02					

LTV Studies – Seat Belts

Front Outboard Seats. On September 30, 1970, (35 F.R., 1970), a final rule was published in the Federal Register extending FMVSS No. 208 (lap belts at all designated seating positions) to LTVs. The NPRM was published in the Federal Register on September 20, 1969, (34 FR 14660), which would have made the baseline date September 1, 1969, or MY 1970 for lap belts. By MY 1970, all LTVs had lap belts and a few had lap/shoulder belts in the front outboard seats. For determining voluntary versus attributable costs, as was discussed earlier, an exception was made for lap belts at the front outboard seats, where the baseline was chosen based on the first State (Wisconsin) to require passenger cars and LTVs to have lap belts. The lap belt installations from MY 1961 of 20 percent for the front outboard seats of LTVs is considered voluntary, and the voluntary percentage is held at that baseline level through MY 1980. By MY 1981, lap belts were replaced by lap/shoulder belts for all front outboard seats in all LTVs. We consider the lap belt voluntary percentage, and the weights and costs without retractors that would have been spent on the voluntary lap belts, as voluntary for lap/shoulder belts that supplanted lap belts in the front outboard positions later.

On July 9, 1975, (40 FR 28805), a final rule was published in the Federal Register amending the effective date to January 1, 1976, of the March 10, 1971, (36 FR 4600) final rule, which extended the requirement for 3-point belts at front outboard seats to most LTVs. Lap belts could still be used for forward control vehicles, convertibles, open-body type vehicles, walk-in van-type trucks, motor homes, and vehicles carrying chassis-mount campers. In 1977, these vehicles made up 15.7 percent of the LTV new vehicle sales. The NPRM was published on September 25, 1970, (35 FR 14941), making the baseline date September 1, 1970, or MY 1971 for front outboard lap/shoulder belts for LTVs. Lap/shoulder belts in the front outboards seats of LTVs by the baseline date are considered voluntary through MY 1971 and the voluntary percentage (3.83%) will be held at that MY 1971 baseline level through MY 2019. As with passenger cars, retractors were not installed before the baseline date of MY 1971 and retractors are considered attributable to the standard. For MY 1972 and later the attributable costs include the incremental cost for lap/shoulder belts over lap belts times the difference in installation rate for MY 1972 through MY 2019 minus the voluntary baseline level of MY 1971. Voluntary costs are based on the MY 1971 installation rate.

Manual Front Outboard Seat Belts Without Retractors. In 1968, all front outboard seats in LTVs had lap belts. From 1969 to 1981, there was a declining percentage of LTVs that had lap belts and an increasing percentage of LTVs with lap/shoulder belts. All MY 1981 LTVs had lap/shoulder belts. As far as we know, there were no separate lap and shoulder belts used on LTVs, and all the LTV systems were integral lap/shoulder belts.

It is assumed that manually adjusted lap belts without retractors were installed through December 31, 1971. Although no cost or weight analysis was performed on manual front outboard seat belts in LTVs for this period, the seat belts used in LTVs are assumed to be very similar to those in passenger cars for the same time frame. Consequently, the weight and cost numbers from the passenger car study are used to determine the LTV figures (McLean et al., 1978). The seat belt and shoulder belt anchorages in LTVs, however, differed from those in the passenger cars. Therefore, the figures from a study of belt assembly anchorages in LTVs are used (Osen & Ludtke, 1985b). Table 141 shows the arithmetic average weight and consumer cost per seat for LTVs for the manual front outboard seat belts without retractors, including the seat belt and shoulder belt assembly anchorages. These values are used through 1971, and then the learning curve is applied using the consumer costs in Table 142.

Table 141. FMVSS No. 208: Average weight and consumer cost per seat of manual front outboard seat belts without retractors in LTVs

Belt Assemblies	Weight (lb)	Consumer Cost (2019$)
Lap Belt Only (1968)	2.25	$28.65
3-Point Belt (1966-1971)	2.54	$30.54

Manual Front Outboard Seat Belts With Retractors. Beginning January 1, 1972, front outboard seats integral lap/shoulder seat belts, seat belt retractors, and seat belt warning systems were required on passenger cars. Seat belt retractors and seat belt warning systems were also required for LTV front outboard seat belt assemblies at this time. We know of no separate lap and shoulder belts ever being used on LTVs. The figures for the 3-point belts were derived from a cost and weight analysis performed on six LTVs, however, there was no analysis performed on the lap belts (Fladmark & Khadilkar, 1996, 1997, 1997a). Since there was little difference in the cost and weight of the lap belt and 3-point belts without retractors (Table 141), the cost of the lap belt with retractor was determined by subtracting the differences from Table 141 of 0.29 lb from the weight and $1.89 from the cost of the 3-point belts with retractors. Table 142 shows the average weight and consumer cost per seat for the manual front outboard seat belts with retractors for LTVs. These figures include the seat belt and shoulder belt assembly anchorages. For the LTV front outboard lap belt analysis, the cost from MY 1968 to 1971 used the Table 141 without retractors cost and weight of $28.65 and 2.25 lb per lap belt and then applied the learning curve to the $46.38 with retractors from Table 142 for MY 1972 and thereafter. As with passenger cars in the front outboard seats, retractors were not installed on LTVs before January 1, 1972. Since the NPRM proposing retractors was published in the Federal Register on September 25, 1970, the baseline date is September 1, 1970, or MY 1971. Since no LTVs had retractors installed in front outboard seat positions before the baseline date, retractors are considered attributable to FMVSS No. 208.

Table 142. FMVSS No. 208: Average weight and consumer cost per seat of manual front outboard seat belts with retractors in LTVs

Belt Assemblies	Weight (lb)	Consumer Cost (2019$)
Lap Belt Only	4.49	$46.38
3-Point Belt (1972-1996)	4.78	$48.26

The front outboard lap/shoulder belt analysis assumed costs of $30.54 for lap/shoulder belts without retractors from Table 141 for MYs 1968 to 1971, then applied the learning curve to the $48.26 estimate from Table 142 starting in MY 1972. The $48.26 cost estimate was based on 1989 models. The cost of manual front outboard seat belts for LTVs in 1989 was $4.35 more expensive than the manual front outboard seat belts in passenger cars in 1989. This relationship held for some of the earlier years, but not all years, even though we used teardown studies for passenger cars and the learning curve for LTVs. For example, in 1974, the teardown study for passenger cars estimated the cost at $50.73 per seat compared to the learning curve for LTVs estimate of $52.20. In 1980, the teardown study for passenger cars estimated the cost at $50.59 per seat compared to the learning curve for LTVs estimate of $50.02.

After January 1, 1976, the FMVSS No. 208 requirements for LTVs were like those for passenger cars, offering three possible options that were discussed earlier in this paper. Manufacturers avoided the automatic belt protection options for LTVs. However, certain types of trucks were still exempt from 3-point belts. The proportion of LTVs installed with 3-point belts increased over the years until 1981 when 100 percent of LTVs had 3-point belts in the front outboard seating positions.

Rear Outboard Seat Belts. On September 30, 1970, (35 F.R., 1970), a final rule was published in the Federal Register extending FMVSS No. 208 (lap belts at all designated seating positions) to LTVs. The NPRM was published in the Federal Register on September 20, 1969, (34 FR 14660), making the baseline date September 1, 1969, or MY 1970 for lap belts. All MY 1970 LTVs had lap belts in the rear outboard seats and are considered voluntary.

From 1968 to 1986 all rear-outboard seats in LTVs had lap only belts. Integral 3-point belts were voluntarily installed in a few LTVs starting in 1987, and subsequently in a gradually increasing list of models. On November 2, 1989, (54 FR 46257), NHTSA published a final rule that extended the requirements for rear-outboard seats with lap/shoulder belts to convertibles, LTVs, multipurpose vehicles, and small buses other than school buses that became effective September 1, 1991. Emergency locking retractors were also required at this time for the rear outboard seats of LTVs. As in the earlier final rule, center seating positions and non-forward-facing seating positions were excluded from the requirements. The NPRM was published in the Federal Register on November 29, 1988, (53 FR 47982), making the baseline date September 1, 1988, or MY 1989. All 3-point belts in the rear outboard seats of LTVs are considered voluntary through MY 1989 and the voluntary percentage (16.8%) is held at that MY 1989 baseline level through MY 2019. In addition, for the remaining 83.2 percent, lap belts would have been supplied voluntarily and the weight and costs of lap belts without retractors would be added to the voluntary totals for MY 1990 to 2019.[42] Since the lap belts weight and cost estimates are the same or more than the lap/shoulder belt costs, the only attributable costs are for retractors.

Although no cost or weight analysis was performed on manual rear outboard seat belts in LTVs for this period, the seat belts used in LTVs are assumed to be very similar to those in passenger cars for the same time frame. Consequently, the weight and cost numbers from the passenger car study are used to determine the LTV figures (McLean et al., 1978; Fladmark, & Khadilkar, 1992c). Table 143 shows the arithmetic average weight and consumer cost per seat for the manual rear outboard seat belts with and without retractors. For lap belts, the $22.80 figure was

[42] Since the weight and cost in Table 143 without retractors is the same for lap belts and 3-point belts and the weight and cost for lap belts with retractors is more than for lap/shoulder belts with retractors, we show no attributable weight or cost for rear outboard seat lap/shoulder belts in Table 169c, except for the weight and cost of retractors.

used through 1971, then the learning curve was applied to the $25.74 with a MY 1980 baseline for MYs 1972 to 1991. For lap/shoulder belts, the learning curve was applied to $25.53 with a MY 1990 baseline for MYs 1987 to 2019.

Table 143. FMVSS No. 208: Average weight and consumer cost per seat of rear outboard seat belts in LTVs

Belt Assemblies	Weight (lb)	Consumer Cost (2019$)
Without Retractors		
Lap Only (1968)	1.83	$22.80
3-Point Belt (1968)	1.83	$22.80
With Retractors		
Lap Only (1972-1989)	2.79	$25.74
3-Point Belt (1988 to 1992)	2.58	$25.53

Retractors were required in MY 1972 and were not installed in any rear outboard seats voluntarily in MY 1971. Thus, retractors are considered attributable to FMVSS No. 208. Before the learning curve was applied, the difference between 3-point rear outboard seat belts with retractors versus 3-point rear outboard seat belts without retractors are 0.75 lb (2.58 - 1.83) and $2.73 ($25.53 - $22.80) per seat.

Front Center Seat Belts. On September 30, 1970, (35 F.R., 1970), a final rule was published in the Federal Register extending FMVSS No. 208 (lap belts at all designated seating positions) to LTVs. The NPRM was published in the Federal Register on September 20, 1969, (34 FR 14660), making the baseline date September 1, 1969, or MY 1970 for lap belts. All LTVs had lap belts in the front center seat by MY 1970, if there was a seating position available, and all are considered voluntary.

We examined the owner's manual of the highest selling LTVs that have a front center seat position (MYs 2002 and 2018 Chevy Silverado, MY 2002 and 2016 Ford F-150, MYs 2002 and 2018 Ram 1500 crew cab, MY 2002 Chevy Suburban, and MY 2002 Ford Explorer) and none of them had a retractor for the airline-style lap belts. The front center seat in the Dodge Ram pickups (starting in MY 2002 for the Ram 1500, and in MY 2003 for the Ram 2500 and Ram 3500) through MY 2019 in only the regular cab pickups had a lap/shoulder belt with a retractor. This lap/shoulder belt has a mini-latch plate and buckle which allows the seat belt to detach from the lower anchor when the seat is folded. A lap belt without a retractor is provided in the crew cab, quad cab, and mega cab on Dodge Ram pickups. Thus, we assume that the front center seat in all LTVs, except the MY 2002 or MYs 2003 to 2019 Dodge Ram regular cabs, have an airline-style lap belt without a retractor.

The weight and cost per seat of front center seat lap belts for LTVs is taken from the estimates for passenger cars shown in Table 135. The $18.50 lap belt cost in MY 1980 was used in the respective learning curves. The weights used for the front center lap belts were 0.90 lb from MY 1968 to 1974, decreasing by 0.02 lb per year from MY 1975 to 1978, and then 0.79 lb for MY 1979 and thereafter.

The weight and cost per seat of front center seat lap/shoulder belts for LTVs is taken from the estimates for LTVs in the rear center seat including the structural changes as shown in Table 146. The $40.20 lap/shoulder belt cost in MY 2010 was used in the learning curve. The weights used for the front center lap/shoulder belt was 5.17 lb.

Table 144. FMVSS No. 208: Average weight and consumer cost per seat of front center seat belts in LTVs

Belt Assemblies	Weight (lb)	Consumer Cost (2019$)
Without Retractor		
Lap Only	Varies from 0.9 to 0.79	$18.50
With Retractor		
3-Point Belt	5.17	$40.20

Rear Center Seat Belts. On September 30, 1970, (35 F.R., 1970), a final rule was published in the Federal Register extending FMVSS No. 208 (lap belts at all designated seating positions) to LTVs. The NPRM was published in the Federal Register on September 20, 1969, (34 FR 14660), making the baseline date September 1, 1969, or MY 1970 for lap belts. All LTVs had lap belts in the rear center seat by MY 1970, if there was a seating position available, and all are considered voluntary.

We examined the owner's manual of many LTVs with a rear center seating position to determine whether any lap belts had a retractor. Since lap/shoulder belts were phased-in with MY 2006, we examined all minivans for MY 2002, and none had a retractor. We also examined the big pickups (Chevy Silverado, Ford F-150, Ram 1500) and several high selling SUVs and found four LTVs with a retractor in the rear center seat – all by Ford. The MY 2001 to 2003 F-150 had a retractor for the Supercrew cab, but not the Supercab. In all three of the Ford SUVs with a retractor in the rear center position, it was only provided in the second row, when the optional 8 passenger seating arrangement was selected. The Ford Explorer had a retractor with a lap belt only in MY 2002. The 60/40 seating had no retractor, but the 40-20-40 seating had a retractor in the center seating position of the second row. In MY 2003 the Ford Explorer had a lap/shoulder belt in the second-row center seats. The MYs 2000 to 2002 Ford Expedition and the MYs 2000 to 2004 Ford Excursion had a retractor in the center seating position of the second row only when there was a center seat in that second row. We examined our data and found that about 0.74 percent of all LTVs in MYs 2001 to 2003 are Ford Supercrew cabs. We do not know what percent of the MY 2002 Ford Explorer had 40-20-40 rear seats, or what percent of the MYs 2000 to 2002 Ford Expeditions or MYs 2000 to 2004 Ford Excursions were sold with 8 passenger seating. For this analysis, we assume that 10 percent of the sales of the SUVs in question had a retractor in the second-row center seating position. The following table shows the combined estimate of the number of LTVs with retractors in MYs 2000 to 2004. By MY 2005 these make/models either had lap/shoulder belts in the rear center seats or were no longer being sold.

Table 145. FMVSS No. 208: Percentages of LTVs with retractors in the rear center seating position MYs 2000 to 2004

Model Year	Retractors in Rear Center Seats	Total LTV Sales	Percent with Retractors in Rear Center Seat
2000	26,427	8,503,130	0.31
2001	80,371	7,888,196	1.02
2002	113,902	9,183,112	1.46
2003	73,948	9,692,451	0.76
2004	2,077	9,540,045	0.02

The latest cost teardown study for a center rear seat lap belt without a retractor is shown in Table 146. The $10.86 (2019$) cost for MY 2003 is used in the learning curve. We have no examples where we had a cost teardown study including a center seat lap belt with a retractor for weight and costs. Thus, we estimated the weight and cost added of having retractors in the rear center seat, by using the weight and cost of rear outboard retractors. Table 134 shows an increase for a retractor of 0.9 lb (2.73 - 1.83) and $2.94 ($25.74 - $22.80). When these differences are multiplied times the percent with retractors in the table above, the result is small – 0.0 to 0.01 lb and a rounded $0.01 to $0.04. These weights and costs were added to Table 162d.

On December 8, 2004, (69 FR 70904), in response to Anton's Law, signed on December 4, 2002, the agency published a final rule mandating lap/shoulder belts for all forward-facing rear seating positions, including center seats, and all rear facing seating positions (the back of the station wagon style), in all motor vehicles with GVWR of less than 10,000 lb (all passenger cars and LTVs). The NPRM was published in the Federal Register on August 6, 2003, (68 FR 46546), making the baseline date September 1, 2002, or MY 2003.

The phase-in effective dates were:

- 50 percent of all vehicles manufactured from September 1, 2005, to August 31, 2006;
- 80 percent of all vehicles manufactured from September 1, 2006, to August 31, 2007; and
- 100 percent of all vehicles manufactured on or after September 1, 2007, must comply.

In 1998, manufacturers began voluntarily installing lap/shoulder belts in the rear center seating position of LTVs. By MY 2003, the baseline year, 51.75 percent of LTVs had rear center lap/shoulder belts. All 3-point belts in the rear center seats of LTVs are considered voluntary through MY 2003 and the voluntary percentage (51.75%) is held at that MY 2003 baseline level through MY 2019. Attributable costs include the difference in costs between lap/shoulder belts and lap belts times the installation rates for MYs 2004 to 2019 minus the voluntary baseline level of MY 2003.

As with passenger cars and as found in our owner's manual search, we found that all rear center lap/shoulder systems in LTVs have retractors.

There is a cost teardown analysis of two lap belts and two lap/shoulder belts for the rear center seat of LTVs (FEV North America, Inc., 2016). Table 146 shows the results. There are two important notes relating to this cost teardown analysis. The back seat frame was changed significantly between the 2004 Hyundai Sante Fe and 2007 Hyundai Sante Fe. As a result, the full back seat frame was weighed and costed out in the analysis. What is shown in Table 146 is the incremental weight (2.95 lb) and cost ($0.00 is shown because the 2007 seat frame cost less than the 2004 seat frame). While there is some difference in the weight and cost of a lap/shoulder belt compared to a lap belt, the largest difference in weight and cost comes from adding a retractor for the lap/shoulder belt.

Table 146. FMVSS No. 208: Lap and lap/shoulder belts in the rear center seat – LTVs

	Belt		**Incremental Structure**		**Total**	
	Weight	**Cost**	**Weight**	**Cost**	**Weight**	**Cost**
Lap Belt – No Retractor						
2003 Ford F-150	0.94	$10.34	0.00	$0.00	0.94	$10.34
2004 Hyundai Sante Fe	0.83	$11.38	0.00	$0.00	0.83	$11.38
Average	0.89	$10.86	0.00	$0.00	0.89	$10.86
Lap/Shoulder Belt – Retractor						
2014 Ford F-150	1.98	$22.79	3.20	$14.81	5.18	$37.59
2007 Hyundai Sante Fe	2.21	$42.80	2.95	$0.00	5.17	$42.80
Average	2.10	$32.79	3.08	$7.40	5.17	$40.20

The consumer cost estimate of rear center 3-point seat belts of 5.17 lb and $40.20 in 2019 dollars is shown in Table 146. The $40.20 cost estimate was based on average MY 2010 vehicles and learning was applied from MY 1998 to 2019.

Summary Calculations for Seat Belts. The total weight and consumer cost of seat belt assemblies and anchorages for MYs 1968 to 2019 were calculated. The starting point for the calculations is the number of seating positions in the average passenger car and LTV by type of position (front outboard, front center, rear outboard, rear center). The rear outboard seats and rear center seats include the second row, the third row, and in some full-size vans the fourth and fifth row. All these rear seating positions are averaged and combined into the rear outboard or rear center position. For example in MY 2005, every passenger car had 2 front outboard seats, 11.49 percent of cars had a front center seat (0.1149 seats in the calculations), the average car had 1.96 rear outboard seats (i.e., 98% of cars have 2 rear outboard seats and 2% of cars did not have a back seat) and 91.8 percent of passenger cars had a rear center seat (0.918 in the calculations). No MY 2005 passenger car had a third row of forward-facing seats. However, a small proportion of cars still had rear-facing third row seats (Taurus, Sable, and Mercedes E wagons) amounting to only 0.0019 seats per car, which were added into the rear center seat position making it total 0.919. The numbers are different for MY 2010. Every MY 2010 passenger car had 2 front outboard seats, but the front center seat was available in only 1.12 percent of cars (0.0112 seats in the calculations), the average car had 1.99 rear outboard seats (i.e., 99.28% of cars had 2 rear outboard seats and 0.72% of cars did not have a back seat) and 92.7 percent of passenger cars had a rear center seat (0.927 in the calculations). No MY 2010 passenger car had a third row of forward-facing seats and no models still had the rear-facing third row seats. For MY 2019, no passenger car had front center seats, 98.7 percent of passenger cars had 2 rear outboard seats and 93.0 percent had a rear center seat.

The arithmetic is slightly more complicated for LTVs. For example in MY 2005, every LTV had 2 front outboard seats, 32.70 percent of LTVs had a front center seat (0.3270 in the calculations), the average LTV had 2.32 rear outboard seats (including the second, third, fourth, and fifth rows), and the average MY 2005 LTV had 0.9372 rear center seats (including the second, third, fourth, and fifth rows). For MY 2010, every LTV had 2 front outboard seats, 24.88 percent of LTVs had a front center seat, the average LTV had 2.34 rear outboard seats (including the second, third, fourth, and fifth rows), and the average MY 2010 LTV had 0.9718 rear center seats (including the second, third, fourth, and fifth rows). For MY 2019, 4.8 percent had a front center seat, the average LTV had 2.424 rear outboard seats (including the second, third, fourth, and fifth rows), and the average MY 2019 LTV had 0.992 rear center seats (including the second, third, fourth, and fifth rows).

Data was collected on the number of seating positions per average LTV and passenger car from the following sources. The MYs were divided into seven groups, i.e., 1966 to 1976, 1977 to 1984, 1985 to 1994, 1995 to 2002, 2003 to 2007, 2008 to 2012, and 2013 to 2019.

1. *1966 to 1976* – National Crash Severity Study, which was a 1976 to 1978 predecessor of the National Automotive Sampling System file. NCSS had a variable indicating how many seats were in the vehicle.
2. *1977 to 1984* – NASS file. In 1982 to 1986, NASS had a variable indicating how many seats were in a car.
3. *1985 to 1994* – 1990 Polk registration file (Polk & Co., n.d.) and *Branham Automobile Reference Book* (Branham, 1985-2001). The Polk file provides the sales figures of all 1990 passenger vehicles broken out by make and model, while the Branham book identifies the number of seating positions in each of the 1990 make-models. The sales figures for each seating position are divided by the overall sales figures to determine the percent market share per position.
4. *1995 to 2002* – 1999 Polk registration file (Polk & Co., n.d.) and *Branham Automobile Reference Book*. We assume that the distribution of belts by seating position for 1999 is a proxy measure for 1995 to 2002.
5. *2003 to 2007* – MY 2005 data collected from cars.com and meshed with Polk registrations for 2005. We assume that the distribution of belts by seating position for MY 2005 is a proxy measure for MY 2003 to 2007.
6. *2008 to 2012* – MY 2010 data collected from cars.com and meshed with Polk registrations for 2010. We assume that the distribution of belts by seating position for MY 2010 is a proxy measure for MY 2008 to 2012.

7. *2013 to 2019* – MY 2016, 2018, and 2019 data were collected from Edmunds.com or the internet while collecting data on head restraints and sales weighted by sales data from the Ward's yearbook (Binder, 2002-2017; Norris, 2018-2020). We assume that the distribution of belts by seating position for MY 2013 to 2015 is interpolated from estimates for MYs 2012 and 2016. Similarly, MY 2017 data is assumed to be midway between the MY 2016 and 2018 data.

The second step in the calculations is to determine the type of seat belt (lap belt, lap/shoulder belt, or automatic belt) used in each seating position for each MY for the average passenger car and LTV. These data were taken from the Kahane (2015) report *Lives Saved by Vehicle Safety Technologies and Associated Federal Motor Vehicle Safety Standards, 1960 to 2012* and updated for MY 2013-2019.

A third step in the calculations, used as supplemental information for the front center seat of passenger cars and LTVs, was an examination of the NASS crashworthiness data system and CISS from MY 1960 to 2019 to determine the percent of the fleet with 2 or 3 front seating positions. Those with 2 front seating positions were assumed to be bucket seats and those with 3 front seating positions were assumed to be bench seats. One problem with this analysis is that crashworthiness data system and CISS sampling frames only collect seating positions on towed vehicles. Since larger vehicles are towed away less often in crashes than smaller vehicles, and larger vehicles more often have 3 front seating positions, this will lead to a reporting bias that reduces the estimates of the percent of the fleet with 3 front seating positions. It is unknown how much this bias affects the results but given that the average costs and weights for the front center seat are a decreasing proportion (5.6% in MY 1968 decreasing to 0.07% in MY 2021 for LTVs) of overall costs and weights, the impact of the bias will be negligible to the final results. Interestingly, the proportion of passenger cars with 3 front seats found in NCSS and NASS for MY 1960 to 1976 were the same (47%).

Since weights and costs are different between lap and lap/shoulder belts, and front seats and rear seats, and outboard versus center seats, the seat belts were divided into the following groups for analysis. No tables are shown for lap/shoulder belts at the front center seat position for passenger cars (since there were never any lap/shoulder belts in the front center seat of passenger cars.

- Lap belts, front seat outboard (see Tables 147a, 148b, 149c, and 150d)
- Lap belts, front seat center (see Tables 151a, 152b, 153c, and 154d)
- Lap belts, rear seat outboard (see Tables 155a, 156b, 157c, and 158d)
- Lap belts, rear seat center (see Tables 159a, 160b, 161c, and 162d)
- Lap/shoulder belts, front seat outboard (see Tables 163a, 164b, 165c, and 166d)
- Lap/shoulder belts, front seat center (see Tables 167a, 168b, and 169c)
- Lap/shoulder belts, rear seat outboard (see Tables 170a, 171b, 172c, and 173d)
- Lap/shoulder belts, rear seat center (see Tables 174a, 175b, 176c, and 177d)
- Automatic belts, front seat outboard (see Tables 178a and 179b)

The third step is to apply the learning curve to each group analyzed.

The fourth step is to multiply the number of average seating positions per vehicle, times the percent of the new vehicle fleet that had lap or lap/shoulder belts, times the learning curve cost in that MY to determine the cost per MY. These were each done separately for passenger cars and LTVs because some of the costs per seat belt type are different.

The fifth step is to consider the baseline and determine voluntary and attributable weights and costs.

In the tables below the "a" Tables (like Table 147a) show the number of seats and the percentage of the fleet where the belt was installed (passenger cars and LTVs). The "b" tables (like 148b) show the weight and consumer cost (passenger cars and LTVs). The "c" tables (like 149c) show the distribution between voluntary and attributable weights and costs for passenger cars. The "d" tables (like 150d) show the distribution between voluntary and attributable weights and costs for LTVs. (Note that we previously calculated that 35% of passenger car and 20% of LTV installations of lap belts for the front outboard seats only were voluntary, based on 1961 installation rates.) Average costs are costs (in most cases after applying the learning curve) multiplied by the number of seats and multiplied by the percent of the vehicles equipped. The average weight per vehicle also has three factors: weight of the technology * number of seats * percent equipped.

Table 147a. FMVSS No. 208: Average number of seating positions and percentages of fleet equipped with manual lap belts in front outboard seats

Model Year	PC	LTV	PC	LTV
	Number of Seats	**Number of Seats**	**Percent Equipped**	**Percent Equipped**
1968	2	2	12.5	100
1969	2	2	0	97.19
1970	2	2	0	96.79
1971	2	2	0	96.17
1972	2	2	0	94.49
1973	2	2	0	94.6
1974	2	2	0	59.52
1975	2	2	0	56.48
1976	2	2	0	55.28
1977	2	2	0	15.67
1978	2	2	0	14.93
1979	2	2	0	15.95
1980	2	2	0	5.72
1981	2	2	0	0

Table 148b. FMVSS No. 208: Weights and consumer costs for manual lap belts in front outboard seats

Model Year	PC Cost per Belt	PC Ave. Cost Per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost Per Veh.	LTV Ave. Weight
1968	$29.09	$7.27	0.60	$28.65	$57.30	4.50
1969	$29.09	$0.00	0	$28.65	$55.69	4.37
1970	$29.09	$0.00	0	$28.65	$55.46	4.36
1971	$29.09	$0.00	0	$28.65	$55.11	4.33
1972	$43.07	$0.00	0	$46.49	$87.86	8.49
1973	$43.07	$0.00	0	$46.38	$87.75	8.50
1974	$0.00	$0.00	0	$46.32	$55.14	5.34
1975	$0.00	$0.00	0	$46.26	$52.26	5.07
1976	$0.00	$0.00	0	$46.20	$51.08	4.96
1977	$0.00	$0.00	0	$46.18	$14.47	1.41
1978	$0.00	$0.00	0	$46.16	$13.78	1.34
1979	$0.00	$0.00	0	$46.14	$14.72	1.43
1980	$0.00	$0.00	0	$46.13	$5.28	0.51
1981	$0.00	$0.00	0	$46.13	$0.00	0

Table 149c. FMVSS No. 208: Weights and consumer costs for manual lap belts in front outboard seats – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.21	0.39	0.60	$2.55	$4.73	$7.27
1969	0	0	0	$0.00	$0.00	$0.00

Table 150d. FMVSS No. 208: Weights and consumer costs for manual lap belts in front outboard seats – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.90	3.60	4.50	$11.46	$45.84	$57.30
1969	0.87	3.50	4.37	$11.14	$44.55	$55.69
1970	0.87	3.48	4.36	$11.09	$44.37	$55.46
1971	0.87	3.46	4.33	$11.02	$44.08	$55.11
1972	0.85	7.63	8.49	$10.85	$77.00	$87.86
1973	0.85	7.64	8.50	$10.84	$76.91	$87.75
1974	0.54	4.81	5.34	$6.81	$48.32	$55.14
1975	0.51	4.56	5.07	$6.46	$45.80	$52.26
1976	0.50	4.47	4.96	$6.31	$44.77	$51.08
1977	0.14	1.27	1.41	$1.79	$12.68	$14.47
1978	0.13	1.21	1.34	$1.70	$12.08	$13.78
1979	0.14	1.29	1.43	$1.82	$12.90	$14.72
1980	0.05	0.46	0.51	$0.65	$4.63	$5.28
1981	0.00	0.00	0.00	$0.00	$0.00	$0.00

Table 151a. FMVSS No. 208: Average number of seating positions and percentages of fleet equipped with manual lap belts in front center seats

Model Year	PC Number of Seats	LTV Number of Seats	PC Percent Equipped	LTV Percent Equipped
1968	0.47	0.799	100	100
1969	0.47	0.799	100	100
1970	0.47	0.799	100	100
1971	0.47	0.799	100	100
1972	0.47	0.799	100	100
1973	0.47	0.799	100	100
1974	0.47	0.799	100	100
1975	0.47	0.799	100	100

Model Year	PC Number of Seats	LTV Number of Seats	PC Percent Equipped	LTV Percent Equipped
1976	0.47	0.799	100	100
1977	0.579	0.753	100	100
1978	0.579	0.753	100	100
1979	0.579	0.753	100	100
1980	0.579	0.753	100	100
1981	0.579	0.753	100	100
1982	0.373	0.581	100	100
1983	0.373	0.581	100	100
1984	0.373	0.581	100	100
1985	0.373	0.581	100	100
1986	0.373	0.581	100	100
1987	0.253	0.477	100	100
1988	0.25	0.477	100	100
1989	0.2	0.477	100	100
1990	0.17	0.477	100	100
1991	0.14	0.37	100	100
1992	0.12	0.35	100	100
1993	0.12	0.33	100	100
1994	0.1	0.3	100	100
1995	0.08	0.29	100	100
1996	0.07	0.32	100	100
1997	0.06	0.27	100	100
1998	0.06	0.25	100	100
1999	0.06	0.23	100	100
2000	0.06	0.22	100	100
2001	0.05	0.2	100	100
2002	0.03	0.17	100	99.61
2003	0.02	0.16	100	99.54
2004	0.02	0.14	100	99.57

Model Year	PC Number of Seats	LTV Number of Seats	PC Percent Equipped	LTV Percent Equipped
2005	0.01	0.15	100	99.60
2006	0.01	0.14	100	99.75
2007	0.01	0.15	100	99.78
2008	0.01	0.11	100	99.75
2009	0.00	0.11	100	99.85
2010	0.00	0.11	100	99.87
2011	0.00	0.10	100	99.87
2012	0.00	0.10	100	99.73
2013	0.00	0.10	0	99.82
2014	0.00	0.09	0	99.77
2015	0.00	0.09	0	99.89
2016	0.00	0.09	0	99.91
2017	0.00	0.09	0	99.91
2018	0.00	0.09	0	99.92
2019	0.00	0.09	0	99.79

Table 152b. FMVSS No. 208: Weights and consumer costs for manual lap belts in front center seat

Model Year	PC Cost per Belt	PC Ave. Cost Per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost Per Veh.	LTV Ave. Weight
1968	$20.43	$9.60	0.42	$20.32	$11.38	0.50
1969	$20.11	$9.45	0.42	$20.00	$11.20	0.50
1970	$19.89	$9.35	0.42	$19.79	$11.08	0.50
1971	$19.67	$9.25	0.42	$19.58	$10.97	0.50
1972	$19.48	$9.16	0.42	$19.40	$10.86	0.50
1973	$19.30	$9.07	0.42	$19.22	$10.77	0.50
1974	$19.17	$9.01	0.42	$19.10	$10.70	0.50
1975	$19.06	$8.96	0.41	$19.00	$10.64	0.49

Model Year	PC Cost per Belt	PC Ave. Cost Per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost Per Veh.	LTV Ave. Weight
1976	$18.94	$8.90	0.40	$18.88	$10.57	0.48
1977	$18.81	$10.89	0.49	$18.77	$11.45	0.51
1978	$18.68	$10.82	0.47	$18.66	$11.38	0.50
1979	$18.58	$10.76	0.46	$18.57	$11.33	0.48
1980	$18.50	$10.71	0.46	$18.50	$11.29	0.48
1981	$18.44	$10.68	0.46	$18.44	$11.25	0.48
1982	$18.40	$6.86	0.29	$18.39	$11.22	0.48
1983	$18.35	$6.84	0.29	$18.33	$11.18	0.48
1984	$18.29	$6.82	0.29	$18.26	$11.14	0.48
1985	$18.24	$6.80	0.29	$18.19	$11.10	0.48
1986	$18.18	$6.78	0.29	$18.13	$11.06	0.48
1987	$18.14	$4.59	0.20	$18.07	$12.47	0.55
1988	$18.11	$4.58	0.20	$18.01	$12.43	0.55
1989	$18.08	$4.57	0.16	$17.96	$12.39	0.55
1990	$18.04	$4.57	0.13	$17.92	$12.36	0.55
1991	$18.02	$4.56	0.11	$17.88	$12.33	0.55
1992	$18.00	$4.50	0.09	$17.84	$12.31	0.55
1993	$17.98	$3.60	0.09	$17.80	$12.28	0.55
1994	$17.96	$3.05	0.08	$17.75	$12.25	0.55
1995	$17.94	$2.51	0.06	$17.72	$12.05	0.54
1996	$17.92	$2.15	0.06	$17.68	$12.02	0.54
1997	$17.90	$2.15	0.05	$17.64	$11.99	0.54
1998	$17.89	$1.79	0.05	$17.60	$11.97	0.54
1999	$17.87	$1.43	0.05	$17.56	$11.94	0.54
2000	$17.86	$1.25	0.05	$17.52	$11.92	0.54
2001	$17.85	$1.07	0.04	$17.49	$11.89	0.54
2002	$17.84	$1.07	0.02	$17.45	$11.82	0.54
2003	$17.83	$1.07	0.02	$17.42	$5.67	0.26
2004	$17.82	$1.07	0.02	$17.39	$5.66	0.26

Model Year	PC Cost per Belt	PC Ave. Cost Per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost Per Veh.	LTV Ave. Weight
2005	$17.81	$0.89	0.01	$17.36	$5.65	0.26
2006	$17.80	$0.53	0.01	$17.33	$5.65	0.26
2007	$17.79	$0.36	0.01	$17.30	$5.64	0.26
2008	$17.79	$0.36	0.01	$17.28	$4.29	0.20
2009	$17.78	$0.18	0.00	$17.26	$4.29	0.20
2010	$17.78	$0.18	0.00	$17.24	$4.28	0.20
2011	$17.77	$0.18	0.00	$17.22	$4.28	0.20
2012	$17.77	$0.18	0.00	$17.20	$4.27	0.20
2013	$0.00	$0.00	0.00	$17.19	$3.91	0.18
2014	$0.00	$0.00	0.00	$17.17	$3.91	0.18
2015	$0.00	$0.00	0.00	$17.15	$3.91	0.18
2016	$0.00	$0.00	0.00	$17.14	$0.92	0.04
2017	$0.00	$0.00	0.00	$17.12	$0.87	0.04
2018	$0.00	$0.00	0.00	$17.11	$0.82	0.04
2019	$0.00	$0.00	0.00	$17.09	$0.82	0.04

Table 153c. FMVSS No. 208: Weights and consumer costs for manual lap belts in front center seats – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.42	0.00	0.42	$9.60	$0.00	$9.60
1969	0.42	0.00	0.42	$9.45	$0.00	$9.45
1970	0.42	0.00	0.42	$9.35	$0.00	$9.35
1971	0.42	0.00	0.42	$9.25	$0.00	$9.25
1972	0.42	0.00	0.42	$9.16	$0.00	$9.16
1973	0.42	0.00	0.42	$9.07	$0.00	$9.07
1974	0.42	0.00	0.42	$9.01	$0.00	$9.01
1975	0.41	0.00	0.41	$8.96	$0.00	$8.96
1976	0.40	0.00	0.40	$8.90	$0.00	$8.90

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1977	0.49	0.00	0.49	$10.89	$0.00	$10.89
1978	0.47	0.00	0.47	$10.82	$0.00	$10.82
1979	0.46	0.00	0.46	$10.76	$0.00	$10.76
1980	0.46	0.00	0.46	$10.71	$0.00	$10.71
1981	0.46	0.00	0.46	$10.68	$0.00	$10.68
1982	0.29	0.00	0.29	$6.86	$0.00	$6.86
1983	0.29	0.00	0.29	$6.84	$0.00	$6.84
1984	0.29	0.00	0.29	$6.82	$0.00	$6.82
1985	0.29	0.00	0.29	$6.80	$0.00	$6.80
1986	0.29	0.00	0.29	$6.78	$0.00	$6.78
1987	0.20	0.00	0.20	$4.59	$0.00	$4.59
1988	0.20	0.00	0.20	$4.58	$0.00	$4.58
1989	0.16	0.00	0.16	$4.57	$0.00	$4.57
1990	0.13	0.00	0.13	$4.57	$0.00	$4.57
1991	0.11	0.00	0.11	$4.56	$0.00	$4.56
1992	0.09	0.00	0.09	$4.50	$0.00	$4.50
1993	0.09	0.00	0.09	$3.60	$0.00	$3.60
1994	0.08	0.00	0.08	$3.05	$0.00	$3.05
1995	0.06	0.00	0.06	$2.51	$0.00	$2.51
1996	0.06	0.00	0.06	$2.15	$0.00	$2.15
1997	0.05	0.00	0.05	$2.15	$0.00	$2.15
1998	0.05	0.00	0.05	$1.79	$0.00	$1.79
1999	0.05	0.00	0.05	$1.43	$0.00	$1.43
2000	0.05	0.00	0.05	$1.25	$0.00	$1.25
2001	0.04	0.00	0.04	$1.07	$0.00	$1.07
2002	0.02	0.00	0.02	$1.07	$0.00	$1.07
2003	0.02	0.00	0.02	$1.07	$0.00	$1.07
2004	0.02	0.00	0.02	$1.07	$0.00	$1.07
2005	0.01	0.00	0.01	$0.89	$0.00	$0.89

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2006	0.01	0.00	0.01	$0.53	$0.00	$0.53
2007	0.01	0.00	0.01	$0.36	$0.00	$0.36
2008	0.01	0.00	0.01	$0.36	$0.00	$0.36
2009	0.00	0.00	0.00	$0.18	$0.00	$0.18
2010	0.00	0.00	0.00	$0.18	$0.00	$0.18
2011	0.00	0.00	0.00	$0.18	$0.00	$0.18
2012	0.00	0.00	0.00	$0.18	$0.00	$0.18
2013 - 2019	0.00	0.00	0.00	$0.00	$0.00	$0.00

Table 154d. FMVSS No. 208: Weights and consumer costs for manual lap belts in front center seats – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.72	0.00	0.72	$16.33	$0.00	$16.33
1969	0.72	0.00	0.72	$16.07	$0.00	$16.07
1970	0.72	0.00	0.72	$15.89	$0.00	$15.89
1971	0.72	0.00	0.72	$15.72	$0.00	$15.72
1972	0.72	0.00	0.72	$15.57	$0.00	$15.57
1973	0.72	0.00	0.72	$15.42	$0.00	$15.42
1974	0.72	0.00	0.72	$15.32	$0.00	$15.32
1975	0.70	0.00	0.70	$15.23	$0.00	$15.23
1976	0.69	0.00	0.69	$15.13	$0.00	$15.13
1977	0.63	0.00	0.63	$14.16	$0.00	$14.16
1978	0.62	0.00	0.62	$14.07	$0.00	$14.07
1979	0.59	0.00	0.59	$13.99	$0.00	$13.99
1980	0.59	0.00	0.59	$13.93	$0.00	$13.93
1981	0.46	0.00	0.46	$13.88	$0.00	$13.88
1982	0.46	0.00	0.46	$10.69	$0.00	$10.69
1983	0.46	0.00	0.46	$10.66	$0.00	$10.66

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1984	0.46	0.00	0.46	$10.63	$0.00	$10.63
1985	0.46	0.00	0.46	$10.60	$0.00	$10.60
1986	0.46	0.00	0.46	$10.56	$0.00	$10.56
1987	0.38	0.00	0.38	$8.66	$0.00	$8.66
1988	0.38	0.00	0.38	$8.64	$0.00	$8.64
1989	0.38	0.00	0.38	$8.62	$0.00	$8.62
1990	0.38	0.00	0.38	$8.61	$0.00	$8.61
1991	0.29	0.00	0.29	$6.67	$0.00	$6.67
1992	0.28	0.00	0.28	$6.30	$0.00	$6.30
1993	0.26	0.00	0.26	$5.93	$0.00	$5.93
1994	0.24	0.00	0.24	$5.39	$0.00	$5.39
1995	0.23	0.00	0.23	$5.20	$0.00	$5.20
1996	0.25	0.00	0.25	$5.73	$0.00	$5.73
1997	0.21	0.00	0.21	$4.83	$0.00	$4.83
1998	0.20	0.00	0.20	$4.47	$0.00	$4.47
1999	0.18	0.00	0.18	$4.11	$0.00	$4.11
2000	0.17	0.00	0.17	$3.93	$0.00	$3.93
2001	0.16	0.00	0.16	$3.57	$0.00	$3.57
2002	0.13	0.00	0.13	$3.02	$0.00	$3.02
2003	0.13	0.00	0.13	$2.84	$0.00	$2.84
2004	0.11	0.00	0.11	$2.48	$0.00	$2.48
2005	0.12	0.00	0.12	$2.66	$0.00	$2.66
2006	0.11	0.00	0.11	$2.49	$0.00	$2.49
2007	0.12	0.00	0.12	$2.66	$0.00	$2.66
2008	0.09	0.00	0.09	$1.95	$0.00	$1.95
2009	0.09	0.00	0.09	$1.95	$0.00	$1.95
2010	0.09	0.00	0.09	$1.95	$0.00	$1.95
2011	0.08	0.00	0.08	$1.78	$0.00	$1.78
2012	0.08	0.00	0.08	$1.77	$0.00	$1.77

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2013	0.08	0.00	0.08	$1.77	$0.00	$1.77
2014	0.07	0.00	0.07	$1.59	$0.00	$1.59
2015	0.07	0.00	0.07	$1.60	$0.00	$1.60
2016	0.07	0.00	0.07	$1.60	$0.00	$1.60
2017	0.07	0.00	0.07	$1.60	$0.00	$1.60
2018	0.07	0.00	0.07	$1.60	$0.00	$1.60
2019	0.07	0.00	0.07	$1.59	$0.00	$1.59

Table 155a. FMVSS No. 208: Average number of seating positions and percentages of fleet equipped with manual lap belts in rear outboard seats

Model Year	PC	LTV	PC	LTV
	Number of Seats	Number of Seats	Percent Equipped	Percent Equipped
1968	1.98	0.39	100	100
1969	1.98	0.39	100	100
1970	1.98	0.39	100	100
1971	1.98	0.39	99.55	100
1972	1.98	0.39	99.62	100
1973	1.98	0.39	99.65	100
1974	1.98	0.39	99.39	100
1975	1.98	0.39	99.04	100
1976	1.98	0.39	99.29	100
1977	1.96	0.83	99.46	100
1978	1.96	0.83	99.39	100
1979	1.96	0.83	99.36	100
1980	1.96	0.83	99.26	100
1981	1.96	0.83	98.29	100
1982	1.96	0.83	95.92	100
1983	1.96	0.83	94.18	100

Model Year	PC	LTV	PC	LTV
	Number of Seats	Number of Seats	Percent Equipped	Percent Equipped
1984	1.96	0.83	94.45	100
1985	1.96	0.83	94.25	100
1986	1.96	0.83	93.14	100
1987	1.96	1.31	90.38	99.71
1988	1.96	1.31	69.33	97.16
1989	1.96	1.31	32.33	83.2
1990	1.96	1.31	0	79.99
1991	1.96	1.31	0	67.75
1992	1.96	1.31	0	0

Table 156b. FMVSS No. 208: Weights and consumer costs for manual lap belts in rear outboard seats

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
1968	$22.80	$45.15	3.62	$22.80	$8.89	0.71
1969	$22.80	$45.15	3.62	$22.80	$8.89	0.71
1970	$22.80	$45.15	3.62	$22.80	$8.89	0.71
1971	$22.80	$44.94	3.61	$22.80	$8.89	0.71
1972	$26.89	$53.03	5.50	$26.94	$10.51	1.09
1973	$26.67	$52.62	5.50	$26.71	$10.42	1.09
1974	$26.52	$52.18	5.49	$26.55	$10.35	1.09
1975	$26.38	$51.74	5.47	$26.41	$10.30	1.09
1976	$26.24	$51.59	5.48	$26.25	$10.24	1.09
1977	$26.09	$50.86	5.44	$26.10	$21.66	2.32
1978	$25.95	$50.55	5.44	$25.95	$21.54	2.32
1979	$25.83	$50.31	5.43	$25.83	$21.44	2.32
1980	$25.74	$50.08	5.43	$25.74	$21.36	2.32
1981	$25.66	$49.43	5.37	$25.66	$21.30	2.32

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
1982	$25.59	$48.10	5.25	$25.59	$21.24	2.32
1983	$25.51	$47.09	5.15	$25.51	$21.17	2.32
1984	$25.42	$47.07	5.16	$25.42	$21.10	2.32
1985	$25.34	$46.81	5.15	$25.33	$21.02	2.32
1986	$25.25	$46.10	5.09	$25.24	$20.95	2.32
1987	$25.18	$44.60	4.94	$25.16	$32.86	3.64
1988	$25.12	$34.13	3.79	$25.10	$31.94	3.55
1989	$25.08	$15.89	1.77	$25.06	$27.32	3.04
1990	$25.07	$0.00	0	$25.05	$26.24	2.92
1991	$0.00	$0.00	0	$25.03	$22.22	2.48
1992	$0.00	$0.00	0	$25.03	$0.00	0

Table 157c. FMVSS No. 208: Weights and consumer costs for manual lap belts in rear outboard seats – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	3.62	0.00	3.62	$45.15	$0.00	$45.15
1969	3.62	0.00	3.62	$45.15	$0.00	$45.15
1970	3.62	0.00	3.62	$45.15	$0.00	$45.15
1971	3.61	0.00	3.61	$44.94	$0.00	$44.94
1972	5.50	0.00	5.50	$53.03	$0.00	$53.03
1973	5.50	0.00	5.50	$52.62	$0.00	$52.62
1974	5.49	0.00	5.49	$52.18	$0.00	$52.18
1975	5.47	0.00	5.47	$51.74	$0.00	$51.74
1976	5.48	0.00	5.48	$51.59	$0.00	$51.59
1977	5.44	0.00	5.44	$50.86	$0.00	$50.86
1978	5.44	0.00	5.44	$50.55	$0.00	$50.55
1979	5.43	0.00	5.43	$50.31	$0.00	$50.31
1980	5.43	0.00	5.43	$50.08	$0.00	$50.08

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1981	5.37	0.00	5.37	$49.43	$0.00	$49.43
1982	5.25	0.00	5.25	$48.10	$0.00	$48.10
1983	5.15	0.00	5.15	$47.09	$0.00	$47.09
1984	5.16	0.00	5.16	$47.07	$0.00	$47.07
1985	5.15	0.00	5.15	$46.81	$0.00	$46.81
1986	5.09	0.00	5.09	$46.10	$0.00	$46.10
1987	4.94	0.00	4.94	$44.60	$0.00	$44.60
1988	3.79	0.00	3.79	$34.13	$0.00	$34.13
1989	1.77	0.00	1.77	$15.89	$0.00	$15.89
1990	0.00	0.00	0.00	$0.00	$0.00	$0.00

Table 158d. FMVSS No. 208: Weights and consumer costs for manual lap belts in rear outboard seats – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.71	0.00	0.71	$8.89	$0.00	$8.89
1969	0.71	0.00	0.71	$8.89	$0.00	$8.89
1970	0.71	0.00	0.71	$8.89	$0.00	$8.89
1971	0.71	0.00	0.71	$8.89	$0.00	$8.89
1972	1.09	0.00	1.09	$10.49	$0.00	$10.49
1973	1.09	0.00	1.09	$10.40	$0.00	$10.40
1974	1.09	0.00	1.09	$10.34	$0.00	$10.34
1975	1.09	0.00	1.09	$10.29	$0.00	$10.29
1976	1.09	0.00	1.09	$10.23	$0.00	$10.23
1977	2.32	0.00	2.32	$21.66	$0.00	$21.66
1978	2.32	0.00	2.32	$21.54	$0.00	$21.54
1979	2.32	0.00	2.32	$21.44	$0.00	$21.44
1980	2.32	0.00	2.32	$21.36	$0.00	$21.36
1981	2.32	0.00	2.32	$21.30	$0.00	$21.30
1982	2.32	0.00	2.32	$21.24	$0.00	$21.24

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1983	2.32	0.00	2.32	$21.17	$0.00	$21.17
1984	2.32	0.00	2.32	$21.10	$0.00	$21.10
1985	2.32	0.00	2.32	$21.03	$0.00	$21.03
1986	2.32	0.00	2.32	$20.96	$0.00	$20.96
1987	3.64	0.00	3.64	$32.89	$0.00	$32.89
1988	3.55	0.00	3.55	$31.97	$0.00	$31.97
1989	3.04	0.00	3.04	$27.34	$0.00	$27.34
1990	2.92	0.00	2.92	$26.27	$0.00	$26.27
1991	2.48	0.00	2.48	$22.24	$0.00	$22.24
1992	0.00	0.00	0.00	$0.00	$0.00	$0.00

Table 159a. FMVSS No. 208: Average number of seating positions and percentages of fleet equipped with manual lap belts in rear center seats

Model Year	PC	LTV	PC	LTV
	Number of Seats	Number of Seats	Percent Equipped	Percent Equipped
1968	0.62	0.09	100	100
1969	0.62	0.09	100	100
1970	0.62	0.09	100	100
1971	0.62	0.09	100	100
1972	0.62	0.09	100	100
1973	0.62	0.09	100	100
1974	0.62	0.09	100	100
1975	0.62	0.09	100	100
1976	0.62	0.09	100	100
1977	0.62	0.14	100	100
1978	0.62	0.14	100	100
1979	0.62	0.14	100	100
1980	0.62	0.14	100	100
1981	0.62	0.14	100	100

Model Year	PC	LTV	PC	LTV
	Number of Seats	Number of Seats	Percent Equipped	Percent Equipped
1982	0.62	0.14	100	100
1983	0.62	0.14	100	100
1984	0.62	0.14	100	100
1985	0.62	0.14	100	100
1986	0.62	0.14	100	100
1987	0.86	0.26	100	100
1988	0.86	0.26	100	100
1989	0.86	0.26	100	100
1990	0.86	0.26	100	100
1991	0.86	0.26	100	100
1992	0.86	0.26	100	100
1993	0.86	0.26	100	100
1994	0.86	0.26	99.51	100
1995	0.90	0.70	99.44	100
1996	0.90	0.70	98.32	100
1997	0.90	0.70	88.40	100
1998	0.90	0.70	73.37	99.77
1999	0.90	0.70	69.14	98.83
2000	0.90	0.70	57.00	97.78
2001	0.90	0.70	40.41	91.53
2002	0.90	0.70	35.14	75.48
2003	0.92	0.94	17.87	48.25
2004	0.92	0.94	10.40	32.80
2005	0.92	0.94	4.85	22.86
2006	0.92	0.94	0.40	12.70
2007	0.92	0.94	0.29	5.94
2008	0.93	0.97	0	0
2009	0.00	0.00	0	0

Table 160b. FMVSS No. 208: Weights and consumer costs for manual lap belts in rear center seats

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
1968	$17.95	$11.13	0.63	$12.70	$1.14	0.08
1969	$17.66	$10.95	0.63	$12.48	$1.12	0.08
1970	$17.47	$10.83	0.63	$12.34	$1.11	0.08
1971	$17.28	$10.71	0.63	$12.20	$1.10	0.08
1972	$17.11	$10.61	0.63	$12.08	$1.09	0.08
1973	$16.96	$10.52	0.63	$11.96	$1.08	0.08
1974	$16.86	$10.45	0.63	$11.88	$1.07	0.08
1975	$16.77	$10.40	0.60	$11.82	$1.06	0.08
1976	$16.67	$10.34	0.57	$11.74	$1.06	0.08
1977	$16.57	$10.27	0.53	$11.67	$1.63	0.12
1978	$16.48	$10.22	0.50	$11.60	$1.62	0.12
1979	$16.40	$10.17	0.47	$11.54	$1.62	0.12
1980	$16.34	$10.13	0.47	$11.50	$1.61	0.12
1981	$16.29	$10.10	0.47	$11.46	$1.60	0.12
1982	$16.24	$10.07	0.48	$11.43	$1.60	0.12
1983	$16.19	$10.04	0.50	$11.39	$1.59	0.12
1984	$16.13	$10.00	0.52	$11.35	$1.59	0.12
1985	$16.08	$9.97	0.54	$11.30	$1.58	0.12
1986	$16.02	$9.93	0.56	$11.26	$1.58	0.12
1987	$15.96	$13.72	0.80	$11.22	$2.92	0.23
1988	$15.89	$13.67	0.83	$11.19	$2.91	0.23
1989	$15.84	$13.62	0.85	$11.16	$2.90	0.23
1990	$15.79	$13.58	0.88	$11.13	$2.89	0.23
1991	$15.74	$13.54	0.90	$11.10	$2.89	0.23
1992	$15.70	$13.51	0.94	$11.08	$2.88	0.23
1993	$15.66	$13.47	0.94	$11.05	$2.87	0.23
1994	$15.62	$13.30	0.93	$11.03	$2.87	0.23

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
1995	$15.57	$13.94	0.98	$11.00	$7.67	0.62
1996	$15.52	$13.74	0.96	$10.98	$7.65	0.62
1997	$15.48	$12.32	0.87	$10.96	$7.64	0.62
1998	$15.44	$10.20	0.72	$10.94	$7.61	0.62
1999	$15.40	$9.58	0.68	$10.92	$7.52	0.61
2000	$15.37	$7.88	0.56	$10.91	$7.43	0.61
2001	$15.34	$5.58	0.40	$10.91	$6.97	0.57
2002	$15.32	$4.84	0.34	$10.91	$5.76	0.48
2003	$15.30	$2.51	0.18	$10.88	$4.93	0.41
2004	$15.29	$1.46	0.10	$10.86	$3.34	0.27
2005	$15.28	$0.68	0.05	$10.85	$2.33	0.19
2006	$15.28	$0.06	0.00	$10.85	$1.29	0.11
2007	$15.28	$0.04	0.00	$10.85	$0.60	0.05
2008	$15.28	$0.00	0.00	$10.85	$0.00	0.00

Table 161c. FMVSS No. 208: Weights and consumer costs for manual lap belts in rear center seats – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.47	0.16	0.63	$8.35	$2.78	$11.13
1969	0.47	0.16	0.63	$8.21	$2.74	$10.95
1970	0.47	0.16	0.63	$8.12	$2.71	$10.83
1971	0.47	0.16	0.63	$8.03	$2.68	$10.71
1972	0.47	0.16	0.63	$7.96	$2.65	$10.61
1973	0.47	0.16	0.63	$7.89	$2.63	$10.52
1974	0.47	0.16	0.63	$7.84	$2.61	$10.45
1975	0.45	0.15	0.60	$7.80	$2.60	$10.40
1976	0.42	0.14	0.57	$7.75	$2.58	$10.34
1977	0.40	0.13	0.53	$7.71	$2.57	$10.27

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1978	0.37	0.12	0.50	$7.66	$2.55	$10.22
1979	0.35	0.12	0.47	$7.63	$2.54	$10.17
1980	0.35	0.12	0.47	$7.60	$2.53	$10.13
1981	0.35	0.12	0.47	$7.58	$2.53	$10.10
1982	0.36	0.12	0.48	$7.55	$2.52	$10.07
1983	0.38	0.13	0.50	$7.53	$2.51	$10.04
1984	0.39	0.13	0.52	$7.50	$2.50	$10.00
1985	0.40	0.13	0.54	$7.48	$2.49	$9.97
1986	0.42	0.14	0.56	$7.45	$2.48	$9.93
1987	0.60	0.20	0.80	$10.29	$3.43	$13.72
1988	0.62	0.21	0.83	$10.25	$3.42	$13.67
1989	0.64	0.21	0.85	$10.21	$3.40	$13.62
1990	0.66	0.22	0.88	$10.18	$3.39	$13.58
1991	0.68	0.23	0.90	$10.16	$3.39	$13.54
1992	0.70	0.23	0.94	$10.13	$3.38	$13.51
1993	0.70	0.23	0.94	$10.10	$3.37	$13.47
1994	0.70	0.23	0.93	$9.98	$3.33	$13.30
1995	0.73	0.24	0.98	$10.45	$3.48	$13.94
1996	0.72	0.24	0.96	$10.30	$3.43	$13.74
1997	0.65	0.22	0.87	$9.24	$3.08	$12.32
1998	0.54	0.18	0.72	$7.65	$2.55	$10.20
1999	0.51	0.17	0.68	$7.19	$2.40	$9.58
2000	0.42	0.14	0.56	$5.91	$1.97	$7.88
2001	0.30	0.10	0.40	$4.18	$1.39	$5.58
2002	0.26	0.09	0.34	$3.63	$1.21	$4.84
2003	0.13	0.04	0.18	$1.89	$0.63	$2.51
2004	0.08	0.03	0.10	$1.10	$0.37	$1.46
2005	0.04	0.01	0.05	$0.51	$0.17	$0.68
2006	0.00	0.00	0.00	$0.04	$0.01	$0.06

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2007	0.00	0.00	0.00	$0.03	$0.01	$0.04
2008	0.00	0.00	0.00	$0.00	$0.00	$0.00

Table 162d. FMVSS No. 208: Weights and consumer costs for manual lap belts in rear center seats – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.08	0.00	0.08	$1.15	$0.00	$1.15
1969	0.08	0.00	0.08	$1.13	$0.00	$1.13
1970	0.08	0.00	0.08	$1.12	$0.00	$1.12
1971	0.08	0.00	0.08	$1.10	$0.00	$1.10
1972	0.08	0.00	0.08	$1.09	$0.00	$1.09
1973	0.08	0.00	0.08	$1.08	$0.00	$1.08
1974	0.08	0.00	0.08	$1.08	$0.00	$1.08
1975	0.08	0.00	0.08	$1.07	$0.00	$1.07
1976	0.08	0.00	0.08	$1.07	$0.00	$1.07
1977	0.12	0.00	0.12	$1.65	$0.00	$1.65
1978	0.12	0.00	0.12	$1.64	$0.00	$1.64
1979	0.12	0.00	0.12	$1.63	$0.00	$1.63
1980	0.12	0.00	0.12	$1.62	$0.00	$1.62
1981	0.12	0.00	0.12	$1.62	$0.00	$1.62
1982	0.12	0.00	0.12	$1.61	$0.00	$1.61
1983	0.12	0.00	0.12	$1.61	$0.00	$1.61
1984	0.12	0.00	0.12	$1.60	$0.00	$1.60
1985	0.12	0.00	0.12	$1.60	$0.00	$1.60
1986	0.12	0.00	0.12	$1.59	$0.00	$1.59
1987	0.23	0.00	0.23	$2.94	$0.00	$2.94
1988	0.23	0.00	0.23	$2.93	$0.00	$2.93
1989	0.23	0.00	0.23	$2.92	$0.00	$2.92
1990	0.23	0.00	0.23	$2.91	$0.00	$2.91

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1991	0.23	0.00	0.23	$2.91	$0.00	$2.91
1992	0.23	0.00	0.23	$2.90	$0.00	$2.90
1993	0.23	0.00	0.23	$2.89	$0.00	$2.89
1994	0.23	0.00	0.23	$2.88	$0.00	$2.88
1995	0.62	0.00	0.62	$7.70	$0.00	$7.70
1996	0.62	0.00	0.62	$7.68	$0.00	$7.68
1997	0.62	0.00	0.62	$7.66	$0.00	$7.66
1998	0.62	0.00	0.62	$7.62	$0.00	$7.62
1999	0.61	0.00	0.61	$7.53	$0.00	$7.53
2000	0.61	0.00	0.61	$7.44	$0.00	$7.44
2001	0.57	0.00	0.57	$6.97	$0.00	$6.97
2002	0.48	0.00	0.48	$5.76	$0.00	$5.76
2003	0.41	0.00	0.41	$4.93	$0.00	$4.93
2004	0.27	0.00	0.27	$3.34	$0.00	$3.34
2005	0.19	0.00	0.19	$2.32	$0.00	$2.32
2006	0.11	0.00	0.11	$1.29	$0.00	$1.29
2007	0.05	0.00	0.05	$0.60	$0.00	$0.60
2008	0.00	0.00	0.00	$0.00	$0.00	$0.00

Table 163a. FMVSS No. 208: Average number of seating positions and percentages of fleet equipped with manual lap/shoulder belts in front outboard seats

Model Year	PC	LTV	PC	LTV
	Number of Seats	Number of Seats	Percent Equipped	Percent Equipped
1968	2	2	87.5	0
1969	2	2	100	2.81
1970	2	2	100	3.21
1971	2	2	100	3.83
1972	2	2	100	5.51
1973	2	2	100	5.4

Model Year	PC	LTV	PC	LTV
	Number of Seats	Number of Seats	Percent Equipped	Percent Equipped
1974	2	2	100	40.48
1975	2	2	99.57	43.52
1976	2	2	99.65	44.72
1977	2	2	99.59	84.33
1978	2	2	99.59	85.07
1979	2	2	99.51	84.05
1980	2	2	99.44	94.28
1981	2	2	98.97	100
1982	2	2	99.29	100
1983	2	2	99.35	100
1984	2	2	99.67	100
1985	2	2	99.72	100
1986	2	2	99.69	100
1987	2	2	93.37	100
1988	2	2	87.77	100
1989	2	2	83.96	100
1990	2	2	59.88	100
1991	2	2	58.92	100
1992	2	2	71.80	100
1993	2	2	73.49	100
1994	2	2	80.68	100
1995	2	2	93.55	100
1996	2	2	97.31	100
1997	2	2	100	100
1998 to 2019	2	2	100	100

Table 164b. FMVSS No. 208: Weights and consumer costs for manual lap/shoulder belts in front outboard seats

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
1968	$31.34	$54.84	5.16	$0.00	$0.00	0
1969	$31.34	$62.68	5.90	$30.54	$1.72	0.14
1970	$31.34	$62.68	5.90	$30.54	$1.96	0.16
1971	$31.34	$62.68	5.90	$30.54	$2.34	0.19
1972	$44.53	$89.06	8.68	$53.33	$5.88	0.53
1973	$46.43	$92.86	9.08	$52.66	$5.69	0.52
1974	$50.73	$101.46	9.08	$52.20	$42.26	3.87
1975	$50.51	$101.03	9.55	$51.81	$45.09	4.16
1976	$50.55	$101.11	10.07	$51.40	$45.97	4.28
1977	$50.52	$101.05	10.57	$50.97	$85.96	8.06
1978	$50.52	$101.05	11.08	$50.58	$86.06	8.13
1979	$50.34	$100.69	11.58	$50.27	$84.50	8.04
1980	$50.31	$100.62	11.57	$50.03	$94.33	9.01
1981	$50.07	$100.14	11.52	$49.82	$99.64	9.56
1982	$49.20	$98.40	11.03	$49.63	$99.26	9.56
1983	$48.30	$96.59	10.51	$49.42	$98.85	9.56
1984	$47.51	$95.03	10.02	$49.20	$98.39	9.56
1985	$46.60	$93.20	9.50	$48.97	$97.94	9.56
1986	$45.65	$91.30	8.97	$48.75	$97.50	9.56
1987	$41.88	$83.76	7.91	$48.57	$97.14	9.56
1988	$43.91	$77.08	6.97	$48.41	$96.81	9.56
1989	$43.91	$73.74	6.67	$48.26	$96.53	9.56
1990	$43.91	$52.59	4.75	$48.16	$96.31	9.56
1991	$43.91	$51.74	4.68	$48.07	$96.13	9.56
1992	$43.91	$63.06	5.70	$47.96	$95.93	9.56
1993	$43.81	$64.39	5.84	$47.85	$95.71	9.56
1994	$43.70	$70.52	6.41	$47.73	$95.47	9.56

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
1995	$43.59	$81.56	7.43	$47.61	$95.22	9.56
1996	$43.48	$84.62	7.73	$47.49	$94.98	9.56
1997	$43.37	$86.74	7.94	$47.37	$94.74	9.56
1998	$43.26	$86.53	7.94	$47.26	$94.51	9.56
1999	$43.15	$86.30	7.94	$47.13	$94.27	9.56
2000	$43.04	$86.09	7.94	$47.02	$94.03	9.56
2001	$42.94	$85.88	7.94	$46.90	$93.81	9.56
2002	$42.84	$85.69	7.94	$46.80	$93.60	9.56
2003	$42.75	$85.50	7.94	$46.70	$93.39	9.56
2004	$42.66	$85.33	7.94	$46.60	$93.20	9.56
2005	$42.58	$85.15	7.94	$46.50	$93.01	9.56
2006	$42.49	$84.99	7.94	$46.42	$92.83	9.56
2007	$42.41	$84.82	7.94	$46.33	$92.66	9.56
2008	$42.34	$84.67	7.94	$46.26	$92.53	9.56
2009	$42.29	$84.58	7.94	$46.21	$92.43	9.56
2010	$42.23	$84.47	7.94	$46.16	$92.31	9.56
2011	$42.17	$84.35	7.94	$46.10	$92.19	9.56
2012	$42.11	$84.22	7.94	$46.03	$92.06	9.56
2013	$42.04	$84.08	7.94	$45.95	$91.90	9.56
2014	$41.97	$83.94	7.94	$45.87	$91.75	9.56
2015	$41.89	$83.79	7.94	$45.79	$91.58	9.56
2016	$41.83	$83.66	7.94	$45.72	$91.44	9.56
2017	$41.77	$83.53	7.94	$45.65	$91.30	9.56
2018	$41.71	$83.41	7.94	$45.59	$91.17	9.56
2019	$41.65	$83.30	7.94	$45.52	$91.05	9.56

Table 165c. FMVSS No. 208: Weights and consumer costs for manual lap/shoulder belts in front outboard seats – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	1.46	3.70	5.16	$17.85	$37.00	$54.84
1969	1.67	4.23	5.90	$20.39	$42.28	$62.68
1970	1.67	4.23	5.90	$20.39	$42.28	$62.68
1971	1.67	4.23	5.90	$20.39	$42.28	$62.68
1972	1.67	7.01	8.68	$20.39	$68.66	$89.06
1973	1.67	7.41	9.08	$20.39	$72.47	$92.86
1974	1.67	7.41	9.08	$20.39	$81.07	$101.46
1975	1.67	7.89	9.55	$20.31	$80.72	$101.03
1976	1.67	8.40	10.07	$20.32	$80.78	$101.11
1977	1.67	8.91	10.57	$20.31	$80.73	$101.05
1978	1.67	9.42	11.08	$20.31	$80.73	$101.05
1979	1.67	9.92	11.58	$20.30	$80.39	$100.69
1980	1.66	9.91	11.57	$20.28	$80.34	$100.62
1981	1.66	9.86	11.52	$20.18	$79.96	$100.14
1982	1.66	9.37	11.03	$20.25	$78.15	$98.40
1983	1.66	8.85	10.51	$20.26	$76.33	$96.59
1984	1.67	8.35	10.02	$20.33	$74.70	$95.03
1985	1.67	7.83	9.50	$20.34	$72.86	$93.20
1986	1.67	7.30	8.97	$20.33	$70.97	$91.30
1987	1.56	6.34	7.91	$19.04	$64.71	$83.76
1988	1.47	5.50	6.97	$17.90	$59.18	$77.08
1989	1.40	5.26	6.67	$17.12	$56.61	$73.74
1990	1.00	3.75	4.75	$12.21	$40.38	$52.59
1991	0.99	3.69	4.68	$12.02	$39.73	$51.74
1992	1.20	4.50	5.70	$14.64	$48.41	$63.06
1993	1.23	4.61	5.84	$14.95	$49.44	$64.39
1994	1.35	5.06	6.41	$16.38	$54.14	$70.52
1995	1.57	5.86	7.43	$18.94	$62.62	$81.56

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	1.63	6.10	7.73	$19.65	$64.97	$84.62
1997	1.67	6.27	7.94	$20.14	$66.60	$86.74
1998	1.67	6.27	7.94	$20.09	$66.43	$86.53
1999	1.67	6.27	7.94	$20.04	$66.26	$86.30
2000	1.67	6.27	7.94	$19.99	$66.10	$86.09
2001	1.67	6.27	7.94	$19.94	$65.94	$85.88
2002	1.67	6.27	7.94	$19.90	$65.79	$85.69
2003	1.67	6.27	7.94	$19.86	$65.65	$85.50
2004	1.67	6.27	7.94	$19.82	$65.51	$85.33
2005	1.67	6.27	7.94	$19.77	$65.38	$85.15
2006	1.67	6.27	7.94	$19.74	$65.25	$84.99
2007	1.67	6.27	7.94	$19.70	$65.13	$84.82
2008	1.67	6.27	7.94	$19.66	$65.01	$84.67
2009	1.67	6.27	7.94	$19.64	$64.94	$84.58
2010	1.67	6.27	7.94	$19.62	$64.85	$84.47
2011	1.67	6.27	7.94	$19.59	$64.76	$84.35
2012	1.67	6.27	7.94	$19.56	$64.66	$84.22
2013	1.67	6.27	7.94	$19.52	$64.55	$84.08
2014	1.67	6.27	7.94	$19.49	$64.44	$83.94
2015	1.67	6.27	7.94	$19.46	$64.33	$83.79
2016	1.67	6.27	7.94	$19.43	$64.23	$83.66
2017	1.67	6.27	7.94	$19.40	$64.13	$83.53
2018	1.67	6.27	7.94	$19.37	$64.04	$83.41
2019	1.67	6.27	7.94	$19.35	$63.96	$83.30

Table 166d. FMVSS No. 208: Weights and consumer costs for lap/shoulder belts in front outboard seats - LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.14	0.00	0.14	$1.72	$0.00	$1.72
1970	0.16	0.00	0.16	$1.96	$0.00	$1.96
1971	0.19	0.00	0.19	$2.34	$0.00	$2.34
1972	0.23	0.29	0.53	$2.69	$3.18	$5.88
1973	0.23	0.28	0.52	$2.65	$3.04	$5.69
1974	0.49	3.38	3.87	$5.63	$36.63	$42.26
1975	0.51	3.65	4.16	$5.85	$39.24	$45.09
1976	0.52	3.76	4.28	$5.91	$40.07	$45.97
1977	0.81	7.25	8.06	$9.17	$76.79	$85.96
1978	0.81	7.32	8.13	$9.16	$76.90	$86.06
1979	0.81	7.23	8.04	$9.02	$75.48	$84.50
1980	0.88	8.13	9.01	$9.82	$84.51	$94.33
1981	0.92	8.64	9.56	$10.25	$89.39	$99.64
1982	0.92	8.64	9.56	$10.21	$89.05	$99.26
1983	0.92	8.64	9.56	$10.16	$88.68	$98.85
1984	0.92	8.64	9.56	$10.12	$88.28	$98.39
1985	0.92	8.64	9.56	$10.07	$87.87	$97.94
1986	0.92	8.64	9.56	$10.03	$87.48	$97.50
1987	0.92	8.64	9.56	$9.99	$87.15	$97.14
1988	0.92	8.64	9.56	$9.96	$86.86	$96.81
1989	0.92	8.64	9.56	$9.93	$86.60	$96.53
1990	0.92	8.64	9.56	$9.90	$86.41	$96.31
1991	0.92	8.64	9.56	$9.89	$86.25	$96.13
1992	0.92	8.64	9.56	$9.86	$86.06	$95.93
1993	0.92	8.64	9.56	$9.84	$85.87	$95.71
1994	0.92	8.64	9.56	$9.82	$85.65	$95.47
1995	0.92	8.64	9.56	$9.79	$85.43	$95.22

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	0.92	8.64	9.56	$9.77	$85.21	$94.98
1997	0.92	8.64	9.56	$9.74	$85.00	$94.74
1998	0.92	8.64	9.56	$9.72	$84.79	$94.51
1999	0.92	8.64	9.56	$9.69	$84.57	$94.27
2000	0.92	8.64	9.56	$9.67	$84.36	$94.03
2001	0.92	8.64	9.56	$9.65	$84.16	$93.81
2002	0.92	8.64	9.56	$9.62	$83.97	$93.60
2003	0.92	8.64	9.56	$9.60	$83.79	$93.39
2004	0.92	8.64	9.56	$9.58	$83.61	$93.20
2005	0.92	8.64	9.56	$9.56	$83.44	$93.01
2006	0.92	8.64	9.56	$9.55	$83.28	$92.83
2007	0.92	8.64	9.56	$9.53	$83.12	$92.65
2008	0.92	8.64	9.56	$9.51	$82.97	$92.48
2009	0.92	8.64	9.56	$9.50	$82.88	$92.38
2010	0.92	8.64	9.56	$9.49	$82.78	$92.26
2011	0.92	8.64	9.56	$9.47	$82.66	$92.13
2012	0.92	8.64	9.56	$9.46	$82.53	$91.99
2013	0.92	8.64	9.56	$9.44	$82.39	$91.83
2014	0.92	8.64	9.56	$9.43	$82.25	$91.68
2015	0.92	8.64	9.56	$9.41	$82.11	$91.52
2016	0.92	8.64	9.56	$9.40	$81.98	$91.38
2017	0.92	8.64	9.56	$9.38	$81.86	$91.24
2018	0.92	8.64	9.56	$9.37	$81.74	$91.11
2019	0.92	8.64	9.56	$9.36	$81.63	$90.99

Table 167a. FMVSS No. 208: Average number of seating positions and percentages of fleet equipped with manual lap/shoulder belts in front center seats

Model Year	PC Number of Seats	LTV Number of Seats	PC Percent Equipped	LTV Percent Equipped
2001	0.06	0.2	0	0
2002	0.06	0.17	0	0.36
2003	0.060	0.160	0	0.40
2004	0.060	0.140	0	0.39
2005	0.050	0.150	0	0.35
2006	0.030	0.140	0	0.22
2007	0.020	0.150	0	0.18
2008	0.020	0.110	0	0.21
2009	0.010	0.110	0	0.12
2010	0.010	0.110	0	0.10
2011	0.010	0.100	0	0.11
2012	0.010	0.100	0	0.21
2013	0	0.1	0	0.14
2014	0	0.09	0	0.19
2015	0	0.09	0	0.11
2016	0	0.09	0	0.09
2017	0	0.09	0	0.09
2018	0	0.09	0	0.08
2019	0	0.09	0	0.21

Table 168b. FMVSS No. 208: Weights and consumer cost for manual lap/shoulder belts in front center seats

Model Year	LTV Cost per Belt	LTV Ave. Cost Per Veh.	LTV Ave. Weight
2001	$0.00	$0.00	0.00
2002	$44.87	$0.16	0.02
2003	$42.87	$0.17	0.02
2004	$41.79	$0.16	0.02
2005	$41.12	$0.15	0.02
2006	$40.80	$0.09	0.01
2007	$40.57	$0.07	0.01
2008	$40.34	$0.09	0.01
2009	$40.27	$0.05	0.01
2010	$40.20	$0.04	0.01
2011	$40.09	$0.05	0.01
2012	$39.91	$0.08	0.01
2013	$39.78	$0.06	0.01
2014	$39.60	$0.08	0.01
2015	$39.50	$0.04	0.01
2016	$39.42	$0.03	0.00
2017	$39.34	$0.04	0.00
2018	$39.27	$0.03	0.00
2019	$39.09	$0.08	0.01

Table 169c. FMVSS No. 208: Lap/shoulder belts in front center seats – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2001	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.02	0.00	0.02	0.16	0.00	0.16
2003	0.02	0.00	0.02	0.17	0.00	0.17
2004	0.02	0.00	0.02	0.16	0.00	0.16
2005	0.02	0.00	0.02	0.15	0.00	0.15
2006	0.01	0.00	0.01	0.09	0.00	0.09
2007	0.01	0.00	0.01	0.07	0.00	0.07
2008	0.01	0.00	0.01	0.09	0.00	0.09
2009	0.01	0.00	0.01	0.05	0.00	0.05
2010	0.01	0.00	0.01	0.04	0.00	0.04
2011	0.01	0.00	0.01	0.05	0.00	0.05
2012	0.01	0.00	0.01	0.08	0.00	0.08
2013	0.01	0.00	0.01	0.06	0.00	0.06
2014	0.01	0.00	0.01	0.08	0.00	0.08
2015	0.01	0.00	0.01	0.04	0.00	0.04
2016	0.00	0.00	0.00	0.03	0.00	0.03
2017	0.00	0.00	0.00	0.04	0.00	0.04
2018	0.00	0.00	0.00	0.03	0.00	0.03
2019	0.01	0.00	0.01	0.08	0.00	0.08

Table 170a. FMVSS No. 208: Average number of seating positions and percentages of fleet equipped with manual lap/shoulder belts in rear outboard seats

Model Year	PC Number of Seats	LTV Number of Seats	PC Percent Equipped	LTV Percent Equipped
1968	1.98	0.39	0	0
1969	1.98	0.39	0	0
1970	1.98	0.39	0	0
1971	1.98	0.39	0.45	0
1972	1.98	0.39	0.38	0
1973	1.98	0.39	0.35	0
1974	1.98	0.39	0.61	0
1975	1.98	0.39	0.96	0
1976	1.98	0.39	0.74	0
1977	1.96	0.83	0.54	0
1978	1.96	0.83	0.61	0
1979	1.96	0.83	0.64	0
1980	1.96	0.83	0.74	0
1981	1.96	0.83	1.71	0
1982	1.96	0.83	4.08	0
1983	1.96	0.83	5.82	0
1984	1.96	0.83	5.55	0
1985	1.96	0.83	5.75	0
1986	1.96	0.83	6.86	0
1987	1.97	1.31	9.62	0.29
1988	1.97	1.31	30.67	2.84
1989	1.97	1.31	67.67	16.8
1990	1.96	1.31	100	20.01
1991	1.96	1.31	100	32.25
1992	1.96	1.31	100	100
1993	1.96	1.31	100	100
1994	1.96	1.31	100	100

Model Year	PC Number of Seats	LTV Number of Seats	PC Percent Equipped	LTV Percent Equipped
1995	1.97	2.21	100	100
1996	1.97	2.21	100	100
1997	1.97	2.21	100	100
1998	1.97	2.21	100	100
1999	1.97	2.21	100	100
2000	1.97	2.21	100	100
2001	1.97	2.21	100	100
2002	1.97	2.21	100	100
2003	1.96	2.32	100	100
2004	1.96	2.32	100	100
2005	1.96	2.32	100	100
2006	1.96	2.32	100	100
2007	1.96	2.32	100	100
2008	1.99	2.34	100	100
2009	1.99	2.34	100	100
2010	1.99	2.34	100	100
2011	1.99	2.34	100	100
2012	1.98	2.34	100	100
2013	1.97	2.35	100	100
2014	1.97	2.36	100	100
2015	1.97	2.37	100	100
2016	1.97	2.39	100	100
2017	1.98	2.43	100	100
2018	1.98	2.47	100	100
2019	1.97	2.43	100	100

Table 171b. FMVSS No. 208: Weights and consumer costs for manual lap/shoulder belts in rear outboard seats

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
1968	$0.00	$0.00	0	$0.00	$0.00	0
1969	$0.00	$0.00	0	$0.00	$0.00	0
1970	$0.00	$0.00	0	$0.00	$0.00	0
1971	$22.80	$0.20	0.02	$0.00	$0.00	0
1972	$35.66	$0.27	0.02	$0.00	$0.00	0
1973	$34.86	$0.24	0.02	$0.00	$0.00	0
1974	$34.13	$0.41	0.03	$0.00	$0.00	0
1975	$33.38	$0.63	0.05	$0.00	$0.00	0
1976	$32.89	$0.48	0.04	$0.00	$0.00	0
1977	$32.57	$0.34	0.03	$0.00	$0.00	0
1978	$32.27	$0.39	0.03	$0.00	$0.00	0
1979	$32.01	$0.40	0.03	$0.00	$0.00	0
1980	$31.80	$0.46	0.04	$0.00	$0.00	0
1981	$31.39	$1.05	0.09	$0.00	$0.00	0
1982	$30.73	$2.46	0.21	$0.00	$0.00	0
1983	$30.01	$3.42	0.29	$0.00	$0.00	0
1984	$29.47	$3.21	0.28	$0.00	$0.00	0
1985	$29.04	$3.27	0.29	$0.00	$0.00	0
1986	$28.62	$3.85	0.35	$0.00	$0.00	0
1987	$28.21	$5.35	0.49	$28.25	$0.11	0.01
1988	$27.32	$16.50	1.56	$27.35	$1.02	0.10
1989	$26.30	$35.06	3.44	$26.31	$5.79	0.57
1990	$25.53	$50.04	5.05	$25.53	$6.69	0.68
1991	$25.07	$49.14	5.05	$25.06	$10.59	1.09
1992	$24.65	$48.32	5.05	$24.60	$32.23	3.38
1993	$24.31	$47.65	5.05	$24.24	$31.75	3.38
1994	$24.02	$47.08	5.05	$23.93	$31.35	3.38

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
1995	$23.74	$46.77	5.08	$23.68	$52.34	5.70
1996	$23.50	$46.30	5.08	$23.47	$51.87	5.70
1997	$23.30	$45.90	5.08	$23.29	$51.47	5.70
1998	$23.12	$45.55	5.08	$23.13	$51.11	5.70
1999	$22.95	$45.22	5.08	$22.97	$50.76	5.70
2000	$22.80	$44.91	5.08	$22.82	$50.44	5.70
2001	$22.66	$44.65	5.08	$22.70	$50.16	5.70
2002	$22.54	$44.41	5.08	$22.58	$49.91	5.70
2003	$22.43	$43.95	5.05	$22.48	$52.16	5.99
2004	$22.33	$43.75	5.05	$22.38	$51.94	5.99
2005	$22.23	$43.56	5.05	$22.29	$51.73	5.99
2006	$22.14	$43.39	5.05	$22.21	$51.54	5.99
2007	$22.06	$43.22	5.05	$22.14	$51.37	5.99
2008	$21.98	$43.65	5.12	$22.08	$51.60	6.03
2009	$21.94	$43.56	5.12	$22.03	$51.49	6.03
2010	$21.88	$43.45	5.12	$21.99	$51.38	6.03
2011	$21.83	$43.34	5.12	$21.94	$51.27	6.03
2012	$21.77	$43.16	5.11	$21.88	$51.14	6.03
2013	$21.70	$42.75	5.08	$21.82	$51.26	6.06
2014	$21.64	$42.63	5.08	$21.76	$51.38	6.09
2015	$21.57	$42.50	5.08	$21.70	$51.49	6.12
2016	$21.52	$42.46	5.09	$21.65	$51.67	6.16
2017	$21.46	$42.41	5.09	$21.59	$52.42	6.26
2018	$21.41	$42.38	5.10	$21.55	$53.18	6.37
2019	$21.36	$42.17	5.09	$21.50	$52.27	6.27

Table 172c. FMVSS No. 208: Weights and consumer costs for manual lap/shoulder belts for rear seat outboard – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00
1971	0.02	0.00	0.02	$0.20	$0.00	$0.20
1972	0.01	0.01	0.02	$0.24	$0.03	$0.27
1973	0.01	0.01	0.02	$0.22	$0.03	$0.24
1974	0.02	0.01	0.03	$0.37	$0.04	$0.41
1975	0.03	0.01	0.05	$0.57	$0.07	$0.63
1976	0.03	0.01	0.04	$0.43	$0.05	$0.48
1977	0.02	0.01	0.03	$0.31	$0.04	$0.34
1978	0.02	0.01	0.03	$0.34	$0.04	$0.39
1979	0.02	0.01	0.03	$0.36	$0.04	$0.40
1980	0.03	0.01	0.04	$0.41	$0.05	$0.46
1981	0.06	0.03	0.09	$0.94	$0.11	$1.05
1982	0.15	0.06	0.21	$2.19	$0.26	$2.46
1983	0.21	0.09	0.29	$3.06	$0.37	$3.42
1984	0.20	0.08	0.28	$2.86	$0.34	$3.21
1985	0.21	0.08	0.29	$2.92	$0.35	$3.27
1986	0.25	0.10	0.35	$3.44	$0.41	$3.85
1987	0.35	0.14	0.49	$4.77	$0.57	$5.35
1988	1.11	0.45	1.56	$14.73	$1.77	$16.50
1989	2.44	1.00	3.44	$31.29	$3.77	$35.06
1990	3.59	1.47	5.05	$44.69	$5.35	$50.04
1991	3.59	1.47	5.05	$43.88	$5.25	$49.14
1992	3.59	1.47	5.05	$43.15	$5.17	$48.32
1993	3.59	1.47	5.05	$42.55	$5.09	$47.65
1994	3.59	1.47	5.05	$42.04	$5.03	$47.08
1995	3.61	1.47	5.08	$41.74	$5.03	$46.77

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	3.61	1.47	5.08	$41.32	$4.98	$46.30
1997	3.61	1.47	5.08	$40.97	$4.93	$45.90
1998	3.61	1.47	5.08	$40.66	$4.90	$45.55
1999	3.61	1.47	5.08	$40.36	$4.86	$45.22
2000	3.61	1.47	5.08	$40.09	$4.83	$44.91
2001	3.61	1.47	5.08	$39.85	$4.80	$44.65
2002	3.61	1.47	5.08	$39.64	$4.77	$44.41
2003	3.59	1.46	5.05	$39.26	$4.70	$43.95
2004	3.59	1.46	5.05	$39.07	$4.68	$43.75
2005	3.59	1.46	5.05	$38.90	$4.66	$43.56
2006	3.59	1.46	5.05	$38.75	$4.64	$43.39
2007	3.59	1.46	5.05	$38.60	$4.62	$43.22
2008	3.63	1.48	5.12	$38.92	$4.73	$43.65
2009	3.63	1.48	5.12	$38.84	$4.72	$43.56
2010	3.63	1.48	5.12	$38.75	$4.71	$43.45
2011	3.63	1.48	5.12	$38.64	$4.69	$43.34
2012	3.63	1.48	5.11	$38.49	$4.67	$43.16
2013	3.61	1.47	5.08	$38.16	$4.59	$42.75
2014	3.61	1.47	5.08	$38.05	$4.58	$42.63
2015	3.61	1.47	5.08	$37.93	$4.57	$42.50
2016	3.61	1.47	5.09	$37.89	$4.57	$42.46
2017	3.62	1.48	5.09	$37.84	$4.57	$42.41
2018	3.62	1.48	5.10	$37.80	$4.57	$42.38
2019	3.61	1.48	5.09	$37.63	$4.54	$42.17

Table 173d. FMVSS No. 208: Lap/shoulder belts in rear outboard seats – LTVs

Model Year	**Weight (lb)**			**Consumer Cost (2019$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1986	0.00	0.00	0.00	$0.00	$0.00	$0.00
1987	0.01	0.00	0.01	$0.10	$0.01	$0.11
1988	0.07	0.03	0.10	$0.91	$0.11	$1.02
1989	0.40	0.17	0.57	$5.19	$0.60	$5.79
1990	0.48	0.20	0.68	$6.00	$0.69	$6.69
1991	0.77	0.32	1.09	$9.49	$1.10	$10.59
1992	2.40	0.98	3.38	$28.94	$3.35	$32.29
1993	2.40	0.98	3.38	$28.54	$3.31	$31.85
1994	2.40	0.98	3.38	$28.20	$3.27	$31.47
1995	4.04	1.66	5.70	$43.28	$9.19	$52.46
1996	4.04	1.66	5.70	$42.85	$9.10	$51.94
1997	4.04	1.66	5.70	$42.48	$9.02	$51.50
1998	4.04	1.66	5.70	$42.15	$8.95	$51.10
1999	4.04	1.66	5.70	$41.84	$8.88	$50.73
2000	4.04	1.66	5.70	$41.56	$8.82	$50.39
2001	4.04	1.66	5.70	$41.31	$8.77	$50.08
2002	4.04	1.66	5.70	$41.09	$8.72	$49.82
2003	4.25	1.74	5.99	$42.48	$9.57	$52.05
2004	4.25	1.74	5.99	$42.28	$9.53	$51.81
2005	4.25	1.74	5.99	$42.10	$9.48	$51.58
2006	4.25	1.74	5.99	$41.93	$9.45	$51.38
2007	4.25	1.74	5.99	$41.77	$9.41	$51.19
2008	4.28	1.75	6.03	$41.86	$9.51	$51.37
2009	4.28	1.75	6.03	$41.77	$9.49	$51.26
2010	4.28	1.75	6.03	$41.67	$9.47	$51.14
2011	4.28	1.75	6.03	$41.56	$9.44	$51.01
2012	4.28	1.75	6.03	$41.45	$9.42	$50.86
2013	4.30	1.76	6.06	$41.49	$9.49	$50.98

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2014	4.32	1.77	6.09	$41.53	$9.56	$51.09
2015	4.34	1.78	6.12	$41.57	$9.62	$51.19
2016	4.37	1.79	6.16	$41.65	$9.71	$51.37
2017	4.44	1.82	6.26	$42.08	$10.02	$52.11
2018	4.52	1.85	6.37	$42.51	$10.33	$52.85
2019	4.45	1.82	6.27	$41.93	$10.00	$51.94

Table 174a. FMVSS No. 208: Average number of seating positions and percentages of fleet equipped with manual lap/shoulder belts in rear center seats

Model Year	PC Number of Seats	LTV Number of Seats	PC Percent Equipped	LTV Percent Equipped
1993	0.86	0.26	0	0
1994	0.86	0.26	0.49	0
1995	0.90	0.70	0.56	0
1996	0.90	0.70	1.68	0
1997	0.90	0.70	11.60	0
1998	0.90	0.70	26.63	0.23
1999	0.90	0.70	30.86	1.17
2000	0.90	0.70	43.00	2.22
2001	0.90	0.70	59.59	8.47
2002	0.90	0.70	64.86	24.52
2003	0.92	0.94	82.13	51.75
2004	0.92	0.94	89.60	67.20
2005	0.92	0.94	95.15	77.14
2006	0.92	0.94	99.60	87.30
2007	0.92	0.94	99.71	94.06
2008	0.93	0.97	100	100
2009	0.93	0.97	100	100
2010	0.93	0.97	100	100
2011	0.93	0.97	100	100

Model Year	PC Number of Seats	LTV Number of Seats	PC Percent Equipped	LTV Percent Equipped
2012	0.93	0.97	100	100
2013	0.92	0.97	100	100
2014	0.92	0.97	100	100
2015	0.91	0.96	100	100
2016	0.91	0.96	100	100
2017	0.93	0.99	100	100
2018	0.95	1.02	100	100
2019	0.93	1.04	100	100

Table 175b. FMVSS No. 208: Weights and consumer costs for manual lap/shoulder belts in rear center seats

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
1993	$0.00	$0.00	0.00			
1994	$52.61	$0.22	0.02			
1995	$50.29	$0.25	0.02			
1996	$47.56	$0.72	0.07			
1997	$43.21	$4.51	0.49	$0.00	$0.00	0.00
1998	$40.64	$9.74	1.12	$49.80	$0.08	0.01
1999	$39.24	$10.90	1.30	$48.07	$0.39	0.04
2000	$38.11	$14.75	1.82	$46.68	$0.72	0.08
2001	$37.13	$19.91	2.52	$45.46	$2.68	0.31
2002	$36.34	$21.21	2.74	$44.44	$7.60	0.88
2003	$35.48	$26.80	3.54	$43.45	$21.07	2.51
2004	$34.79	$28.67	3.87	$42.63	$26.84	3.26
2005	$34.23	$29.95	4.11	$41.96	$30.33	3.74
2006	$33.76	$30.93	4.30	$41.41	$33.88	4.23
2007	$33.38	$30.61	4.30	$40.97	$36.11	4.56
2008	$33.05	$30.63	4.35	$40.64	$39.50	5.03

Model Year	PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight	LTV Cost per Belt	LTV Ave. Cost per Veh.	LTV Ave. Weight
2009	$32.87	$30.46	4.35	$40.42	$39.28	5.03
2010	$32.68	$30.28	4.35	$40.20	$39.06	5.03
2011	$32.47	$30.10	4.35	$39.97	$38.84	5.03
2012	$32.28	$29.91	4.35	$39.74	$38.62	5.03
2013	$32.08	$29.61	4.33	$39.49	$38.23	5.01
2014	$31.90	$29.31	4.31	$39.27	$37.89	4.99
2015	$31.72	$29.02	4.29	$39.04	$37.56	4.98
2016	$31.58	$28.87	4.29	$38.86	$37.27	4.96
2017	$31.44	$29.24	4.36	$38.69	$38.23	5.11
2018	$31.32	$29.62	4.44	$38.54	$39.19	5.26
2019	$31.20	$29.02	4.36	$38.40	$39.82	5.36

Table 176c. FMVSS No. 208: Weights and consumer costs for manual lap/shoulder belts in rear center seats – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1993	0.00	0.00	0.00	$0.00	$0.00	$0.00
1994	0.02	0.00	0.02	$0.20	$0.02	$0.22
1995	0.02	0.00	0.02	$0.23	$0.02	$0.25
1996	0.07	0.00	0.07	$0.66	$0.06	$0.72
1997	0.46	0.03	0.49	$4.11	$0.40	$4.51
1998	1.06	0.07	1.12	$8.82	$0.93	$9.74
1999	1.23	0.08	1.30	$9.83	$1.07	$10.90
2000	1.71	0.11	1.82	$13.26	$1.49	$14.75
2001	2.37	0.15	2.52	$17.86	$2.06	$19.91
2002	2.58	0.16	2.74	$18.98	$2.24	$21.21
2003	3.34	0.21	3.54	$23.91	$2.89	$26.80
2004	3.64	0.22	3.87	$25.51	$3.15	$28.67
2005	3.68	0.42	4.11	$25.64	$4.31	$29.95

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2006	3.72	0.58	4.30	$25.73	$5.20	$30.93
2007	3.72	0.58	4.30	$25.42	$5.19	$30.61
2008	3.75	0.60	4.35	$25.38	$5.25	$30.63
2009	3.75	0.60	4.35	$25.23	$5.24	$30.46
2010	3.75	0.60	4.35	$25.07	$5.22	$30.28
2011	3.75	0.60	4.35	$24.90	$5.20	$30.10
2012	3.75	0.60	4.35	$24.73	$5.18	$29.91
2013	3.73	0.60	4.33	$24.47	$5.14	$29.61
2014	3.72	0.59	4.31	$24.21	$5.10	$29.31
2015	3.70	0.59	4.29	$23.96	$5.06	$29.02
2016	3.70	0.59	4.29	$23.83	$5.04	$28.87
2017	3.76	0.60	4.36	$24.13	$5.12	$29.24
2018	3.83	0.61	4.44	$24.43	$5.19	$29.62
2019	3.76	0.60	4.36	$23.92	$5.09	$29.02

Table 177d. FMVSS No. 208: Lap/shoulder belts in rear center seats – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1997	0	0	0	0	0	0
1998	0.01	0.00	0.01	$0.08	$0.00	$0.08
1999	0.04	0.00	0.04	$0.39	$0.00	$0.39
2000	0.08	0.00	0.08	$0.73	$0.00	$0.73
2001	0.31	0.00	0.31	$2.70	$0.00	$2.70
2002	0.88	0.00	0.88	$7.64	$0.00	$7.64
2003	2.51	0.00	2.51	$21.17	$0.00	$21.17
2004	2.51	0.75	3.26	$20.75	$6.20	$26.95
2005	2.51	1.23	3.74	$20.42	$10.02	$30.44
2006	2.51	1.72	4.23	$20.14	$13.84	$33.98
2007	2.51	2.05	4.56	$19.91	$16.28	$36.19

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2008	2.60	2.43	5.03	$20.45	$19.06	$39.51
2009	2.60	2.43	5.03	$20.33	$18.96	$39.29
2010	2.60	2.43	5.03	$20.21	$18.85	$39.06
2011	2.60	2.43	5.03	$20.09	$18.73	$38.82
2012	2.60	2.43	5.03	$19.97	$18.62	$38.58
2013	2.59	2.42	5.01	$19.77	$18.43	$38.20
2014	2.58	2.41	4.99	$19.60	$18.27	$37.87
2015	2.57	2.40	4.98	$19.43	$18.11	$37.54
2016	2.57	2.39	4.96	$19.28	$17.98	$37.26
2017	2.64	2.47	5.11	$19.78	$18.44	$38.22
2018	2.72	2.54	5.26	$20.27	$18.90	$39.18
2019	2.78	2.59	5.36	$20.60	$19.20	$39.80

Table 178a. FMVSS No. 208: Percentages of fleet equipped, average weights (lb), and costs: Weights of automatic seat belts in front outboard seats

Model Year	PC Percent Equipped	LTV Percent Equipped	Ave. PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight
1974	0	0	0	0	0
1975	0.43	0	$62.64	$0.54	0.09
1976	0.35	0	$59.48	$0.42	0.08
1977	0.41	0	$57.28	$0.47	0.09
1978	0.41	0	$55.84	$0.46	0.09
1979	0.49	0	$54.66	$0.54	0.11
1980	0.56	0	$53.79	$0.60	0.12
1981	1.03	0	$166.07	$3.42	0.27
1982	0.71	0	$160.73	$2.28	0.19
1983	0.65	0	$256.66	$3.34	0.20
1984	0.33	0	$252.21	$1.66	0.10
1985	0.28	0	$248.97	$1.39	0.08

Model Year	PC Percent Equipped	LTV Percent Equipped	Ave. PC Cost per Belt	PC Ave. Cost per Veh.	PC Ave. Weight
1986	0.31	0	$245.86	$1.52	0.09
1987	6.63	0	$214.00	$28.38	1.99
1988	12.23	0	$199.28	$48.74	3.84
1989	16.04	0	$193.82	$62.18	4.73
1990	40.12	0	$183.56	$147.29	11.97
1991	41.08	0	$171.84	$141.19	11.24
1992	28.2	0	$162.35	$91.57	7.40
1993	26.51	0	$173.11	$91.79	7.52
1994	19.32	0	$169.45	$65.48	5.07
1995	6.45	0	$171.97	$22.18	1.86
1996	2.69	0	$173.16	$9.32	0.78
1997	0	0	0	0	0

Table 179b. FMVSS No. 208: Weights and consumer costs for automatic belts in front outboard seats – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1974	0.00	0.00	0.00	$0.00	$0.00	$0.00
1975	0.09	0.00	0.09	$0.54	$0.00	$0.54
1976	0.08	0.00	0.08	$0.42	$0.00	$0.42
1977	0.09	0.00	0.09	$0.47	$0.00	$0.47
1978	0.09	0.00	0.09	$0.46	$0.00	$0.46
1979	0.11	0.00	0.11	$0.54	$0.00	$0.54
1980	0.12	0.00	0.12	$0.60	$0.00	$0.60
1981	0.27	0.00	0.27	$3.42	$0.00	$3.42
1982	0.19	0.00	0.19	$2.28	$0.00	$2.28
1983	0.20	0.00	0.20	$3.34	$0.00	$3.34
1984	0.10	0.00	0.10	$1.66	$0.00	$1.66
1985	0.08	0.00	0.08	$1.39	$0.00	$1.39

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1986	0.09	0.00	0.09	$1.52	$0.00	$1.52
1987	0.15	1.84	1.99	$2.05	$26.32	$28.38
1988	0.20	3.64	3.84	$2.62	$46.13	$48.74
1989	0.23	4.50	4.73	$3.02	$59.15	$62.18
1990	0.43	11.54	11.97	$5.46	$141.83	$147.29
1991	0.44	10.79	11.24	$5.49	$135.70	$141.19
1992	0.33	7.07	7.40	$4.12	$87.44	$91.57
1993	0.32	7.21	7.52	$4.06	$87.73	$91.79
1994	0.25	4.83	5.07	$3.31	$62.17	$65.48
1995	0.14	1.72	1.86	$2.03	$20.16	$22.18
1996	0.11	0.67	0.78	$1.66	$7.66	$9.32
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00

Pretensioners, Load Limiters, and Adjustable Anchors

While seat belts reduce the risk of fatal and serious injuries, rib and abdominal injuries may be suffered in high-speed collisions especially if the seat belt is not correctly positioned. These risks are minimized with seat belt pretensioners, load limiters, and adjustable anchors. These three safety features are discussed together since they were introduced into the fleet at essentially the same time and they all are related to seat belts. Adjustable anchors are required in FMVSS No. 208 (see 49 C.F.R., S7.1.2). The upper torso restraint shall include a movable component which has a minimum of two adjustment positions. Although pretensioners and load limiters are not mandatory for meeting NHTSA standards, the agency has evaluated them and found them beneficial. NHTSA found in its frontal New Car Assessment Program test, a 35-mph impact into a rigid barrier with belted dummies, that vehicles could improve their test results by adding pretensioners and load limiters to their belt systems. An evaluation of pretensioners and load limiters showed that a belted driver or right front passenger has, on the average, an estimated 12.8 percent lower fatality risk if the belt has a pretensioner and a load limiter than if it does not have either (95% confidence bounds: 2.6% to 23.0%) (Walz, 2003; Kahane, 2013, pp. 1–3).

Pretensioners. There have been a variety of pretensioners used that work in somewhat similar ways. Some pretensioners just lock the seat belt webbing and don’t allow it to extend further. The more effective systems tighten the seat belt webbing. In a crash, the air bag sensors and air bag ignition circuits are typically used to determine the level of deceleration and to determine when to engage the pretensioners. Pretensioners retract the seat belt almost instantly to remove excess slack and keep the occupant restrained. Excessive slack allows too much occupant motion during a crash, thus increasing the chance of contact with components such as the steering wheel, dashboard, or windshield and the possibility of increased potential of injury in a crash. The three types of pretensioners that have been used include mechanical, electrical, and mostly pyrotechnic. Mechanical pretensioners use preloaded springs that are released mechanically or by an inertial wheel and a pendulum system to lock the webbing. Electrical pretensioners replace the mechanical means with an electrical motor to tighten the webbing. Pyrotechnic pretensioners fire a pyrotechnic device to tighten the seat belt a prescribed amount upon sensing a crash event. This keeps the occupant travel to a minimum and helps optimize occupant position for effective use of the restraint capabilities of the air bag systems.

Load Limiters. In severe crashes where a car collides with an obstacle at extremely high speed, a seat belt can inflict injury to the occupant as it exerts the necessary force to restrain them. As a passenger's inertial speed increases, it takes a greater force to bring the passenger to a stop, i.e., the faster you are going upon impact, the harder you will move into the seat belt. When forces on the shoulder belt rise above a predetermined level, load limiters allow the belt to give or yield while controlling the tension in the belt, typically by spooling it out of the retractor, to avoid concentrating too much force on the occupant's chest. Load limiters in recent vehicles typically use a torsion bar built into the seat belt retractor. The torsion bar is a metal rod that will twist when sufficient torque is applied. In minor collisions, the torsion bar will hold its shape and the seat belt retractor will lock normally. But, when the force applied by the webbing reaches the design limit, the torsion bar twists and allows the webbing to spool out of the retractor.

Adjustable Anchors. An adjustable upper belt anchor improves the seat belt's protective effect by letting the occupant change the position of the shoulder strap to accommodate that person's size, which increases the ease and comfort of seat belt use for car occupants of above or below average height. The NPRM for adjustable anchors was published in the Federal Register (59 FR 21740) on April 26, 1994, making the baseline date September 1, 1993, or MY 1994. The effective date of the final rule was September 1, 1997, or MY 1998. Adjustable anchor costs will be considered voluntary through MY 1994 and the voluntary percentage (30.99% for passenger cars and 10.85% for LTVs) will be held at that MY 1994 baseline level through MY 2019. Attributable costs will be the difference between the installation rates for MYs 1995 to 2019 minus the voluntary baseline level of MY 1994.

A study was conducted in 2000 on fourteen 1992 to 1999 make-model passenger vehicles, including nine vehicles with pretensioners, load limiters, adjustable anchors, or a combination of these technologies and five baseline vehicles, to determine the weight and consumer cost of pretensioners, load limiters, and adjustable anchors (Khadilkar et al., 2001a, 2001a). Four of the MY 1999 vehicles had pyrotechnic pretensioners and four did not and the average cost for both sets was almost identical. Thus, we considered both types of pretensioners together. Table 180 shows the arithmetic average weight and consumer cost of all three technologies. This is before considering the learning curve.

Table 180. FMVSS No. 208: Average weights and consumer costs per seat of pretensioners, load limiters, and adjustable anchors

Component	Weight (lb)	Consumer Cost (2019$)
Pretensioners	0.16	$17.65
Load Limiters	0.33	$6.50
Adjustable Anchors	0.65	$4.89
Total for All Three	1.14	$29.04

Pretensioners and load limiters are voluntarily installed in passenger vehicles by the automotive manufacturers and not required by NHTSA, their costs are not attributed to FMVSS No. 208, but are included in the voluntary totals. NHTSA has never required installation of these technologies but encouraged it by listing the makes and models of vehicles that offered them in its annual *Buying a Safer Car* brochures, which were published starting in 1997, These brochures are no longer available and are no longer on the internet. Mercedes-Benz introduced pretensioners in the front seats of their S-class cars in 1981. The introduction of pretensioners in the front seat was spread over many years, although most models received them sometime from 1998 to 2006. Front seat pretensioners were in 55 percent of both passenger cars and LTVs by MY 2002.

Before MY 2003, only Audi, Mercedes, and Volvo had introduced pretensioners in the rear seat of some of their passenger car models (Audi in MY 1998, Volvo in MY 1999, and Mercedes in MY 2000), and the pretensioners were installed on outboard and center seat positions. Volvo extended the use of pretensioners to LTVs in MY 2000, Audi in MY 2001, and Mercedes in MY 2007.

Volvo introduced load limiters on its 850 series in 1995. Load limiters for the front outboard seats mostly entered the new-vehicle fleet from 1997 to 2002. By MY 2002, 91 percent of new cars and 75 percent of new LTVs were already being equipped with load limiters at the outboard front seats. All new passenger cars and LTVs had pretensioners and load limiters by MY 2008 at the outboard front seating positions. Estimates of load limiters sales were developed by taking load limiter information by make/model in the appendix of the evaluation and weighting them by Wards sales data (Kahane, 2003, pp. 1–3). Mercedes included load limiters with the make/models that had rear seat pretensioners in MY 2000 for passenger cars and MY 2007 for LTVs. Volvo introduced load limiters in the rear seat for children in MY 2007 in both passenger cars and LTVs, and then had an adjustable load limiter for children and adults starting in MY 2015.[43] Data on vehicles with rear seat pretensioners was gathered from cars.com. Cars.com does not have data on rear seat load limiters.[44] We know that Volvo didn't introduce load limiters in the rear seat until MY 2007 and Mercedes introduced them at the same time as pretensioners in the rear seat. We don't have an estimate of the costs of the adjustable load limiter introduced in MY 2015. It is likely that the additional costs to add adjustability to the load limiter are mostly software costs.

On December 12, 1990, the National Transportation Safety Board recommended that manufacturers of passenger vehicles provide an adjustable upper anchorage for the shoulder portion of the seat belts. The manufacturers responded to the National Transportation Safety

[43] Information on rear seat pretensioners and load limiters prior to MY 2011 were found at the following websites:

- www.firehouse.com/article/10568057/pre-tensioner-systems-design-function
- www.usedecus.com/en/mercedes/c-class-w203/mercedes-c-class-w203-rear-middle-seat-belt-pretensioner-trw-2038600269-33007402/
- www.mbusa.com/vcm/MB/DigitalAssets/pdfmb/.../MB_Safety_Passive_18.pdf
- www.ntsb.gov/news/events/Documents/2016_rssw_WS_Jakobsson.pdf

[44] Go to Cars.com, click *Research & Reviews* at the top of the page. Next, enter the make/model/year and click *Research*. Click *Compare all trims*, expand a downward arrow, then click *View full specs*. Under specifications, click *Safety*. Near the end of the list find either *Front Seat Pretensioners* or *Front and Rear Seat Pretensioners*.

Board with their plans to include adjustable upper anchors in their vehicles by MY. Many of the manufacturers were only planning to include adjustable anchors for 4-door passenger cars, but some included certain LTVs. Many manufacturers believed that because the anchorage point was far behind the driver for a 2-door vehicle that the adjustability of the anchorage point was of little value to the driver. These plans, which are no longer on the internet, were combined with sales data to form the basis of our estimates of the percent of the fleet provided with adjustable anchors. The earliest information we found was that the Jaguar sedans had adjustable anchors in MY 1987. Because they make up such a small percentage of the new car fleet, we started the table in MY 1989. NHTSA later proposed that all passenger cars and LTVs be required to have adjustable anchors.

The New Car Assessment Program asked for and received information from the manufacturers on rear seat pretensioners and rear seat load limiters and this information is combined in the file found at www.nhtsa.gov/file-downloads?p=nhtsa/downloads/Safercar/.

We used the data in columns Q-T for MYs 2011 to 2019, which indicate whether the pretensioners or load limiters are standard or optional as well as the seat positions where they are located. For the few optional pretensioners in VW vehicles in MY 2011 to 2013 we assumed 10 percent of their total sales would be taken as an option. The data were sales weighted by make/model/MY using data from the *Ward's Automotive Yearbooks* (Binder, 2002-2017; Norris, 2018-2020).

Table 181 shows the estimated percent of the fleet and the associated weight and consumer cost for front seat pretensioners. Table 182 shows the same information for rear seat pretensioners. Table 183 shows the estimated percent of the fleet and the associated weight and consumer cost for front seat load limiters, Table 184 for rear seat load limiters and Table 185 and Table 186 show the same information for front seat adjustable anchors for passenger cars and LTVs. The estimated cost for passenger cars and LTVs is shown after applying the learning curve, which uses the seat belt progress rate of 0.96. Table 187 and Table 188 show the combined passenger car and Table 189 and Table 190 show the combined LTVs weights and costs for front and rear seat pretensioners, load limiters, and adjustable anchorages.

Table 181. FMVSS No. 208: Average weights (lb) and consumer costs: Weights for voluntarily supplied front seat pretensioners

Model Year	PC Percent	PC Weight	PC Cost	LTV Percent	LTV Weight	LTV Cost
1995	0.27	0.00	$0.13	0.01	0.00	$0.00
1996	0.51	0.00	$0.23	0	0.00	$0.00
1997	1.01	0.00	$0.43	0.02	0.00	$0.01
1998	10.67	0.03	$3.98	3.03	0.01	$1.13
1999	13.84	0.04	$4.89	8.38	0.03	$2.96
2000	30.04	0.10	$10.13	12.64	0.04	$4.26
2001	49.87	0.16	$16.09	38.56	0.12	$12.44
2002	55.11	0.18	$17.27	55.72	0.18	$17.46

Model Year	PC Percent	PC Weight	PC Cost	LTV Percent	LTV Weight	LTV Cost
2003	62.11	0.20	$19.06	60.91	0.19	$18.69
2004	70.62	0.23	$21.29	68.92	0.22	$20.78
2005	79.05	0.25	$23.47	81.45	0.26	$24.18
2006	99.57	0.32	$29.16	84.53	0.27	$24.76
2007	100	0.32	$28.95	93.42	0.30	$27.04
2008	100	0.32	$28.67	100	0.32	$28.67
2009	100	0.32	$28.51	100	0.32	$28.51
2010	100	0.32	$28.34	100	0.32	$28.34
2011	100	0.32	$28.17	100	0.32	$28.17
2012	100	0.32	$28.00	100	0.32	$28.00
2013	100	0.32	$27.83	100	0.32	$27.83
2014	100	0.32	$27.68	100	0.32	$27.68
2015	100	0.32	$27.52	100	0.32	$27.52
2016	100	0.32	$27.40	100	0.32	$27.40
2017	100	0.32	$27.28	100	0.32	$27.28
2018	100	0.32	$27.18	100	0.32	$27.18
2019	100	0.32	$27.08	100	0.32	$27.08

Table 182. FMVSS No. 208: Average weights (lb) and consumer costs: Weights for voluntarily supplied rear seat pretensioners

Model Year	PC Percent	PC Weight	PC Cost	LTV Percent	LTV Weight	LTV Cost
1998	0.80	0.00	$0.30	0.00	0.00	$0.00
1999	0.96	0.00	$0.36	0.00	0.00	$0.00
2000	2.24	0.01	$0.82	0.19	0.00	$0.09
2001	2.92	0.01	$1.02	0.26	0.00	$0.10
2002	3.32	0.01	$1.12	0.58	0.00	$0.22
2003	3.51	0.01	$1.16	0.57	0.00	$0.21
2004	4.24	0.01	$1.38	0.97	0.00	$0.35
2005	4.25	0.01	$1.36	0.83	0.00	$0.29

Model Year	PC Percent	PC Weight	PC Cost	LTV Percent	LTV Weight	LTV Cost
2006	4.22	0.01	$1.33	0.51	0.00	$0.18
2007	4.34	0.01	$1.36	0.64	0.00	$0.22
2008	4.56	0.02	$1.41	0.86	0.00	$0.29
2009	5.37	0.02	$1.65	0.98	0.00	$0.33
2010	4.31	0.01	$1.32	2.54	0.01	$0.86
2011	4.66	0.02	$1.42	3.45	0.01	$1.16
2012	6.35	0.02	$1.94	3.58	0.01	$1.18
2013	7.09	0.02	$2.14	3.29	0.01	$0.99
2014	7.74	0.03	$2.32	3.69	0.01	$1.03
2015	6.64	0.02	$1.98	3.29	0.01	$0.95
2016	7.70	0.03	$2.27	4.36	0.01	$1.23
2017	7.14	0.02	$2.06	4.74	0.02	$1.44
2018	10.72	0.04	$2.98	5.30	0.02	$1.64
2019	10.81	0.04	$3.07	7.85	0.03	$2.35

Table 183. FMVSS No. 208: Average weights (lb) and consumer costs: Weights for voluntarily supplied front seat load limiters

Model Year	PC Percent	PC Weight	PC Cost	LTV Percent	LTV Weight	LTV Cost
1994	0	0.00	$0.00	0	0.00	$0.00
1995	0.17	0.00	$0.03	0	0.00	$0.00
1996	0.18	0.00	$0.03	0	0.00	$0.00
1997	2.25	0.01	$0.35	1.97	0.01	$0.31
1998	9.22	0.06	$1.32	8.61	0.06	$1.23
1999	55.77	0.37	$7.25	28.73	0.19	$3.74
2000	67.57	0.45	$8.41	44.23	0.29	$5.51
2001	79.37	0.52	$9.60	59.73	0.39	$7.23
2002	91.20	0.60	$10.79	75.18	0.50	$8.90
2003	92.08	0.61	$10.72	77.66	0.51	$9.04
2004	96.48	0.64	$11.08	79.57	0.53	$9.14

Model Year	PC Percent	PC Weight	PC Cost	LTV Percent	LTV Weight	LTV Cost
2005	97.74	0.65	$11.11	84.31	0.56	$9.58
2006	99.57	0.66	$11.21	83.32	0.55	$9.38
2007	99.56	0.66	$11.11	100	0.66	$11.16
2008	100	0.66	$11.07	100	0.66	$11.07
2009	100	0.66	$11.02	100	0.66	$11.02
2010	100	0.66	$10.97	100	0.66	$10.97
2011	100	0.66	$10.92	100	0.66	$10.92
2012	100	0.66	$10.86	100	0.66	$10.86
2013	100	0.66	$10.81	100	0.66	$10.81
2014	100	0.66	$10.75	100	0.66	$10.75
2015	100	0.66	$10.70	100	0.66	$10.70
2016	100	0.66	$10.66	100	0.66	$10.66
2017	100	0.66	$10.62	100	0.66	$10.62
2018	100	0.66	$10.58	100	0.66	$10.58
2019	100	0.66	$10.55	100	0.66	$10.55

Table 184. FMVSS No. 208: Average weights (lb) and consumer costs: Weights for voluntarily supplied rear seat load limiters

Model Year	PC Percent	PC Weight	PC Cost	LTV Percent	LTV Weight	LTV Cost
1998	0.80	0.01	$0.12	0.00	0.00	$0.00
1999	0.96	0.01	$0.12	0.00	0.00	$0.00
2000	2.24	0.01	$0.28	0.19	0.00	$0.03
2001	2.92	0.02	$0.35	0.26	0.00	$0.04
2002	3.32	0.02	$0.39	0.58	0.00	$0.08
2003	3.51	0.02	$0.41	0.57	0.00	$0.08
2004	4.24	0.03	$0.49	0.97	0.01	$0.13
2005	4.25	0.03	$0.48	0.83	0.01	$0.11
2006	4.22	0.03	$0.47	0.51	0.00	$0.07
2007	4.34	0.03	$0.48	0.64	0.00	$0.08

Model Year	PC Percent	PC Weight	PC Cost	LTV Percent	LTV Weight	LTV Cost
2008	4.56	0.04	$0.50	0.86	0.01	$0.11
2009	5.37	0.05	$0.59	0.98	0.01	$0.13
2010	4.31	0.04	$0.47	2.54	0.02	$0.33
2011	4.42	0.04	$0.48	10.77	0.08	$1.37
2012	5.37	0.04	$0.60	12.10	0.09	$1.55
2013	5.17	0.04	$0.58	9.66	0.06	$1.04
2014	6.09	0.05	$0.68	9.97	0.06	$1.07
2015	7.56	0.04	$0.82	9.40	0.06	$1.01
2016	10.93	0.05	$1.17	20.00	0.13	$2.14
2017	9.97	0.05	$1.08	12.16	0.08	$1.36
2018	10.11	0.13	$1.07	16.11	0.11	$1.80
2019	13.47	0.14	$1.45	15.46	0.05	$1.75

Table 185. FMVSS No. 208: Average weights and consumer costs for front seat adjustable anchors in passenger cars

Model Year	Percent Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1989	0.51	0.01	0.00	0.01	$0.08	$0.00	$0.08
1990	0.51	0.01	0.00	0.01	$0.07	$0.00	$0.07
1991	1.79	0.02	0.00	0.02	$0.24	$0.00	$0.24
1992	13.71	0.18	0.00	0.18	$1.67	$0.00	$1.67
1993	21.97	0.29	0.00	0.29	$2.51	$0.00	$2.51
1994	30.99	0.40	0.00	0.40	$3.42	$0.00	$3.42
1995	37.54	0.40	0.09	0.49	$3.33	$0.70	$4.03
1996	38.71	0.40	0.10	0.50	$3.27	$0.81	$4.08
1997	50.00	0.40	0.25	0.65	$3.19	$1.96	$5.15
1998	100	0.40	0.90	1.30	$3.10	$6.90	$9.99
1999	100	0.40	0.90	1.30	$3.03	$6.75	$9.78
2000	100	0.40	0.90	1.30	$2.98	$6.64	$9.63
2001	100	0.40	0.90	1.30	$2.95	$6.56	$9.51

Model Year	Percent Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2002	100	0.40	0.90	1.30	$2.92	$6.50	$9.41
2003	100	0.40	0.90	1.30	$2.89	$6.44	$9.33
2004	100	0.40	0.90	1.30	$2.87	$6.39	$9.26
2005	100	0.40	0.90	1.30	$2.85	$6.35	$9.20
2006	100	0.40	0.90	1.30	$2.83	$6.31	$9.15
2007	100	0.40	0.90	1.30	$2.82	$6.28	$9.10
2008	100	0.40	0.90	1.30	$2.81	$6.25	$9.05
2009	100	0.40	0.90	1.30	$2.80	$6.23	$9.03
2010	100	0.40	0.90	1.30	$2.79	$6.21	$9.00
2011	100	0.40	0.90	1.30	$2.78	$6.19	$8.96
2012	100	0.40	0.90	1.30	$2.77	$6.16	$8.93
2013	100	0.40	0.90	1.30	$2.76	$6.14	$8.90
2014	100	0.40	0.90	1.30	$2.75	$6.12	$8.87
2015	100	0.40	0.90	1.30	$2.74	$6.10	$8.83
2016	100	0.40	0.90	1.30	$2.73	$6.08	$8.81
2017	100	0.40	0.90	1.30	$2.72	$6.06	$8.78
2018	100	0.40	0.90	1.30	$2.71	$6.04	$8.75
2019	100	0.40	0.90	1.30	$2.71	$6.03	$8.73

Table 186. FMVSS No. 208: Average weights and consumer costs for front seat adjustable anchors in LTVs

Model Year	Percent Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1989	0	0.00	0.00	0.00	$0.00	$0.00	$0.00
1990	0.1	0.00	0.00	0.00	$0.01	$0.00	$0.01
1991	0.08	0.00	0.00	0.00	$0.01	$0.00	$0.01
1992	0.23	0.00	0.00	0.00	$0.03	$0.00	$0.03
1993	11.48	0.15	0.00	0.15	$1.31	$0.00	$1.31
1994	10.85	0.14	0.00	0.14	$1.20	$0.00	$1.20
1995	12.57	0.14	0.02	0.16	$1.17	$0.18	$1.35

Model Year	Percent Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	13.62	0.14	0.04	0.18	$1.14	$0.29	$1.44
1997	50.00	0.14	0.51	0.65	$1.12	$4.03	$5.15
1998	100	0.14	1.16	1.30	$1.08	$8.91	$9.99
1999	100	0.14	1.16	1.30	$1.06	$8.72	$9.78
2000	100	0.14	1.16	1.30	$1.04	$8.58	$9.63
2001	100	0.14	1.16	1.30	$1.03	$8.48	$9.51
2002	100	0.14	1.16	1.30	$1.02	$8.39	$9.41
2003	100	0.14	1.16	1.30	$1.01	$8.32	$9.33
2004	100	0.14	1.16	1.30	$1.01	$8.26	$9.26
2005	100	0.14	1.16	1.30	$1.00	$8.20	$9.20
2006	100	0.14	1.16	1.30	$0.99	$8.15	$9.15
2007	100	0.14	1.16	1.30	$0.99	$8.11	$9.10
2008	100	0.14	1.16	1.30	$0.98	$8.07	$9.05
2009	100	0.14	1.16	1.30	$0.98	$8.05	$9.03
2010	100	0.14	1.16	1.30	$0.98	$8.02	$9.00
2011	100	0.14	1.16	1.30	$0.97	$7.99	$8.96
2012	100	0.14	1.16	1.30	$0.97	$7.96	$8.93
2013	100	0.14	1.16	1.30	$0.97	$7.93	$8.90
2014	100	0.14	1.16	1.30	$0.96	$7.90	$8.87
2015	100	0.14	1.16	1.30	$0.96	$7.87	$8.83
2016	100	0.14	1.16	1.30	$0.96	$7.85	$8.81
2017	100	0.14	1.16	1.30	$0.95	$7.83	$8.78
2018	100	0.14	1.16	1.30	$0.95	$7.80	$8.75
2019	100	0.14	1.16	1.30	$0.95	$7.78	$8.73

Table 187. FMVSS No. 208: Average weights and consumer costs for pretensioners, load limiters, and adjustable anchors in passenger cars – front seat

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1988	0.00	0.00	0.00	$0.00	$0.00	$0.00
1989	0.01	0.00	0.01	$0.08	$0.00	$0.08
1990	0.01	0.00	0.01	$0.07	$0.00	$0.07
1991	0.02	0.00	0.02	$0.24	$0.00	$0.24
1992	0.18	0.00	0.18	$1.67	$0.00	$1.67
1993	0.29	0.00	0.29	$2.51	$0.00	$2.51
1994	0.40	0.00	0.40	$3.42	$0.00	$3.42
1995	0.40	0.09	0.49	$3.49	$0.70	$4.19
1996	0.41	0.10	0.51	$3.53	$0.81	$4.34
1997	0.42	0.25	0.67	$3.97	$1.96	$5.93
1998	0.50	0.90	1.39	$8.40	$6.90	$15.29
1999	0.82	0.90	1.71	$15.17	$6.75	$21.92
2000	0.94	0.90	1.84	$21.52	$6.64	$28.17
2001	1.09	0.90	1.98	$28.64	$6.56	$35.20
2002	1.18	0.90	2.08	$30.98	$6.50	$37.47
2003	1.21	0.90	2.11	$32.67	$6.44	$39.11
2004	1.27	0.90	2.16	$35.25	$6.39	$41.64
2005	1.30	0.90	2.20	$37.42	$6.35	$43.77
2006	1.38	0.90	2.28	$43.20	$6.31	$49.52
2007	1.38	0.90	2.28	$42.87	$6.28	$49.15
2008	1.38	0.90	2.28	$42.54	$6.25	$48.79
2009	1.38	0.90	2.28	$42.33	$6.23	$48.56
2010	1.38	0.90	2.28	$42.11	$6.21	$48.31
2011	1.38	0.90	2.28	$41.87	$6.19	$48.05
2012	1.38	0.90	2.28	$41.63	$6.16	$47.79
2013	1.38	0.90	2.28	$41.40	$6.14	$47.54
2014	1.38	0.90	2.28	$41.18	$6.12	$47.30
2015	1.38	0.90	2.28	$40.96	$6.10	$47.06

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2016	1.38	0.90	2.28	$40.79	$6.08	$46.86
2017	1.38	0.90	2.28	$40.62	$6.06	$46.68
2018	1.38	0.90	2.28	$40.47	$6.04	$46.51
2019	1.38	0.90	2.28	$40.33	$6.03	$46.36

Table 188. FMVSS No. 208: Average weights and consumer costs for pretensioners and load limiters in passenger cars – rear seats

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1998	0.01	0.00	0.01	$0.42	$0.00	$0.42
1999	0.01	0.00	0.01	$0.46	$0.00	$0.46
2000	0.02	0.00	0.02	$1.02	$0.00	$1.02
2001	0.03	0.00	0.03	$1.33	$0.00	$1.33
2002	0.03	0.00	0.03	$1.50	$0.00	$1.50
2003	0.03	0.00	0.03	$1.56	$0.00	$1.56
2004	0.04	0.00	0.04	$1.90	$0.00	$1.90
2005	0.04	0.00	0.04	$1.85	$0.00	$1.85
2006	0.05	0.00	0.05	$1.88	$0.00	$1.88
2007	0.05	0.00	0.05	$1.92	$0.00	$1.92
2008	0.06	0.00	0.06	$2.10	$0.00	$2.10
2009	0.07	0.00	0.07	$2.46	$0.00	$2.46
2010	0.05	0.00	0.05	$1.98	$0.00	$1.98
2011	0.06	0.00	0.06	$2.10	$0.00	$2.10
2012	0.07	0.00	0.07	$2.76	$0.00	$2.76
2013	0.07	0.00	0.07	$2.91	$0.00	$2.91
2014	0.08	0.00	0.08	$3.23	$0.00	$3.23
2015	0.09	0.00	0.09	$3.10	$0.00	$3.10
2016	0.12	0.00	0.12	$3.82	$0.00	$3.82
2017	0.11	0.00	0.11	$3.49	$0.00	$3.49

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2018	0.11	0.00	0.11	$4.20	$0.00	$4.20
2019	0.14	0.00	0.14	$4.69	$0.00	$4.69

Table 189. FMVSS No. 208: Average weights and consumer costs for pretensioners, load limiters, and adjustable anchors in LTVs – front seat

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1988	0.00	0.00	0.00	$0.00	$0.00	$0.00
1989	0.00	0.00	0.00	$0.00	$0.00	$0.00
1990	0.00	0.00	0.00	$0.01	$0.00	$0.01
1991	0.00	0.00	0.00	$0.01	$0.00	$0.01
1992	0.00	0.00	0.00	$0.03	$0.00	$0.03
1993	0.15	0.00	0.15	$1.31	$0.00	$1.31
1994	0.14	0.00	0.14	$1.20	$0.00	$1.20
1995	0.14	0.02	0.16	$1.36	$0.00	$1.36
1996	0.14	0.04	0.18	$1.33	$0.11	$1.44
1997	0.15	0.51	0.66	$1.61	$3.86	$5.47
1998	0.21	1.16	1.37	$3.62	$8.74	$12.36
1999	0.36	1.16	1.52	$7.92	$8.55	$16.48
2000	0.47	1.16	1.63	$10.98	$8.42	$19.40
2001	0.66	1.16	1.82	$20.86	$8.31	$29.18
2002	0.82	1.16	1.97	$27.54	$8.23	$35.77
2003	0.85	1.16	2.01	$28.90	$8.16	$37.06
2004	0.89	1.16	2.05	$31.08	$8.10	$39.18
2005	0.96	1.16	2.12	$34.92	$8.04	$42.96
2006	0.96	1.16	2.12	$35.28	$8.00	$43.28
2007	1.10	1.16	2.26	$39.34	$7.95	$47.30
2008	1.12	1.16	2.28	$40.88	$7.91	$48.79
2009	1.12	1.16	2.28	$40.67	$7.89	$48.56
2010	1.12	1.16	2.28	$40.45	$7.87	$48.31

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2011	1.12	1.16	2.28	$40.22	$7.84	$48.05
2012	1.12	1.16	2.28	$39.99	$7.81	$47.79
2013	1.12	1.16	2.28	$39.76	$7.78	$47.54
2014	1.12	1.16	2.28	$39.55	$7.75	$47.30
2015	1.12	1.16	2.28	$39.33	$7.72	$47.06
2016	1.12	1.16	2.28	$39.17	$7.70	$46.86
2017	1.12	1.16	2.28	$39.00	$7.68	$46.68
2018	1.12	1.16	2.28	$38.86	$7.65	$46.51
2019	1.12	1.16	2.28	$38.73	$7.63	$46.36

Table 190. FMVSS No. 208: Average weights and consumer costs for pretensioners and load limiters in LTVs – rear seat

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1999	0.00	0.00	0.00	$0.00	$0.00	$0.00
2000	0.00	0.00	0.00	$0.12	$0.00	$0.12
2001	0.00	0.00	0.00	$0.13	$0.00	$0.13
2002	0.01	0.00	0.01	$0.30	$0.00	$0.30
2003	0.01	0.00	0.01	$0.29	$0.00	$0.29
2004	0.01	0.00	0.01	$0.48	$0.00	$0.48
2005	0.01	0.00	0.01	$0.40	$0.00	$0.40
2006	0.01	0.00	0.01	$0.25	$0.00	$0.25
2007	0.01	0.00	0.01	$0.31	$0.00	$0.31
2008	0.01	0.00	0.01	$0.41	$0.00	$0.41
2009	0.01	0.00	0.01	$0.46	$0.00	$0.46
2010	0.03	0.00	0.03	$1.19	$0.00	$1.19
2011	0.10	0.00	0.10	$2.53	$0.00	$2.53
2012	0.11	0.00	0.11	$2.74	$0.00	$2.74
2013	0.08	0.00	0.08	$2.04	$0.00	$2.04
2014	0.08	0.00	0.08	$2.11	$0.00	$2.11

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2015	0.07	0.00	0.07	$1.96	$0.00	$1.96
2016	0.15	0.00	0.15	$3.37	$0.00	$3.37
2017	0.10	0.00	0.10	$2.80	$0.00	$2.80
2018	0.13	0.00	0.13	$3.43	$0.00	$3.43
2019	0.08	0.00	0.08	$4.10	$0.00	$4.10

Passenger Car Studies – Frontal Air Bags

Frontal air bags are designed to save lives and prevent injuries by cushioning occupants as they move forward in a frontal crash. Frontal air bags reduce the likelihood of injury to an occupant's head, neck, face, chest, and abdomen. It is important to note, however, that the air bags are supplemental restraints. The presence of an air bag does not mean it is less important for occupants to use their seat belts. The seat belt, which provides protection in all kinds of crashes, is the primary means of occupant restraint. Frontal air bags provide significant supplemental protection in frontal crashes. Today's frontal air bag requirements have been evolving for more than 50 years. NHTSA issued its first public notice concerning air bags in 1969. Starting in 1972, vehicle manufacturers had the option of installing air bags in passenger cars as a means of complying with FMVSS No. 208. GM installed driver and passenger air bags in approximately 10,000 passenger cars in the mid-1970s, but then stopped their production.

We decided to assume our baseline would be linked to the final rule that resulted in air bag production restarting. That was the final rule, published in the Federal Register on July 17, 1984 (49 FR 28962), that required automatic restraint systems for the front outboard seats in passenger cars in response to the persistent low usage rate of manual belts. The requirement was phased in starting September 1, 1986, with full implementation by September 1, 1989. The front center seat of passenger cars was exempt from, and rear seats were not covered by, the requirements. The NPRM was published in the Federal Register on October 14, 1983, (48 FR 48622) making the baseline date September 1, 1983, or MY 1984. There were no driver side air bags or passenger side air bags in MY 1984 passenger cars or LTVs, thus we assume that the baseline is 0 percent and all air bags are attributed to FMVSS No. 208.

To encourage the development and introduction of non-belt automatic restraint systems, the requirement also provided that manufacturers that installed a non-belt system, such as an air bag, at the driver's seating position could install a manual lap/shoulder belt rather than an automatic system at the front right seating position. A further amendment in March 1987 extended this option until September 1, 1993, to expedite the introduction of driver air bags while allowing adequate lead-time for introduction of right front passenger air bags.

In 1991, Congress directed NHTSA to issue a final rule requiring that automatic crash protection must be provided by an inflatable restraint (i.e., an air bag) in passenger cars, MPVs, and buses (all LTVs with a GVWR of 8,500 lb or less). In addition, the seating positions protected by an air bag must also have a manual lap/shoulder belt. The final rule was published in the Federal Register on September 2, 1993, requiring at least 95 percent of each manufacturer's passenger cars manufactured on or after September 1, 1996, and before September 1, 1997, to have an air bag and a manual lap/shoulder belt at both the driver's and right front passenger's seating position (58 F.R: Vol. 58, 1993). Every passenger car manufactured on or after September 1, 1997, must be so equipped. The vehicle manufacturers, however, were ahead of the implementation schedule. Nearly every 1996 MY passenger car had both driver- and passenger-side air bags as standard equipment.

Like the automatic restraint requirements issued in 1984, the air bag requirements were performance requirements that did not specify the design of an air bag system. Instead, vehicles had to meet specified injury criteria, including criteria for the head and chest, measured on test dummies during a barrier crash test at speeds up to 30 mph. These criteria had to be met for air bag equipped vehicles both when the dummies were belted and when they were unbelted. These requirements applied to the performance of the vehicle, and not to the air bags as a separate item of motor vehicle equipment. This permitted vehicle manufacturers to tune the performance of the air bag to the crash pulse and other specific attributes of each of their vehicles and left them free to select specific attributes for their air bags, such as dimensions, actuation time, etc.

A series of cost and weight analyses were performed on air bags from twelve passenger cars of various MYs (Khadilkar et al., 1988b, 1988c; Fladmark & Khadilkar, 1992, 1992a, 1992b, 1996, 1997, 1997a).[45] Table 208-22 shows the arithmetic average weight and consumer cost, for three MY groups, for driver air bags and dual air bags and the MY vehicles that were analyzed. The passenger bag weights and costs below are simply the subtraction of the driver side air bag from the dual air bag results.

Redesigned Frontal Air Bags

Frontal air bags have constantly evolved over time. The previous section discussed just the basic frontal air bags. In October 1995, NHTSA began a series of actions to reduce and eventually eliminate the adverse effect of air bags for infants, children, and other high-risk occupants while retaining, to the largest extent possible, the great life-saving benefits of air bags for most people. Specifically, on March 19, 1997, NHTSA amended FMVSS No. 208, effective immediately (i.e., in time to allow implementation in MY 1998 or, at the latest MY 1999), relaxing some aspects of the frontal impact test for the unrestrained dummy to facilitate the introduction of redesigned air bags that deploy less forcefully. Instead of a barrier-crash test with an actual vehicle, manufacturers could temporarily use a sled test with a deceleration pulse stipulated in FMVSS No. 208, resembling the deceleration of a typical large passenger car in a barrier impact – i.e., relatively gradual (62 F.R., 1997).

In approximately 84 percent of driver air bags and 70 percent of passenger bags, suppliers achieved less forceful deployments by literally depowering the air bags: removing some of the gas-generating propellant. Others replaced or supplemented the propellant with a cylinder of stored argon gas. The agency has no cost teardown studies for redesigned frontal air bags of MYs 1998 to 2006.

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[45] Only driver air bags were specifically cost estimated for a MY 1987 Ford Tempo and MY 1987 Mercedes 190. The multiplier for these 1988 reports was 1.64. The multiplier for all of the other air bag teardown contracts was 1.51. The analysis has adjusted the 1988 results to 1.51.

Advanced Frontal Air Bags

In 1998, Congress directed NHTSA to issue a final rule mandating the use of advanced air bags to improve occupant protection for occupants of different sizes, belted and unbelted, while minimizing the risk to infants, children, and other occupants from injuries and deaths caused by air bags. On May 12, 2000, the agency added a section S14 to FMVSS No. 208 to phase in advanced frontal air bags from September 1, 2003, to September 1, 2006. The options for advanced air bags are that they do not deploy at all for children (suppression), deploy only at a low level of force (low-risk deployment), or track an occupant's motion and suppress the air bag if they are too close (dynamic automatic suppression). However, no vehicles have ever employed dynamic automatic suppression. The predominant option is suppression, based on a weight sensor in the right front seat that automatically switches off the air bag unless it detects a mass greater than a predetermined threshold. Some manufacturers use weight sensors with two thresholds: suppression upon sensing low mass, low-risk deployment for an intermediate range of mass (e.g., a range that includes the average weight of a 6-year-old child), and normal deployment above that range.

During this timeframe, NHTSA also modified and, in some cases, strengthened selected performance requirements in FMVSS No. 208. The agency reinstated a barrier crash test with an unbelted 50th percentile adult male anthropomorphic test device (dummy), in place of the sled test; however, the maximum speed for that test is now in a range of 20 to 25 mph (as compared to the range of 0 to 30 mph in the original barrier test and the sled test with a 28-to-30 mph velocity change). NHTSA may conduct the test with a barrier that is perpendicular to the vehicle's line of travel or tilted at any angle up to 30° in either direction to simulate an oblique crash. Also, during this timeframe, the standard required testing the performance for small-stature adults represented by a belted 5th percentile female Hybrid III ATD in a 30-mph perpendicular-barrier test. The test with the belted 50th percentile male ATD was upgraded from 30 mph to 35 mph, phasing in from September 1, 2007, to September 1, 2010. On August 31, 2006, (71 FR 51768), the agency amended FMVSS No. 208 to likewise upgrade the test with the belted 5th percentile female from 30 mph to 35 mph, phasing in from September 1, 2009, to September 1, 2012. The NPRM was published in the Federal Register on August 6, 2003, (68 FR 46539). During the 2000s, in addition to designing to the amended regulations, manufacturers also introduced features to tailor deployments to the needs of the occupant. The features include multi-stage inflators to allow various alternative force levels for deployments, seat-belt use sensors that can influence whether or how forcefully the air bag should deploy, and seat-track sensors that can detect if an occupant is sitting close to the air bag (65 F.R: 30679, 2000, 71: 57168, 2006; Greenwell, 2013). These same features were used to meet the variety of changes required by amendments in air bag testing requirements.

A cost teardown report on MY 2007 vehicles estimated the total cost of dual air bags at that time including all the advanced air bags technologies (Ludtke & Associates, 2008). One of the four MY 2007 vehicles used in the passenger car analysis was an LTV. The SUV air bag estimates were very similar to the weights and costs of the 3 passenger cars and all were combined into one average. As Table 191 shows, even with advanced technologies being added to the weight and cost of air bags the overall weight and cost went down substantially compared to MY 1996. Some of this cost reduction, which we cannot quantify, might be due to the relaxation of the unbelted test requirements. We assume the same weights and costs for advanced air bags for LTVs as for passenger cars.

Table 191. FMVSS No. 208: Average weights and consumer costs of air bags in passenger cars – data from teardown analyses

Model Year	Weight (lb)	Consumer Cost (2019$)
Driver Air Bags		
1987	25.93	$528.84
1992-1996	13.46	$393.77
2007	4.00	$196.77
Passenger Air Bags		
1992-1996	13.30	$156.11
2007	8.80	$192.69
Dual Air Bags		
1992-1996	26.76	$549.89
2007	12.80	$389.46

The high estimate of driver air bags in 1987 probably reflects the inefficiencies of initial implementation. In its cost teardowns the agency assumes many of the components of the basic system are charged to the driver air bag (for example the crash sensors, the electronic control unit (ECU), wiring to everything but the passenger bag, etc.) Thus, historically the driver air bag costs are higher than the passenger air bag costs (see Table 191 for 1992 to 1996 models where the driver side is credited with 2.5 times the cost of the passenger side: $393.77 versus $156.11). This changes dramatically by the next cost teardown of MY 2007 (and is assumed to change by 2004 with the phase-in) with the addition of advanced technologies which focus mainly on the passenger side. The passenger air bag itself is larger and covers more area than the driver air bag and is more expensive. The weight sensor and ECU for it add cost to the point that the passenger air bag is about the same cost as the driver side, even though the driver side is still charged with the crash sensors and basic ECU. See Tables 192 and 193 for the comparisons.

The main components of an air bag system in MYs 1992 to 1996 are the:

- Air Bag Module. The air bag module contains both an inflator unit and the lightweight fabric air bag. The driver air bag module is in the steering wheel hub, and the passenger air bag module is in the instrument panel.
- Igniter/Inflator. The igniter assemblies are electrical devices that ignite a chemical gas generator that uses a sodium azide/sodium nitrate generant. Upon ignition, the generant produces nitrogen gas that fills the bag assemblies, creating a cushion effect. Some vehicles use a cylinder of compressed argon gas rather than/in addition to an ignitable propellant.
- Control Module/Sensors. The control module is usually installed in the longitudinal center of the car between the passenger and engine compartment. The sensors continuously monitor the acceleration and deceleration of the vehicle and send this

information to a microprocessor where the crash pulse of a vehicle is stored. When the microprocessor recognizes the crash pulse from the sensor, an electrical current is sent to the inflator of the airbags that should be deployed.

- Clock Spring. The clock spring, or supplemental inflatable restraint coil, or SIR coil, is in the steering column and has several wraps of wire that look much like the spring in a clock. This assembly allows for one end to be connected to the wiring harness for the air bag system and the other end to be connected to the air bag in the steering wheel. The wraps of wire wind in and out as the steering wheel is turned, which allows the steering wheel to move while maintaining the electrical connection to the airbag module.
- Wiring Harness. The wiring harness is a collection of wires that is designed to control electrical functions in one section of a vehicle. Most wiring harnesses feature simple plug-in connectors, so components can be changed without the need to splice wires.
- Knee Bolster. The knee bolster is a padded bar on the lower part of the dashboard that is used in conjunction with frontal air bags to reduce lower limb injury and the risk of gliding under the seat belt during a crash.

Table 192 shows the arithmetic average weight and consumer cost of the principal components of dual air bags for MYs 1992 to 1996. Table 193 shows similar information for MY 2007. Note that the MY 2007 systems do not include a knee bolster, probably because the function of the knee bolster has been designed into the lower dash and cannot be identified as a knee bolster per se. Here we have combined and averaged four different vehicles, and given things similar names, although each manufacturer may handle the weight sensing and electronic control function for suppression and low risk air bags on the passenger side differently.

Table 192. FMVSS No. 208: Average weights and consumer costs of principal components in dual air bags in passenger cars from 1992 to 1996

Principal Component	Weight (lb)	Consumer Cost (2019$)
Driver Air Bag and Inflator Assembly	3.60	$90.14
Passenger Air Bag and Inflator Assembly	11.58	$177.61
Knee Bolster	7.37	$40.96
Control Module and Sensors	2.87	$185.57
Clock Spring Assembly	0.41	$18.74
Total	26.76	$549.89

Table 193. FMVSS No. 208: Average weights and consumer costs for principal components (driver and passenger) in dual air bag system in passenger cars for MY 2007

Principal Components	**Weight (lb)**		**Consumer Cost (2019$)**	
	Driver	**Passenger**	**Driver**	**Passenger**
Air Bag	2.97	7.15	$88.28	$132.73
ECU	0.80	1.23	$92.52	$31.52
Crash Sensor	0.19	0.00	$13.74	$0.00
Seat Sensor	0.02	0.11	$0.95	$10.99
Strain/Occupant Sensor	0.00	0.20	$0.00	$14.08
Dash Light	0.01	0.00	$0.36	$0.72
Belt Use Sensor	0.03	0.11	$0.92	$2.64
Total	4.00	8.80	$196.77	$192.69

Tables 194 and 195 provide the results of all the calculations for passenger car air bags by MY for the driver position and passenger position. Provided are the average weight and cost, considering the percent of the fleet that had air bags.

For weight, 25.93 lb was assumed for driver air bags from 1985 to 1989, 13.46 lb was assumed for driver air bags from 1992 to 1996, and 4.0 lb was assumed for 2007 to 2019. In between these years we assume a linear decline in weight from 1989 to 1992 and then from 1996 to 2007. The difference between the dual air bags and driver side air bags of 13.3 lb found in 1992 to 1996 models was assumed for the passenger side through 1996. For the passenger side air bag, for 2004 to 2019, 8.8 lb was assumed and in between those years a linear decline is assumed starting at 13.3 lb in 1996 and reaching the weight of the 2007 passenger side air bag without counting the advanced air bag features of 7.15 lb in 2003.

For cost, $528.84 was assumed for driver air bags from 1985 to 1987 (in Table 194 the driver cost in MY 1985 is $528.84 * 0.11% [percent installed for MY 1985] or 0.0011 = $0.58), $393.77 was assumed for driver air bags from 1992 to 1996, and $196.77 was assumed for 2007 to 2019. In between these years we assume a linear decline in cost from 1987 to 1992 and then from 1996 to 2007. The difference between the dual air bags and driver side air bags of $156.11 found in 1992 to 1996 models was assumed for the passenger side through 1996. For the passenger side air bag, for 2004 to 2019, $192.69 was assumed and in between those years (1997 to 2003) a linear decline is assumed starting at $156.11 in 1996 and reaching the cost of the MY 2007 passenger side air bag alone without counting the advanced air bag features of $132.73 in 2003. We use these linear declines because air bags were constantly evolving, and suppliers were under constant pressure from the manufacturers to make them less expensive and we do not have cost estimates for every MY. We used the data from the teardown studies where available, and then the learning curve was applied from MY 2007 to 2019 for the driver side and from MY 2004 to 2019 for the passenger side.

Table 194. FMVSS No. 208: Weights and consumer costs for driver air bags in passenger cars

Model Year	Percent Install	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1984	0	0	0	0	0	0	0
1985	0.11	0	0.03	0.03	0	$0.58	$0.58
1986	0.53	0	0.14	0.14	0	$2.80	$2.80
1987	0.92	0	0.24	0.24	0	$4.87	$4.87
1988	1.23	0	0.29	0.29	0	$6.17	$6.17
1989	3.22	0	0.67	0.67	0	$15.29	$15.29
1990	25.68	0	4.74	4.74	0	$114.99	$114.99
1991	32.83	0	5.24	5.24	0	$138.14	$138.14
1992	51.15	0	6.88	6.88	0	$201.41	$201.41
1993	62.77	0	8.45	8.45	0	$247.17	$247.17
1994	83.61	0	11.25	11.25	0	$329.23	$329.23
1995	99.54	0	13.40	13.40	0	$391.96	$391.96
1996	99.98	0	13.46	13.46	0	$393.69	$393.69
1997	100	0	12.60	12.60	0	$375.86	$375.86
1998	100	0	11.74	11.74	0	$357.95	$357.95
1999	100	0	10.88	10.88	0	$340.05	$340.05
2000	100	0	10.02	10.02	0	$322.14	$322.14
2001	100	0	9.16	9.16	0	$304.23	$304.23
2002	100	0	8.30	8.30	0	$286.32	$286.32
2003	100	0	7.44	7.44	0	$268.41	$268.41
2004	100	0	6.58	6.58	0	$250.50	$250.50
2005	100	0	5.72	5.72	0	$232.59	$232.59
2006	100	0	4.86	4.86	0	$214.68	$214.68
2007	100	0	4.00	4.00	0	$196.77	$196.77
2008	100	0	4.00	4.00	0	$195.39	$195.39
2009	100	0	4.00	4.00	0	$194.58	$194.58
2010	100	0	4.00	4.00	0	$193.65	$193.65
2011	100	0	4.00	4.00	0	$192.64	$192.64

Model Year	Percent Install	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2012	100	0	4.00	4.00	0	$191.58	$191.58
2013	100	0	4.00	4.00	0	$190.49	$190.49
2014	100	0	4.00	4.00	0	$189.43	$189.43
2015	100	0	4.00	4.00	0	$188.32	$188.32
2016	100	0	4.00	4.00	0	$187.43	$187.43
2017	100	0	4.00	4.00	0	$186.54	$186.54
2018	100	0	4.00	4.00	0	$185.72	$185.72
2019	100	0	4.00	4.00	0	$184.97	$184.97

Table 195. FMVSS No. 208: Weights and consumer costs for right front passenger air bags in passenger cars

Model Year	Percent Install	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	0.05	0	0.01	0.01	0	$0.08	$0.08
1988	0.03	0	0.00	0.00	0	$0.05	$0.05
1989	0.39	0	0.05	0.05	0	$0.61	$0.61
1990	1.4	0	0.19	0.19	0	$2.19	$2.19
1991	0.59	0	0.08	0.08	0	$0.92	$0.92
1992	4.45	0	0.59	0.59	0	$6.95	$6.95
1993	12.3	0	1.64	1.64	0	$19.20	$19.20
1994	54.88	0	7.30	7.30	0	$85.68	$85.68
1995	88.77	0	11.81	11.81	0	$138.58	$138.58
1996	93.24	0	12.40	12.40	0	$145.56	$145.56
1997	100	0	12.42	12.42	0	$152.77	$152.77
1998	100	0	11.54	11.54	0	$149.43	$149.43
1999	100	0	10.66	10.66	0	$146.09	$146.09
2000	100	0	9.79	9.79	0	$142.75	$142.75

Model Year	Percent Install	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2001	100	0	8.91	8.91	0	$139.41	$139.41
2002	100	0	8.03	8.03	0	$136.07	$136.07
2003	100	0	7.15	7.15	0	$132.73	$132.73
2004	100	0	8.80	8.80	0	$198.42	$198.42
2005	100	0	8.80	8.80	0	$196.30	$196.30
2006	100	0	8.80	8.80	0	$194.41	$194.41
2007	100	0	8.80	8.80	0	$192.69	$192.69
2008	100	0	8.80	8.80	0	$191.15	$191.15
2009	100	0	8.80	8.80	0	$190.25	$190.25
2010	100	0	8.80	8.80	0	$189.23	$189.23
2011	100	0	8.80	8.80	0	$188.12	$188.12
2012	100	0	8.80	8.80	0	$186.97	$186.97
2013	100	0	8.80	8.80	0	$185.79	$185.79
2014	100	0	8.80	8.80	0	$184.65	$184.65
2015	100	0	8.80	8.80	0	$183.47	$183.47
2016	100	0	8.80	8.80	0	$182.52	$182.52
2017	100	0	8.80	8.80	0	$181.59	$181.59
2018	100	0	8.80	8.80	0	$180.72	$180.72
2019	100	0	8.80	8.80	0	$179.93	$179.93

LTV Studies - Frontal Air Bags

Although FMVSS No. 208 has long required the installation of seat belts at all designated seating positions in LTVs, it did not originally require those vehicles to provide automatic crash protection at the same time as passenger cars. On March 26, 1991, (56 FR 12472), a final rule was published in the Federal Register amending FMVSS No. 208 to extend automatic protection to front outboard seats to most but not all LTVs, by extending the requirements to trucks and MPVs with a GVWR of 8,500 lb or less. The rule provided that the automatic restraint requirement would be phased into most LTVs over a three-year period starting on September 1, 1994. The two types of automatic crash protection available to manufacturers for installation in their vehicles were air bags and automatic belts. However, in September 1993 NHTSA amended FMVSS No. 208 to require that all passenger cars and applicable LTVs provide automatic protection by means of air bags. Every LTV (with a GVWR of 8,500 lb or less) manufactured on or after September 1, 1998, had to have an air bag and a manual lap/shoulder belt at both the driver's and right front passenger's seating positions. The vehicle manufacturers were far ahead of the implementation schedule, and many MY 1996 LTVs had air bags. The NPRM was published in the Federal Register on January 9, 1990, (55 FR 747) making the baseline date September 1, 1989, or MY 1990. In MY 1990, no LTVs had frontal air bags. Thus, all air bag installations are considered attributable to FMVSS No. 208.

A series of cost and weight analyses were performed on air bags from six MY 1995 to 1996 LTVs (Fladmark & Khadilkar, 1996a, 1997, sec. 5, 1997a, secs. 7–8). These weight and cost estimates are very close to the MY 1992 to 1996 passenger cars shown in Table 192. One of the four MY 2007 vehicles used in the passenger car analysis was an LTV. The SUV air bag estimates were very similar to the weights and costs of the 3 passenger cars and all were combined into one average, the same costs were used for passenger cars for MY 2007 as shown in Table 191. Table 196 shows the arithmetic average weights and consumer costs for driver air bags and dual air bags in LTVs.

Table 196. FMVSS No. 208: Average weights and consumer costs of air bags in LTVs

Model Year	Weight (lb)	Consumer Cost (2019$)
Driver Air Bags		
1995-1996	14.31	$368.39
2007	4.00	$193.34
Passenger Air Bags		
1995-1996	12.17	$163.52
2007	8.80	$189.32
Dual Air Bags		
1995-1996	26.48	$531.91
2007	12.80	$382.66

The main components of an air bag system are the air bag module, igniter/inflator, control module/sensors, clock spring, wiring harness, and knee bolster. Table 197 shows the average costs of the principal components of dual air bags for 1995 and 1996. The total cost and weight of air bags and the cost of the main components are about the same as in passenger cars. Table 193 shows the breakdown of principal components for dual air bags for 2007. Since we assume that passenger car and LTV air bags have essentially the same weight and cost impacts by this time, it isn't necessary to repeat the same table.

Table 197. FMVSS No. 208: Average weights and consumer costs of principal components in dual air bags in LTVs from 1995 to 1996

Principal Components	**Weight (lb)**	**Consumer Cost (2019$)**
Driver Air Bag and Inflator Assembly	3.50	$79.16
Passenger Air Bag and Inflator Assembly	10.39	$143.56
Knee Bolster	7.82	$43.46
Control Module and Sensors	3.00	$190.47
Clock Spring Assembly	0.43	$18.87
Wiring Harness	1.34	$53.83
Total	26.48	$531.91

Tables 198 and 199 provide the results of all the calculations for LTV air bags by MY. Provided are the average weight and cost, taking into account the percent of the fleet that had air bags.

For weight, 14.31 lb was assumed for driver air bags from 1992 to 1996, and 4.0 lb was assumed for 2007 to 2019. In between these years we assume a linear decline in weight from 1996 to 2007. For the passenger side air bag, we assume 12.17 lb for 1994 to 1996 and for 2004 to 2019, 8.8 lb was assumed and in between those years a linear decline is assumed starting at 12.17 lb in 1996 and reaching the weight of the 2007 passenger side air bag without counting the advanced air bag features of 7.15 lb in 2003.

For cost, LTV driver air bags costs of $528.84 for 1987, taken from the passenger car cost Table 191, $368.39 taken from Table 196 for 1995 to 1996, and $193.34 taken from Table 196 was assumed for 2007 to 2019. In between these years we assume a linear decline in cost from 1987 to 1995 and then from 1996 to 2007.

The difference between the dual air bags and driver side air bags of $163.52 found in 1995 to 1996 models was assumed for the passenger side through 1996. For the passenger side air bag, the same estimate as was found for passenger cars passenger side air bags without the advanced features of $132.73 was assumed for 2003, and then for 2004 to 2019, $192.69 was assumed. In between those years (1997 to 2003) a linear decline is assumed starting at $163.52 in 1996 and reaching the cost of the MY 2007 passenger side air bag without counting the advanced air bag features of $132.73 in 2003. We used the data from the teardown studies where available, and then the learning curve was applied starting in MY 2007 for the driver side and MY 2004 for the passenger side.

Table 198. FMVSS No. 208: Weights and consumer costs for driver air bags in LTVs

Model Year	**Percent Install**	**Weight (lb)**			**Consumer Cost (2019$)**		
		Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1991	0	0	0	0	0	0	0
1992	13.05	0	1.87	1.87	0	$55.93	$55.93
1993	19.31	0	2.76	2.76	0	$78.88	$78.88
1994	32.32	0	4.62	4.62	0	$125.55	$125.55
1995	82.5	0	11.81	11.81	0	$303.92	$303.92
1996	96.99	0	13.88	13.88	0	$357.31	$357.31
1997	96.97	0	12.63	12.63	0	$342.10	$342.10
1998	99.74	0	11.70	11.70	0	$336.31	$336.31
1999	99.88	0	10.43	10.43	0	$321.20	$321.20
2000	100	0	9.16	9.16	0	$305.99	$305.99
2001	100	0	7.87	7.87	0	$290.38	$290.38
2002	100	0	6.58	6.58	0	$274.78	$274.78
2003	100	0	5.29	5.29	0	$259.18	$259.18
2004	100	0	4.00	4.00	0	$243.58	$243.58
2005	100	0	4.00	4.00	0	$227.97	$227.97
2006	100	0	4.00	4.00	0	$212.37	$212.37
2007	100	0	4.00	4.00	0	$196.77	$196.77
2008	100	0	4.00	4.00	0	$195.39	$195.39
2009	100	0	4.00	4.00	0	$194.58	$194.58
2010	100	0	4.00	4.00	0	$193.65	$193.65
2011	100	0	4.00	4.00	0	$192.64	$192.64
2012	100	0	4.00	4.00	0	$191.58	$191.58
2013	100	0	4.00	4.00	0	$190.48	$190.48
2014	100	0	4.00	4.00	0	$189.43	$189.43
2015	100	0	4.00	4.00	0	$188.32	$188.32

Model Year	Percent Install	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2016	100	0	4.00	4.00	0	$187.42	$187.42
2017	100	0	4.00	4.00	0	$186.54	$186.54
2018	100	0	4.00	4.00	0	$185.72	$185.72
2019	100	0	4.00	4.00	0	$184.96	$184.96

Table 199. FMVSS No. 208: Weights and consumer costs for right front passenger air bags in LTVs

Model Year	Percent Install	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1993	0	0	0	0	0	0	0
1994	7.86	0	1.0	1.0	0	$12.85	$12.85
1995	14.97	0	1.8	1.8	0	$24.48	$24.48
1996	41.46	0	5.0	5.0	0	$67.79	$67.79
1997	71.59	0	8.2	8.2	0	$113.91	$113.91
1998	99.64	0	10.7	10.7	0	$154.16	$154.16
1999	99.88	0	10.0	10.0	0	$150.14	$150.14
2000	100	0	9.3	9.3	0	$145.92	$145.92
2001	100	0	8.6	8.6	0	$141.53	$141.53
2002	100	0	7.9	7.9	0	$137.13	$137.13
2003	100	0	7.2	7.2	0	$132.73	$132.73
2004	100	0	8.8	8.8	0	$198.43	$198.43
2005	100	0	8.8	8.8	0	$196.30	$196.30
2006	100	0	8.8	8.8	0	$194.42	$194.42
2007	100	0	8.8	8.8	0	$192.69	$192.69
2008	100	0	8.8	8.8	0	$191.15	$191.15
2009	100	0	8.8	8.8	0	$190.25	$190.25
2010	100	0	8.8	8.8	0	$189.23	$189.23
2011	100	0	8.8	8.8	0	$188.12	$188.12
2012	100	0	8.8	8.8	0	$186.97	$186.97
2013	100	0	8.8	8.8	0	$185.79	$185.79

Model Year	Percent Install	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2014	100	0	8.8	8.8	0	$184.65	$184.65
2015	100	0	8.8	8.8	0	$183.47	$183.47
2016	100	0	8.8	8.8	0	$182.52	$182.52
2017	100	0	8.8	8.8	0	$181.59	$181.59
2018	100	0	8.8	8.8	0	$180.72	$180.72
2019	100	0	8.8	8.8	0	$179.93	$179.93

Manual On-Off Switches

While air bags were providing significant overall safety benefits, NHTSA was very concerned that the early designs had adverse effects, especially on children in rear-facing child seats installed in front passenger seating positions. To address this dilemma, NHTSA published a final rule on May 23, 1995, (60 FR 27233) amending FMVSS No. 208 to allow manual on-off switches for passenger-side air bags in pickup trucks and other vehicles with small or no rear seats. The NPRM was published in the Federal Register on October 7, 1994, (59 FR 51158), making the baseline date September 1, 1994, or MY 1995. Regardless of the baseline date, a manual on-off switch was not required by the standard but was an option provided to manufacturers. Thus, it is considered voluntary and not attributable to the standard. The final rule allowed manufacturers the option of installing a manual device that motorists could use to deactivate the front passenger-side air bag in vehicles manufactured on or after June 22, 1995, that cannot accommodate rear-facing child seats anywhere except in the front seat. The manual on-off switch had to use an ignition key to turn off the passenger air bag and to turn on the air bag. In addition, the manufacturer had to install a warning light that was separate from the air bag readiness indicator, which would indicate when the air bag was turned off. The light had to be visible to both the driver and the passenger. Less than 1 percent of passenger cars had an on-off switch for vehicles with no rear seat or with a rear seat that was so small that it couldn't accommodate a child restraint. But by MY 1998, switches for the passenger bag had become standard equipment in all pickup trucks with a GVWR of 8,500 lb or less that could not accommodate a rear-facing infant seat in the rear seat. That basically includes all pickups with conventional cabs (no rear seats) and extended cabs (small rear seats) and only excludes certain full crew cabs. An air bag on-off switch was also provided in some SUVs, like the Jeep Wrangler and in some full-size cargo vans that didn't have a rear seat. In MY 1998, almost 42 percent of all LTVs had an on-off switch. The 2000 advanced air bag rule included a sunset provision on these original equipment air bag on-off switches, sunsetting them on September 1, 2012. By MY 2012, there were no more manual on-off switches installed by manufacturers for the front right passenger air bag. The issue of children being injured by passenger side air bags was being significantly reduced by suppression of the air bag or low-risk deployment, as well as moving children into the rear seat.

A cost and weight analysis was performed on air bag on-off switch systems (Fladmark & Khadilkar, 1998). The sample consisted of one passenger car and one minivan of MY 1998 for which the original equipment manufacturer had supplied aftermarket on-off switches for both the driver and for the right front passenger. Because these switches were nearly identical, we have assumed that the cost of a factory-installed switch for the right front passenger would be half of the cost per vehicle found in the teardown study. Table 200 shows the arithmetic average weight and consumer cost of one on-off switch.

Table 200. FMVSS No. 208: Average weight and consumer cost for one passenger side on-off switch

Component	Weight (lb)	Consumer Cost (2019$)
On-off Switch	0.65	$38.98

Tables 201 and 202 show the percentages of the fleets equipped with manual on-off switches and the average weights and consumer costs after applying the learning curve for passenger cars and LTVs.

Table 201. FMVSS No. 208: Average weights and consumer costs for manual on-off switches in passenger cars

Model Year	% Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	0	0.00	0	0.00	$0.00	0	$0.00
1997	0	0.00	0	0.00	$0.00	0	$0.00
1998	0.01	0.00	0	0.00	$0.00	0	$0.00
1999	0.30	0.00	0	0.00	$0.11	0	$0.11
2000	0.22	0.00	0	0.00	$0.08	0	$0.08
2001	0.71	0.00	0	0.00	$0.24	0	$0.24
2002	0.68	0.00	0	0.00	$0.23	0	$0.23
2003	0.69	0.00	0	0.00	$0.23	0	$0.23
2004	0.58	0.00	0	0.00	$0.19	0	$0.19
2005	0.51	0.00	0	0.00	$0.17	0	$0.17
2006	0.22	0.00	0	0.00	$0.07	0	$0.07
2007	0.07	0.00	0	0.00	$0.02	0	$0.02
2008	0.17	0.00	0	0.00	$0.06	0	$0.06
2009	0.09	0.00	0	0.00	$0.03	0	$0.03
2010	0	0.00	0	0.00	$0.00	0	$0.00

Model Year	% Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2011	0	0.00	0	0.00	$0.00	0	$0.00
2012	0	0.00	0	0.00	$0.00	0	$0.00

Table 202. FMVSS No. 208: Average weights and consumer costs for manual on-off switches in LTVs

Model Year	% Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	0	0	0	0	$0.00	0	$0.00
1997	21.44	0.14	0	0.14	$9.41	0	$9.41
1998	41.87	0.27	0	0.27	$16.32	0	$16.32
1999	41.97	0.27	0	0.27	$15.42	0	$15.42
2000	41.16	0.27	0	0.27	$14.56	0	$14.56
2001	38.97	0.25	0	0.25	$13.41	0	$13.41
2002	28.65	0.19	0	0.19	$9.70	0	$9.70
2003	17.89	0.12	0	0.12	$6.00	0	$6.00
2004	15.73	0.10	0	0.10	$5.23	0	$5.23
2005	6.03	0.04	0	0.04	$2.00	0	$2.00
2006	4.61	0.03	0	0.03	$1.53	0	$1.53
2007	2.00	0.01	0	0.01	$0.66	0	$0.66
2008	1.50	0.01	0	0.01	$0.50	0	$0.50
2009	0.66	0.00	0	0.00	$0.22	0	$0.22
2010	0.66	0.00	0	0.00	$0.22	0	$0.22
2011	0.68	0.00	0	0.00	$0.22	0	$0.22
2012	0	0.00	0	0.00	$0.00	0	$0.00

Summary Tables for FMVSS No. 208/209/210

Table 203 for passenger cars and Table 204 for LTVs summarize the total consumer weight and cost of the occupant protection systems installed in these vehicles for MYs 1968 to 2019. These totals include all the manual belts, automatic belts, pretensioners, load limiters, and adjustable anchors, air bags and manual on-off switches. The summary calculations are the average weight and cost per vehicle considering installation rates.

Table 203. Summary table for FMVSS Nos. 208/209/210 – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	6.2	4.2	10.4	$83.49	$44.51	$128.00
1969	6.2	4.4	10.6	$83.20	$45.02	$128.23
1970	6.2	4.4	10.6	$83.01	$44.99	$128.00
1971	6.2	4.4	10.6	$82.82	$44.96	$127.78
1972	8.1	7.2	15.3	$90.78	$71.35	$162.13
1973	8.1	7.6	15.7	$90.19	$75.12	$165.31
1974	8.1	7.6	15.7	$89.80	$83.72	$173.52
1975	8.1	8.0	16.2	$89.91	$83.39	$173.29
1976	8.1	8.6	16.6	$89.41	$83.42	$172.83
1977	8.1	9.0	17.1	$90.55	$83.34	$173.89
1978	8.1	9.5	17.6	$90.15	$83.33	$173.48
1979	8.0	10.0	18.1	$89.88	$82.98	$172.86
1980	8.0	10.0	18.1	$89.69	$82.92	$172.60
1981	8.2	10.0	18.2	$92.23	$82.59	$174.82
1982	7.9	9.6	17.4	$87.25	$80.93	$168.17
1983	7.9	9.1	17.0	$88.12	$79.20	$167.32
1984	7.8	8.6	16.4	$86.25	$77.54	$163.79
1985	7.8	8.1	15.9	$85.74	$76.29	$162.03
1986	7.8	7.7	15.5	$85.63	$76.66	$162.29
1987	7.8	8.8	16.6	$85.35	$99.98	$185.33
1988	7.4	10.1	17.5	$84.21	$116.72	$200.93
1989	6.6	11.7	18.3	$82.19	$138.84	$221.03
1990	5.8	21.9	27.7	$77.18	$308.13	$385.31
1991	5.8	21.5	27.3	$76.35	$323.13	$399.48
1992	6.1	20.7	26.8	$78.21	$352.76	$430.97
1993	6.2	23.6	29.8	$77.78	$412.00	$489.78
1994	6.4	30.1	36.5	$78.38	$539.59	$617.97
1995	6.5	34.6	41.1	$79.39	$622.55	$701.95

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	6.6	34.4	41.0	$79.27	$621.16	$700.43
1997	6.9	33.3	40.1	$80.58	$605.61	$686.19
1998	7.4	32.2	39.6	$87.82	$589.09	$676.90
1999	7.9	30.4	38.3	$94.62	$567.48	$662.09
2000	8.4	28.7	37.1	$103.20	$545.91	$649.11
2001	9.1	26.9	36.1	$113.16	$524.39	$637.55
2002	9.4	25.2	34.6	$115.94	$502.89	$618.83
2003	10.0	23.5	33.5	$120.45	$481.45	$601.89
2004	10.3	24.3	34.6	$123.87	$529.02	$652.89
2005	10.3	23.6	33.9	$125.16	$509.76	$634.92
2006	10.4	22.9	33.3	$129.88	$490.51	$620.39
2007	10.4	22.0	32.4	$128.85	$470.68	$599.53
2008	10.5	22.0	32.5	$128.83	$467.78	$596.61
2009	10.5	22.0	32.5	$128.50	$465.95	$594.45
2010	10.5	22.0	32.5	$127.51	$463.86	$591.37
2011	10.5	22.0	32.5	$127.08	$461.60	$588.67
2012	10.5	22.0	32.5	$127.13	$459.21	$586.34
2013	10.5	22.0	32.5	$126.27	$456.70	$582.96
2014	10.4	22.0	32.5	$125.93	$454.32	$580.26
2015	10.4	22.0	32.5	$125.11	$451.85	$576.95
2016	10.5	22.0	32.5	$125.37	$449.86	$575.23
2017	10.5	22.0	32.6	$125.13	$448.01	$573.14
2018	10.6	22.1	32.7	$126.13	$446.29	$572.42
2019	10.6	22.0	32.6	$125.73	$444.51	$570.24

Table 204. Summary table for FVMSS Nos. 208/209/210 – LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	2.41	3.60	6.01	$37.83	$45.84	$83.67
1969	2.53	3.50	6.03	$38.94	$44.55	$83.49
1970	2.55	3.48	6.03	$38.95	$44.37	$83.32
1971	2.57	3.46	6.03	$39.08	$44.08	$83.16
1972	2.97	7.93	10.90	$40.69	$80.19	$120.88
1973	2.97	7.93	10.90	$40.40	$79.94	$120.34
1974	2.91	8.19	11.10	$39.18	$84.95	$124.13
1975	2.89	8.21	11.10	$38.90	$85.05	$123.94
1976	2.87	8.22	11.09	$38.65	$84.83	$123.48
1977	4.02	8.52	12.54	$48.42	$89.48	$137.90
1978	4.01	8.53	12.53	$48.11	$88.98	$137.09
1979	3.98	8.52	12.50	$47.90	$88.38	$136.28
1980	3.97	8.59	12.56	$47.39	$89.14	$136.53
1981	3.82	8.64	12.46	$47.05	$89.39	$136.44
1982	3.82	8.64	12.46	$43.75	$89.05	$132.80
1983	3.82	8.64	12.46	$43.61	$88.68	$132.29
1984	3.82	8.64	12.46	$43.45	$88.28	$131.73
1985	3.82	8.64	12.46	$43.30	$87.87	$131.17
1986	3.82	8.64	12.46	$43.14	$87.48	$130.62
1987	5.18	8.64	13.82	$54.57	$87.16	$141.74
1988	5.15	8.67	13.81	$54.40	$86.96	$141.37
1989	4.97	8.80	13.78	$54.07	$87.20	$141.27
1990	4.93	8.83	13.77	$53.76	$87.10	$140.87
1991	4.70	8.95	13.65	$51.43	$87.35	$138.78
1992	3.83	11.49	15.32	$49.67	$145.34	$195.01
1993	3.96	12.38	16.34	$49.72	$168.05	$217.77
1994	3.93	15.20	19.13	$49.70	$227.32	$277.02
1995	5.95	23.95	29.90	$67.33	$425.70	$493.04

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1996	5.98	29.26	35.23	$67.35	$522.16	$589.52
1997	6.09	31.63	37.72	$75.74	$553.89	$629.63
1998	6.27	33.85	40.12	$83.98	$592.95	$676.94
1999	6.43	31.89	38.32	$86.92	$573.35	$660.27
2000	6.57	29.91	36.48	$88.99	$553.51	$642.50
2001	6.92	27.90	34.82	$98.61	$533.15	$631.76
2002	7.49	25.90	33.39	$104.83	$512.83	$617.66
2003	9.20	23.98	33.18	$116.38	$493.43	$609.81
2004	9.08	25.09	34.17	$115.40	$549.44	$664.84
2005	9.01	25.57	34.58	$114.53	$535.27	$649.80
2006	8.90	26.06	34.96	$112.54	$521.35	$633.89
2007	8.97	26.39	35.36	$114.86	$506.23	$621.09
2008	9.04	26.77	35.81	$115.63	$506.00	$621.63
2009	9.03	26.77	35.80	$114.96	$504.06	$619.01
2010	9.05	26.77	35.82	$115.22	$501.84	$617.06
2011	9.11	26.77	35.88	$115.92	$499.43	$615.34
2012	9.12	26.77	35.89	$115.44	$496.91	$612.36
2013	9.09	26.77	35.87	$114.33	$494.36	$608.69
2014	9.10	26.78	35.88	$113.86	$491.91	$605.77
2015	9.11	26.78	35.89	$113.31	$489.36	$602.67
2016	9.20	26.78	35.98	$114.50	$487.32	$601.82
2017	9.30	26.88	36.19	$114.62	$486.12	$600.74
2018	9.49	26.99	36.47	$115.99	$485.07	$601.06
2019	9.43	27.01	36.44	$116.30	$483.37	$599.67

Table 205 provides the breakdown of costs between seat belts and frontal air bags for passenger cars and LTVs. Pretensioners, load limiters and adjustable anchors have been added in with seat belts and manual on-off switches have been added in with air bags. In MY 2019 when there are no more manual on-off switches, the cost of frontal air bags is the same for passenger cars and LTVs. The cost of seat belts was higher for passenger cars initially because they had more lap/shoulder belts than LTVs and remained higher during the automatic belt years of 1975 to 1996. Then the total cost of seat belts in LTVs became higher than passenger cars because LTVs have more seating positions on average than passenger cars.

Table 205. FMVSS Nos. 208/209/210: Summary table of consumer costs: Weights – seat belts versus air bags – passenger cars and LTVs (all costs in 2019 dollars)

Model Year	Passenger Cars			LTVs		
	Seat Belts	**Air Bags**	**Total**	**Seat Belts**	**Air Bags**	**Total**
1968	$128.00	$0.00	$128.00	$83.67	$0.00	$83.67
1969	$128.23	$0.00	$128.23	$83.49	$0.00	$83.49
1970	$128.00	$0.00	$128.00	$83.32	$0.00	$83.32
1971	$127.78	$0.00	$127.78	$83.16	$0.00	$83.16
1972	$162.13	$0.00	$162.13	$120.88	$0.00	$120.88
1973	$165.31	$0.00	$165.31	$120.34	$0.00	$120.34
1974	$173.52	$0.00	$173.52	$124.13	$0.00	$124.13
1975	$173.29	$0.00	$173.29	$123.94	$0.00	$123.94
1976	$172.83	$0.00	$172.83	$123.48	$0.00	$123.48
1977	$173.89	$0.00	$173.89	$137.90	$0.00	$137.90
1978	$173.48	$0.00	$173.48	$137.09	$0.00	$137.09
1979	$172.86	$0.00	$172.86	$136.28	$0.00	$136.28
1980	$172.60	$0.00	$172.60	$136.53	$0.00	$136.53
1981	$174.82	$0.00	$174.82	$136.44	$0.00	$136.44
1982	$168.17	$0.00	$168.17	$132.80	$0.00	$132.80
1983	$167.32	$0.00	$167.32	$132.29	$0.00	$132.29
1984	$163.79	$0.00	$163.79	$131.73	$0.00	$131.73
1985	$161.45	$0.58	$162.03	$131.17	$0.00	$131.17
1986	$159.49	$2.80	$162.29	$130.62	$0.00	$130.62
1987	$180.39	$4.94	$185.33	$141.74	$0.00	$141.74
1988	$194.71	$6.22	$200.93	$141.37	$0.00	$141.37
1989	$205.13	$15.90	$221.03	$141.20	$0.00	$141.20
1990	$268.13	$117.18	$385.31	$140.81	$0.00	$140.81
1991	$260.41	$139.07	$399.48	$138.55	$0.00	$138.55
1992	$222.61	$208.36	$430.97	$137.44	$55.93	$193.37

Model Year	Passenger Cars			LTVs		
	Seat Belts	Air Bags	Total	Seat Belts	Air Bags	Total
1993	$223.41	$266.37	$489.78	$137.69	$78.88	$216.57
1994	$203.06	$414.91	$617.97	$136.40	$138.40	$274.80
1995	$171.40	$530.54	$701.95	$161.95	$328.40	$490.35
1996	$161.18	$539.26	$700.43	$161.77	$425.10	$586.87
1997	$157.55	$528.64	$686.19	$164.20	$465.43	$629.63
1998	$169.51	$507.39	$676.90	$170.14	$506.80	$676.94
1999	$175.84	$486.25	$662.09	$173.51	$486.76	$660.27
2000	$184.15	$464.97	$649.11	$176.00	$466.47	$642.47
2001	$193.66	$443.88	$637.55	$186.43	$445.32	$631.75
2002	$196.21	$422.62	$618.83	$196.03	$421.61	$617.64
2003	$200.52	$401.37	$601.89	$211.88	$397.91	$609.78
2004	$203.78	$449.12	$652.89	$217.55	$447.24	$664.78
2005	$205.86	$429.06	$634.92	$223.48	$426.28	$649.76
2006	$211.22	$409.17	$620.39	$225.55	$408.31	$633.87
2007	$210.04	$389.49	$599.53	$230.94	$390.12	$621.06
2008	$210.01	$386.60	$596.61	$234.78	$387.04	$621.82
2009	$209.59	$384.86	$594.45	$234.15	$385.05	$619.20
2010	$208.49	$382.88	$591.37	$234.04	$383.10	$617.14
2011	$207.91	$380.76	$588.67	$233.25	$380.98	$614.23
2012	$207.80	$378.54	$586.34	$232.57	$378.54	$611.11
2013	$206.69	$376.27	$582.96	$233.06	$376.27	$609.33
2014	$206.17	$374.08	$580.26	$231.87	$374.08	$605.95
2015	$205.16	$371.80	$576.95	$231.22	$371.79	$603.01
2016	$205.29	$369.94	$575.23	$231.16	$369.94	$601.10
2017	$205.01	$368.13	$573.14	$231.86	$368.13	$599.98
2018	$205.98	$366.44	$572.42	$234.19	$366.44	$600.63
2019	$205.35	$364.90	$570.24	$233.86	$364.89	$598.75

FMVSS No. 211 – [Does not currently exist]

FMVSS No. 212, Windshield mounting

FMVSS No. 212 became effective on January 1, 1970, (passenger cars) and September 1, 1978, (MPVs, trucks, buses) and establishes windshield retention requirements for motor vehicles during crashes. The purpose of this standard is to reduce crash injuries and fatalities by providing for retention of the vehicle windshield during a crash, thereby utilizing fully the penetration-resistance and injury-avoidance properties of the windshield glazing material and preventing the ejection of occupants through the windshield. This standard applies to passenger cars, MPVs, trucks, and buses having a GVWR of 10,000 lb or less. However, it does not apply to forward control vehicles, walk-in van-type vehicles, or to open-body type vehicles with fold-down or removable windshields (Kahane, 1985).

The standard requires that when a vehicle traveling longitudinally forward at any speed up to and including 30 mph impacts a fixed collision barrier that is perpendicular to the line of travel of the vehicle, the windshield mounting of the vehicle shall retain not less than the minimum portion of the windshield periphery specified in the following:

- Vehicles with automatic restraint systems shall retain not less than 50 percent of the portion of the windshield periphery on each side of the vehicle longitudinal centerline.
- Vehicles without automatic restraint systems shall retain not less than 75 percent of the windshield periphery.

Before 1963, windshields were sealed inside a rubber gasket or molding that in turn was attached and sealed to the frame. It was a relatively loose attachment. In low-speed impacts, the rubber gasket had some energy absorbing give. At higher speeds, the gasket could partly or completely tear away from the frame, beginning during the initial vehicle collision and deformation and continuing as occupants impacted the windshield.

Bonding of the windshield directly to its frame with adhesives gradually (1963 to 1985) superseded the earlier method of first enclosing the windshield in a rubber gasket and then attaching the gasket to the frame. Adhesive bonding resembles HPR windshields in that it is primarily a technical advance, the synthesis of resilient sealing materials, than an addition of hardware to the car. The new bonding materials allowed the elimination of rubber gaskets in return for an inexpensive sealant and a minor increase in labor costs. Thus, the shift to adhesive bonding began in some vehicles well before anybody anticipated FMVSS No. 212, but rubber gaskets persisted in other make-models for quite a few years after the standard. Although rubber gaskets are generally a looser installation than adhesive bonding, they can readily be designed to meet FMVSS No. 212. Each installation method has advantages, and the gradual shift from one to the other was motivated by various factors, sometimes including FMVSS No. 212. However, vehicle manufacturers could meet the standard with either method.

Pickup trucks, vans, and SUVs also kept rubber gaskets during most of the 1970s, and in many cases after FMVSS No. 212 was extended to LTVs (September 1, 1978). Manufacturers may have been especially concerned that operation on rough roads could accelerate deterioration of adhesive bonds, as compared to rubber gaskets. Adhesive bonding was gradually phased in from 1978 to approximately 1985. The final transition to adhesive bonding may have been spurred by anticipation of safety benefits, cost advantages with the second-generation sealants, and a 1976 rule allowing NHTSA to conduct the FMVSS No. 212 test in a wider range of temperatures, from 15 to 110°F.

A 1980 study compared rubber gaskets to adhesive bonding in one passenger car and three LTVs (McLean et al., 1980, pp. 33–40).[46] Table 206 shows the arithmetic average weight and consumer cost for the windshield mountings.

Table 206. FMVSS No. 212: Average weights and consumer costs for windshield mountings in passenger vehicles

Material	Weight (lb)	Consumer Cost ($2019)
Rubber Gasket	5.92	$25.18
Adhesive Bonding	0.69	$8.94

The substantial decrease in weight and consumer cost, when using adhesive bonding, cannot be attributed to the standard. Manufacturers could have moved to the use of the less costly adhesive bonding even without the standard. Furthermore, adhesive bonding was in common use on windshields long before the standard was proposed, and rubber gaskets continued to be used for some years after the standard took effect. Because weight and costs were less with adhesive bonding and the standard did not require manufacturers to change to adhesive bonding, no weight and cost have been assigned to FMVSS No. 212.

Ford Motor Company in comments on the NHTSA evaluation report of FMVSS No. 205/212 questioned whether the preceding cost analysis realistically accounted for the full cost of adhesive bonding. Ford stated "to achieve an acceptable appearance with adhesive bonding, interior and exterior moldings must be added to hide the bond area. In addition, a blackout paint band is generally added to the periphery of the glazing to block vision of the bond area and the underside of the trim moldings. As a result, adhesive bonding results in a cost and weight penalty, except on some luxury models and convertibles that have interior and exterior trim moldings installed for other reasons" (Ford Motor Company, 1985).

FMVSS No. 213, Child restraint systems

FMVSS No. 213 became effective on April 1, 1971, and specifies requirements for child restraint systems used in motor vehicles and aircraft. The purpose of this standard is to reduce the number of children killed or injured in motor vehicle crashes and in aircraft. This standard applies primarily to aftermarket equipment that may be purchased for use in a vehicle, rather than to the vehicle itself. However, there were a small percentage of passenger cars (mostly Volvos) and a slightly larger percentage of LTVs (mainly minivans) that had built-in child restraints in the second seat. Typically, built-in child restraints were provided as optional equipment. Built-in child restraints were not required, but were allowed by FMVSS No. 213, and could be considered voluntary compliance. However, no cost studies of built-in child restraints have been done, and none are planned by the agency.

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[46] The multiplier from variable cost to consumer cost used for FMVSS 212 was 2.95 and was adjusted to 1.51 to be consistent with the rest of the analysis.

FMVSS No. 214, Side impact protection

FMVSS No. 214 became effective on January 1, 1973, and specified performance requirements for protection of occupants in side impact crashes. The purpose of this standard is to reduce the risk of serious and fatal injury to occupants of passenger cars, MPVs, trucks, and buses in side impact crashes. FMVSS No. 214 has been significantly upgraded twice since its inception as a quasi-static crush test. The original FMVSS No. 214 set strength requirements for doors, effective January 1, 1973, in passenger cars and extended to pickup trucks, vans, buses and SUVs (all LTVs) of 10,000 lb or less GVWR, effective September 1, 1993. The first upgrade added a dynamic crash test requirement, phased-in for passenger cars from September 1, 1993, to September 1, 1996, and effective for LTVs up to 6,000 lb GVWR on September 1, 1998. The second upgrade added a 20-mph side impact crash test with a pole, with phase-in scheduled from September 1, 2010, to September 1, 2014, for both passenger cars and LTVs of 10,000 lb or less GVWR.

Each of these upgrades addressed different types of side impacts and/or different modes of injury and did not replace the need for vehicles to meet the previous tests. It does not appear that side door beams were redesigned or that the structure or padding used to meet the dynamic test were decreased when torso bags and window curtains were used to meet the pole test. Thus, the countermeasures used to meet these three tests are discussed separately, with three separate learning curves, and then added together to determine the total added weight and cost of FMVSS No. 214. Safety1965 for side impact is the basic structure of a passenger car or LTV, without side door beams which were introduced around 1969.

This standard is associated with three vehicle modifications whose weight and cost impacts have been evaluated by NHTSA:

- **Side door beams**
- **Thoracic trauma index for the dummy in a side-impact test improvement by structure and padding**
- **Window curtain and side air bags**

The outline of the FMVSS No. 214 discussion below is to discuss side door beams for passenger cars, side door beams for LTVs, TTI(d) improvements for passenger cars, TTI(d) improvements for LTVs, and finally window curtain and side air bags for passenger cars and LTVs together.

Side Door Beams to Meet the Quasi-Static Test

Passenger Cars – Side Door Beams. FMVSS No. 214 originally specified performance requirements, effective January 1, 1973, for each side door in a passenger car to mitigate occupant injuries in side impacts by reducing the extent to which the side structure of a car is pushed into the passenger compartment during a side impact. On October 30, 1970, (35 FR 16801) a final rule was published in the Federal Register establishing FMVSS No. 214 (side door strength, passenger cars). The NPRM was published in the Federal Register on December 11, 1968, (33 FR 18386) making the baseline date September 1, 1968, or MY 1969. An estimated 17.64 percent of the passenger car fleet had side door beams in MY 1969. Thus, 17.64 percent will be considered voluntary for MY 1969 and the voluntary percentage will be held at that MY 1969 baseline level through MY 2019. Attributable costs will be the difference between the installation rates for MY 1970 to 2019 minus the voluntary baseline level of MY 1969.

The standard initially specified a three-stage quasi-static[47] crush test (initial, intermediate, and peak) to measure the crush resistance of the side doors and required each door to resist crush forces that are applied by a piston pressing a 12-inch diameter steel cylinder inward against the door's outside surface in a laboratory test.

Early studies concerning side impact protection demonstrated that in fatal side collisions most occupants die because of the door structures collapsing inward on them. The quasi-static crush tests were intended to ensure that there were strong door structures to limit this intrusion. Under the peak crush test, the vehicle door may not be deformed more than 18 inches inward when the door is subjected to a force of 7,000 lb or two times the curb weight of the vehicle, whichever is less.[48] The standard, however, does not attempt to regulate directly the level of crash forces on an occupant who strikes or is struck by the car's interior during a side impact crash. Since the standard became effective on January 1, 1973, vehicle manufacturers have generally chosen to meet its performance requirements by reinforcing the side doors with metal beams. The added side door beam helps to make a pole, tree, guardrail, or other fixed object slide by the occupant's position, thus reducing intrusion into the passenger compartment.

The side door beam of that era was a metal bar of channel design, typically 8 inches wide and with channels 2 inches deep. It was located inside each side door, close to the outside surface, about 10 inches above the sill. It ran the length of the door, being attached to the door frame vertical members at the hinge and latch ends of the door, and it may have been accompanied by local reinforcement of the B-pillar at the floor level.

Three cost and weight analyses were performed on side door beams and body pillars from 23 make-model 2-door passenger cars and fourteen make-model 4-door passenger cars representing implementation and trend systems from 1973 to 1981 (McLean et al., 1978, pp. 22–37; Harvey & Eckel, 1979; Gladstone et al., 1982a).[49] (Changes in the body pillars discussed in the October 1978 study were a result of model redesign and not directly related to the standard, therefore, the weight and consumer cost for them were not included in the side door strength calculations). Table 207 shows the sales-weighted average weights and consumer costs for the side door beams in 2- and 4-door passenger cars.

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[47] This test is referred to as a quasi-static test because the cylinder moves (so it is not a purely static test) but at such a slow rate that it does not have a dynamic aspect to the test.

[48] The standard was amended on March 17, 1980, to add a new door crush test (a 3-stage crush test) allowing the seats to be installed during the test. In this test, the peak force is 3.5 times the curb weight or 12,000 lb, whichever is smaller.

[49] For each cost and weight analyses the multiplier of 1.40 was adjusted to 1.51 to make it consistent with the rest of the analysis.

Table 207. FMVSS No. 214: Average weights and consumer costs per vehicle of side door beams in 2-door and 4-door passenger cars from cost teardown studies

Model Year	Weight (lb)	Consumer Cost ($2019)
2-Door		
1973	33.39	$74.00
1975-1978	23.90	$57.48
1979-1981	28.17	$67.30
4-Door		
1973	43.53	$132.38
1975-1979	26.60	$109.16
1979-1981	23.98	$78.88

For MYs 1975 to 1979, some design refinement had occurred with the door beams for the 4-door models, with more refinement occurring with the 1980 models. All through the late 1970s and early 1980s, downsizing was occurring, and vehicle designs were incorporating design features into the vehicle bodies to cope with requirements and relying less on just door beams, consequently, door beams were becoming lighter and less costly.

In the 4-door passenger cars, the refinements and downsizing resulted in a 45 percent decrease in weight from 1973 to 1979-1981, with the 1979 to 1981 weight less than the weight for the 2-door models. The cost for the 4-door models decreased 40 percent in the same period; however, the 1979 to 1981 costs were still greater than the 2-door models. The costs and weights of the 1975 to 1978 2-door models are lower than in both 1973 and in 1979 to 1981.

While the 2-door models saw a decrease of 28 percent in weight and 22 percent in cost from 1973 to 1975-1978, there was an increase of 18 percent in weight and 17 percent in cost from 1975-1978 to 1979-1981. This may be an artifact of the specific make-models selected for the 1975 to 1978 study. Notwithstanding this exception, there appears to be a general downward trend from 1972 to 1979-1981 in both the 2- and 4-door passenger cars. The weights and costs found for MY 1979 to 1981 passenger cars were used in the analysis for all MYs 1979 to 2019 passenger cars.

Sales of 2-door and 4-door passenger cars changed dramatically over the period. Two-door cars peaked in 1974 with 64 percent of the market and almost continuously lost market share to 4-door cars and hit a low of 7.5 percent of the market in MY 2018 and 8.5 percent of the market in MY 2019. We examined 2-door and 4-door passenger cars separately, and then combined them by the distribution of 2-door and 4-door vehicles in the fleet for each MY separately. Changes in weight from MYs 1973 to 1981 were assumed to be linearly decreasing. The learning curve using the 1979 data matched the earlier teardown data very well for 2-door cars but did not match the cost estimates for MY 1973 or MYs 1975 to 1978 vehicles. Thus, for 4-door cars the teardown data was used through MY 1981 and the learning curve was applied past that point. The average weight and consumer cost of the side impact protection to the quasi-static requirements of the standard in any given MY are shown in Table 208 as well as the percentages of passenger cars that were 2-door models.

Table 208. FMVSS No. 214: Weights and consumer costs to the quasi-static test met by side door beams – passenger cars – weighted by 2-door and 4-door models

Model Year	% 2-Doors	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0	0	0	0	$0.00	$0.00	$0.00
1969	54.82	6.70	0	6.70	$20.31	$0.00	$20.31
1970	57.94	6.64	6.98	13.62	$19.10	$20.06	$39.16
1971	58.43	6.63	9.93	16.56	$18.45	$27.61	$46.06
1972	56.14	6.67	11.99	18.67	$18.26	$32.81	$51.07
1973	57.79	6.65	25.38	32.03	$17.68	$67.54	$85.22
1974	64.32	6.22	29.06	35.29	$16.03	$74.85	$90.88
1975	61.32	5.95	27.77	33.72	$15.29	$71.40	$86.69
1976	60.91	5.64	26.31	31.94	$15.14	$70.70	$85.85
1977	59.15	5.32	24.83	30.15	$15.11	$70.56	$85.67
1978	58.51	4.99	23.30	28.29	$15.03	$70.19	$85.23
1979	59.96	4.67	21.82	26.49	$12.69	$59.25	$71.94
1980	58.06	4.66	21.75	26.41	$12.66	$59.09	$71.75
1981	49.72	4.60	21.47	26.06	$12.78	$59.69	$72.47
1982	45.83	4.57	21.33	25.90	$12.63	$58.95	$71.58
1983	41.07	4.53	21.17	25.70	$12.61	$58.90	$71.51
1984	41.56	4.54	21.18	25.72	$12.50	$58.34	$70.84
1985	38.59	4.52	21.08	25.60	$12.45	$58.11	$70.56
1986	37.42	4.51	21.04	25.55	$12.37	$57.74	$70.11
1987	34.93	4.49	20.96	25.44	$12.33	$57.57	$69.90
1988	37.78	4.51	21.05	25.56	$12.20	$56.94	$69.14
1989	38.32	4.51	21.07	25.59	$12.12	$56.57	$68.69
1990	32.97	4.47	20.89	25.36	$12.15	$56.75	$68.90
1991	31.77	4.46	20.85	25.31	$12.12	$56.58	$68.70
1992	27.78	4.44	20.71	25.14	$12.14	$56.67	$68.81

Model Year	% 2-Doors	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1993	28.35	4.44	20.73	25.17	$12.07	$56.35	$68.41
1994	27.95	4.44	20.71	25.15	$11.98	$55.93	$67.90
1995	26.03	4.42	20.65	25.07	$11.92	$55.67	$67.59
1996	23.50	4.40	20.56	24.96	$11.88	$55.47	$67.35
1997	21.57	4.39	20.49	24.88	$11.83	$55.24	$67.07
1998	19.61	4.38	20.43	24.80	$11.78	$55.01	$66.80
1999	19.73	4.38	20.43	24.81	$11.69	$54.60	$66.30
2000	19.08	4.37	20.41	24.78	$11.62	$54.27	$65.89
2001	18.66	4.37	20.39	24.76	$11.55	$53.94	$65.50
2002	17.68	4.36	20.36	24.72	$11.50	$53.68	$65.18
2003	15.87	4.35	20.30	24.64	$11.46	$53.50	$64.96
2004	17.21	4.36	20.34	24.70	$11.37	$53.08	$64.45
2005	14.33	4.34	20.24	24.58	$11.36	$53.02	$64.37
2006	15.08	4.34	20.27	24.61	$11.28	$52.69	$63.97
2007	14.26	4.34	20.24	24.58	$11.24	$52.49	$63.73
2008	14.53	4.34	20.25	24.59	$11.19	$52.23	$63.42
2009	14.65	4.34	20.26	24.59	$11.15	$52.08	$63.24
2010	13.51	4.33	20.22	24.55	$11.14	$52.00	$63.14
2011	10.81	4.31	20.12	24.43	$11.14	$52.02	$63.16
2012	12.29	4.32	20.17	24.49	$11.07	$51.70	$62.77
2013	14.17	4.33	20.24	24.57	$11.00	$51.34	$62.33
2014	12.12	4.32	20.17	24.49	$10.98	$51.28	$62.26
2015	12.70	4.32	20.19	24.51	$10.92	$51.00	$61.92
2016	8.91	4.30	20.06	24.35	$10.94	$51.09	$62.04
2017	8.12	4.29	20.03	24.32	$10.91	$50.95	$61.87
2018	7.52	4.29	20.01	24.30	$10.88	$50.81	$61.69
2019	8.46	4.29	20.04	24.33	$10.83	$50.56	$61.38

LTVs – Side Door Beams. The number of LTV occupant fatalities increased during the 1980s primarily due to the greatly increasing sales of these vehicles and their use for passenger transportation. Side impacts were a significant cause of these fatalities. Consequently, NHTSA extended the side door strength requirements of FMVSS No. 214 to LTVs with a GVWR of 10,000 lb or less starting September 1, 1993. The final rule was published in the Federal Register on June 14, 1991, (56 FR 27427) extending FMVSS No. 214 side door strength requirement to LTVs. The NPRM was published in the Federal Register on December 22, 1989, (54 FR 52826) making the baseline date September 1, 1989, or MY 1990.

Prior to MY 1990, some door reinforcement was already present. However, manufacturers responded by adding reinforcement beams to the doors, perhaps along with very minor strengthening of the A- and B-pillars around the door hinge and door latch areas. Since manufacturers responded to the rulemaking by adding structure, and we only cost estimated that added structure, none of the incremental costs are considered in the baseline fleet and all costs are attributable to the standard. A study conducted in 1998 looked at the side safety systems of 2-door LTVs from five pre-standard (1987) make models and five corresponding post-standard (1994) make-model LTVs (Fladmark & Khadilkar, 1998a). The study found that none of the pre-standard vehicles had a side door beam. The cost teardown analysis determined that the A- and B-pillar in both the pre- and post-standard LTVs had the same weight and cost; consequently, changes made to meet the standard were incorporated into the door only. Thus, there was no voluntary compliance or costs spent before the baseline date.

Table 209 shows the arithmetic incremental average weight and consumer cost of the safety equipment such as side door beams and supporting structures contained in post-standard compared to pre-standard side doors. These estimates are for the two front doors. Other functional and cosmetic components of the doors, such as sheet metal, window systems, and interior decoration are not included. Our customary methodology is to attribute only the difference between pre- and post-standard, 15 lb and $20.38, to FMVSS No. 214 and not the full weight and cost of the equipment (side door beams and reinforcements to the A-pillars, B-pillars and front doors) in the post-standard vehicles, 23.76 lb and $40.79, to FMVSS No. 214. In this case, we assume that the difference between the full weight and cost and the incremental weight and cost was already in the structure of the LTV, part of the body-in-white, and is considered part of Safety1965 (i.e., 8.76 lb and $20.41).

Table 209. Average incremental weight and consumer cost of side impact protection quasi-static test for FMVSS No. 214 in LTVs

Component	Weight (lb)	Consumer Cost ($2019)
Front Side Doors (2)	15.00	$20.38

NHTSA has no cost teardowns of the cost for side door beams for 3-door (minivans or vans with one rear door) or 4-door LTVs (crew cab pickups, SUVs/CUVs, and minivans and vans with two rear doors). We estimated the average number of doors per LTV by model year by examining two sources of data. First, we deciphered VINs that show the types of vehicles or number of doors for MYs 1990 to 2014 and weighted those by Polk registration data (Polk & Co., n.d.). Second, we used the Domestic Light Truck Output by Body Style table in the *Ward's Automotive Yearbooks* for MYs 2012 to 2019 (Binder, 2002-2017; Norris, 2018-2020). One difficulty was in determining how many rear doors should be counted for extended cabs, for which the number of doors could not be deciphered with a VIN. Some pickups with extended cabs have no rear doors, some have one rear door, and some have 2 rear doors. The size of rear doors on extended cabs is not as wide as on front doors. For this analysis, we assumed that the average pickup truck with extended cab had 1 rear door for weight and cost purposes. A sensitivity analysis, assuming each extended cab had 2 rear doors, only changed the average number of rear doors by 0.06 per vehicle. So, the results are not very sensitive to that assumption. We assumed that the weight and cost for rear door side door beams would be the same as for front doors on a per door basis (note that Table 209 weight and cost is for 2 front doors).

The average number of doors per LTV changed significantly between MY 1990 (2.60) and 2019 (3.93) because the percent of regular cab pickup trucks (with 2 doors) compared to all pickups dropped significantly from 77 percent for MY 1990 to 8 percent for MY 2019, 4-door SUVs changed from 45 percent of all SUVs in MY 1990 to 99.7 percent of all SUVs for MY 2019, and minivans changed from all 3-door vehicles in MY 1990 to almost all 4-door vehicles for MY 2019.

Table 210 provides the average number of side doors per LTV, the percent that had side door beams installed, and the estimated incremental weight and cost for the quasi-static test for FMVSS No. 214 for LTVs after applying the learning curve.

Table 210. FMVSS No. 214: Average weights and consumer costs: Weights of quasi-static test for LTVs

Model Year	Ave. # of Doors	% Installed	Weight (lb)			Consumer Cost (2019$)		
			Voluntary	Attr.	Total	Voluntary	Attr.	Total
1990	2.60	0	0	0	0	$0.00	$0.00	$0.00
1991	2.73	11.44	0	2.35	2.35	$0.00	$3.24	$3.24
1992	2.78	12.71	0	2.65	2.65	$0.00	$3.65	$3.65
1993	2.87	18.88	0	4.07	4.07	$0.00	$5.57	$5.57
1994	2.88	100	0	21.60	21.60	$0.00	$29.35	$29.35
1995	2.97	100	0	22.25	22.25	$0.00	$30.00	$30.00
1996	3.19	100	0	23.94	23.94	$0.00	$32.03	$32.03
1997	3.19	100	0	23.93	23.93	$0.00	$31.80	$31.80
1998	3.29	100	0	24.69	24.69	$0.00	$32.57	$32.57
1999	3.41	100	0	25.55	25.55	$0.00	$33.47	$33.47
2000	3.44	100	0	25.80	25.80	$0.00	$33.55	$33.55
2001	3.54	100	0	26.56	26.56	$0.00	$34.32	$34.32
2002	3.64	100	0	27.27	27.27	$0.00	$35.00	$35.00
2003	3.64	100	0	27.26	27.26	$0.00	$34.79	$34.79

Model Year	Ave. # of Doors	% Installed	Weight (lb)			Consumer Cost (2019$)		
			Voluntary	Attr.	Total	Voluntary	Attr.	Total
2004	3.72	100	0	27.91	27.91	$0.00	$35.41	$35.41
2005	3.72	100	0	27.91	27.91	$0.00	$35.21	$35.21
2006	3.71	100	0	27.86	27.86	$0.00	$34.96	$34.96
2007	3.76	100	0	28.17	28.17	$0.00	$35.17	$35.17
2008	3.71	100	0	27.83	27.83	$0.00	$34.60	$34.60
2009	3.74	100	0	28.02	28.02	$0.00	$34.73	$34.73
2010	3.76	100	0	28.16	28.16	$0.00	$34.81	$34.81
2011	3.74	100	0	28.08	28.08	$0.00	$34.58	$34.58
2012	3.89	100	0	29.19	29.19	$0.00	$35.80	$35.80
2013	3.90	100	0	29.26	29.26	$0.00	$35.73	$35.73
2014	3.91	100	0	29.29	29.29	$0.00	$35.62	$35.62
2015	3.90	100	0	29.22	29.22	$0.00	$35.37	$35.37
2016	3.91	100	0	29.30	29.30	$0.00	$35.33	$35.33
2017	3.91	100	0	29.32	29.32	$0.00	$35.22	$35.22
2018	3.92	100	0	29.41	29.41	$0.00	$35.19	$35.19
2019	3.93	100	0	29.45	29.45	$0.00	$35.12	$35.12

Structure and Padding Improvements to Meet FMVSS No. 214 Upgrade – Dynamic Test Requirement and TTI(d)

Passenger Cars – Dynamic Test. NHTSA's analysis of real-world crash data showed that strengthening the side doors with metal beams was indeed effective in single-vehicle crashes but had little effect on reducing fatalities in multi-car crashes (Kahane, 1982a, pp. 100–108). Consequently, FMVSS No. 214 was amended in October 1990 to upgrade its test procedures and performance requirements for passenger cars.

The amendments required that each passenger car, in addition to the quasi-static crush performance requirements, must protect its occupants in a full-scale dynamic crash test in which the passenger car is struck on either side by a moving deformable barrier simulating another vehicle. Instrumented test dummies are positioned in the target car to measure the potential for injuries to an occupant's torso and pelvis. Accelerations at the dummy's upper rib, lower rib, and lower spine are measured, and a Thoracic Trauma Index on the dummy, TTI(d) is calculated from these accelerations. Four-door passenger cars must score 85 or less, while 2-door passenger cars must score 90 or less. In addition, the pelvis acceleration must be less than 130g. However, the safety benefits are mainly from chest injury reduction. The requirements were phased in with 10 percent of new passenger cars in MY 1994, 25 percent in 1995, 40 percent in 1996, and 100 percent in 1997 (i.e., after September 1, 1996).

On October 30, 1990, (55 FR 45721) a final rule was published in the Federal Register upgrading FMVSS No. 214, adding a dynamic side impact test for passenger cars. The NPRM was published in the Federal Register on January 27, 1988, (53 FR 2239) making the baseline date September 1, 1987, or MY 1988.

NHTSA's Final Regulatory Impact Analysis estimated that 42.23 percent of passenger cars already met the final rule based on testing of MY 1984 vehicles. An estimated 10 percent of 2-door passenger cars met the 90 TTI(d) standard and an estimated 61.5 percent of 4-door passenger cars met the 85 TTI(d) standard (NHTSA, 1990).[50] However, most passenger cars were improved substantially and TTI(d) on average went considerably below the required levels. A 2007 NHTSA evaluation shows that the average TTI(d) level without side air bags was 69 for 2-door cars and 63 for 4-door cars and with side air bags dropped to 44 for 2-door cars and 48 for 4-door cars (Kahane, 2007, pp. 11–12). Weight and costs are estimated for this improvement in TTI(d) levels without side air bags in this section, rather than on the increase in the percent of passenger cars that comply.

This 2007 NHTSA evaluation suggests that TTI(d) already began to improve in 1986, 2 years before the NPRM. The early improvement is not surprising, given that NHTSA had clearly advised the public well before the 1988 NPRM that the agency would do something about side impact. The 2007 evaluation report and the lives-saved model suggest that TTI(d) had improved at a relatively linear pace from 1985 to the start of the phase-in. While TTI(d) improvement and percent of the fleet that complies with the standard do not necessarily coincide, we will assume a similar relatively linear improvement over the years from 1985 to 1993. We will assume that the estimated improvement percentages up to and including MY 1988 are voluntary, since they are before the baseline year.

Units of TTI(d) Improvement Based on 2007 Evaluation

Relative to MY 1985	2-door	4-door
1985	0	0
1986	2	1
1987	4	2
1988	6	3
1989	8	4
1990	10	5
1991	12	7
1992	15	10

[50] The results of this analysis are in the preamble to the final rule on the dynamic side impact test. Go to https://www.loc.gov/collections/federal-register/ or google Federal Register October 30, 1990, at page 45741.

Relative to MY 1985	2-door	4-door
1993-1996 not certified	*19*	*14*
Certified (1994 and onwards)	*45*	*22*

A NHTSA evaluation provided test data during the phase-in period on 36 of 52 passenger car make/model groups and sales data (Kahane, 1999, App. B, p. 185). These 52 vehicles represent roughly 75 percent of the passenger car sales from 1993 to 1996. We also knew manufacturer's compliance claims on all 52 make/model vehicles, but if no test data were available and the manufacturer did not claim compliance for the make/model/MY, we assumed it was not in compliance. This assumption that if a manufacturer doesn't claim compliance – the vehicle is not in compliance – will result in the minimum estimate of compliance. There could be vehicles that were not tested by the manufacturer. There could be vehicles that passed the test, but were not 20 percent below the injury criteria, and the manufacturer didn't want to claim compliance and risk the possibility that NHTSA would test the vehicle and it wouldn't pass based on test variability. These test and sales results were compiled into the following estimates of the minimum percentages of the passenger car fleet complying with the TTI(d) requirements during the phase-in years of MYs 1993 to 1996, weighted by 2-door/4-door sales information from Table 208.

Table 211. FMVSS No. 214: Estimated minimum compliance with TTI(d) requirements during the phase-in (%)

Model Year	2-door Cars	4-door Cars	Weighted Average
1993	16.1	40.8	33.8
1994	15.8	60.0	47.6
1995	43.8	66.5	60.6
1996	55.1	80.9	74.9

Thus, we assume a linear increase in the percentage of 2-door cars improving from 2.0 percent in MY 1986 to 16.1 percent in MY 1993 and in the percentage of 4-door cars improving from 5.1 percent in MY 1986 to 40.8 percent in MY 1993. These improvement percentages are then weighted by the 2-door/4-door sales distribution as found in Table 208.

The costs for dynamic side impact testing are over and above the baseline vehicles that meet the quasi-static test. We assume the voluntary compliance for earlier MYs is composed of similar changes (in terms of structure and padding) that were found during the MY 1994 phase-in.

Manufacturers initially relied on one or more of the following strategies to ensure their vehicles met the dynamic test:

- No changes necessary to meet the dynamic test
- Major structure changes applied to the A-pillars, the front and rear door or rear panel (2-door models), the B-pillar, the C-pillar, or other components
- Minor structure changes such as additional or strengthened door beams and some additional steel plates
- Padding added to inside of door skin or inner door structure

NHTSA sent information requests to vehicle manufacturers asking them to identify any components that were added or redesigned to meet the dynamic performance requirements. The requests were reviewed to determine which alternative the vehicle manufacturers chose, and it is our belief that an estimated 56 percent of the vehicles certified to comply with this requirement had major structural reinforcement changes and added padding, 21 percent had minor structural changes and added padding, 6 percent just added padding to comply, while 17 percent of the vehicles had no structural changes or added padding (Kahane, 1999). All vehicles continued to have side door beams and other equipment previously installed to meet the original, quasi-static requirement of FMVSS No. 214.

Since our teardown cost analysis was limited to a sample of nine vehicles that all had major structure changes, a simple average of these teardowns would be a substantial overestimate of the cost of FMVSS No. 214. Therefore, to calculate a realistic cost of the standard, it was necessary to generate estimates for the vehicles that did not have major structure changes, append those estimates to the contractor's costs, and average the results.

Here is a more detailed discussion of the cost implications of the alternative methods to secure compliance with FMVSS No. 214.

- Major Structure Changes with Padding. Substantial structural changes were applied to the A-pillars, the front and rear door or rear panel (2-door models), the B-pillar, and the C-pillar. The changes to the pillars were to help support the loads on the door hinges and latches and provide additional structural rigidity so that impact loads could be transferred to the rest of the vehicle body without buckling. In some cases, a dashboard level cross-member between left and right A-pillars was added. Floor cross-members linking the left and right B-pillars were added or strengthened and the same was done for the C-pillars. Changes to the doors and rear panels (2-door models) typically consisted of additional door beams and energy absorbing designs in the inner door structure. Three cost and weight analyses comprised two make-model 2-door passenger cars and seven make-model 4-door passenger cars representing systems from 1994 to 1998 (Fladmark & Khadilkar, 1996b, 1997b, 1998, sec. 6). For the learning curve calculations, we will assume these costs represent MY 1996 vehicles. These contractor reports attempted to estimate separately the cost and weight of equipment needed only to meet the dynamic standard versus equipment needed to meet the quasi-static requirement. However, we have added these costs and weights to produce a single, more consistent and reliable estimate of the total cost and weight of FMVSS No. 214. Table 212 shows the arithmetic average total weight and consumer cost of the side impact protection system (dynamic and quasi-static requirements) in 2- and 4-door passenger cars in MYs 1994 to 1998.

Table 212. FMVSS No. 214: Average weights and consumer costs of dynamic plus quasi-static requirements in 2-door and 4-door passenger cars with major structure changes

Car Type	Weight (lb)	Consumer Cost ($2019)
2-Door	70.33	$308.51
4-Door	90.59	$376.43

- Cost and Weight of Padding. Padding was typically affixed to the inside of the door skin or inner door structure. The foam padding was strategically placed with one piece to protect the upper and lower rib cage of the occupant and other piece located to protect the pelvis. As stated above, the contractor did not teardown any vehicles whose modifications were limited to padding. Therefore, we reviewed the contractor's nine teardowns of vehicles that received padding plus major structure and isolated the costs specifically related to padding. Next, we compared the padding in these vehicles to padding in vehicles that did not receive major structure and found them quite similar in size and shape. The component cost summaries, with corresponding photographs from the sample vehicles in the teardown cost studies, were analyzed and the padding information was extracted. The arithmetic average for the padding incorporated into the front door, rear door, and in some cases the B-pillar was calculated for the 1994 to 1998 MY passenger cars. Table 213 shows the average weight and consumer cost of just the padding in the 2- and 4-door passenger cars.

Table 213. FMVSS No. 214: Average weights and consumer costs of padding in 2-door and 4-door passenger cars

Car Type	Weight (lb)	Consumer Cost ($2019)
2-Door	0.91	$13.65
4-Door	1.27	$19.32

- Cost and Weight of Minor Structure Changes. Minor structure changes usually consisted of additional or strengthened door beams and some additional steel plates added to strengthen areas on the pillars around the door latches and hinges. As stated above, teardowns were limited to vehicles with major structure changes. In order to estimate the cost of new structure in the 21 percent of vehicles that had only minor changes, we needed to: (1) establish some kind of ratio of the cost of minor to major structural changes; (2) isolate in the teardown sample the FMVSS No. 214 costs specifically associated with major structural changes, as opposed to, padding or continuation of the equipment needed to meet the quasi-static requirement; and (3) multiply the ratio of minor to major structure by the cost of major structure.

    1) In the seven teardown vehicles for which we also had clear diagrams or enumerations of the new structure, we found an average of 4.43 relatively massive and costly new structural components per vehicle, such as large-size pillar stiffeners, cross members, beams, and sill reinforcements. Information requests to the manufacturers furnished

detailed diagrams or enumerations of new structure in six make-models that we described above as receiving only minor structure. For the most part, these new structures were limited to a few very low-cost items such as small, localized beams and sills, but some models received one or even two massive and costly components. In all, these six make-models received an average of 0.83 massive and costly components per vehicle. Therefore, we estimate that the cost ratio of minor to major structure must have been close to 0.83/4.43 = 19 percent.

2) The top section of Table 214 shows an example of how the cost of minor structure was determined. Starting with the average cost of major new structure in the teardown vehicles (e.g., $376.43 in 4-door passenger cars from Table 212), deduct the cost or weight of padding (e.g., $19.32 from Table 213) and the cost or weight of the existing structures used for meeting the quasi-static requirements of FMVSS No. 214 (e.g., $78.88 from Table 207). The remainder ($278.24 in the 4-door passenger cars) is the cost of the added major structures.

3) Multiply the cost or weight of added major structures in the teardown sample by 19 percent to obtain an estimate of the cost or weight of added minor structures ($52.86), as shown in the lower section of Table 214.

Table 214. FMVSS No. 214: Determination of the average weight and consumer cost: Weights of minor structure changes in 2-door and 4-door passenger cars

	Category	2-door		4-door	
		Weight (lb)	Consumer Cost (2019$)	Weight (lb)	Consumer Cost (2019$)
	214 Teardown Studies	70.33	$308.51	90.59	$376.43
-	Padding	0.91	$13.65	1.27	$19.32
-	Quasi-static Requirements	28.17	$67.30	23.98	$78.88
=	Major Structure	41.25	$227.56	65.34	$278.24
*	Percentage Change	0.19	0.19	0.19	0.19
=	Minor Structure	7.84	$43.24	12.41	$52.86

- No Structural Changes or Padding. Some vehicles did not have to incorporate any structural changes or added padding to their vehicles to meet the dynamic standard. Of course, even in these vehicles, the equipment used to meet the quasi-static requirement would continue to be in place. Therefore, no weight or cost was attributed to those vehicles that already met the standard.

Table 214 shows the costs for each of the countermeasures alone. However, the vehicles that had both the major and minor structures also had padding. Table 215 shows the average weight and consumer cost of the side impact protection system in 2- and 4-door passenger cars, broken out by the changes incorporated by the vehicle manufacturers. These are incremental costs to the quasi-static test requirements. It is necessary to add the cost of padding to the major and minor structures in the vehicles that have more than one of those items.

Table 215. FMVSS No. 214: Average weights and consumer costs of dynamic requirements alone in all passenger cars

Changed to Meet Dynamic Standard	**Weight (lb)**	**Consumer Cost ($2019)**	**Percent of Cars**
2-Door			
Major Structure Changes + Padding	42.16	$241.21	56
Minor Structure Changes + Padding	8.75	$56.89	21
Padding	0.91	$13.65	6
Quasi-static Only	0	$ 0.00	17
4-Door			
Major Structure Changes + Padding	66.61	$297.56	56
Minor Structure Changes + Padding	13.68	$72.19	21
Padding	1.27	$19.32	6
Quasi-static Only	0	$0.00	17
Weighted Average	40.25	$182.95	

For the learning curve analysis, separate learning curves are derived for 2-door cars using the $147.84 and a separate learning curve is derived for 4-door cars using $182.95 for MY 1996 vehicles, then they are weighted by the percent of the fleet that is 2-door and 4-door cars that was shown in Table 208.

Table 216 shows the average weight and consumer cost for FMVSS No. 214 dynamic test for passenger cars by MY.

Table 216. FMVSS No. 214: Weights and consumer costs of the dynamic test for passenger cars weighted by 2-door and 4-door models

Model Year	Percent Improved	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1985	0.00	0.00	0.00	0.00	$0.00	$0.00	$0.00
1986	3.94	1.37	0.00	1.37	$10.32	$0.00	$10.32
1987	8.03	2.82	0.00	2.82	$18.99	$0.00	$18.99
1988	11.79	4.09	0.00	4.09	$25.77	$0.00	$25.77
1989	15.65	4.08	1.34	5.41	$24.48	$8.02	$32.50
1990	20.39	4.17	3.04	7.22	$23.80	$17.38	$41.18
1991	24.69	4.19	4.59	8.78	$23.16	$25.36	$48.52
1992	29.67	4.26	6.47	10.73	$22.74	$34.50	$57.24
1993	33.82	4.25	7.95	12.20	$22.16	$41.42	$63.58
1994	48.47	4.26	13.25	17.51	$21.58	$67.16	$88.74
1995	61.18	4.29	17.99	22.28	$21.05	$88.20	$109.25
1996	74.86	4.34	23.20	27.54	$20.59	$110.19	$130.78
1997	100	4.37	32.70	37.07	$20.07	$150.24	$170.31
1998	100	4.40	32.96	37.36	$19.70	$147.47	$167.17
1999	100	4.40	32.94	37.34	$19.31	$144.56	$163.87
2000	100	4.41	33.02	37.44	$19.02	$142.33	$161.35
2001	100	4.42	33.08	37.50	$18.77	$140.49	$159.26
2002	100	4.44	33.21	37.64	$18.59	$139.12	$157.71
2003	100	4.47	33.44	37.91	$18.47	$138.23	$156.70
2004	100	4.45	33.27	37.71	$18.25	$136.63	$154.88
2005	100	4.50	33.64	38.14	$18.20	$136.24	$154.45
2006	100	4.48	33.55	38.03	$18.03	$134.94	$152.97
2007	100	4.50	33.65	38.15	$17.92	$134.14	$152.06
2008	100	4.49	33.62	38.11	$17.78	$133.07	$150.85
2009	100	4.49	33.60	38.09	$17.69	$132.43	$150.13
2010	100	4.51	33.75	38.26	$17.65	$132.06	$149.71
2011	100	4.56	34.10	38.66	$17.65	$132.13	$149.78
2012	100	4.53	33.91	38.44	$17.51	$131.04	$148.54

Model Year	Percent Improved	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2013	100	4.50	33.66	38.16	$17.35	$129.82	$147.16
2014	100	4.53	33.93	38.46	$17.33	$129.67	$147.00
2015	100	4.52	33.86	38.38	$17.22	$128.87	$146.09
2016	100	4.59	34.35	38.94	$17.28	$129.32	$146.60
2017	100	4.60	34.45	39.05	$17.24	$129.04	$146.28
2018	100	4.61	34.53	39.14	$17.21	$128.82	$146.03
2019	100	4.60	34.41	39.00	$17.14	$128.26	$145.40

LTVs – Dynamic Test. Starting September 1, 1998, LTVs with a GVWR of 6,000 lb or less were subject to the same dynamic requirements as the passenger cars. No teardown studies have been performed on the changes made because of this requirement. LTVs had a much greater probability than passenger cars of meeting the dynamic requirement without any changes. At the time this final rule was written, NHTSA believed that all LTVs would have met the final rule requirements without adding any weight or cost. Further support of this belief was a MY 1991 Toyota pickup that had a TTI(d) of 55, which was well below the 85 TTI(d) required, and an information request sent to manufacturers at the time the agency was evaluating FMVSS No. 214. The information request did not show any clear evidence of structural modification in 10 MY 1999 pickup trucks (Kahane, 2007).

Window Curtain and Side Air Bags to Meet the Pole Test

Passenger car and LTV window curtains and side air bags are discussed together for ease of presentation.

During the 1990s, manufacturers and suppliers developed window curtain and side air bags to protect an occupant’s head, torso, and pelvis in side impacts – specifically near-side impacts to the side of the vehicle adjacent to where the occupant is seated – even more effectively than the structure and padding originally employed to meet FMVSS Nos. 201 and 214. Some window curtain air bags are designed to deploy in rollover crashes or to reduce an occupant’s risk of complete or partial ejection from the vehicle in crashes, or both, but these rollover window curtains are discussed in the section on FMVSS No. 226, Ejection mitigation. Side air bags were first offered in MY 1996 in the United States on 1 percent of passenger cars sold that year.

In 1999 then NHTSA administrator Ricardo Martinez challenged the auto industry to develop test procedures to assess the injury risks from side air bags for out-of-position occupants (for example, children lying down on the seat and their heads close to a deploying side air bag or children or adults with their heads next to the side roof rail and a deploying window curtain). In response, the industry convened a technical working group of safety experts representing the automobile manufacturers, restraint suppliers, and researchers and developed tests to assess the potential injury risks for out-of-position occupants. NHTSA monitors these side impact voluntary guidelines to assure that side air bags don’t pose a significant threat to small children and adults. NHTSA has no data indicating how much these voluntary guidelines add to the cost of side air bags and window curtains. The cost estimates for side air bags and window curtains include designs which meet the voluntary guidelines, but we can't separate the costs that were incurred for just the voluntary guidelines. Thus, we make no estimates related to voluntary versus attributable costs for these voluntary guidelines for out-of-position side air bag testing.

On September 11, 2007, (72 FR 51908) a final rule was published in the Federal Register adding a pole test to FMVSS No. 214, Side impact protection for passenger cars and LTVs. The NPRM was published in the Federal Register on May 17, 2004, (69 FR 27990) making the baseline date September 1, 2003, or MY 2004. Costs will thus be considered voluntary through MY 2004 and the voluntary percentage will be held at that MY 2004 baseline level through MY 2019. Attributable costs will be the difference between the installation rates for MYs 2005 to 2019 minus the voluntary baseline level of MY 2004.

Types of air bags: There are three major types of air bags designed to deploy in side impacts.

Torso air bags provide an energy-absorbing cushion between the occupant's torso and the vehicle's side structure during lateral impacts. They usually are built into the seat and deploy from there, but sometimes are built into the door. Some, but not all torso bags extend downward to also protect the pelvis. Volvo introduced torso bags in the United States, making them standard equipment on all their MY 1996 cars. Torso air bags mounted into the seat required seat structure redesign to accommodate the air bag module location, as well as foam and stitching changes to accommodate the torso air bag deployment.

Window curtain air bags are built into the roof-rail area above the side window and deploy downward to cover the window area. They provide a cushion between the occupant's head and some of the rigid surfaces of the vehicle interior, such as the roof rail, the window sill, the A-pillar, and the B-pillar. They might also prevent partial or complete ejection of the occupant through the side-window area and prevent direct occupant contact with the striking vehicle or object. Some early designs of window curtain bags had a limited longitudinal span, leaving a substantial portion of the window uncovered or they were inflatable tubular structures with a limited vertical span. Many recent window curtains cover a wide longitudinal and vertical span, including most of the side-window area and the harder structures around it. BMW introduced inflatable tubes for head protection, in combination with torso bags in their 1998 500-series and 700-series cars. In 1999, Mercedes E-series and Volvo S-80 had window curtains plus torso bags. Window curtains alone, without torso bags, did not appear until MY 2001, as options in some Chrysler, Dodge, and Saturn cars.

Combination bags are torso bags that deploy outward from the seat and then quickly upward to also provide head protection. Unlike window curtains, they cover a somewhat limited area immediately to the occupant's side. Combination bags were standard in 1999 on Lincoln Town Car and Continental and Infiniti Q45, G20, and QX4; also optional on some other Ford cars and LTVs. Installation of combination bags peaked at about 8 percent of passenger cars in MY 2005 and 4 percent of LTVs in MY 2003. By MY 2010, combination bags were limited primarily to convertibles, where there is no roof rail for installing a window curtain air bag. Suppliers have developed a head-impact air bag for use in convertibles; it covers an area like a window curtain but deploys up from the door rather than down from the roof rail. These are considered combination bags in this analysis.

Window curtain plus torso bags combined is the most extensive side-impact protection. The window curtains are separate from the torso bags, although they usually share components such as sensors and the control module. By MY 2006, window curtain plus torso bags, the configuration that covers the largest area and intuitively appears to provide the most protection were the clear preference. By MY 2016, about 98 percent of new cars and almost 100 percent of new LTVs had window curtain plus torso bags for drivers and right front passengers. The remaining 2 percent of passenger cars had combination bags in convertibles.

The September 11, 2007, final rule upgrading FMVSS No. 214 by adding a crash test of a 20-mph side impact with a 10-inch diameter pole, at a 75-degree angle (i.e., 15° forward of a purely lateral impact) essentially required side air bags to protect the head. Whether a torso bag was needed to meet the pole test or the dynamic test or neither was not as clear. The phase-in required compliance by:

- 20 percent of vehicles manufactured between September 1, 2009, and September 1, 2010;
- 50 percent of vehicles manufactured between September 1, 2010, and September 1, 2011;
- 75 percent of vehicles manufactured between September 1, 2011, and September 1, 2012; and
- 100 percent of vehicles manufactured on or after September 1, 2012.

While no safety standard explicitly requires vehicles to have window curtain or side air bags, every manufacturer used these countermeasures to certify compliance to the pole test. Window curtains were the principal technology available for cushioning an occupant in oblique impacts and combination bags or door-mounted head-impact bags are used in convertibles without a roof rail.

The percentage of vehicles with side air bags by MY (MYs 1996 to 2011) was provided in the Kahane (2014) evaluation of the fatality reduction by side air bags. These estimates were updated with data for this report and passenger cars and LTVs were considered separately, as were torso bags for front and rear seat occupants. Data related to the percentage of the fleet that had different types of side air bags were examined from three sources – data from FARS, data from Polk registrations using VIN information, and NHTSA compliance data. In general, NHTSA compliance data was used for MYs 2012 to 2019 and Polk registration data was used for years before MY 2012. The differences in the percentages from the Polk data and FARS data are generally not large and the Polk data were selected over FARS data, simply because it is a much larger source of data than fatal crashes in FARS. NHTSA compliance data indicates whether the make/model has standard or optional air bags. When optional air bags were claimed, the take rate on that specific make/model for that specific air bag (torso or window curtain) was taken from the Factory Installed Equipment pages of the Automotive News Yearbook and inserted into the compliance data. The percentage of the fleet with the different types of air bags are provided in Table 214-10 for passenger cars and LTVs by MY. For costing purposes, these are summed into three types of side air bags: torso bags, combination bags, and window curtains (combining both non-rollover and rollover window curtains). In FMVSS No. 226, we will count the incremental weight and cost for rollover sensors and a rollover window curtain compared to a non-rollover window curtain. For FMVSS No. 214 we will only count the weight and cost of the non-rollover window curtain.

Table 217. FMVSS No. 214: Percentages of passenger cars and LTVs with different types of side air bags

Model Year	Passenger Cars			LTVs		
	Torso	Combination Bags	Window Curtain	Torso	Combination Bags	Window Curtain
1996	1.00	0.00	0.00	0.00	0.00	0.00
1997	3.70	0.00	0.00	0.00	0.00	0.00
1998	10.80	0.00	0.80	3.20	0.00	0.00
1999	12.40	3.10	1.90	4.20	0.30	0.00
2000	19.50	4.70	3.10	7.50	1.00	0.10
2001	24.00	6.40	10.20	10.00	3.40	0.70
2002	24.20	6.40	13.00	18.10	2.90	1.10
2003	21.30	6.20	15.30	14.50	3.80	4.50
2004	23.10	7.40	19.20	19.80	3.20	13.30
2005	25.80	8.00	23.00	19.10	2.70	17.30
2006	38.40	5.80	38.30	26.00	1.90	27.80
2007	56.70	3.20	61.00	32.00	1.10	47.40
2008	73.40	5.50	78.30	45.00	1.50	64.00
2009	88.20	4.90	92.90	60.10	0.60	79.10
2010	91.90	4.40	95.40	77.50	1.90	91.00
2011	94.30	5.00	94.90	84.80	1.90	92.10
2012	96.30	3.70	96.30	89.00	1.60	96.80
2013	96.07	3.93	96.07	91.45	0.77	99.23
2014	97.38	2.62	97.38	93.06	1.84	98.16
2015	96.50	2.10	97.90	94.90	0.00	100.00
2016	98.20	1.80	98.20	96.17	0.00	100.00
2017	97.77	2.23	97.77	99.99	0.01	99.99
2018	98.59	1.41	98.59	99.98	0.02	99.98
2019	98.21	1.79	98.21	99.99	0.01	99.99

Side air bag costs. Based on cost teardown studies by Khadilkar et al. (2003) and Ludtke et al. (2004, Table 4-1, pp. 4–3), [51] NHTSA estimated the costs of side air bags in the Final Regulatory Impact Analysis (NHTSA, 2007a). We went back to the same cost teardown studies to identify the weights of side air bag systems. The weights and costs apply to both passenger cars and LTVs. No pattern was identified that would indicate that weights or costs were higher or lower for LTVs compared to passenger cars.

As with frontal air bags, side air bags also changed over time. Because of the oblique angle of the pole test and the requirement to pass the test with a 5th percentile female dummy in the forward seating position (as well as the 50th percentile male in the mid seating position), many of the voluntarily provided torso, combination bags, and window curtain air bags were not wide enough to comply with the new oblique pole test. In addition, many vehicles needed two sensors per side of the vehicle to determine that a side impact with a narrow pole had occurred and the side air bags and window curtain should be deployed. Thus, we need two cost estimates for side air bags of all types, one that is pre-standard (up to MY 2009) and one for post-standard (MY 2009 and later) window curtains. Although many of the side air bags were not wide enough to meet the oblique pole test, these pre-standard side air bags did provide significant benefits to occupants. Side air bags and window curtains changed again with the evolution of the ejection mitigation window curtain. Ejection mitigation window curtains relate to the new FMVSS No. 226, and their weights and costs will be discussed in the section on FMVSS No. 226.

Table 218 provides the estimated cost increases by type of side air bag for both the pre-standard side air bags and the post-standard side air bags. The pre-standard side air bag 2-sensor cost estimates below are the basis for what is provided into the learning curve analysis, and then additions were made for the percentage of the fleet with 4 sensors and for the additional cost for post-standard side air bags for MY 2009 through MY 2019.

Table 218. FMVSS No. 214: Weight and consumer cost: Weights before learning curve for side impact oblique pole test for passenger cars or LTVs – side air bags for both sides of the vehicle

2-sensors	**Pre-standard Side Air Bags**		**Post-standard Side Air Bags**	
Side Air Bag Type	**Weight**	**Cost**	**Weight**	**Cost**
Torso + Sensors	6.39	$137.89	6.90	$144.85
Combination + Sensors	7.09	$153.32	7.34	$167.24
Curtain Alone	6.78	$173.42	7.24	$177.59
Torso + Sensors Plus Curtain	13.18	$311.31	14.14	$322.44

4-sensors	**Pre-standard Side Air Bags**		**Post-standard Side Air Bags**	
Side Air Bag Type	**Weight**	**Cost**	**Weight**	**Cost**
Torso + Sensors	6.69	$186.49	7.19	$193.44

[51] Mercury Monterey air bag not included because it was much heavier and costlier than others.

4-sensors	Pre-standard Side Air Bags		Post-standard Side Air Bags	
Side Air Bag Type	**Weight**	**Cost**	**Weight**	**Cost**
Combination + Sensors	7.39	$201.92	7.63	$215.83
Curtain Alone	6.78	$173.42	7.24	$177.59
Torso + Sensors Plus Curtain	13.47	$359.90	14.43	$371.03

Side impact sensors. To determine the percentage of the fleet that had 2 side impact sensors per vehicle versus 4 side impact sensors per vehicle, data on a make-model year basis was collected from the Homatro data book.[52] This book includes every make-model in the fleet and provides information on air bags and sensors. Data was collected and compared to make-model sales for MYs 2001, 2005, and 2009. MY 2009 is the last year for which data is provided in this series of books. Given that a vehicle had side impact sensors, the percent distribution between 2 sensors and 4 sensors per vehicle changed dramatically between MYs 2001 and 2009. Other years from MYs 1996 to 2000 were interpolated or extended from these data. It was assumed that only vehicles with no rear seat would have 2 sensors from MY 2016 and later. Data was collected on the percentage of passenger cars and LTVs that had no rear seat from MYs 2016, 2018, and 2019 and data was interpolated to fill in the remaining years. Table 219 shows these results.

Table 219. FMVSS No. 214: Side impact sensor data for passenger cars and LTVs percent distribution between 2 and 4 sensors, given these vehicles had sensors

Model Year	Passenger Cars		LTVs	
	2 Sensors	**4 Sensors**	**2 Sensors**	**4 Sensors**
1996	100.00%	0.00%	0.00%	0.00%
1997	98.08%	1.92%	0.00%	0.00%
1998	96.16%	3.84%	100.00%	0.00%
1999	94.24%	5.76%	93.80%	6.20%
2000	92.32%	7.68%	87.61%	12.39%
2001	90.39%	9.61%	81.41%	18.59%
2002	83.97%	16.03%	74.78%	25.22%
2003	77.55%	22.45%	68.15%	31.85%
2004	71.12%	28.88%	61.53%	38.47%
2005	64.70%	35.30%	54.90%	45.10%
2006	58.35%	41.65%	45.15%	54.85%

[52] Mitchell International, LLC, prepared for Holmatro, Inc. *The Rescuer's Guide to Vehicle Safety Systems, Seventh Edition, 1985-2009, Domestic and Imported Cars and Truck.*

Model Year	Passenger Cars		LTVs	
	2 Sensors	4 Sensors	2 Sensors	4 Sensors
2007	52.00%	48.00%	35.40%	64.60%
2008	45.65%	54.35%	25.65%	74.35%
2009	39.30%	60.70%	15.90%	84.10%
2010	33.88%	66.12%	14.41%	85.59%
2011	28.46%	71.54%	12.91%	87.09%
2012	23.04%	76.96%	11.42%	88.58%
2013	17.63%	82.37%	9.93%	90.07%
2014	12.21%	87.79%	8.43%	91.57%
2015	6.79%	93.21%	6.94%	93.06%
2016	1.37%	98.63%	5.45%	94.55%
2017	1.22%	98.79%	4.72%	95.28%
2018	1.06%	98.94%	4.00%	96.00%
2019	1.32%	98.68%	4.01%	95.99%

Table 220 provides the estimated weight and cost added to the average passenger car for torso bags, Table 221 provides the estimate for combination side air bags for passenger cars, and Table 222 provides the estimates for window curtains for passenger cars. Table 223 provides the estimated weight and cost added to the average LTV for torso bags, Table 224 provides the estimate for combination side air bags for LTVs, and Table 225 provides the estimates for window curtains for LTVs. Side air bags provided through MY 2004 are considered voluntary and that voluntary percentage is held through MY 2019 if the percent of the fleet equipped increases. That isn’t always the case for combination side air bags and here the cost and weight per combination bag must be held constant for the voluntary percentage that decreases over time, since they are replaced with torso bags.

Sensor costs were attributed to torso bags or combination bags for most vehicles. However, there were a percentage of vehicles that had a window curtain and not a torso bag or combination bag. For these vehicles, sensor costs were attributed to window curtains. This way we assure ourselves of not counting sensor costs twice for the same vehicle. Torso bags were introduced first, and you needed a side impact sensor to trigger the bag deployment. Thus, it seemed logical to attribute sensor costs for those vehicles with torso or combination bags first and pick up the remainder of window curtains without torso bags or a combination bag in a separate calculation. Table 226 shows the percentages of passenger cars and LTVs that supplied window curtains without a torso bag or combination bag. These percentages were multiplied by the average weight of 2 sensors (0.29 pound) and average cost of 2 sensors ($48.59 in 2019$) plus the additional weight and cost to account for the percentage of the fleet that supplied 4 sensors and added into the window curtain average costs in Table 222 for passenger cars and Table 225 for LTVs.

Table 220. FMVSS No. 214: Average weights and consumer costs of front seat torso air bags in passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1995	0.00	0.00	0.00	$0.00	$0.00	$0.00
1996	0.06	0.00	0.06	$2.22	$0.00	$2.22
1997	0.24	0.00	0.24	$7.05	$0.00	$7.05
1998	0.69	0.00	0.69	$17.98	$0.00	$17.98
1999	0.79	0.00	0.79	$19.39	$0.00	$19.39
2000	1.25	0.00	1.25	$28.87	$0.00	$28.87
2001	1.54	0.00	1.54	$34.21	$0.00	$34.21
2002	1.56	0.00	1.56	$34.02	$0.00	$34.02
2003	1.38	0.00	1.38	$29.95	$0.00	$29.95
2004	1.50	0.00	1.50	$32.53	$0.00	$32.53
2005	1.50	0.18	1.68	$32.68	$3.82	$36.50
2006	1.51	1.00	2.50	$32.74	$21.69	$54.43
2007	1.51	2.20	3.71	$32.76	$47.65	$80.41
2008	1.51	3.30	4.81	$32.77	$71.35	$104.12
2009	1.63	4.61	6.24	$34.65	$97.64	$132.28
2010	1.64	4.88	6.52	$34.76	$103.51	$138.27
2011	1.64	5.06	6.70	$34.87	$107.49	$142.36
2012	1.65	5.21	6.86	$35.02	$110.97	$145.99
2013	1.65	5.21	6.86	$35.20	$111.20	$146.41
2014	1.65	5.31	6.97	$35.44	$113.96	$149.40
2015	1.66	5.26	6.92	$35.69	$113.41	$149.11
2016	1.66	5.40	7.06	$36.03	$117.14	$153.18
2017	1.66	5.37	7.03	$35.80	$115.71	$151.51
2018	1.66	5.43	7.09	$35.59	$116.32	$151.91
2019	1.66	5.40	7.06	$35.37	$115.00	$150.37

Table 221. FMVSS No. 214: Average weights and consumer costs of combination air bags in passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1998	0.00	0.00	0.00	$0.00	$0.00	$0.00
1999	0.22	0.00	0.22	$5.77	$0.00	$5.77
2000	0.33	0.00	0.33	$7.95	$0.00	$7.95
2001	0.46	0.00	0.46	$10.11	$0.00	$10.11
2002	0.46	0.00	0.46	$9.92	$0.00	$9.92
2003	0.44	0.00	0.44	$9.53	$0.00	$9.53
2004	0.53	0.00	0.53	$11.35	$0.00	$11.35
2005	0.53	0.04	0.58	$11.37	$0.92	$12.29
2006	0.42	0.00	0.42	$8.99	$0.00	$8.99
2007	0.23	0.00	0.23	$5.03	$0.00	$5.03
2008	0.40	0.00	0.40	$8.75	$0.00	$8.75
2009	0.37	0.00	0.37	$8.60	$0.00	$8.60
2010	0.33	0.00	0.33	$7.80	$0.00	$7.80
2011	0.38	0.00	0.38	$8.95	$0.00	$8.95
2012	0.28	0.00	0.28	$6.70	$0.00	$6.70
2013	0.30	0.00	0.30	$7.19	$0.00	$7.19
2014	0.20	0.00	0.20	$4.85	$0.00	$4.85
2015	0.16	0.00	0.16	$3.93	$0.00	$3.93
2016	0.14	0.00	0.14	$3.42	$0.00	$3.42
2017	0.17	0.00	0.17	$4.23	$0.00	$4.23
2018	0.11	0.00	0.11	$2.67	$0.00	$2.67
2019	0.14	0.00	0.14	$3.39	$0.00	$3.39

Table 222. FMVSS No. 214: Average weights and consumer costs of window curtains in passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00
1998	0.05	0.00	0.05	$1.92	$0.00	$1.92
1999	0.13	0.00	0.13	$3.99	$0.00	$3.99
2000	0.21	0.00	0.21	$5.99	$0.00	$5.99
2001	0.69	0.00	0.69	$17.69	$0.00	$17.69
2002	0.88	0.00	0.88	$21.28	$0.00	$21.28
2003	1.04	0.00	1.04	$23.82	$0.00	$23.82
2004	1.30	0.00	1.30	$28.31	$0.00	$28.31
2005	1.30	0.26	1.56	$27.11	$5.37	$32.47
2006	1.30	1.30	2.60	$26.03	$25.90	$51.93
2007	1.31	2.84	4.15	$25.35	$55.19	$80.54
2008	1.31	4.02	5.33	$24.49	$75.40	$99.89
2009	1.39	5.35	6.75	$24.70	$94.82	$119.53
2010	1.39	5.53	6.92	$23.98	$95.19	$119.17
2011	1.39	5.48	6.87	$23.03	$90.81	$113.84
2012	1.39	5.58	6.97	$22.49	$90.30	$112.78
2013	1.39	5.57	6.96	$22.08	$88.41	$110.49
2014	1.39	5.66	7.05	$21.74	$88.51	$110.25
2015	1.39	5.70	7.09	$21.41	$87.75	$109.16
2016	1.39	5.72	7.11	$21.16	$87.08	$108.25
2017	1.39	5.69	7.08	$20.94	$85.70	$106.64
2018	1.39	5.75	7.14	$20.75	$85.78	$106.53
2019	1.39	5.72	7.11	$20.57	$84.67	$105.24

Table 223. FMVSS No. 214: Average weights and consumer costs of front seat torso air bags in LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00
1998	0.20	0.00	0.20	$5.27	$0.00	$5.27
1999	0.27	0.00	0.27	$6.58	$0.00	$6.58
2000	0.48	0.00	0.48	$11.28	$0.00	$11.28
2001	0.64	0.00	0.64	$14.69	$0.00	$14.69
2002	1.17	0.00	1.17	$26.25	$0.00	$26.25
2003	0.94	0.00	0.94	$21.05	$0.00	$21.05
2004	1.29	0.00	1.29	$28.80	$0.00	$28.80
2005	1.25	0.00	1.25	$27.93	$0.00	$27.93
2006	1.30	0.41	1.70	$29.34	$9.19	$38.52
2007	1.30	0.80	2.11	$29.68	$18.29	$47.96
2008	1.31	1.67	2.98	$30.01	$38.20	$68.21
2009	1.41	2.88	4.29	$31.95	$65.02	$96.97
2010	1.42	4.12	5.54	$31.66	$92.27	$123.94
2011	1.42	4.65	6.06	$31.39	$103.04	$134.43
2012	1.42	4.95	6.37	$31.13	$108.81	$139.95
2013	1.42	5.13	6.55	$30.91	$111.87	$142.79
2014	1.42	5.25	6.67	$30.74	$113.74	$144.48
2015	1.42	5.38	6.80	$30.58	$115.99	$146.57
2016	1.42	5.48	6.90	$30.49	$117.61	$148.11
2017	1.42	5.75	7.18	$30.35	$122.90	$153.25
2018	1.42	5.76	7.18	$30.22	$122.40	$152.62
2019	1.42	5.76	7.18	$30.06	$121.73	$151.79

Table 224. FMVSS No. 214: Average weights and consumer costs of combination air bags in LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1998	0.00	0.00	0.00	$0.00	$0.00	$0.00
1999	0.02	0.00	0.02	$0.56	$0.00	$0.56
2000	0.07	0.00	0.07	$1.71	$0.00	$1.71
2001	0.24	0.00	0.24	$5.52	$0.00	$5.52
2002	0.21	0.00	0.21	$4.62	$0.00	$4.62
2003	0.27	0.00	0.27	$6.01	$0.00	$6.01
2004	0.23	0.00	0.23	$5.06	$0.00	$5.06
2005	0.20	0.00	0.20	$4.28	$0.00	$4.28
2006	0.14	0.00	0.14	$3.07	$0.00	$3.07
2007	0.08	0.00	0.08	$1.82	$0.00	$1.82
2008	0.11	0.00	0.11	$2.53	$0.00	$2.53
2009	0.05	0.00	0.05	$1.12	$0.00	$1.12
2010	0.14	0.00	0.14	$3.55	$0.00	$3.55
2011	0.14	0.00	0.14	$3.55	$0.00	$3.55
2012	0.12	0.00	0.12	$2.99	$0.00	$2.99
2013	0.06	0.00	0.06	$1.44	$0.00	$1.44
2014	0.14	0.00	0.14	$3.44	$0.00	$3.44
2015	0.00	0.00	0.00	$0.00	$0.00	$0.00
2016	0.00	0.00	0.00	$0.00	$0.00	$0.00
2017	0.00	0.00	0.00	$0.01	$0.00	$0.01
2018	0.00	0.00	0.00	$0.04	$0.00	$0.04
2019	0.00	0.00	0.00	$0.02	$0.00	$0.02

Table 225. FMVSS No. 214: Average weights and consumer costs of window curtains in LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1999	0.00	0.00	0.00	$0.00	$0.00	$0.00
2000	0.01	0.00	0.01	$0.19	$0.00	$0.19
2001	0.05	0.00	0.05	$1.21	$0.00	$1.21
2002	0.07	0.00	0.07	$1.79	$0.00	$1.79
2003	0.31	0.00	0.31	$7.03	$0.00	$7.03
2004	0.90	0.00	0.90	$19.87	$0.00	$19.87
2005	0.90	0.27	1.18	$19.09	$5.74	$24.83
2006	0.90	0.99	1.89	$18.41	$20.07	$38.48
2007	0.91	2.34	3.25	$18.82	$48.26	$67.09
2008	0.91	3.49	4.40	$18.56	$70.75	$89.31
2009	0.98	4.83	5.81	$18.86	$93.33	$112.19
2010	0.97	5.68	6.65	$17.85	$104.26	$122.11
2011	0.97	5.74	6.70	$16.77	$99.36	$116.13
2012	0.97	6.08	7.05	$16.60	$104.22	$120.82
2013	0.97	6.25	7.22	$16.16	$104.39	$120.55
2014	0.97	6.16	7.12	$15.46	$98.65	$114.11
2015	0.97	6.30	7.27	$15.47	$100.82	$116.29
2016	0.97	6.30	7.26	$15.14	$98.71	$113.85
2017	0.96	6.28	7.24	$14.51	$94.56	$109.06
2018	0.96	6.28	7.24	$14.37	$93.66	$108.03
2019	0.96	6.28	7.24	$14.25	$92.89	$107.15

Table 226. FMVSS No. 214: Percentages of fleet with side impact sensors for window curtains only

Model Year	Passenger Cars	LTVs
2001	0.0	0
2002	1.2	0.1
2003	1.0	1.6
2004	0.4	3.3
2005	0.1	3.4
2006	1.0	4.7
2007	4.8	16.2
2008	5.5	19.0
2009	4.9	19.0
2010	3.6	13.5
2011	0.6	7.3
2012	0.0	8.4
2013	0.0	7.0
2014	0.0	3.3
2015	0.0	5.1
2016	0.0	3.8
2017	0.0	0.0
2018	0.0	0.0
2019	0.0	0.0

Rear seat torso air bags are not required by FMVSS No. 214, yet have been voluntarily added to an increasing percentage of passenger cars starting in MY 2004 and a small percentage of LTVs starting in MY 2010 (see Tables 227 and 228 to see the percent installed). The percentage of passenger cars and LTVs with rear seat torso air bags was taken from the same Polk data and compliance data that was used for the front seat torso air bags. The weight and cost for rear seat torso air bags was taken from front seat torso air bag estimates, except that the sensor weights and costs are excluded. You can use the same sensors for front and rear seat torso air bags, so no weights and costs are included for sensors. The estimated weight and cost of two rear seat torso air bags are 6.1 lb and $84.58 (2019$) for both passenger cars and LTVs before learning. All rear seat torso air bags are considered voluntary. Table 227 for passenger cars and Table 228 for LTVs show the added weight and cost to the average vehicle for voluntarily installed rear seat torso air bags.

Rear seat window curtains have already been included in the weight and cost of window curtains. Since most window curtains cover the front and rear seats, there is no reason to consider them separately.

Table 227. FMVSS No. 214: Average weights and consumer costs of rear seat torso side air bags in passenger cars

Model Year	Percent Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2003	0.0	0	0	0	$0.00	$0.00	$0.00
2004	0.4	0.02	0	0.024	$0.31	$0.00	$0.31
2005	0.4	0.02	0	0.024	$0.30	$0.00	$0.30
2006	0.5	0.03	0	0.031	$0.37	$0.00	$0.37
2007	0.4	0.02	0	0.024	$0.29	$0.00	$0.29
2008	0.3	0.02	0	0.018	$0.21	$0.00	$0.21
2009	0.5	0.03	0	0.033	$0.38	$0.00	$0.38
2010	1.7	0.11	0	0.112	$1.28	$0.00	$1.28
2011	2.0	0.13	0	0.132	$1.48	$0.00	$1.48
2012	13.6	0.90	0	0.898	$9.87	$0.00	$9.87
2013	19.2	1.26	0	1.264	$13.67	$0.00	$13.67
2014	21.5	1.42	0	1.419	$15.11	$0.00	$15.11
2015	20.1	1.33	0	1.326	$13.93	$0.00	$13.93
2016	20.3	1.34	0	1.341	$13.93	$0.00	$13.93
2017	18.5	1.22	0	1.219	$12.54	$0.00	$12.54
2018	20.2	1.34	0	1.336	$13.62	$0.00	$13.62
2019	22.0	1.45	0	1.454	$14.71	$0.00	$14.71

Table 228. FMVSS No. 214: Average weights and consumer costs of rear seat torso side air bags in LTVS

Model Year	Percent Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2009	0.0	0.00	0	0.00	$0.00	$0.00	$0.00
2010	3.1	0.20	0	0.20	$2.33	$0.00	$2.33
2011	2.4	0.16	0	0.16	$1.77	$0.00	$1.77

Model Year	Percent Installed	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2012	3.4	0.22	0	0.22	$2.43	$0.00	$2.43
2013	2.7	0.17	0	0.17	$1.89	$0.00	$1.89
2014	5.6	0.37	0	0.37	$3.94	$0.00	$3.94
2015	3.8	0.25	0	0.25	$2.66	$0.00	$2.66
2016	3.4	0.23	0	0.23	$2.35	$0.00	$2.35
2017	3.5	0.23	0	0.23	$2.38	$0.00	$2.38
2018	4.4	0.29	0	0.29	$2.98	$0.00	$2.98
2019	5.7	0.38	0	0.38	$3.82	$0.00	$3.82

Summary Tables for FMVSS No. 214

Tables 229 and 230 summarize the total weights and costs of the side impact protection systems installed in passenger cars and LTVs for MYs 1968 to 2019. That includes side door beams, structure and padding used to meet the TTI(d) and dynamic testing requirements, and side air bags.

Table 229. Average weights and consumer costs of all FMVSS No. 214 countermeasures: side door beams, padding, structure, and side air bags in passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attributable	Total	Voluntary	Attributable	Total
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	6.70	0.00	6.70	$20.31	$0.00	$20.31
1970	6.64	6.98	13.62	$19.10	$20.06	$39.16
1971	6.63	9.93	16.56	$18.45	$27.61	$46.06
1972	6.67	11.99	18.67	$18.26	$32.81	$51.07
1973	6.65	25.38	32.03	$17.68	$67.54	$85.22
1974	6.22	29.06	35.29	$16.03	$74.85	$90.88
1975	5.95	27.77	33.72	$15.29	$71.40	$86.69
1976	5.64	26.31	31.94	$15.14	$70.70	$85.85
1977	5.32	24.83	30.15	$15.11	$70.56	$85.67
1978	4.99	23.30	28.29	$15.03	$70.19	$85.23
1979	4.67	21.82	26.49	$12.69	$59.25	$71.94
1980	4.66	21.75	26.41	$12.66	$59.09	$71.75

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attributable	Total	Voluntary	Attributable	Total
1981	4.60	21.47	26.06	$12.78	$59.69	$72.47
1982	4.57	21.33	25.90	$12.63	$58.95	$71.58
1983	4.53	21.17	25.70	$12.61	$58.90	$71.51
1984	4.54	21.18	25.72	$12.50	$58.34	$70.84
1985	4.52	21.08	25.60	$12.45	$58.11	$70.56
1986	5.88	21.04	26.92	$22.68	$57.74	$80.43
1987	7.31	20.96	28.26	$31.32	$57.57	$88.89
1988	8.60	21.05	29.65	$37.97	$56.94	$94.91
1989	8.59	22.41	31.00	$36.60	$64.59	$101.19
1990	8.64	23.93	32.58	$35.96	$74.12	$110.08
1991	8.66	25.44	34.09	$35.28	$81.94	$117.23
1992	8.70	27.17	35.87	$34.88	$91.17	$126.05
1993	8.69	28.68	37.37	$34.22	$97.77	$131.99
1994	8.69	33.97	42.66	$33.56	$123.09	$156.65
1995	8.71	38.63	47.35	$32.97	$143.87	$176.84
1996	8.80	43.76	52.57	$34.69	$165.66	$200.35
1997	9.00	53.19	62.19	$38.95	$205.47	$244.43
1998	9.52	53.38	62.91	$51.39	$202.48	$253.86
1999	9.92	53.37	63.29	$60.16	$199.16	$259.32
2000	10.58	53.43	64.01	$73.44	$196.60	$270.04
2001	11.48	53.47	64.95	$92.34	$194.43	$286.77
2002	11.70	53.57	65.26	$95.31	$192.80	$288.11
2003	11.67	53.74	65.41	$93.24	$191.73	$284.97
2004	12.16	53.61	65.77	$102.12	$189.71	$291.83
2005	12.19	54.36	66.55	$101.02	$199.37	$300.39
2006	12.08	56.11	68.19	$97.45	$235.21	$332.67
2007	11.90	58.93	70.84	$92.60	$289.46	$382.06
2008	12.07	61.19	73.26	$95.19	$332.06	$427.24
2009	12.26	63.81	76.07	$97.18	$376.97	$474.15

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attributable	Total	Voluntary	Attributable	Total
2010	12.31	64.37	76.69	$96.60	$382.77	$479.37
2011	12.41	64.77	77.17	$97.13	$382.45	$479.58
2012	13.06	64.88	77.94	$102.65	$384.00	$486.65
2013	13.43	64.68	78.11	$106.48	$380.77	$487.25
2014	13.51	65.07	78.59	$105.45	$383.42	$488.86
2015	13.38	65.00	78.38	$103.10	$381.04	$484.14
2016	13.41	65.52	78.93	$102.77	$384.64	$487.41
2017	13.33	65.53	78.87	$101.67	$381.41	$483.07
2018	13.39	65.71	79.10	$100.73	$381.72	$482.45
2019	13.53	65.57	79.10	$102.01	$378.48	$480.49

Table 230. Average weights and consumer costs of all FMVSS No. 214 countermeasures: side door beams and side air bags in LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attributable	Total	Voluntary	Attributable	Total
1990	0.00	0.00	0.00	$0.00	$0.00	$0.00
1991	0.00	2.35	2.35	$0.00	$3.24	$3.24
1992	0.00	2.65	2.65	$0.00	$3.65	$3.65
1993	0.00	4.07	4.07	$0.00	$5.57	$5.57
1994	0.00	21.60	21.60	$0.00	$29.35	$29.35
1995	0.00	22.25	22.25	$0.00	$30.00	$30.00
1996	0.00	23.94	23.94	$0.00	$32.03	$32.03
1997	0.00	23.93	23.93	$0.00	$31.80	$31.80
1998	0.20	24.69	24.89	$5.27	$32.57	$37.84
1999	0.29	25.55	25.84	$7.14	$33.47	$40.60
2000	0.56	25.80	26.36	$13.18	$33.55	$46.73
2001	0.94	26.56	27.50	$21.43	$34.32	$55.74
2002	1.45	27.27	28.72	$32.67	$35.00	$67.68
2003	1.52	27.26	28.78	$34.09	$34.79	$68.88
2004	2.42	27.91	30.33	$53.73	$35.41	$89.14

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attributable	Total	Voluntary	Attributable	Total
2005	2.35	28.18	30.53	$51.30	$40.95	$92.24
2006	2.34	29.25	31.59	$50.81	$64.22	$115.03
2007	2.30	31.31	33.60	$50.32	$101.72	$152.04
2008	2.33	32.99	35.32	$51.10	$143.55	$194.65
2009	2.44	35.73	38.16	$51.93	$193.08	$245.02
2010	2.74	37.97	40.71	$55.39	$231.34	$286.73
2011	2.69	38.47	41.16	$53.48	$236.98	$290.46
2012	2.73	40.23	42.95	$53.15	$248.83	$301.98
2013	2.62	40.64	43.26	$50.40	$251.99	$302.39
2014	2.89	40.70	43.59	$53.57	$248.00	$301.57
2015	2.64	40.91	43.54	$48.71	$252.18	$300.89
2016	2.61	41.07	43.69	$47.99	$251.65	$299.64
2017	2.62	41.35	43.97	$47.24	$252.68	$299.92
2018	2.68	41.44	44.12	$47.61	$251.25	$298.86
2019	2.76	41.48	44.25	$48.16	$249.74	$297.90

FMVSS No. 215 – [Does not currently exist]

FMVSS No. 216, Roof crush resistance

Initial Standard

FMVSS No. 216 went into effect on September 1, 1973, (passenger cars) and September 1, 1993, (MPVs, trucks, and buses) and established strength requirements for the passenger compartment roof. The purpose of this standard is to reduce deaths and injuries due to the crushing of the roof into the occupant compartment in rollover crashes. The original standard applied to passenger cars, MPVs, trucks, and buses with a GVWR of 6,000 lb or less. It did not apply to school buses or to vehicles that conform to the rollover test requirements of FMVSS No. 208 by means that require no action by vehicle occupants, and convertibles (except for optional compliance with the standard as an alternative to the rollover test requirements of FMVSS No. 208). FMVSS No. 216 is a performance standard limiting the amount of crush allowed when a load is gradually applied to the roof of a vehicle.

In October 1967 almost six years before the eventual effective date of FMVSS No. 216, NHTSA issued an ANPRM broaching possible limits on the intrusion of a vehicle's roof, front, side, and rear structures into the passenger compartment during crashes. The roof intrusion portion of the ANPRM was a starting point for FMVSS No. 216. The industry developed a procedure for measuring static roof crush resistance, SAE Recommended Practice J374, dated December 1968, without defining specific pass-fail levels. Soon after, the new generation of hardtops with more vulnerable roof structures spurred NHTSA to issue FMVSS No. 216, with an NPRM in January 1971, a final rule on December 8, 1971, (36 FR 23299), and an effective date of September 1, 1973, establishing FMVSS No. 216 for passenger cars. The NPRM was published in the Federal Register on January 6, 1971, (36 FR 166) making the baseline date for passenger cars September 1, 1970, or MY 1971. The FMVSS largely incorporates the J374 procedure and sets a 5-inch limit on crush given a load of 1 1/2 times the unloaded vehicle weight, but no more than 5,000 lb if the vehicle is a passenger car, applied to one of the sides of the roof, at the forward edge (Kahane, 1989, pp. 4–8; 32 F.R., 1971; SAE, 1973;).

A rather simple quasi-static test (where the load is gradually applied) was preferred to a staged rollover crash because there was no repeatable, standardized rollover test that would have worked for all make-models. A vehicle is required to support 1 1/2 times its weight, rather than just its own weight, because rollovers involve an additional dynamic load when the vehicle flips onto its roof. However, passenger cars weighing over 3,333 lb need only support a 5,000-pound load, less than 1 1/2 times their weight and are essentially held to a less strict FMVSS No. 216 requirement, since they are generally less rollover-prone than LTVs and lighter passenger cars.

NHTSA tested 14 used passenger cars of MYs 1964 to 1972, and all 14 passenger cars complied with FMVSS No. 216 (Kahane, 1989, pp. 39–51). While NHTSA did not test any LTVs from this period, it is believed that all LTVs would also have passed in MY 1965. Thus, we have decided to claim that all passenger cars and LTVs could have met an FMVSS No. 216 test in MY 1965 and this baseline is considered Safety1965. Only incremental costs are included in this report over the safety equipment that was standard equipment on every MY 1965 passenger car and LTV, defined as Safety1965.

While all pre-standard vehicles complied with FMVSS No. 216 initial standard, the standard may have resulted in two changes. While full-sized hardtops did pass FMVSS No. 216, the full-sized hardtops of the late 1960s and early 1970s typically had borderline performance in the test. This body style was phased out (redesigned as a pillared hardtop or sedan) a few years before or after FMVSS No. 216 took effect. Although some true hardtops were built after 1973 and did meet FMVSS No. 216, they were pretty much gone by the late 1970s. These changes did not have any direct cost because it was cheaper to build a sedan than a hardtop. However, there is an indirect cost of lost sales. Hardtops were attractive for sales, which meant higher prices. Unfortunately, these intangible costs cannot be determined by cost teardown analysis.

While all passenger cars could meet the standard in MY 1965, it appears that manufacturers decided to improve the performance of some of their passenger cars by the effective date and that pillars or roof structure were strengthened, without major redesign of the vehicles. This could occur for one of two reasons. There were make/models introduced after MY 1965 that didn’t do as well on the test or manufacturers decided that the passing margin of some make/models was not great enough to certify compliance, given test variability, and decided to increase the strength of pillars to assure compliance. A study was conducted in 1982 to determine the implementation consumer cost and weight variance of FMVSS No. 216 in 1974 MY vehicles compared to the 1973 MY vehicles (Gladstone et al., 1982d, pp. 8-1–8-22). Twenty-four passenger cars from 1974, along with comparable 1973 make-models, were reviewed. The changes were analyzed upward from the belt line and included a review of the A-, B-, and C-pillars and the roof structure. From this study, we discovered that 21 of the 24 make-models (87.5%) did not receive any overall vehicle redesign in 1974. For the 3 make-models with changes, we assume that changes in the pillars and roof design from 1973 to 1974 are specifically due to FMVSS No. 216 and are attributable to the standard since it was after the baseline on MY 1971. Table 231 shows the estimated average increase in weight and consumer cost of roof crush attributable to FMVSS No. 216 in passenger cars before considering the learning curve.[53]

Table 231. FMVSS No. 216: Average weight and consumer cost of roof crush initial standard for passenger cars

Model Year	Weight (lb)	Consumer Cost (2019$)
1974	2.93	$4.98

Table 232 shows the incremental weights and costs for the initial roof crush standard for the average passenger car.

Table 232. FMVSS No. 216: Average weight and consumer cost of roof crush resistance initial standard – passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1973	0.00	0.00	0.00	$0.00	$0.00	$0.00
1974	0.00	2.93	2.93	$0.00	$4.98	$4.98
1975	0.00	2.93	2.93	$0.00	$4.89	$4.89
1976	0.00	2.93	2.93	$0.00	$4.82	$4.82
1977	0.00	2.93	2.93	$0.00	$4.77	$4.77
1978	0.00	2.93	2.93	$0.00	$4.74	$4.74
1979	0.00	2.93	2.93	$0.00	$4.71	$4.71
1980	0.00	2.93	2.93	$0.00	$4.69	$4.69
1981	0.00	2.93	2.93	$0.00	$4.68	$4.68
1982	0.00	2.93	2.93	$0.00	$4.66	$4.66
1983	0.00	2.93	2.93	$0.00	$4.65	$4.65
1984	0.00	2.93	2.93	$0.00	$4.64	$4.64
1985	0.00	2.93	2.93	$0.00	$4.62	$4.62
1986	0.00	2.93	2.93	$0.00	$4.61	$4.61
1987	0.00	2.93	2.93	$0.00	$4.60	$4.60
1988	0.00	2.93	2.93	$0.00	$4.59	$4.59

[53] As discussed earlier in the report, a progress rate of 0.98 was assumed for FMVSS No. 216 learning.

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1989	0.00	2.93	2.93	$0.00	$4.58	$4.58
1990	0.00	2.93	2.93	$0.00	$4.57	$4.57
1991	0.00	2.93	2.93	$0.00	$4.57	$4.57
1992	0.00	2.93	2.93	$0.00	$4.56	$4.56
1993	0.00	2.93	2.93	$0.00	$4.56	$4.56
1994	0.00	2.93	2.93	$0.00	$4.55	$4.55
1995	0.00	2.93	2.93	$0.00	$4.54	$4.54
1996	0.00	2.93	2.93	$0.00	$4.54	$4.54
1997	0.00	2.93	2.93	$0.00	$4.53	$4.53
1998	0.00	2.93	2.93	$0.00	$4.53	$4.53
1999	0.00	2.93	2.93	$0.00	$4.53	$4.53
2000	0.00	2.93	2.93	$0.00	$4.52	$4.52
2001	0.00	2.93	2.93	$0.00	$4.52	$4.52
2002	0.00	2.93	2.93	$0.00	$4.51	$4.51
2003	0.00	2.93	2.93	$0.00	$4.51	$4.51
2004	0.00	2.93	2.93	$0.00	$4.51	$4.51
2005	0.00	2.93	2.93	$0.00	$4.50	$4.50
2006	0.00	2.93	2.93	$0.00	$4.50	$4.50
2007	0.00	2.93	2.93	$0.00	$4.49	$4.49
2008	0.00	2.93	2.93	$0.00	$4.49	$4.49
2009	0.00	2.93	2.93	$0.00	$4.49	$4.49
2010	0.00	2.93	2.93	$0.00	$4.49	$4.49
2011	0.00	2.93	2.93	$0.00	$4.48	$4.48
2012	0.00	2.93	2.93	$0.00	$4.48	$4.48
2013	0.00	2.93	2.93	$0.00	$4.48	$4.48
2014	0.00	2.93	2.93	$0.00	$4.48	$4.48
2015	0.00	2.93	2.93	$0.00	$4.47	$4.47
2016	0.00	2.93	2.93	$0.00	$4.47	$4.47
2017	0.00	2.93	2.93	$0.00	$4.47	$4.47

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2018	0.00	2.93	2.93	$0.00	$4.47	$4.47
2019	0.00	2.93	2.93	$0.00	$4.46	$4.46

NHTSA believes that LTVs met the initial FMVSS No. 216 by MY 1965 well before the effective date of September 1, 1993. Thus, we have decided to claim that all passenger cars and LTVs could have met an FMVSS No. 216 test in MY 1965 and this baseline is considered Safety1965. The final rule extending FMVSS No. 216 to LTVs with GVWR of 6,000 lb or less was published in the Federal Register on April 17, 1991, (56 FR 15510). The NPRM was published on November 2, 1989, (54 FR 46275) making the baseline September 1, 1989, or MY 1990. NHTSA has no data on compliance levels by MY for LTVs during the baseline period or before. No cost studies of roof crush in LTVs have been performed, and none are planned by the agency. Consequently, it was assumed that there were no incremental weights and costs for the initial roof crush standard of FMVSS No. 216 for LTVs.

Upgraded Roof Crush Standard

On May 12, 2009, (74 FR 22347) NHTSA published in the Federal Register a final rule upgrading FMVSS No. 216, Roof crush resistance for passenger cars and LTVs of 10,000 lb GVWR or less. The NPRM was issued on August 25, 2005, (70 FR 49223) making the baseline date September 1, 2004, or MY 2005. NHTSA upgraded FMVSS No. 216 in several ways; the upgraded standard is called FMVSS No. 216a. First, before the upgrade, the standard applied only to vehicles up to 6,000 lb GVWR and the test involved loading the roof with 1 1/2 times the vehicle's unloaded vehicle weight (and no more than 5,000 lb if the vehicle is a passenger car). The upgrade extends the standard to vehicles up to 10,000 lb GVWR; test weight is 3 times the unloaded vehicle weight for vehicles under 6,000 lb GVWR; it is 1 1/2 times the unloaded vehicle weight for vehicles from 6,000 to 10,000 lb GVWR. Convertibles are exempt from the standard. Second, vehicles must meet the force requirement in a two-sided test. The same vehicle must meet the force requirements when tested on one-side of the vehicle and then on the other side of the vehicle. Third, the rule establishes a new requirement for maintenance of headroom, i.e., survival space, during testing in addition to the existing limit on roof crush (5 inches) during the test.

Compliance with the upgraded standard for the first part of the rule affecting those under 6,000 lb GVWR was phased in as follows.

- 20 percent of vehicles manufactured on or after September 1, 2012, and before September 1, 2013, must comply.
- 50 percent of vehicles manufactured on or after September 1, 2013, and before September 1, 2014, must comply.
- 75 percent of vehicles manufactured on or after September 1, 2014, and before September 1, 2015, must comply.
- 100 percent of vehicles manufactured on or after September 1, 2015, must comply.

The second part of the rule, which applies to vehicles with a GVWR of 6,000 to 10,000 lb, had an effective date of September 1, 2016 (MY 2017). For vehicles that are 6,000 to 10,000 lb GVWR and are manufactured in more than one stage or altered, the effective date is September 1, 2017.

Early compliance rates were determined based on data collected for the Final Regulatory Impact Analysis that accompanied the final rule (NHTSA, 2009b). The compliance rate with the final rule strength to weight ratio of 3.0 was 17.96 percent for passenger cars starting in MY 2004. This is a voluntary rate, since it is based on MY 2004 to 2008 vehicles, and assumed to apply to MY 2004, and the baseline year is MY 2005. An examination of the MY 2004 to 2008 testing shows no obvious difference between passenger cars and LTVs in the strength to weight ratio, for those vehicles under 6,000 lb GVWR. The compliance rate for those LTVs under 6,000 lb GVWR with the final rule strength to weight ratio of 3.0 was also 17.96 percent starting in MY 2004. The MY 2004 compliance rate of 28.9 percent for all LTVs (up to 10,000 lb GVWR) was determined by weighting those under 6,000 lb GVWR (17.96% compliance by 74% of sales) with those LTVs of 6,000 to 10,000 lb GVWR (60% compliance by 26% of sales). These compliance rates of 17.96 percent for passenger cars and 28.9 percent for LTVs are assumed to apply from MY 2004 to 2011 and are considered voluntary.

The agency has compliance data provided by the manufacturers for MY 2011 to 2016. All passenger cars and LTVs had to comply by MY 2017, unless they were convertibles, and compliance data was not requested by NHTSA for MY 2017, 2018, and 2019. The percent of the MY 2017, 2018, and 2019 fleet that were convertibles and assumed not to be in compliance is available in the *Ward's Automotive Yearbooks* (Binder, 2002-2017; Norris, 2018-2020).[54]

In the case of MY 2011 and 2012, manufacturer's certification of compliance is supplied voluntarily since the upgraded standard did not apply yet to these MY. However, because the manufacturer's compliance data is supplied voluntarily, it may not be as complete as if compliance data reporting were required. For example, one manufacturer only certified compliance with two make-models for MY 2011 and four make-models for MY 2012 (yet NHTSA tested five MY 2004 to 2008 make-models that passed). This could mean that the manufacturer had not yet tested these vehicles to the upgraded FMVSS No. 216a test and was not willing to use the NHTSA test results from older make-models to certify compliance. Thus, we suspect that the certified compliance rates will be low compared to true voluntary compliance. The certified compliance rates for MY 2011 were 9.8 percent for passenger cars and 13.0 percent for LTVs under 6,000 lb GVWR. Both rates were below the voluntary compliance rate we found from MY 2004 to 2008 testing of 17.96 percent for both. For MY 2012 the certified compliance rates supplied by the manufacturers were 25.47 percent for passenger cars and 11.5 percent for LTVs under 6,000 lb GVWR. Since the certified compliance for passenger cars is greater for MY 2012 than the MY 2004 to 2008 test results, we will use the 25.47-percent compliance rate for passenger cars with 17.96 percent considered voluntary and the difference (or 7.51 percent) as attributable to meeting the upgraded standard for passenger cars for MY 2012. Since the certified compliance rate for LTVs under 6,000 lb went down from MY 2011 to

[54] The Ward's Yearbooks do not include body styles for import LTVs. Data for convertibles is available in the Ward's Yearbooks in the body style pages for domestic passenger cars, import passenger cars, and domestic LTVs. The sales of a few convertible LTVs were included from the manufacturer's compliance data.

2012, we will assume the same 28.9 percent voluntary compliance found in MY 2004 for LTVs in MY 2012.

The certified compliance rates for MYs 2013 to 2016 were taken from compliance data. For passenger cars sales weighted compliance with FMVSS No. 216a was 72.14 percent for MY 2013, 89.21 percent for MY 2014, 95.82 percent for MY 2015, and 98.56 percent for MY 2016. Compliance did not reach 100 percent because convertibles are exempt. For MY 2017, 2018, and 2019 passenger cars compliance is 100 percent minus the percent of the fleet that are convertibles.

The sales weighted compliance rates for all LTVs (up to 10,000 lb GVWR) were 37.10 percent in MY 2013, 49.05 percent in MY 2014, 64.47 percent in MY 2015, and 76.66 percent in MY 2016. Compliance data was not collected for MY 2017. Not all LTVs were required to meet FMVSS No. 216a by MY 2017, as both incomplete vehicles and convertibles were exempt for MY 2017. A study was conducted on the vehicles that are used as incomplete vehicles that were under 10,000 lb GVWR (Ram pickup, Ram Promaster Van, Sprinter, Ford Super Duty Pickup, Silverado, Chevrolet Express Van, Sienna, and GMC Savanna). These vehicles were not certified as complying in MY 2016, so for our purposes we assumed they would not comply in MY 2017. We assumed incomplete vehicles would comply in MY 2018 and 2019 as required. Data was taken from 2013 to 2019 FARS as a percentage of all vehicles in FARS that were incomplete vehicles on a make/model basis. We used FARS because incomplete vehicles are coded in FARS. We assumed that the average percentage of incomplete vehicles on a make/model basis over this 2013 to 2019 period would be applicable to MY 2017 and then applied those percentages to sales data from Wards for MY 2017. For MY 2017 compliance is 100 percent minus the percent of the fleet that are incomplete vehicles minus the percent of the fleet that are convertibles. For MY 2018 and 2019 compliance is 100 percent minus the percent of the fleet that are convertibles. Table 216-3 shows the estimated compliance rates for FMVSS No. 216a. No compliance data were available prior to MY 2004, and we have assumed no compliance prior to that date.

Table 233. FMVSS No. 216a: Estimated percent compliance rate with FMVSS No. 216 upgrade

Model Year	Passenger Cars	LTVs
2003	0.0	0.0
2004	18.0	28.9
2005	18.0	28.9
2006	18.0	28.9
2007	18.0	28.9
2008	18.0	28.9
2009	18.0	28.9
2010	18.0	28.9
2011	18.0	28.9

Model Year	Passenger Cars	LTVs
2012	25.5	28.9
2013	72.1	37.1
2014	89.2	49.1
2015	95.8	64.5
2016	98.6	76.7
2017	97.9	98.4
2018	97.9	98.8
2019	97.9	98.8

The difference between these compliance rates and the voluntary compliance rate (17.96 percent for passenger cars and 28.9 percent for LTVs) will be attributable to FMVSS No. 216a.

Weight and cost estimates were taken from a contractor's cost teardown study (Ricardo, 2018). There is no single countermeasure (like an air bag) that all manufacturers use to meet the standard. Based on this cost teardown report, the manufacturers met the upgraded FMVSS No. 216 by a variety of methods which included adding reinforcements to roof pillars; strengthening existing pillars or reinforcements in roof pillars, by increasing the steel gauge, by using higher-strength steel or by using hot-stamped boron steel; increasing the thickness of the roof bow, roof rail, rear header, and windshield header, etc. Ford introduced the use of tubular, high-strength hydroformed A-pillar/roof rail members to strengthen the roof structure. The approaches varied significantly between manufacturers, as evidenced by the number of changes between the pre- and post-standard vehicles – between 13 and 38 individual parts were changed or added to the seven different vehicles examined.

Table 234 shows the pre-upgrade and post-upgrade strength to weight ratios (SWR) for the 7 vehicles in the cost teardown study. These vehicles were chosen based on the availability of SWR test results, the difference in the SWR being at least 1.0 or a change from a non-complying SWR of less than 3.0 for passenger cars to a complying SWR of more than 3.0 (e.g., the Chevy Impala).

The first three vehicles on Table 234 all met FMVSS No. 216a in the pre-upgrade test. The Dodge Ram 1500 extended cab has a GVWR of greater than 6,000 lb and the SWR standard is 1.50. It is likely that this vehicle was upgraded even though it met FMVSS No. 216a because it might have difficulty passing with the Dodge Ram 2500 model. The Ford Edge and Honda Accord both complied with FMVSS No. 216a by having scores above 3.0 in the pre-upgrade test. There were no obvious differences, besides the Dodge Ram 1500 extended cab being over 6,000 lb GVWR and meeting a separate standard, between passenger cars and LTVs in the pre- and post-upgrade SWR scores or in the difference in SWR achieved.

Table 234. FMVSS No. 216a: Strength to weight ratio for cost teardown vehicles

Vehicle	Pre MY	Pre SWR	Post MY	Post SWR	Difference SWR
Dodge Ram 1500 Extended Cab – LTV	2007	1.70	2010	2.97	1.27
Ford Edge – LTV	2009	3.50	2016	5.11	1.61
Honda Accord – PC	2010	3.87	2014	4.92	1.05
Ford Mustang – PC	2006	2.70	2016	4.43	1.73
Grand Cherokee – LTV	2008	2.20	2011	4.63	2.43
Buick LaCrosse – PC	2005	2.60	2010	4.90	2.30
Chevy Impala – PC	2003	2.90	2011	3.45	0.55

Table 235 shows the estimated incremental weight and consumer cost for passenger cars and LTVs in the cost teardown study. There appears to be no obvious difference in the increase in weight or costs between passenger cars and LTVs. This suggests that the expected increase in weight and cost are determined by at least two factors: the baseline pre-upgrade vehicle and the target SWR and the final weight or cost increase that the designer is attempting to achieve. There are different solutions that increase both weight and costs, that increase cost but limit the weight increase, that increase weight but limit the cost increase. Without significantly more cost teardown studies, NHTSA can't identify how manufacturers decided to meet FMVSS No. 216a for different groups of vehicles (like LTVs less than 6,000 lb GVWR versus LTVs of 6,000 lb or greater) but can only use an average weight and cost increase based on what was found in the cost teardown study. That is an average increase in weight of 36.2 lb and an average increase in cost of $108.42 in 2019$. This will be applied to both passenger cars and all LTVs.

Table 235. FMVSS 216a: Estimated increase in weight and consumer cost for cost teardown vehicles

Vehicle	Pre Wt. lb	Pre 2019$	Post Wt. lb	Post 2019$	Difference Wt. lb	Difference 2019$
Dodge Ram – LTV	201.6	$473.29	265.4	$593.14	63.8	$119.84
Ford Edge – LTV	304.5	$804.09	363.6	$917.09	59.2	$113.00
Honda Accord – PC	187.2	$442.71	206.5	$551.54	19.3	$108.83
Ford Mustang – PC	160.0	$373.34	173.1	$463.16	13.1	$89.82
Grand Cherokee – LTV	247.9	$517.47	255.8	$650.34	7.9	$132.87

Vehicle	Pre Wt. lb	Pre 2019$	Post Wt. lb	Post 2019$	Difference Wt. lb	Difference 2019$
Buick LaCrosse – PC	196.9	$572.73	255.7	$672.00	58.8	$99.27
Chevy Impala – PC	173.9	$535.26	205.0	$630.58	31.2	$95.32
Average	210.3	$531.27	246.5	$639.69	36.2	$108.42

Table 236 for passenger cars shows the combined estimated weight and consumer cost impacts for the upgraded FMVSS No. 216a standard. Table 237 shows the combined estimated weight and consumer cost impacts for the upgraded FMVSS No. 216a standard for LTVs.

Table 236. FMVSS No. 216a: Average weight and consumer cost for passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2003	0.00	0.00	0.00	$0.00	$0.00	$0.00
2004	6.50	0.00	6.50	$20.85	$0.00	$20.85
2005	6.50	0.00	6.50	$20.43	$0.00	$20.43
2006	6.50	0.00	6.50	$20.19	$0.00	$20.19
2007	6.50	0.00	6.50	$20.03	$0.00	$20.03
2008	6.50	0.00	6.50	$19.90	$0.00	$19.90
2009	6.50	0.00	6.50	$19.84	$0.00	$19.84
2010	6.50	0.00	6.50	$19.77	$0.00	$19.77
2011	6.50	0.00	6.50	$19.69	$0.00	$19.69
2012	6.50	2.72	9.21	$19.61	$8.20	$27.82
2013	6.50	19.60	26.10	$19.47	$58.74	$78.22
2014	6.50	25.77	32.27	$19.33	$76.69	$96.03
2015	6.50	28.17	34.66	$19.19	$83.21	$102.40
2016	6.50	29.16	35.65	$19.09	$85.66	$104.75
2017	6.50	28.91	35.40	$18.98	$84.47	$103.45
2018	6.50	28.93	35.43	$18.90	$84.17	$103.06
2019	6.50	28.91	35.40	$18.83	$83.78	$102.61

Table 237. FMVSS No. 216a: Average weight and consumer cost for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2003	0.00	0.00	0.00	$0.00	$0.00	$0.00
2004	10.45	0.00	10.45	$33.54	$0.00	$33.54
2005	10.45	0.00	10.45	$32.86	$0.00	$32.86
2006	10.45	0.00	10.45	$32.48	$0.00	$32.48
2007	10.45	0.00	10.45	$32.21	$0.00	$32.21
2008	10.45	0.00	10.45	$32.01	$0.00	$32.01
2009	10.45	0.00	10.45	$31.91	$0.00	$31.91
2010	10.45	0.00	10.45	$31.80	$0.00	$31.80
2011	10.45	0.00	10.45	$31.68	$0.00	$31.68
2012	10.45	0.00	10.45	$31.55	$0.00	$31.55
2013	10.45	2.97	13.42	$31.32	$8.90	$40.22
2014	10.45	7.29	17.74	$31.10	$21.70	$52.80
2015	10.45	12.87	23.32	$30.87	$38.02	$68.90
2016	10.45	17.28	27.73	$30.70	$50.77	$81.47
2017	10.45	24.90	35.35	$30.54	$72.76	$103.30
2018	10.45	25.30	35.75	$30.40	$73.61	$104.01
2019	10.45	25.30	35.75	$30.29	$73.34	$103.62

FMVSS No. 217, Bus emergency exits and window retention and release

FMVSS No. 217 became effective on September 1, 1973, and establishes minimum requirements for bus window retention and release to reduce the likelihood of passenger ejection in crashes and for emergency exits to facilitate passenger exit in emergencies. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies of this standard have been done.

FMVSS No. 218, Motorcycle helmets

FMVSS No. 218 became effective on March 1, 1974, and establishes minimum performance requirements for helmets designed for use by motorcyclists and other motor vehicle users to reduce deaths and injuries resulting from head impacts. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. Some cost estimates have been made regarding motorcycle helmets (NHTSA, 2011, App. B).

FMVSS No. 219, Windshield zone intrusion

FMVSS No. 219 became effective on September 1, 1976, (passenger cars) and September 1, 1977, (MPVs, trucks, and buses) and specifies limits for the displacement into the windshield area of motor vehicle components during a crash. The purpose of this standard is to reduce crash injuries and fatalities that result from occupants contacting vehicle components displaced near or through the windshield. This standard applies to passenger cars and to MPVs, trucks, and buses with a GVWR of 10,000 lb or less. However, it does not apply to forward control vehicles, walk-in van-type vehicles or to body-type vehicles with fold-down or removable windshields. The final rule was published in the Federal Register on June 16, 1975, (40 FR 25462) for passenger cars and LTVs. Two NPRMs were published in the Federal Register on FMVSS No. 219 on August 31, 1972, (37 FR 17763) and May 20, 1974, (39 FR 17768) making the baseline date September 1, 1971, or MY 1972.

McVetty et al. (1982) conducted a study on twelve make-model pre-standard (1976) passenger cars, and their corresponding implementation (1977) and post-standard (1978) systems. From that study, we singled out 10 make-models that did not receive an overall vehicle redesign in 1977. Those ten make-models had no changes in weight and cost from 1976 to 1978. Because our teardowns did not show any added weight or cost in the standards implementation year, we will not attribute any weight or cost to FMVSS No. 219. However, it is conceivable that a more thorough teardown study including vehicles from the baseline year of MY 1972 could have revealed costs of changes made in anticipation of FMVSS No. 219, if there were any.

The agency has no data indicating that the hood crumple features related to FMVSS No. 219 (for example, a pre-crimp in the hood sheet metal or hinge changes to keep the hood from intruding into the windshield) resulted in direct variable cost and weight additions to the vehicles. There were certainly some sort of research and development (R&D) and tooling costs associated with this change at some point after Safety1965. However, the agency has no estimate of the R&D and tooling costs, and based on the methodology used in this analysis, R&D and tooling costs that do not lead to direct variable costs are not included in this analysis. NHTSA’s method of estimating indirect costs is linked to the absolute value of direct variable cost changes. If we don’t have a direct variable cost estimate for the change, we don’t have a basis for estimating indirect costs. The agency has no plans to do further analysis into FMVSS No. 219.

FMVSS No. 220, School bus rollover protection

FMVSS No. 220 became effective on April 1, 1977, and establishes performance requirements for school bus rollover protection to reduce the number of deaths and the severity of injuries that result from failure of the school bus body structure to withstand forces encountered in rollover crashes. A cost study was completed in 1979 (Harvey et al., 1979c). Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

FMVSS No. 221, School bus body joint strength

FMVSS No. 221 became effective on April 1, 1977, and establishes requirements for the strength of the body panel joints in school bus bodies to reduce deaths and injuries resulting from the structural collapse of school bus bodies during crashes. A cost study was completed in 1979 (Harvey et al., 1979c, pp. 13–19). Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

FMVSS No. 222, School bus passenger seating and crash protection

FMVSS No. 222 became effective on April 1, 1977, and establishes occupant protection requirements for school bus passenger seating and restraining barriers to reduce the number of deaths and the severity of injuries that result from the impact of school bus occupants against structures within the vehicle during crashes and sudden driving maneuvers. A cost study was completed in 1979 (Harvey et al., 1979c, pp. 19–23). Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

FMVSS No. 223, Rear impact guards

FMVSS No. 223 became effective on January 26, 1998, and specifies requirements for rear impact guards for trailers and semi-trailers to reduce the number of deaths and serious injuries that occur when light duty vehicles collide with the rear end of trailers and semi-trailers. A cost study was completed in 2013 (Waltonen Engineering, 2013). Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

FMVSS No. 224, Rear impact protection

FMVSS No. 224 became effective on January 26, 1998, and establishes requirements for the installation of rear impact guards on trailers and semi-trailers with a GVWR of 10,000 lb or more to reduce the number of deaths and serious injuries occurring when light duty vehicles impact the rear of trailers and semi-trailers of 10,000 lb or more. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

FMVSS No. 225, Child restraint anchorage systems

FMVSS No. 225 establishes requirements for child restraint anchorage systems to ensure their proper location and strength for the effective securing of child restraints, to reduce the likelihood of the anchorage systems' failure, and to increase the likelihood that child restraints are properly secured and thus more fully achieve their potential effectiveness in motor vehicles. This standard applies to passenger cars; trucks and MPVs with a GVWR of 8,500 lb or less, except walk-in van-type vehicles and vehicles manufactured to be sold exclusively to the U.S. Postal Service; and buses (including school buses) with a GVWR of 10,000 lb or less, except shuttle buses. The LATCH system (lower anchorages and tethers for children) does not use the seat belts in the vehicle to secure child restraints, but uses horizontal bars (lower anchorages) that are secured in the vehicle seat bight (between the seat cushion and seat back) and tether anchorages (a tether strap that is connected to tether anchorage hardware that can be positioned in various places) for upper child restraint support of forward facing seats.

The final rule establishing FMVSS No. 225 for passenger cars and LTVs and amending FMVSS No. 213 to require upper and lower tethers on child safety seats was published in the Federal Register on March 5, 1999, (64 FR 10786). The NPRM was published in the Federal Register on February 20, 1997, (62 FR 7858) making the baseline date September 1, 1996, or MY 1997. There were no vehicles with LATCH by the baseline date of MY 1997, thus all weights and costs are attributable to the standard. There may have been some vehicles with upper tether anchorages available before MY 2000, but NHTSA has no data on what percentage were supplied by MY.

Percent of Fleet Required – On forward-facing child safety seats (with a few exceptions), testing with upper tethers with reduced excursion requirements became effective on September 1, 1999, and testing with an installation using lower attachments became effective on September 1, 2002. In passenger cars, an 80-percent phase-in, excluding convertibles, of upper tether anchorages extended from September 1, 1999, to September 1, 2000, and then 100 percent of passenger cars and LTVs of 8,500 GVWR or less were required to comply starting September 1, 2000. Lower anchorages were phased-in for 20 percent of passenger cars and LTVs of 8,500 GVWR or less from September 1, 2000, to September 1, 2001, 50-percent compliance from September 1, 2001, to September 1, 2002, and then 100-percent compliance starting September 1, 2002.

Data to determine what percent of the fleet was installed with upper tethers and lower anchors could not be found for the early MYs starting in MY 2000 but is available for MY 2010, 2011, 2016, and 2019. NHTSA's Office of Compliance did not ask manufacturers to supply certification data for MY 2000 to 2002 during the phase-in, but surely manufacturers met the required use of upper tethers and lower anchors during the phase-in period. For this analysis we are going to assume that manufacturers exactly met the requirements for the phase-in period, even though it is likely that they exceeded the percentage requirements during the phase-in period. Table 238 shows the percentage of the fleet required for passenger cars and LTVs by model year.

Table 238. Percentage of fleet required to meet FMVSS No. 225 – passenger cars and LTVs

Model Year	Passenger Cars		LTVs	
	Upper Tethers	Lower Anchors	Upper Tethers	Lower Anchors
1999	0	0	0	0
2000	80	0	0	0
2001	100	20	100	20
2002	100	50	100	50
2003-2019	100	100	100	100

Number of Seating Positions Covered – A vehicle with three or more designated forward-facing rear seating positions is required to have tether anchorages in at least three of those positions and lower anchorages in at least two of those positions. The parts of the system include a lower anchorage for both sides (inboard and outboard) of a designated seating position, a tether anchor, a cover for the tether anchor, and a button or some other marking for the lower anchors (four buttons or markings for two seating positions).

According to FMVSS No. 225, a vehicle with only two rear seating positions would have two sets of lower anchors and two tether anchors, and a vehicle with three or more seating rear seating positions must have two sets of lower anchors and three tether anchors. A vehicle with no rear seating positions must have lower anchors and a tether for the front right seat. Vehicles with two sets of rear seats (a second and third row of seats) might have anchors in both sets of rear seats, thus letting parents decide where they would rather seat their children. The lower anchors are located between the seat back and the seat bottom cushion (within the seat bight). Most passenger cars would have the top tether on the rear seat package shelf with a cover over the anchorage to hide it. However, the tether anchor can be in other places. For example, with minivans the tether anchor for the second row of seats is typically located on the back bottom of the seat, without any type of cover and the tether anchor could be located on the roof or any strong structure to the rear of the seating position.

To determine the percentage of the fleet that was supplied with LATCH equipment, data was taken from four sources. First, we studied a University of Michigan Transportation Research Institute study of 98 vehicles with LATCH; 88 were MY 2011 vehicles and 10 were MY 2010 vehicles (Klinich et al., 2012). The findings were that in the second row, only 7 of 98 vehicles provided 3 lower anchors and 3 tethers, while the other 91 vehicles provided the required 2 lower anchor positions and 3 tethers. Of the 21 SUVs or minivans that had a third row, 11 had no lower anchors, 2 had 2 lower anchor positions and 8 had 1 lower anchor position. For the third-row tether, 4 had no tethers and 15 had 1 tether position and 2 vehicles had 3 tethers.

A similar analysis to determine the percentage of the fleet supplied with LATCH equipment was undertaken using NHTSA (2010) data from *Buying a Safer Car for Child Passengers 2010: A Guide for Parents.* This study tells what seating positions have lower anchors by make-model. This data was weighted by Polk registration data (Polk & Co., n.d.) by make/model. We estimated the number of upper tether anchors per vehicle, based on the following rationale: 1 if no rear seat or no lower anchors; 2 if the rear seat had only 2 designated seating positions; 3 if the rear seats have 3 or more designated seating positions, but the vehicle has only 2 seating positions with lower anchors; 4 or more if there are 4 or more seats with lower anchors (and if the second and third row each have 3 seating positions and the 2 outboard seats in each row have lower anchors we assume all 6 positions have the upper anchors). After weighting these UMTRI and Buying a Safer Car data by the percentage of vehicles with no rear seat, these two data sets resulted in essentially the same data (see Table 239). The Buying a Safer Car for Child Passengers 2010: A Guide for Parents has not been updated since 2010.

The IIHS instituted a rating system for the ease of use of LATCH. We took data from their study on a make/model basis and meshed it with sales data to estimate the number of anchorages supplied by manufacturers for MY 2016 and 2019.[55] A summary of our analysis of the IIHS data is also shown in Table 239. The estimates by all sources are similar. In the MY 2019 IIHS analysis we noticed for the first time that some manufacturers are supplying one bar as a lower anchorage for the middle seating position, allowing a child restraint to be used in the middle position with the other bar being the outboard seat bar. We counted this one bar as half of the weight and cost of the typical lower anchor. Some other vehicles allow the middle seating position to be used by attaching to two outboard seat bars, one on each side.

[55] See IIHS.org/iihs/ratings. Enter the make and model of the vehicle, then select the vehicle from the drop-down list. To find the anchorages for specific vehicles, choose a vehicle and click on the LATCH ease of use rating. This will take you to a diagram of the seats in the vehicles and the anchorages installed.

Table 239. FMVSS No. 225: Estimated average number of lower anchors and upper tether anchors per vehicle

Model Year	Estimates Based On	Passenger Cars		LTVs	
		Lower Anchors	Upper Tether Anchors	Lower Anchors	Upper Tether Anchors
2010	Buying a Safer Car	2.12	2.91	2.04	2.79
2011	UMTRI Data	2.09	2.97	2.19	3.11
2016	IIHS Data	2.03	2.92	2.12	3.03
2019	IIHS Data	2.02	2.89	2.18	3.16

Weight and Cost Estimates – Using data from the Ricardo Inc. (2014) cost teardown study of this standard we found the average cost of lower anchors and upper tether anchors by averaging the results from 6 vehicles – a MY 2013 Ford Fusion, MY 2011 VW Passat, MY 2013 Hyundai Elantra, MY 2014 Honda Odyssey, MY 2012 Chevrolet Equinox, and MY 2012 Ford F-250 Supercab. Based on this data, there appears to be no difference in cost between passenger cars and LTVs, thus we will use the same cost estimates for both. Table 240 shows these results averaged over the 6 vehicles.

Table 240. FMVSS No. 225: Weight and consumer cost of lower anchors and upper tethers per seat position in passenger cars and LTVs

	Weight (lb)	Cost (2019$)
Lower anchor	0.51	$1.92
Upper tether	0.20	$0.75

Based on our analysis of the data from NHTSA, UMTRI, and IIHS and sales estimates of the percent of the fleet with various seating capacities, estimates were made of the percent of the fleet that had LATCH and the number of lower anchorages and upper tether anchorages provided by MY. Table 241 shows these estimates for passenger cars and Table 242 for LTVs after interpolating between years for which data are available. These estimates also consider the percentage of the fleet which are required to meet the standard during the phase-in period and the percentage of the fleet with no rear seats by types of vehicles (for example, the percent of pickups sold that were regular cabs with no rear seat versus pickups with rear seats).

Table 241. FMVSS No. 225: Average number of lower anchors and upper tethers per passenger car

Model Year	Percent of Passenger Cars With Rear Seat	Average Number of	
		Lower Anchors	Upper Tethers
2000	97.0	0.00	2.34
2001	97.0	0.41	2.93
2002	97.0	1.04	2.93
2003	96.0	2.06	2.91
2004	96.0	2.06	2.91
2005	96.0	2.06	2.91
2006	96.0	2.06	2.91
2007	96.0	2.06	2.91
2008	98.6	2.09	2.96
2009	98.6	2.09	2.96
2010	98.6	2.09	2.96
2011	98.6	2.09	2.96
2012	98.6	2.08	2.95
2013	97.3	2.05	2.92
2014	97.3	2.04	2.91
2015	97.3	2.03	2.90
2016	98.6	2.03	2.92
2017	98.8	2.03	2.91
2018	98.9	2.03	2.91
2019	98.7	2.02	2.89

Table 242. FMVSS No. 225: Average number of lower anchors and upper tethers per LTV

Model Year	Percent of LTVs with Rear Seat	Average Number of	
		Lower Anchors	Upper Tethers
2000	92.4	0	0
2001	92.4	0.439	3.111
2002	92.4	1.096	3.111
2003	92.4	2.193	3.111
2004	92.4	2.193	3.111
2005	92.4	2.193	3.111
2006	92.4	2.193	3.111
2007	92.4	2.193	3.111
2008	92.4	2.193	3.111
2009	92.4	2.193	3.111
2010	92.4	2.193	3.111
2011	92.4	2.193	3.111
2012	92.4	2.173	3.085
2013	92.4	2.154	3.060
2014	92.4	2.135	3.034
2015	92.4	2.116	3.009
2016	94.6	2.122	3.029
2017	95.3	2.144	3.076
2018	96.0	2.166	3.124
2019	96.0	2.179	3.156

Table 243 and Table 244 show the average weight and consumer cost for passenger cars and LTVs after applying the learning curve. They consider the costs per seating position and the estimated number of seating positions that had lower anchors and tether anchors.

Table 243. FMVSS No. 225: Average weights and consumer costs for lower anchors and tether anchors in passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1999	0.00	0.00	0.00	$0.00	$0.00	$0.00
2000	0.00	0.46	0.46	$0.00	$2.65	$2.65
2001	0.00	0.79	0.79	$0.00	$4.51	$4.51
2002	0.00	1.11	1.11	$0.00	$5.53	$5.53
2003	0.00	1.62	1.62	$0.00	$7.39	$7.39
2004	0.00	1.62	1.62	$0.00	$7.04	$7.04
2005	0.00	1.62	1.62	$0.00	$6.81	$6.81
2006	0.00	1.62	1.62	$0.00	$6.64	$6.64
2007	0.00	1.62	1.62	$0.00	$6.51	$6.51
2008	0.00	1.65	1.65	$0.00	$6.50	$6.50
2009	0.00	1.65	1.65	$0.00	$6.44	$6.44
2010	0.00	1.65	1.65	$0.00	$6.38	$6.38
2011	0.00	1.65	1.65	$0.00	$6.31	$6.31
2012	0.00	1.64	1.64	$0.00	$6.22	$6.22
2013	0.00	1.62	1.62	$0.00	$6.08	$6.08
2014	0.00	1.61	1.61	$0.00	$5.99	$5.99
2015	0.00	1.60	1.60	$0.00	$5.90	$5.90
2016	0.00	1.61	1.61	$0.00	$5.87	$5.87
2017	0.00	1.61	1.61	$0.00	$5.82	$5.82
2018	0.00	1.60	1.60	$0.00	$5.78	$5.78
2019	0.00	1.60	1.60	$0.00	$5.72	$5.72

Table 244. FMVSS No. 225: Average weights and consumer costs for lower anchors and tether anchors in LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2000	0.00	0.00	0.00	$0.00	$0.00	$0.00
2001	0.00	0.84	0.84	$0.00	$4.78	$4.78
2002	0.00	1.17	1.17	$0.00	$5.87	$5.87
2003	0.00	1.73	1.73	$0.00	$7.88	$7.88
2004	0.00	1.73	1.73	$0.00	$7.51	$7.51
2005	0.00	1.73	1.73	$0.00	$7.26	$7.26
2006	0.00	1.73	1.73	$0.00	$7.08	$7.08
2007	0.00	1.73	1.73	$0.00	$6.94	$6.94
2008	0.00	1.73	1.73	$0.00	$6.83	$6.83
2009	0.00	1.73	1.73	$0.00	$6.76	$6.76
2010	0.00	1.73	1.73	$0.00	$6.70	$6.70
2011	0.00	1.73	1.73	$0.00	$6.63	$6.63
2012	0.00	1.72	1.72	$0.00	$6.50	$6.50
2013	0.00	1.70	1.70	$0.00	$6.38	$6.38
2014	0.00	1.69	1.69	$0.00	$6.26	$6.26
2015	0.00	1.67	1.67	$0.00	$6.15	$6.15
2016	0.00	1.68	1.68	$0.00	$6.13	$6.13
2017	0.00	1.70	1.70	$0.00	$6.16	$6.16
2018	0.00	1.72	1.72	$0.00	$6.19	$6.19
2019	0.00	1.73	1.73	$0.00	$6.20	$6.20

FMVSS No. 226, Ejection mitigation

The goal of FMVSS No. 226 is to prevent ejection of unrestrained occupants and to prevent the partial ejection of belted occupants through side windows in rollovers and other crashes. On January 19, 2011, (76 FR 3212) NHTSA published in the Federal Register the final rule for passenger cars and LTVs. The NPRM was published in the Federal Register on December 2, 2009, (74 FR 63180) making the baseline date September 1, 2009, or MY 2010. The standard applies to passenger cars and LTVs with GVWR of 10,000 lb or less, except convertibles and some other vehicles. The phase-in period includes:

- 25 percent of new vehicles produced from September 1, 2013, to August 31, 2014;
- 50 percent from September 1, 2014, to August 31, 2015;
- 75 percent from September 1, 2015, to August 31, 2016; and
- All new vehicles starting September 1, 2016.

The technology used by manufacturers to meet this new standard is window curtain air bags that deploy in rollovers, stay inflated for six seconds,[56] are large enough to cover the side-window area, and are strong enough to contain the occupant. For this analysis the term we use for these larger window curtains that deploy in a rollover is a rollover window curtain. Rollover window curtains would be needed on all side windows, including both front and rear seats, back to at least the third row.[57] A window curtain air bag designed for side impacts can be upgraded to a rollover window curtain by adding a rollover sensor in the vehicle and modifying the electronic control module that sends the signal to deploy, increasing the height and width of the air bag, redesigning tethers inside the air bag to strengthen the bag between the pillars to help hold in unbelted occupants, adding more gas to fill the larger rollover window curtain, and changing the weave of the window curtain bag fabric so that it maintains sufficient inflation to provide occupant containment for 6 seconds. Window curtains that deploy in rollovers first became available on 2002 Ford Explorers and Mercury Mountaineers (although agency testing indicates that these early curtains would not have met all the requirements of future FMVSS No. 226). As more side-impact window curtains have been upgraded to rollover window curtains, curtains have generally been designed to cover a larger area and stay inflated longer.

Cost estimates were derived for the Final Regulatory Impact Analysis based on a cost teardown report (NHTSA, 2011a, pp. 135; Ludtke & Associates, 2004). Costs for a wider and longer window curtain were estimated based on the area covered in square centimeters for a vehicle with a relatively large window curtain (MY 2004 Honda Accord) compared to a similar sized vehicle that provided the typical sized window curtain for side impacts (MY 2003 Toyota Camry). Neither of these vehicles would have passed the retention requirements of FMVSS No. 226, but they provided reasonable measurements for the increase in window curtain size NHTSA anticipated would be necessary to pass the ejection mitigation test procedure. For a passenger car, the increased weight and cost were estimated to average 0.73 lb and $11.60 (2019$). LTVs needed even longer air bags to cover those vehicles with 3 rows of seats and a few with 4 rows of seats. Even though the standard only requires up to 3 rows of seats to be covered, manufacturers have extended the window curtain to the back of the vehicle to anchor the window curtain and cover the additional fourth row for the 0.8 percent of vehicles that have 4 rows. NHTSA estimates that 36 percent of LTVs would cover 3 rows of seats or have the window curtain extend into the cargo area to anchor the window curtain at the rear of the vehicle. Factoring in these longer window curtains, the average LTV rollover window curtain would weigh 0.91 lb and cost $14.61 (2019$).

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[56] Investigations of rollover crashes show that vehicles may transverse long distances and roll over several times. Unbelted occupants are most often ejected at the end of the rollover sequence. Crash testing indicates that rollover duration ranges up to 6 seconds.

[57] In vehicles with more than three rows of seats, the standard applies to the first three rows of seats and to 600 mm beyond the third row of seats; see 49 CFR Part 571.226 S5.2.1.2(a).

Costs for a larger inflator were estimated based on the additional window curtain size that needed to be filled with gas. NHTSA estimated that the propellant and casing for the inflator needed to increase in size by 28 percent and that this would increase the weight of the inflator and the cost of the inflator. Table 245 shows these increases in weight and cost.

Based on testing, it was determined that the tether at the lower part of the window curtain would need to be strengthened to meet the 100 mm displacement requirement. In some cases, the manufacturers would shorten the length of the side window curtain tethers to provide the required tension. Thus, it was assumed that there would be no incremental cost associated with the tethers on average. Similarly, the agency believes there will be no cost increase to change the weave in the air bag fabric to keep the air bag inflated for 6 seconds.

A rollover sensor is needed to detect a rollover and deploy the side air bags and window curtains in the event of a rollover. Only one rollover sensor is needed per vehicle. Based on information supplied by sensor suppliers, it was determined that the cost of a rollover sensor would be like the cost of a yaw sensor used for ESC. Thus, the weight and cost of a rollover sensor were estimated to be 0.34 lb and $46.50 (2019$).[58]

Table 245. FMVSS No. 226: Weights and consumer costs: Weights for passenger cars and LTVs

Component	Passenger Cars		LTVs	
	Weight (lb)	**Cost (2019$)**	**Weight (lb)**	**Cost (2019$)**
Larger Curtain	0.73	$11.66	0.91	$14.61
Larger Inflator	1.32	$2.96	1.66	$3.71
Rollover Sensor	0.34	$46.50	0.34	$46.50
Total	2.39	$61.11	2.91	$64.82

For this analysis, we have separated the weight and cost of the rollover sensor from the larger curtain (which includes the larger inflator), because in any given model year until ejection mitigation curtains are required, we have larger percentages of the new vehicle fleet that have rollover sensors than have larger curtains.

NHTSA tested several window curtains during the rulemaking process and only found one LTV (a MY 2007 Mazda CX-9) that could pass all the test requirements of the final FMVSS No. 226 for rollover window curtains. Since this model met the standard before the NPRM, the cost for this model will be considered voluntary. There were no fully compliant passenger cars that NHTSA knows about that could be considered as voluntary compliance. Manufacturers started providing a main cost element of ejection mitigation window curtain technology (the rollover sensor) in some of the fleet in MY 2002. Since the baseline date is MY 2010, the percentage of passenger cars and LTVs with rollover sensors in MY 2010 and earlier model years are considered voluntary, the MY 2010 baseline year installation rate is considered voluntary for all

[58] The weight of the yaw rate sensor is an average of seven MY 2005 vehicles' yaw rate sensors from a cost teardown study on ESC provided in Ludtke & Associates (2006). Cost for a rollover sensor taken from the FRIA in NHTSA (2011a) and brought up to 2019$.

MY 2011 and later passenger cars and LTVs, and the difference between the percent of the fleet with rollover sensors and the baseline percent for MY 2011 and later are considered attributable.

Data on the percentage of the fleet with rollover sensors was determined by examining the percentage of vehicles with rollover window curtains (although almost all of these vehicles didn't meet the FMVSS No. 226 requirements, they did have a rollover sensor) by model year that was provided in the Kahane (2014) evaluation of the fatality reduction by side air bags. At the same time, as we update the FMVSS No. 214 percentages, we updated this report for the percent of the fleet that had rollover sensors and passenger cars and LTVs were considered separately. Data was collected from Polk files, from FARS files, and from NHTSA compliance data. For rollover sensors, the data from the Polk files was selected until MYs 2015/2016 when Polk data was not available and FARS data was used. For larger window curtains, compliance data was available starting in MY 2012 and for LTVs we included the Mazda CX-9 sales. The percentage of the fleet with rollover sensors are shown in Table 246 for passenger cars and Table 247 for LTVs by MY. Cost data from Table 245 for rollover sensors were put into the learning curve and the results are shown in Table 246. The basis for these cost estimates used in the learning curves were MY 2005 make models. Rollover sensors have the same learning curve cost estimates for passenger cars and LTVs, but the curtains are larger and more expensive for LTVs than for passenger cars.

Table 247 for passenger cars and Table 248 for LTVs show the estimates for rollover sensors, showing the percentage of the fleet with rollover sensor per model year and the distribution of weight and cost between voluntary and attributable.

Table 246. FMVSS No. 226: Learning curve cost: Weights

Model Year	Passenger Cars		LTVs	
	Rollover Sensor	Larger Curtain	Rollover Sensor	Larger Curtain
2002	$0.00	$0.00	$63.50	0
2003	$56.27	$0.00	$56.27	0
2004	$51.29	$0.00	$51.29	0
2005	$46.50	$0.00	$46.50	0
2006	$43.04	$0.00	$43.07	0
2007	$40.10	$13.32	$40.21	$16.73
2008	$38.01	$12.79	$38.42	$16.16
2009	$37.07	$12.50	$37.35	$15.77
2010	$35.92	$12.20	$36.16	$15.40
2011	$34.81	$11.94	$35.12	$15.08
2012	$33.94	$11.70	$34.28	$14.78
2013	$33.14	$11.48	$33.40	$14.48
2014	$32.38	$11.29	$32.58	$14.23

Model Year	Passenger Cars		LTVs	
	Rollover Sensor	Larger Curtain	Rollover Sensor	Larger Curtain
2015	$31.53	$11.12	$31.69	$14.00
2016	$30.92	$10.98	$31.04	$13.83
2017	$30.34	$10.86	$30.44	$13.67
2018	$29.86	$10.76	$29.95	$13.53
2019	$29.46	$10.67	$29.54	$13.41

Table 247. FMVSS No. 226: Average weights and consumer costs of rollover sensors for ejection mitigation in passenger cars

Model Year	Percent of Fleet	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2002	0.0	0.00	0.00	0.00	$0.00	$0.00	$0.00
2003	1.2	0.00	0.00	0.00	$0.68	$0.00	$0.68
2004	0.9	0.00	0.00	0.00	$0.46	$0.00	$0.46
2005	0.7	0.00	0.00	0.00	$0.33	$0.00	$0.33
2006	1.4	0.00	0.00	0.00	$0.60	$0.00	$0.60
2007	1.3	0.00	0.00	0.00	$0.52	$0.00	$0.52
2008	2.9	0.01	0.00	0.01	$1.10	$0.00	$1.10
2009	1.9	0.01	0.00	0.01	$0.70	$0.00	$0.70
2010	7.6	0.03	0.00	0.03	$2.73	$0.00	$2.73
2011	13.7	0.03	0.02	0.05	$2.65	$2.12	$4.77
2012	12.9	0.03	0.02	0.04	$2.58	$1.80	$4.38
2013	15.7	0.03	0.03	0.05	$2.52	$2.68	$5.20
2014	28.2	0.03	0.07	0.10	$2.46	$6.67	$9.13
2015	60.5	0.03	0.18	0.20	$2.40	$16.68	$19.08
2016	70.8	0.03	0.21	0.24	$2.35	$19.54	$21.89
2017	90.94	0.03	0.28	0.31	$2.31	$25.29	$27.59
2018	97.94	0.03	0.30	0.33	$2.27	$26.98	$29.25
2019	97.87	0.03	0.30	0.33	$2.24	$26.60	$28.84

Table 248. FMVSS No. 226: Average weights and consumer costs of rollover sensors for ejection mitigation in LTVs

Model Year	Percent of Fleet	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2001	0.0	0.00	0.00	0.00	$0.00	$0.00	$0.00
2002	1.0	0.00	0.00	0.00	$0.64	$0.00	$0.64
2003	1.1	0.00	0.00	0.00	$0.62	$0.00	$0.62
2004	3.5	0.01	0.00	0.01	$1.80	$0.00	$1.80
2005	10.7	0.04	0.00	0.04	$4.98	$0.00	$4.98
2006	20.0	0.07	0.00	0.07	$8.61	$0.00	$8.61
2007	37.8	0.13	0.00	0.13	$15.16	$0.00	$15.16
2008	55.4	0.19	0.00	0.19	$21.06	$0.00	$21.06
2009	63.6	0.21	0.00	0.21	$23.58	$0.00	$23.58
2010	78.5	0.26	0.00	0.26	$28.20	$0.00	$28.20
2011	78.8	0.26	0.00	0.27	$27.33	$0.10	$27.43
2012	78.3	0.26	0.00	0.26	$26.58	$0.00	$26.58
2013	83.9	0.26	0.02	0.28	$26.02	$1.79	$27.81
2014	88.7	0.26	0.03	0.30	$25.42	$3.30	$28.72
2015	93.4	0.26	0.05	0.31	$24.75	$4.70	$29.45
2016	96.6	0.26	0.06	0.33	$24.27	$5.60	$29.87
2017	97.6	0.26	0.06	0.33	$23.82	$5.80	$29.62
2018	98.8	0.26	0.07	0.33	$23.44	$6.07	$29.52
2019	98.8	0.26	0.07	0.33	$23.13	$5.99	$29.12

Table 249 and Table 250 show the estimated weight and cost for making window curtains and their inflators larger to pass FMVSS No. 226. To determine the voluntary cost and weight of the one LTV make/model NHTSA knows of that passed FMVSS No. 226 early, the percent of the LTV fleet that the sales of the Mazda CX-9 represent were multiplied by the weights and costs from Table 245. That model represents less than one-half of one percent of LTV sales. Those results are shown in Table 250. We did not include the weight and cost for the rollover sensor itself since that weight and cost was already counted in Table 248.

Table 249. FMVSS No. 226: Average weights and consumer costs of larger curtains for ejection mitigation in passenger cars

Model Year	Percent of Fleet	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2010	0	0.00	0.00	0.00	$0.00	$0.00	$0.00
2011	0	0.00	0.00	0.00	$0.00	$0.00	$0.00
2012	0.4	0.00	0.01	0.01	$0.00	$0.05	$0.05
2013	11.8	0.00	0.24	0.24	$0.00	$1.35	$1.35
2014	22.4	0.00	0.46	0.46	$0.00	$2.53	$2.53
2015	51.7	0.00	1.06	1.06	$0.00	$5.75	$5.75
2016	70.8	0.00	1.45	1.45	$0.00	$7.78	$7.78
2017	90.94	0.00	1.87	1.87	$0.00	$9.88	$9.88
2018	97.94	0.00	2.01	2.01	$0.00	$10.54	$10.54
2019	97.87	0.00	2.01	2.01	$0.00	$10.44	$10.44

Table 250. FMVSS No. 226: Average weights and consumer costs of larger curtains for ejection mitigation in LTVs

Model Year	Percent of Fleet	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2006	0.0	0.00	0.00	0.00	$0.00	$0.00	$0.00
2007	0.2	0.00	0.00	0.00	$0.03	$0.00	$0.03
2008	0.5	0.01	0.00	0.01	$0.07	$0.00	$0.07
2009	0.4	0.01	0.00	0.01	$0.06	$0.00	$0.06
2010	0.4	0.01	0.00	0.01	$0.07	$0.00	$0.07
2011	0.5	0.01	0.00	0.01	$0.07	$0.00	$0.07
2012	2.8	0.01	0.06	0.07	$0.07	$0.35	$0.41
2013	18.1	0.01	0.45	0.46	$0.06	$2.54	$2.60
2014	46.5	0.01	1.18	1.20	$0.06	$6.52	$6.58
2015	68.3	0.01	1.74	1.76	$0.06	$9.46	$9.52
2016	76.6	0.01	1.96	1.97	$0.06	$10.48	$10.55
2017	84.4	0.01	2.16	2.17	$0.06	$11.43	$11.49
2018	98.8	0.01	2.53	2.54	$0.06	$13.27	$13.33
2019	98.8	0.01	2.53	2.54	$0.06	$13.15	$13.21

The total weight and consumer cost impact of FMVSS No. 226 for passenger cars is the combination of Table 247 plus Table 249, and the total weight and consumer cost impact of FMVSS No. 226 for LTVs is the combination of Table 248 plus Table 250. These combined effects are shown in Table 251 for passenger cars and Table 252 for LTVs,

Table 251. FMVSS No. 226: Average weights and consumer costs of rollover sensors and larger curtains for ejection mitigation in passenger cars

Model Year	**Weight (lb)**			**Consumer Cost (2019$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
2002	0.00	0.00	0.00	$0.00	$0.00	$0.00
2003	0.00	0.00	0.00	$0.68	$0.00	$0.68
2004	0.00	0.00	0.00	$0.46	$0.00	$0.46
2005	0.00	0.00	0.00	$0.33	$0.00	$0.33
2006	0.00	0.00	0.00	$0.60	$0.00	$0.60
2007	0.00	0.00	0.00	$0.52	$0.00	$0.52
2008	0.01	0.00	0.01	$1.10	$0.00	$1.10
2009	0.01	0.00	0.01	$0.70	$0.00	$0.70
2010	0.03	0.00	0.03	$2.73	$0.00	$2.73
2011	0.03	0.02	0.05	$2.65	$2.12	$4.77
2012	0.03	0.03	0.05	$2.58	$1.85	$4.43
2013	0.03	0.27	0.30	$2.52	$4.04	$6.56
2014	0.03	0.53	0.56	$2.46	$9.20	$11.66
2015	0.03	1.24	1.27	$2.40	$22.43	$24.83
2016	0.03	1.67	1.69	$2.35	$27.32	$29.67
2017	0.03	2.15	2.17	$2.31	$35.17	$37.47
2018	0.03	2.32	2.34	$2.27	$37.51	$39.78
2019	0.03	2.32	2.34	$2.24	$37.04	$39.28

Table 252. FMVSS No. 226: Average weight and consumer costs of rollover sensors and larger curtains for ejection mitigation in LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2001	0.00	0.00	0.00	$0.00	$0.00	$0.00
2002	0.00	0.00	0.00	$0.64	$0.00	$0.64
2003	0.00	0.00	0.00	$0.62	$0.00	$0.62
2004	0.01	0.00	0.01	$1.80	$0.00	$1.80
2005	0.04	0.00	0.04	$4.98	$0.00	$4.98
2006	0.07	0.00	0.07	$8.61	$0.00	$8.61
2007	0.13	0.00	0.13	$15.19	$0.00	$15.19
2008	0.20	0.00	0.20	$21.13	$0.00	$21.13
2009	0.22	0.00	0.22	$23.64	$0.00	$23.64
2010	0.28	0.00	0.28	$28.27	$0.00	$28.27
2011	0.28	0.00	0.28	$27.40	$0.11	$27.50
2012	0.28	0.06	0.34	$26.64	$0.35	$26.99
2013	0.28	0.47	0.75	$26.08	$4.33	$30.41
2014	0.28	1.22	1.49	$25.48	$9.82	$35.30
2015	0.28	1.79	2.07	$24.82	$14.16	$38.97
2016	0.28	2.02	2.29	$24.33	$16.08	$40.41
2017	0.28	2.22	2.50	$23.88	$17.22	$41.10
2018	0.28	2.60	2.87	$23.50	$19.34	$42.84
2019	0.28	2.60	2.87	$23.19	$19.15	$42.34

Section 4 – FMVSS 300, 400, and 500 Series

The FMVSS 300, 400, and 500 series specify requirements for vehicles and components to prevent or reduce the severity of fires, protect occupants from hazards during vehicle operation, and provide safety for low-speed vehicles.

FMVSS No. 301, Fuel system integrity

FMVSS No. 301 became effective on January 1, 1968, (passenger cars), in January 1976 (MPVs, trucks, [all LTVs] and buses with a GVWR of 10,000 lb or less), and on April 1, 1977, (school buses with a GVWR greater than 10,000 lb). The standard specifies requirements for the integrity of motor vehicle fuel systems. The purpose of this standard is to reduce deaths and injuries occurring from fires that result from fuel spillage during and after motor vehicle crashes and from ingestion of fuels during siphoning. This standard applies to:

- passenger cars;
- MPVs, trucks, and buses that have a GVWR of 10,000 lb or less and use fuel with a boiling point above 0°C; and
- school buses that have a GVWR greater than 10,000 lb and use fuel with a boiling point above 0°C.

On February 3, 1967, (32 FR 2414) NHTSA published a final rule in the Federal Register on FMVSS No. 301 for passenger cars. The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. On August 20, 1973, (38 FR 22397) a final rule was published in the Federal Register extending the standard to LTVs. The NPRM was published in the Federal Register on August 29, 1970, (35 FR 13799) making the baseline date September 1, 1969, or MY 1970. It is believed that the fuel tank in every MY 1965 passenger car and LTV met the basic safety requirements of FMVSS No. 301 for a frontal impact test at 30 mph and for this study this equipment has been defined as Safety1965.

On March 21, 1974, (39 FR 10588) NHTSA published a final rule adding lateral and rear impact tests to FMVSS No. 301 for passenger cars and extending these requirements to LTVs. The NPRM was published on August 20, 1973, (38 FR 22417) making the baseline date September 1, 1972, or MY 1973. Originally, cars only had to pass a front impact test into a rigid barrier at 30 mph. Fuel spillage after the impact was not allowed to exceed 1 ounce while the car was still in motion and 5 ounces during the first 5 minutes after the car came to a stop. During the next 25 minutes, fuel spillage could not exceed 1 ounce during any 1-minute interval (Parsons, 1990, pp. xvii, 3-25–3-28).[59]

[59] Footnote 4, page 1–4 of the Parson (1990) evaluation said earlier studies found no significant difference in fire rates or costs of passenger cars between pre-1968 and post-1968 passenger cars.

During the 1970s, FMVSS No. 301 was significantly upgraded over a 3-year phase-in period.

- Effective September 1, 1975. Passenger cars had to meet a static rollover test. Immediately after the frontal test, the damaged vehicle was slowly rotated 90, 180 (up-side down), and 270°, holding at each of these positions for five minutes. Fuel spillage could not exceed one ounce during any one-minute interval in this process.
- Effective September 1, 1976. Passenger cars had to meet 30 mph frontal, oblique frontal, and rear-impact tests, plus a 20-mph lateral test, with each test followed by a static rollover test. The cars had the same limits on fuel spillage as in the original frontal test. LTVs with GVWR less than or equal to 6,000 lb had to meet 30 mph frontal and rear-impact tests followed by the static rollover. LTVs with GVWR of 6,000-10,000 (including small LTV-based school buses) had to meet the frontal test without static rollover.
- Effective September 1, 1977. All LTVs with GVWR of 10,000 lb or less (including small school buses) had to meet the same requirements as passenger cars: frontal, oblique frontal, rear-impact, and lateral tests with subsequent rollover.

These amendments resulted in weight and cost increases. The type and extent of modifications near the time of the MY 1976 to 1978 upgrade varied greatly by make-model. Strategies used by the manufacturers included (Parsons, 1990, pp. 4-11–4-22):

- strengthening the fuel tank or other components of the fuel delivery system,
- strengthening the structures that hold the fuel tank in place,
- shielding the fuel tank and delivery system from other parts of the vehicle,
- relocating parts of the fuel system further away from other parts of the vehicle or areas likely to be damaged during impacts, and
- relocating other parts of the vehicle further away from the fuel system or reshaping them to make them less likely to damage the fuel system.

On December 1, 2003, (68 FR 67068) NHTSA published a final rule in the Federal Register to upgrade the rear- and lateral-impact test procedures of FMVSS No. 301 for passenger cars and LTVs (sometimes called FMVSS No. 301R for the amended rear impact test). The NPRM was published in the Federal Register on November 13, 2000, (65 FR 67693) making the baseline date September 1, 2000, or MY 2001. The final rule replaced the full rear impact test procedure with an offset rear impact test procedure specifying that only a portion of the width of the rear of the test vehicle be impacted at 50 mph. Under the new rear impact procedure, a lighter deformable barrier is used. The barrier is very similar to the one used for dynamic testing of the side impact protection standard, except that the rear impact barrier’s face is mounted slightly lower to simulate the diving of the front end of a vehicle during pre-crash braking. The new requirements were phased in with compliance required by:

- 40 percent of vehicles manufactured after September 1, 2006, and before September 1, 2007;

- 70 percent of vehicles manufactured after September 1, 2007, and before September 1, 2008; and
- 100 percent of vehicles manufactured after September 1, 2008.

In the same December 1, 2003, final rule, NHTSA changed the side impact test to use the FMVSS No. 214 side impact barrier, effective September 1, 2014. Based on test data, it was believed that all passenger cars and LTVs would pass this side impact test change with no additional cost.

Passenger Car Studies

Initial MY 1968 standard – Cost analyses by the agency did not show any substantive changes from MY 1967 to 1968 needed to meet the original FMVSS No. 301 (McLean et al., 1978, pp. 63–77).[60] Statistical analyses of post-crash fire rates did not show a significant difference between pre-1968 and MY 1968+ cars. Based on our evaluation of fire-related crashes NHTSA believes that cars sold in the United States generally would have been capable of meeting the FMVSS No. 301 frontal impact test for some years before the regulation was proposed. NHTSA has not attempted to determine whether LTVs would have also met an FMVSS No. 301 frontal impact test by MY 1965, but it is quite likely. Thus, we have decided to claim that all passenger cars and LTVs could have met an FMVSS No. 301 frontal impact test in MY 1965 and this baseline is considered Safety1965. Only incremental costs are included in this report over the safety equipment that was standard equipment on every MY 1965 passenger car and LTV, defined as Safety1965.

MY 1976 upgrade – Fuel system elements of 12 post-standard (MY 1976) passenger cars and their corresponding pre-standard (MY 1967) make-models were examined to determine the weight and consumer cost of equipment changes in response to FMVSS No. 301 (McLean et al., 1978, pp. 63–87). Table 253 shows the sales-weighted average weight and consumer cost increase (before applying the learning curve) of implementing the 1976 requirement,[61] with the difference attributable to FMVSS No. 301 in passenger cars because the changes were made after the baseline date. We have no data on percent compliance before the effective date (from 1967 to 1976). None of the MY 1967 or 1968 models were tested for compliance to our knowledge. However, all 12 make/models were changed between MY 1967 and 1976 implying that perhaps none of them might have passed the updated requirements. Thus, we have assumed 100-percent compliance on the MY 1976 effective date and no compliance before that date. The evaluation indicated that post-standard passenger cars had 14 percent fewer fires than pre-standard passenger cars, after controlling for vehicle age (Parsons, 1983, p. 3). However, this analysis did not show a statistically significant reduction of post-crash fires for LTVs, nor could it show a statistically significant reduction in post-crash fatalities related to fire. The crash data is not refined enough to determine what percent of pre-MY 1976 vehicles could comply with the standard.

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[60] The multiplier used in the McLean et al. (1978) study for FMVSS No. 301 varied considerably from model to model. The variable cost for each make/model was multiplied by a consistent 1.51 and total costs were sales weighted to get the estimates in Table 253.

[61] As discussed earlier in the report, a progress rate of 0.98 was assumed for FMVSS No. 301 for learning.

Table 253. FMVSS No. 301: Average weights and consumer costs of the fuel tank and fuel tank filler tube in passenger cars – MY 1976 to 1978 requirements

Category	Weight (lb)	Consumer Cost ($2019)
Pre-Standard (MY 1968)	24.22	$49.70
Post-Standard (MY 1976)	25.44	$94.95
Difference	1.22	$45.25

Table 254 shows the average weight and consumer cost after applying the learning curve for the MYs 1976 to 1978 requirements for passenger cars. It assumes 100-percent compliance in MY 1976.

Table 254. FMVSS No. 301: Average weights and consumer costs – MY 1976 to 1978 requirements for passenger cars

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1975	0	0	0	$0.00	$0.00	$0.00
1976	0	1.22	1.22	$0.00	$45.25	$45.25
1977	0	1.22	1.22	$0.00	$44.08	$44.08
1978	0	1.22	1.22	$0.00	$43.47	$43.47
1979	0	1.22	1.22	$0.00	$43.09	$43.09
1980	0	1.22	1.22	$0.00	$42.85	$42.85
1981	0	1.22	1.22	$0.00	$42.66	$42.66
1982	0	1.22	1.22	$0.00	$42.50	$42.50
1983	0	1.22	1.22	$0.00	$42.34	$42.34
1984	0	1.22	1.22	$0.00	$42.17	$42.17
1985	0	1.22	1.22	$0.00	$42.01	$42.01
1986	0	1.22	1.22	$0.00	$41.87	$41.87
1987	0	1.22	1.22	$0.00	$41.74	$41.74
1988	0	1.22	1.22	$0.00	$41.63	$41.63
1989	0	1.22	1.22	$0.00	$41.54	$41.54
1990	0	1.22	1.22	$0.00	$41.45	$41.45
1991	0	1.22	1.22	$0.00	$41.38	$41.38
1992	0	1.22	1.22	$0.00	$41.31	$41.31

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1993	0	1.22	1.22	$0.00	$41.24	$41.24
1994	0	1.22	1.22	$0.00	$41.17	$41.17
1995	0	1.22	1.22	$0.00	$41.10	$41.10
1996	0	1.22	1.22	$0.00	$41.04	$41.04
1997	0	1.22	1.22	$0.00	$40.98	$40.98
1998	0	1.22	1.22	$0.00	$40.92	$40.92
1999	0	1.22	1.22	$0.00	$40.85	$40.85
2000	0	1.22	1.22	$0.00	$40.79	$40.79
2001	0	1.22	1.22	$0.00	$40.74	$40.74
2002	0	1.22	1.22	$0.00	$40.69	$40.69
2003	0	1.22	1.22	$0.00	$40.64	$40.64
2004	0	1.22	1.22	$0.00	$40.59	$40.59
2005	0	1.22	1.22	$0.00	$40.54	$40.54
2006	0	1.22	1.22	$0.00	$40.50	$40.50
2007	0	1.22	1.22	$0.00	$40.45	$40.45
2008	0	1.22	1.22	$0.00	$40.41	$40.41
2009	0	1.22	1.22	$0.00	$40.39	$40.39
2010	0	1.22	1.22	$0.00	$40.36	$40.36
2011	0	1.22	1.22	$0.00	$40.33	$40.33
2012	0	1.22	1.22	$0.00	$40.29	$40.29
2013	0	1.22	1.22	$0.00	$40.25	$40.25
2014	0	1.22	1.22	$0.00	$40.22	$40.22
2015	0	1.22	1.22	$0.00	$40.18	$40.18
2016	0	1.22	1.22	$0.00	$40.15	$40.15
2017	0	1.22	1.22	$0.00	$40.11	$40.11
2018	0	1.22	1.22	$0.00	$40.08	$40.08
2019	0	1.22	1.22	$0.00	$40.05	$40.05

MY 2007-2009 Upgrade – The cost of the MY 2007 to 2009 FMVSS No. 301 upgrade was estimated in a cost teardown study (Ricardo Inc., 2014a). Ricardo Inc. examined 6 pre-standard and their counterpart post-standard vehicles, the MYs 1998 and 2007 VW Jetta, MYs 1998 and 2008 Ford Mustang, MYs 1998 and 2008 Honda Civic, MYs 2000 and 2010 Hyundai Elantra, MYs 2000 and 2007 Toyota RAV4 (an LTV), and the MY 1998 Buick LeSabre and MY 2005 Buick LaCrosse. Of those 6 pre-standard vehicles, the Honda Civic and Ford Mustang passed the test; the remaining 4 vehicles did not.

From research done to determine the impacts of the standard on weight and costs, the following generalizations were made:

- Most FMVSS No. 301R test failures occurred in the fuel neck but were primarily driven by the routing of the fuel neck from the body side to the fuel tank and its proximity to other parts that moved under test conditions leading to rupture of the tube.
- FMVSS No. 301R did not drive the design of the fuel tank including the choice of steel or plastic materials. The overriding expert opinion was that the design of the body structure should prevent all impingement on the fuel tank under the test conditions. Based on this the fuel tank was not considered an influencing factor in the study.
- For the vehicles and MYs analyzed in the study the primary load carrying structure to manage the loads generated by the FMVSS No. 301R test is the rear frame rails, so other chassis or body structures such as suspension, and styling were not considered.

The system components contributing to FMVSS No. 301R were broken down into two groups (the fuel filler neck system and structural chassis components) for an in-depth analysis of these components:

- Fuel Filler Neck System
- Fuel Cap Assembly and Breather Valve Assembly
- Fuel Filler Neck Assembly – Fuel Filler Neck, Fuel Filler Breather, Tubes, Connectors & Purchased Parts
- Fuel Filler Valve Assembly
- Sub-assembly and Final Assembly Costs
- Structural Chassis Components – Rear Frame Rails, Stiffeners, Patches, Sub-assembly and Final Assembly Costs

The most unusual finding in this FMVSS No. 301R cost teardown analysis is that the two vehicles that passed the standard in the baseline vehicles (Honda Civic and Ford Mustang) had similar weight and cost increases as the four vehicles that failed the standard in the baseline vehicles. The reason is that there were major design changes to the rear suspension mountings in many vehicles during this period (including the Honda Civic, Ford Mustang, and Hyundai Elantra in our sample of six vehicles) and components needed to be added for some vehicles that were not on the baseline vehicles to assure compliance with FMVSS No. 301R.

Table 255 shows the estimated incremental average weights and costs for the MY 2007 to 2009 FMVSS No. 301R requirements for passenger cars (Ricardo Inc., 2014a).[62] Since one of the six vehicles averaged in the teardown study was an LTV, the weight and cost for the LTV was like passenger cars, and we have no other cost data on LTVs, we will assume the same cost for LTVs as for passenger cars.

Table 255. FMVSS No. 301R: Weights and consumer costs: Weights for passenger cars and LTVs

	Weight (lb)	**Consumer Cost (2019$)**
Filler Neck	0.22	$6.02
Structure	14.64	$40.85
Total	14.86	$46.87

The Pai (2014) evaluation estimated compliance with the MYs 2007 to 2009 requirements based on two data sets. First, as part of the evaluation, NHTSA tested a sample of MYs 1996 to 2000 vehicles to the FMVSS No. 301R final rule, combined them with previous testing, and after weighting them for sales, found that in MY 2005 and earlier, and for the baseline year of MY 2001, the average compliance rate was 38.55 percent for passenger cars. We have no compliance data prior to MY 1996, thus we are assuming no compliance for MY 1995 and earlier. However, based on the cost teardown study, this does not necessarily mean that there are no attributable weight and cost impacts in later model years for that complying part of the fleet. Second, based on compliance data, manufacturers certified compliance for passenger cars during the phase-in period at 45.58 percent for MY 2007, 70.65 percent for MY 2008, and 100 percent for MY 2009 (as required).

The Honda Civic and Ford Mustang cost teardown results present a dilemma in determining what percent of the complying vehicles we should assume have voluntary costs and what percent have attributable costs. Based on our methodology we assume all complying vehicles by the baseline have voluntary costs. We know that 3 of the 6 vehicles in the cost teardown changed rear suspension mountings and these were three different manufacturers. Without any further information, we will assume that half of the complying vehicles that would have been considered voluntary starting with the phase-in period would have met the standard voluntarily and the other half had to make changes to comply and are attributable. This means that the voluntary compliance starting in MY 1996 is 38.55 percent for passenger cars and 48.63 percent for LTVs, but starting in MY 2007, the voluntary percentage changes to half of this level and the voluntary percentage is 38.55 percent/2 = 19.28 percent for passenger cars and 48.63 percent/2 = 24.32 percent for LTVs. Thus, we assume that starting in MY 2007, half of the otherwise voluntarily complying vehicles made changes to their rear suspensions for other reasons and needed to then make changes to comply with the standard.

[62] Summing Ricardo Inc. (2014a) data from the two right columns of Table 3 for the 6 vehicles and dividing by 6; Table 4 is incorrect.

Table 256 shows the estimated incremental weights and costs for passenger cars for FMVSS No. 301R for the MY 2007 requirements.

Table 256. FMVSS No. 301R: Average weights and consumer costs for passenger cars

Model Year	**Weight (lb)**			**Consumer Cost (2019$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1995	0.00	0.00	0.00	$0.00	$0.00	$0.00
1996	5.73	0.00	5.73	$19.58	$0.00	$19.58
1997	5.73	0.00	5.73	$19.18	$0.00	$19.18
1998	5.73	0.00	5.73	$18.95	$0.00	$18.95
1999	5.73	0.00	5.73	$18.78	$0.00	$18.78
2000	5.73	0.00	5.73	$18.64	$0.00	$18.64
2001	5.73	0.00	5.73	$18.54	$0.00	$18.54
2002	5.73	0.00	5.73	$18.45	$0.00	$18.45
2003	5.73	0.00	5.73	$18.38	$0.00	$18.38
2004	5.73	0.00	5.73	$18.31	$0.00	$18.31
2005	5.73	0.00	5.73	$18.25	$0.00	$18.25
2006	5.73	0.00	5.73	$18.20	$0.00	$18.20
2007	2.86	3.91	6.77	$9.07	$12.38	$21.45
2008	2.86	7.63	10.50	$9.03	$24.08	$33.11
2009	2.86	11.99	14.86	$9.01	$37.73	$46.74
2010	2.86	11.99	14.86	$8.98	$37.61	$46.60
2011	2.86	11.99	14.86	$8.95	$37.50	$46.45
2012	2.86	11.99	14.86	$8.92	$37.38	$46.30
2013	2.86	11.99	14.86	$8.90	$37.26	$46.16
2014	2.86	11.99	14.86	$8.87	$37.16	$46.03
2015	2.86	11.99	14.86	$8.85	$37.05	$45.90
2016	2.86	11.99	14.86	$8.83	$36.97	$45.79
2017	2.86	11.99	14.86	$8.81	$36.89	$45.69
2018	2.86	11.99	14.86	$8.79	$36.81	$45.60
2019	2.86	11.99	14.86	$8.77	$36.75	$45.52

LTV Studies

As discussed above for passenger cars, we have decided to claim that all passenger cars and LTVs could have met an FMVSS No. 301 frontal impact test in MY 1965 and this baseline is considered Safety1965.

FMVSS No. 301 was extended to LTVs in January 1976. To determine the weight and consumer cost of the equipment changes in response to FMVSS No. 301 requirements fuel system elements of two pre-standard (MY 1976) LTVs and their corresponding post-standard (MY 1977) make-models were examined (McLean et al., 1978, pp. 63–87).

Examination of the 1976 and 1977 MY LTVs did not make a clearly defined conclusion on the implementation of the standard. One selected vehicle indicated an increase in weight of 11.73 lb and cost of $8.50 in 2019 dollars, while the other vehicle exhibited no cost or weight increase from MYs 1976 to 1977. Because of the small sample size and the possibility that the vehicle with no change could have made the equipment changes a year earlier, we prefer to attribute the full weight and cost imposed for passenger cars to LTVs. As with passenger cars, we have no data on percent compliance before the effective date, so we have assumed 100-percent compliance on the MY 1977 effective date for LTVs and no compliance before that date.

Table 257 shows the sales-weighted average weight and cost for the MYs 1977 to 1978 requirements for LTVs. Table 258 shows the sales-weighted average weight and consumer cost (after applying the learning curve) of implementing the MY 1977 requirement, with the difference attributable to FMVSS No. 301 in LTVs. The weight added is 1.22 lb for MYs 1977 to 2019, while the cost per year is determined by the learning curve.

Table 257. FMVSS No. 301: Average weights and consumer costs of the fuel tank and fuel tank filler tube in LTVs – MY 1977 to 1978 requirements

Category	Weight (lb)	Consumer Cost ($2019)
Pre-Standard (MY 1968)	24.22	$49.70
Post-Standard (MY 1977)	25.44	$94.95
Difference	1.22	$45.25

Table 258. FMVSS No. 301: Average weights and consumer costs MYs 1977 to 1978 requirements for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1976	0	0	0	$0.00	$0.00	$0.00
1977	0	1.22	1.22	$0.00	$44.08	$44.08
1978	0	1.22	1.22	$0.00	$43.47	$43.47
1979	0	1.22	1.22	$0.00	$43.09	$43.09
1980	0	1.22	1.22	$0.00	$42.85	$42.85

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1981	0	1.22	1.22	$0.00	$42.66	$42.66
1982	0	1.22	1.22	$0.00	$42.50	$42.50
1983	0	1.22	1.22	$0.00	$42.34	$42.34
1984	0	1.22	1.22	$0.00	$42.17	$42.17
1985	0	1.22	1.22	$0.00	$42.01	$42.01
1986	0	1.22	1.22	$0.00	$41.87	$41.87
1987	0	1.22	1.22	$0.00	$41.74	$41.74
1988	0	1.22	1.22	$0.00	$41.63	$41.63
1989	0	1.22	1.22	$0.00	$41.54	$41.54
1990	0	1.22	1.22	$0.00	$41.45	$41.45
1991	0	1.22	1.22	$0.00	$41.38	$41.38
1992	0	1.22	1.22	$0.00	$41.31	$41.31
1993	0	1.22	1.22	$0.00	$41.24	$41.24
1994	0	1.22	1.22	$0.00	$41.17	$41.17
1995	0	1.22	1.22	$0.00	$41.10	$41.10
1996	0	1.22	1.22	$0.00	$41.04	$41.04
1997	0	1.22	1.22	$0.00	$40.98	$40.98
1998	0	1.22	1.22	$0.00	$40.92	$40.92
1999	0	1.22	1.22	$0.00	$40.85	$40.85
2000	0	1.22	1.22	$0.00	$40.79	$40.79
2001	0	1.22	1.22	$0.00	$40.74	$40.74
2002	0	1.22	1.22	$0.00	$40.69	$40.69
2003	0	1.22	1.22	$0.00	$40.64	$40.64
2004	0	1.22	1.22	$0.00	$40.59	$40.59
2005	0	1.22	1.22	$0.00	$40.54	$40.54
2006	0	1.22	1.22	$0.00	$40.50	$40.50
2007	0	1.22	1.22	$0.00	$40.45	$40.45
2008	0	1.22	1.22	$0.00	$40.41	$40.41
2009	0	1.22	1.22	$0.00	$40.39	$40.39

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2010	0	1.22	1.22	$0.00	$40.36	$40.36
2011	0	1.22	1.22	$0.00	$40.33	$40.33
2012	0	1.22	1.22	$0.00	$40.29	$40.29
2013	0	1.22	1.22	$0.00	$40.25	$40.25
2014	0	1.22	1.22	$0.00	$40.22	$40.22
2015	0	1.22	1.22	$0.00	$40.18	$40.18
2016	0	1.22	1.22	$0.00	$40.15	$40.15
2017	0	1.22	1.22	$0.00	$40.11	$40.11
2018	0	1.22	1.22	$0.00	$40.08	$40.08
2019	0	1.22	1.22	$0.00	$40.05	$40.05

MYs 2007-2009 Upgrade – The Pai (2014) evaluation estimated compliance with the MYs 2007 to 2009 requirements based on two data sets. First, as part of the evaluation, NHTSA tested a sample of MYs 1996 to 2000 vehicles to the FMVSS No. 301 final rule, combined them with previous testing by NHTSA, and after weighting them for sales, found that in MY 2005 and earlier, including the baseline year of MY 2001, the average compliance rate was 48.63 percent for LTVs. As discussed in the passenger car section, we will assume that half of the complying vehicles starting with the phase-in in MY 2007 would have to make changes to their vehicles to comply and half would not. This changes the voluntary complying percentage from 48.63 percent to 24.32 percent for LTVs. Second, based on compliance data, manufacturers certified compliance for LTVs during the phase-in period at 64.48 percent for MY 2007, 85.94 percent for MY 2008, and 100 percent for MY 2009 (as required).

Table 259 shows the estimated incremental weights and costs for the MY 2007 to 2009 FMVSS No. 301R requirements for LTVs.

Table 259. FMVSS No. 301R: Average weights and consumer costs – MY 2007 requirements for LTVs

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1995	0.00	0.00	0.00	$0.00	$0.00	$0.00
1996	7.23	0.00	7.23	$24.69	$0.00	$24.69
1997	7.23	0.00	7.23	$24.20	$0.00	$24.20
1998	7.23	0.00	7.23	$23.91	$0.00	$23.91
1999	7.23	0.00	7.23	$23.69	$0.00	$23.69

Model Year	Weight (lb)			Consumer Cost (2019$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2000	7.23	0.00	7.23	$23.52	$0.00	$23.52
2001	7.23	0.00	7.23	$23.38	$0.00	$23.38
2002	7.23	0.00	7.23	$23.27	$0.00	$23.27
2003	7.23	0.00	7.23	$23.18	$0.00	$23.18
2004	7.23	0.00	7.23	$23.10	$0.00	$23.10
2005	7.23	0.00	7.23	$23.02	$0.00	$23.02
2006	7.23	0.00	7.23	$22.96	$0.00	$22.96
2007	3.61	5.97	9.58	$11.44	$18.90	$30.34
2008	3.61	9.16	12.77	$11.40	$28.88	$40.28
2009	3.61	11.25	14.86	$11.36	$35.37	$46.74
2010	3.61	11.25	14.86	$11.33	$35.27	$46.60
2011	3.61	11.25	14.86	$11.29	$35.15	$46.45
2012	3.61	11.25	14.86	$11.26	$35.04	$46.30
2013	3.61	11.25	14.86	$11.22	$34.94	$46.16
2014	3.61	11.25	14.86	$11.19	$34.84	$46.03
2015	3.61	11.25	14.86	$11.16	$34.74	$45.90
2016	3.61	11.25	14.86	$11.13	$34.66	$45.79
2017	3.61	11.25	14.86	$11.11	$34.58	$45.69
2018	3.61	11.25	14.86	$11.09	$34.51	$45.60
2019	3.61	11.25	14.86	$11.07	$34.45	$45.52

FMVSS No. 302, Flammability of interior materials

FMVSS No. 302 became effective on September 1, 1972, and specifies burn resistance requirements for materials used in the occupant compartments of motor vehicles. The purpose of the standard is to reduce the deaths and injuries to motor vehicle occupants caused by vehicle fires, especially those originating in the interior of the vehicle from sources such as matches or cigarettes. This standard applies to passenger cars, MPVs, trucks, (all LTVs), and buses. No cost studies of this standard have been done, and none are planned by the agency.

FMVSS No. 303, Fuel system integrity of compressed natural gas vehicles

FMVSS No. 303 became effective on April 25, 1994, and specifies requirements for the integrity of motor vehicle fuel systems using CNG, including the CNG fuel systems of bi-fuel, dedicated, and dual fuel CNG vehicles. The purpose of the standard is to reduce deaths and injuries occurring from fires that result from fuel leakage during and after motor vehicle crashes. This standard applies to passenger cars, MPVs, trucks, (all LTVs), and buses that have a GVWR of 10,000 lb or less and school buses regardless of weight that use CNG as a motor fuel. There are very few light vehicles powered by CNG in the fleet. No cost studies of this standard have been done, and none are currently planned by the agency.

FMVSS No. 304, Compressed natural gas fuel container integrity

FMVSS No. 304 became effective March 27, 1995, and specifies requirements for the integrity of CNG, motor vehicle fuel containers. The purpose of this standard is to reduce deaths and injuries occurring from fires that result from fuel leakage during and after motor vehicle crashes. This standard applies to each passenger car, MPV, truck, (all LTVs), and bus that use CNG as a motor fuel and to each container designed to store CNG as motor fuel on-board any motor vehicle. No cost studies of this standard have been done, and none are currently planned by the agency.

FMVSS No. 305, Electric-powered vehicles: electrolyte spillage and electrical shock protection

FMVSS No. 305 became effective on September 27, 2000, and specifies requirements for limitation of electrolyte spillage, retention of propulsion batteries during a crash, and electrical isolation of the chassis from the high-voltage system to be met by vehicles that use electricity as propulsion. The purpose of this standard is to reduce deaths and injuries during a crash that occur because of electrolyte spillage from propulsion batteries, intrusion of propulsion battery system components into the occupant compartment, and electrical shock. This standard applies to passenger cars and to MPVs, trucks, (all LTVs), and buses with a GVWR of 10,000 lb or less, that use more than 48 nominal volts of electricity as propulsion power and whose speed attainable in 1.6 km on a paved level surface is more than 40 kmh. No cost studies of this standard have been done, and none are currently planned by the agency.

FMVSS No. 401, Interior trunk release

FMVSS No. 401 became effective on September 1, 2001, (MY 2002) and establishes the requirements for providing an interior trunk release mechanism that makes it possible for a person trapped inside the trunk compartment of a passenger car to escape from the compartment. The standard was intended to give children that trapped themselves in a trunk and the victims of crime that were forced into a trunk the chance to free themselves. This standard applies to passenger cars that have a trunk compartment. It does not apply to passenger cars with a back door; thus, it does not apply to station wagons or hatchbacks. The analysis to determine the percent of the passenger car fleet affected by the standard was completed using Polk data for MYs 2000 to 2011 (Polk & Co., n.d.) and data from the *Ward's Automotive Yearbook* for MYs 2012 to 2019 (Binder, 2002-2017; Norris, 2018-2020). For analysis by body style, the standard applied to convertibles, 2-door passenger cars, and 4-door passenger cars; it does not apply to 3-door passenger cars and 5-door passenger cars and station wagons. FMVSS No. 401 also does not apply to LTVs, since none have ever been produced with a trunk lid. No cost teardown studies of this standard have been done, and none are currently planned by the agency. In addition, no regulatory evaluation or regulatory impact analysis was completed for the NPRM (published on December 17, 1999, at 64 FR 07672) or final rule. However, in the preamble to the final rule, which was published in the Federal Register on October 20, 2000, (65 FR 63014), NHTSA estimated the cost for an interior trunk release pull handle (which are now commonly glow-in-the-dark) at $2.00. Since this estimate was in year 2000 dollars, the estimated cost in 2019 dollars is $2.88 ($2.00 * 1.4389). The 1.4389 multiplier is used to adjust the estimated cost from 2000 economics to 2019 economics based on the implicit GDP price deflator. No weight estimate was made in the final rule. For purposes of this analysis, we assume that a plastic handle with a short cable to attach it to the trunk release mechanism would weigh about 0.1 lb.

During the rulemaking, Ford said all of its MY 2000 passenger cars would come equipped with an interior trunk release mechanism. We assume Ford was referring to all passenger cars that have a trunk lid and would not count station wagons and hatchbacks. Except for Ford for MYs 2000 and 2001, we know of no other manufacturer that supplied an interior trunk release handle before the MY 2002 effective date. The baseline for FMVSS No. 401 is September 1, 1999, or MY 2000. Thus, the percentage of passenger cars with interior trunk releases in MY 2000 are considered voluntary, and the MY 2000 baseline year installation rate (14.1% installation for passenger cars) is considered voluntary for all MY 2000 and later passenger cars. Ford's sales in MY 2001 decreased relative to other manufacturers and only 13.1 percent of the fleet had interior trunk releases in MY 2001. The difference between the percentage of the fleet with interior trunk releases and 14.1 percent for passenger cars for MY 2002 and later are considered attributable.

Table 260 shows the percentage of passenger cars that were estimated to meet FMVSS No. 401 by MY, and the average weight and cost impacts.

Table 260. FMVSS No. 401: Average weights and consumer costs – interior trunk release in passenger cars

Model Year	Percent of Fleet	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2000	14.1	0.01	0.00	0.01	$0.50	$0.00	$0.50
2001	13.1	0.01	0.00	0.01	$0.44	$0.00	$0.44
2002	91.3	0.01	0.08	0.09	$0.41	$2.22	$2.63
2003	90.5	0.01	0.08	0.09	$0.38	$2.08	$2.46
2004	91.5	0.01	0.08	0.09	$0.37	$2.03	$2.40
2005	89.3	0.01	0.08	0.09	$0.36	$1.92	$2.28
2006	89.8	0.01	0.08	0.09	$0.35	$1.89	$2.24
2007	86.6	0.01	0.07	0.09	$0.35	$1.78	$2.13
2008	87.0	0.01	0.07	0.09	$0.34	$1.76	$2.10
2009	86.8	0.01	0.07	0.09	$0.34	$1.74	$2.08

Model Year	Percent of Fleet	Weight (lb)			Consumer Cost (2019$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2010	84.9	0.01	0.07	0.08	$0.33	$1.68	$2.01
2011	87.4	0.01	0.07	0.09	$0.33	$1.72	$2.05
2012	85.6	0.01	0.07	0.09	$0.33	$1.66	$1.99
2013	86.8	0.01	0.07	0.09	$0.33	$1.67	$2.00
2014	85.9	0.01	0.07	0.09	$0.32	$1.64	$1.96
2015	86.1	0.01	0.07	0.09	$0.32	$1.63	$1.95
2016	86.5	0.01	0.07	0.09	$0.32	$1.63	$1.95
2017	85.1	0.01	0.07	0.09	$0.32	$1.59	$1.91
2018	84.5	0.01	0.07	0.08	$0.31	$1.57	$1.88
2019	82.1	0.01	0.07	0.08	$0.31	$1.51	$1.82

FMVSS No. 402 – [Does not currently exist]

FMVSS No. 403, Platform lift systems for motor vehicles

FMVSS No. 403 became effective on December 27, 2004, and specifies requirements for platform lifts used to assist people with limited mobility in entering or leaving a motor vehicle. The purpose of this standard is to prevent injuries and fatalities to passengers and bystanders during the operation of platform lifts installed in motor vehicles. This standard applies to platform lifts designed to carry passengers into and out of motor vehicles. No cost teardown studies of this standard have been done, and none are currently planned by the agency. However, cost estimates were made in the Final Regulatory Evaluation supporting the final rule.

The final rule that was published in the Federal Register on December 27, 2002, (67 FR 79416) and as far as we know has not affected any passenger cars to date but would apply to LTVs with platform lifts. NPRMs were published on July 27, 2000, (65 FR 46228) and February 26, 1993, (58 FR 11562).

The final rule sets a wide variety of standards, including minimum sizes for platforms, and performance standards for strength and slip resistance. It requires handrails, threshold warning signals, retainer barriers and interlocks to keep the lift from operating while the vehicle is in motion, etc. Most platform lifts sold are for public use: transit buses, motorcoaches, over-the-road and charter buses, and school buses. However, some are sold for private use for vehicles with GVWR of 10,000 lb or less and are typically installed in vans. Many wheelchair occupants use ramps to enter vans, but the standard does not apply to ramps. The standard applies only to platform lifts. Platform lifts for the larger public-use vehicles are required to meet more parts of the standard than are platform lifts designed for the smaller private use vehicles.

There is not much data on how many private-use vehicles are converted per year to include a platform lift. In the Final Regulatory Evaluation it was estimated that between 8,800 and 17,000 vehicles are converted each year to include platform lifts for private use (NHTSA, 2002). Since the United States armed forces have been involved in combat operations since before the effective date of this rule and since the U.S. population has been on average getting older, for this analysis, we'll assume the higher level of 17,000. We will also assume that all these conversions are for LTVs and essentially none are for passenger cars.

Almost all these platform lifts for private use on LTVs are installed as aftermarket equipment and are not installed by the original equipment manufacturer. Because they are aftermarket equipment, their costs do not fit into the focus of this report, that is: what is the cost added to the average passenger car and LTV due to the FMVSS? If an original equipment manufacturer entered into a contract with a platform lift manufacturer and had the lift provided as an option on a new vehicle, then that lift would be considered original equipment. But that has not been the typical business practice. Typically, on paper, the vehicle dealer sells the vehicle to the customer and then has it shipped to another firm that installs the platform lift, and then brings it back to the customer. Many other customers have lifts installed on used vehicles. Vehicles under either of these business practices are considered aftermarket vehicles.

The Final Regulatory Evaluation estimated the cost increase for those new parts required by the standard for platform lifts to be $206.98 in 2019 dollars before applying the learning curve. This included a high-contrast standee platform marking, control-system lettering size and illumination, threshold-warning device and visual/audible signal, occupied-outer-barrier interlock device, and a lift-interlock relay switch. Even though the Final Regulatory Evaluation did not estimate the incremental weight of the new devices required, two of these improvements (markings and illumination) add almost no weight, while the others are electronic devices which add very little weight. Combined, we estimate the incremental weight for LTVs affected to be 1.0 lb.

For this analysis, we estimated the weight and cost impact if platform lifts were original equipment, just to see how it would affect the estimates. The average weight and cost impact for LTVs fluctuates, because we assumed constant sales of 17,000 platform lifts, while sales of LTVs fluctuate each year. The cost impact would average between $0.23 and $0.62 per vehicle over the 2005 to 2019 MY period. After averaging platform lift sales into all LTV sales, the weight impact comes out to about 0.003 lb.

Since these are considered aftermarket sales, these weights and costs have not been added into the summary tables as part of the average weight and cost impact of the FMVSS on LTVs. These weight and cost impacts are borne by the purchasers of platform lifts and are not part of the price that an average consumer pays for a new LTV.

FMVSS No. 404, Platform lift installations in motor vehicles

FMVSS No. 404 became effective on December 27, 2004, and specifies requirements for vehicles with platform lifts used to assist people with limited ability in entering or leaving a motor vehicle.[63] The purpose of this standard is to prevent injuries and fatalities to passengers and bystanders during the operation of platform lifts installed in motor vehicles. This standard applies to motor vehicles equipped with a platform lift to carry passengers into and out of the motor vehicle. No cost teardown studies of this standard have been done, and none are currently

[63] The final rule establishing FMVSS No. 403 and No. 404 was published December 27, 2002, at 67 FR 79416, and appears in Docket No. NHTSA-2002-13917-0001.

planned by the agency. However, cost estimates made in the rulemaking process were combined with the discussion related to FMVSS No. 403.

FMVSS No. 500, Low-speed vehicles

FMVSS No. 500 became effective on June 17, 1998, and specifies requirements for low-speed vehicles to ensure that low-speed vehicles operated on the public streets, roads, and highways are equipped with minimum motor vehicle equipment appropriate for motor vehicle safety. A low-speed vehicle is a four-wheeled motor vehicle, other than a truck, whose top speed is greater than 20 mph, but not greater than 25 mph. Low speed vehicles are required to meet a very limited set of motor vehicle safety standards. As such, low speed vehicles are not comparable to passenger cars and LTVs from a motor vehicle safety cost perspective. Neither their sales nor their costs have been included in this analysis. No cost studies of this standard have been done, and none are currently planned by the agency.

Federal Register Notices reviewed for this analysis[64]

FMVSS No. 103, Windshield defrosting and defogging systems

April 27, 1968, (33 FR 6465), final rule for passenger cars and LTVs. NPRM on December 28, 1967, (32 FR 20865).

FMVSS No. 104, Windshield wiping and washing systems

February 3, 1967, (32 FR 2410), final rule for passenger cars. NPRM on December 3, 1966, (31 FR 15212).

April 27, 1968, (33 FR 6465), extended to LTVs. NPRM on December 28, 1967, (32 FR 20865). Several other standards were covered in the same NPRM and final rule, including FMVSS Nos. 103, 112, 113, 114, 202, 206, 219.

FMVSS No. 105, Braking systems

September 2, 1972, (37 FR 17970), final rule for FMVSS No. 105a for passenger cars and light trucks. NPRM on November 11, 1970, (35 FR 17345) effective September 1, 1974, (subsequently revised).

January 2, 1981, (46 FR 55), there was a requirement for an emergency brake warning switch among other things that was effective for the 1984 make-model LTVs. NPRM was October 18, 1979, (44 FR 60113).

FMVSS No. 108, Side marker lamps

February 3, 1967, (32 FR 2414), applicable to side marker lamps for both passenger cars and light trucks. NPRM on December 3, 1966, (31 FR 15212).

FMVSS No. 108, CHMSL

October 18, 1983, (48 FR 48235), CHMSL final rule for passenger cars. NPRM on January 8, 1981, at (46 FR 2132).

[64] Federal Register notices can be found online at federalregister.gov since 1994, and at govinfo.gov prior to 1994.

April 19, 1991, (56 FR 16015), extending center high mounted stop lamps to light trucks. NPRM on May 31, 1990, (55 FR 22039).

FMVSS No. 112, Headlamp concealment devices

April 27, 1968, (33 FR 6465), final rule for passenger cars and LTVs. NPRM on December 28, 1967, (32 FR 20865). Later added to FMVSS No. 108 and FMVSS No. 112 was reserved.

FMVSS No. 113, Hood latch systems

April 27, 1968, (33 FR 6465), final rule for passenger cars and LTVs. NPRM on December 28, 1967, (32 FR 20865).

FMVSS No. 114, Theft protection and rollaway prevention

March 30, 2010, (79 FR 15621), final rule on transmission shift interlock for passenger cars and LTVs. NPRM on August 25, 2009, (74 FR 42837).

FMVSS No. 118, Power-operated windows

July 23, 1970, (35 FR 11797), final rule for passenger cars and MPVs. NPRM on August 23, 1969, (34 FR 13608).

June 24, 1988, (53 FR 23766), final rule extended requirements to LTVs. NPRM on October 16, 1987, (52 FR 38488).

FMVSS No. 124, Accelerator control systems

April 8, 1972, (37 FR 7097), final rule for passenger cars and LTVs. NPRM on September 30, 1970, (35 FR 15241).

FMVSS No. 126, Electronic control systems

On April 6, 2007, (72 FR 17236), NHTSA published in the Federal Register a final rule on FMVSS No. 126 to require ESC on passenger cars and LTVs. NPRM on September 18, 2006, (71 FR 54712).

FMVSS No. 138, Tire pressure monitoring systems

April 8, 2005, (49 FR 18136), final rule for passenger cars and LTVs. NPRM on July 26, 2001, (66 FR 38984).

FMVSS No. 139, New pneumatic radial tires

June 26, 2003, (68 FR 38116), final rule for tires on passenger cars and LTVs. NPRM on March 5, 2002, (67 FR 10050).

FMVSS No. 141, Minimum sound requirements for hybrid and electric vehicles

December 14, 2016, (81 FR 90416), final rule for passenger cars and LTVs that are hybrid and electric vehicles. Petitions for reconsideration answered and effective dates amended February 26, 2018, (83 FR 8182). NPRM on January 14, 2013, (78 FR 2797).

FMVSS No. 201, Interior padding

February 3, 1967, (32 FR 2414) applicable to passenger cars. NPRM on December 3, 1966, (31 FR 15212).

November 29, 1979, (44 FR 68470), final rule extended to LTVs. NPRM on September 25, 1970, (35 FR 14936). Subsequent NPRM on November 9, 1978, (43 FR 52264).

FMVSS No. 201 was substantially upgraded for upper interior head protection on August 18, 1995, (60 FR 43031). The NPRM was published in the Federal Register on February 8, 1993, (58 FR 7506) applicable to passenger cars and LTVs.

The final rule amending FMVSS No. 201 allowing areas covered by dynamically deployed head restraints (window curtains) to be tested at 12 mph instead of 15 mph was published in the Federal Register on August 4, 1998, (63 FR 41451) and is in Docket No. NHTSA-1998-3847-0001.

FMVSS No. 202, Head restraints

February 14, 1968, (33 FR 2945), final rule for passenger cars. NPRM on December 28, 1967, (32 FR 20865).

September 25, 1989, (54 FR 39183), final rule extending requirements to LTVs. NPRM on December 13, 1988, (53 FR 50047).

December 4, 2004, (69 FR 74848), final rule head restraint upgrade for passenger cars and LTVs. NPRM on January 4, 2001, (66 FR 968).

FMVSS Nos. 203 and 204, Steering column system

February 3, 1967, (32 FR 2414), final rule for passenger cars. NPRM on December 3, 1966, (31 FR 15212).

November 29, 1979, (44 FR 68470) extended final rule to LTVs. NPRM November 9, 1978, (43 FR 52264).

FMVSS No. 205, Glazing materials

February 3, 1967, (32 FR 2410), final rule for passenger cars and LTVs. NPRM on December 3, 1966, (31 FR 15212).

FMVSS No. 206, Door locks

February 3, 1967, (32 FR 2414), final rule for door locks and door retention components for passenger cars. NPRM on December 3, 1966, (31 FR 15212).

January 24, 1969, (34 FR 1150), final rule for door locks and door retention components for LTVs. NPRM on December 28, 1967, (32 FR 20868).

September 28, 1995, (60 FR 50124), final rule extending standard to back doors for passenger cars and LTVs. NPRM on August 30, 1994, (59 FR 44691).

February 6, 2007, (72 FR 53385), final rule affecting sliding doors, only affected LTVs. NPRM on December 15, 2004, (69 FR 75020).

FMVSS No. 207, Seating systems

February 3, 1967, (32 FR 2414), final rule for seat back locks, only affected passenger cars. NPRM on December 3, 1966, (31 FR 15212).

FMVSS No. 208, Occupant crash protection

February 3, 1967, (32 FR 2414), required lap belts at all designated seating positions for passenger cars. NPRM on December 3, 1966, (31 FR 15212). This rule also required shoulder belts at the front outboard seats of passenger cars if the lap belts could not keep the dummy from contacting the windshield header in static tests. Since the lap belts could not keep the dummy from contacting the windshield header, this rule in effect required shoulder belts for the front outboard seats of passenger cars effective January 1, 1968.

May 7, 1970, (35 FR 7187), initial NPRM for automatic occupant protection, did not become a final rule.

September 30, 1970, (35 F.R., 1970), final rule extending 208 (lap belts at all designated seating positions) to LTVs. NPRM on September 20, 1969, (34 FR 14660).

November 3, 1970, (35 FR 16927), final rule for passenger cars and LTVs to permit automatic occupant protection as one of three ways to comply with FMVSS No. 208. NPRM was published on May 7, 1970, (35 FR 7187).

March 1, 1971, (35 FR 4600), final rule amending FMVSS No. 208 to require lap belts to have emergency-locking or automatic-locking retractors at all outboard seating positions (front and rear) and lap/shoulder belts at front outboard seats to have manual or emergency locking retractors for both passenger cars and LTVs. NPRM on retractors on September 25, 1970, (35 FR 14941).

March 10, 1971, (36 FR 4600), final rule extended the requirement for 3-point belts at front outboard seats to most LTVs. July 9, 1975, (40 FR 28805), a final rule amended the effective date to January 1, 1976. The NPRM for the March 10, 1971, final rule was published on September 25, 1970, (35 FR 14941).

June 20, 1973, (38 FR 16072), final rule amending FMVSS No. 208 to require integral 3-point belts at front outboard seats in passenger cars. NPRM on April 20, 1973, (38 FR 9830).

July 9, 1975, (40 FR 28805), final rule amending FMVSS No. 208, extending 3-point belts at front outboard seats to LTVs. NPRM on June 3, 1975, (40 FR 23897).

July 5, 1977, (42 FR 34289), final rule requiring automatic occupant protection at front outboard seats in passenger cars. NPRM on June 14, 1976, (41 FR 24070), rescinded in 1981 before its effective date.

July 17, 1984, (49 FR 28962), final rule amending FMVSS No. 208 to require automatic occupant protection at front outboard seats in passenger cars. NPRM on October 14, 1983, (48 FR 48622).

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May 23, 1995, (60 FR 27233), final rule amending FMVSS No. 208 to allow manual on-off switches for passenger air bags in pickup trucks and other vehicles with small or no rear seats. NPRM on October 7, 1994, (59 FR 51158).

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December 8, 2004, (69 FR 70904), final rule requiring 3-point belts for center rear seats for passenger cars and LTVs. NPRM was published August 6, 2003, (68 FR 46546).

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FMVSS No. 212, Windshield mounting

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FMVSS No. 214, Side impact

October 30, 1970, (35 FR 16801), final rule establishing FMVSS No. 214 (side door strength, passenger cars). NPRM on December 11, 1968, (33 FR 18386), first NPRM.

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June 14, 1991, (56 FR 27427), final rule extending FMVSS No. 214 side door strength requirement to LTVs. NPRM on December 22, 1989, (54 FR 52826).

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September 11, 2007, (72 FR 51908), final rule adding a pole test to FMVSS No. 214, Side impact protection for passenger cars and LTVs. NPRM published in the Federal Register on May 17, 2004, (69 FR 27990).

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FMVSS No. 219, Windshield zone intrusion

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FMVSS No. 225, lower anchors and tethers for children – LATCH

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NPRM on February 20, 1997, (62 FR 7858).

FMVSS No. 226, Ejection mitigation

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FMVSS No. 401, Interior trunk release

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Appendix A: Learning Curve Sensitivity Analysis

Since the learning curve is an important concept that affects the overall cost estimate, it is appropriate to determine how sensitive the results are based on the assumptions made in the analysis related to the learning curve. Based on cost teardown data, Table 6 shows the progress rates for five safety technologies. The main analysis uses the progress rates derived for those five technologies and extends them to other very similar technologies (for example a 0.96 progress rate is applied to all manual seat belt technologies), and then uses an average progress rate of 0.93 for almost all of the other safety technologies not in Table 6.

The goal of this exercise is to determine how sensitive the cost estimates are based on an analysis reflecting a range of possible learning rates. We view this as a useful exercise if only to indicate the possible degree of error in our estimates due to learning.

For this exercise we are comparing the total cost and the trend in costs of five calculations for both passenger cars and LTVs. Based on the estimates of progress rates in Table 6, we have chosen the highest (0.96), lowest (0.87), and average (0.93) progress rates and applied them to every safety technology where we had applied learning before. We compare those to the results from the main analysis, along with the costs if we assumed no learning at all. The No Learning sensitivity analysis takes cost estimates from the teardown studies and assumes, for example:

If there is only one teardown analysis (for MY 2000 vehicles), the same costs are applied to every MY that the technology was installed (MYs 1990 to 2019 in this example).

If there are two teardown analyses (for MYs 1992 and 2000) and there was no specific knowledge about when technology or costs changed, the MY 1992 costs apply to the MYs 1990 to 1992 vehicles, a linear interpolation of costs between the two years would apply to MYs 1993 to 1999 vehicles, then the MYs 2000 costs would apply to MY 2000 to 2019 vehicles.

Table A-1 shows the results of the learning curve sensitivity analysis for MY 2019 vehicles. Total costs are compared to the main analysis results on a dollar basis and a percentage basis, and total costs are compared to the average price paid for a passenger car or LTV. Several observations about the results of Table A-1 are:

- The impact of applying the learning curve, compared to assuming that there is no learning taking place for MY 2019 vehicles, are $535.08 for passenger cars and $478.04 for LTVs. This amounts to a reduction in estimated safety costs of 22.0 percent for passenger cars and 21.1 percent for LTVs by applying the main analysis learning curve assumptions.
- There is a small difference in costs of applying a progress rate of 0.93 compared to the main analysis. This would be expected since we assume a 0.93 progress rate for almost all safety technologies for which we don’t have specific data. The difference for passenger cars is -$13.10 and the difference for LTVs is -$8.65.
- The difference in costs of applying a progress rate of 0.96 compared to the main analysis is $174.52 for passenger cars and $171.27 for LTVs. The percentage difference is 7.2 percent for passenger cars and 7.5 percent for LTVs.
- The difference in costs of applying a progress rate of 0.87 compared to the main analysis is -$336.79 for passenger cars and -$320.87 for LTVs. The percentage difference ranges from -13.9 percent for passenger cars to -14.1 percent for LTVs.

- The difference in the percentage of the cost of a new passenger car or LTV that the FMVSS costs comprise, given that a progress rate of 0.87, 0.93, 0.96, no learning, or the main analysis range from 7.9 percent to 11.2 percent for passenger cars and 5.1 percent to 7.2 percent for LTVs.

Table A-1. Sensitivity analysis of learning curve costs for MY 2019 vehicles – voluntary and attributable costs (in 2019$)

Passenger Cars Progress Rate	**Cost**	**Difference From Main Analysis**		**Percent of Average Price Paid per Car $26,385**
		$	**Ratio**	
0.87	$2,091.18	-336.79	0.861	7.9%
0.93	$2,414.87	-$13.10	0.995	9.2%
Main Analysis	$2,427.97	$0.00	1.000	9.2%
0.96	$2,602.49	$174.52	1.072	9.9%
No Learning	$2,963.04	$535.08	1.220	11.2%

LTVs Progress Rate	**Cost**	**Difference From Main Analysis**		**Percent of Average Price Paid per LTV $38,207**
		$	**Ratio**	
0.87	$1,948.34	-336.79	0.859	5.1%
0.93	$2,260.56	-$8.65	0.996	5.9%
Main Analysis	$2,269.21	$0.00	1.000	5.9%
0.96	$2,440.48	$171.27	1.075	6.4%
No Learning	$2,747.25	$478.04	1.211	7.2%

Table A-2 shows a sensitivity analysis of different progress rates over time. Table A-3 shows how those results compare to the main analysis. Several observations about the results of Table A-2 and Table A-3 are:

- As a reminder of how the learning curve works, if we have a cost estimate for MY 2000 vehicles, the learning curve will assign higher costs for MYs prior to MY 2000 based on the learning curve going backwards and lower costs for MYs after MY 2000 as manufacturers learn how to produce their products more efficiently. The results of this method appear in MY 1970 when the costs with progress rates can be slightly higher than the costs with no learning.

- For some of the more important early standards, NHTSA had several teardown studies years apart. As a result, the learning curve was not used for some of the standards in the early years and the teardown results were used for cost estimation.
- Comparing the main analysis to no learning in Table A-3 (dividing estimated costs for no learning at the 1.00 progress rate by estimated costs of the main analysis), the impact of the learning curve is relatively small in MY 1970 to 1980 (at most 3 percentage points). The impact of the learning curve grows over time as more years accumulate and more technologies are added. By MY 2019, if a learning curve was not assumed, costs would be 22.0 percent higher for passenger cars and 21.1 percent higher for LTVs.
- For MYs 1980 to 2019 shown in Table A-2, costs typically increase as the progress rate increases from 0.87, to 0.93, to the main analysis, to 0.96, and to no learning, with the exception of passenger cars and LTVs in MY 1990 and 2000. The ups and downs of the LTV costs in MY 1990 can be explained by examining how rear-wheel ABS costs were estimated. Table A-4 shows in detail what happens in MY 1990 for LTVs. Similar results occur for MY 2000 for LTVs and MYs 1990 and 2000 for passenger cars. Essentially, the cost teardown study used in the main analysis was based on MYs 2004 and 2005 vehicles with a 0.87 progress rate. With the learning curve methodology, the cost estimates are higher in MY 2000 and even higher in MY 1990, than in MY 2005. Furthermore, in the sensitivity analysis, the costs are different because we change the progress rate from 0.87 to 0.93 and 0.96. The second column in Table A-4 shows an example of how the costs change based on the different progress rates chosen for the sensitivity analysis.
- Here is a more detailed analysis for Table A-4 for LTVs in MY 1990. Two teardown studies of 4-wheel ABS were the basis of the 0.87 progress rate. The rear-wheel ABS was estimated to cost 93.57 percent of the cost of 4-wheel ABS. The vehicles used in the cost teardown study were MY 2004 to 2005 vehicles, with an average estimated cost of $472.75 for 4-wheel ABS. Thus, the rear-wheel ABS costs would be $442.35 ($472.75 * 0.9357), which was used as the no learning cost for MYs 2004 to 2019. Based on the learning curve analysis, the estimate of cost was built up for years prior to the MY 2005 cost of $442.35, based on the progress rate. Because ABS was one of the technologies used to determine progress rates in Table 6, the 0.87 progress rate was used for both the main analysis and the 0.87 sensitivity analysis (both had an average cost per LTV in 1990 of rear-wheel ABS of $773.54), and the costs are close to the no learning sensitivity analysis ($794.56), as would be expected. For MY 1990, the 0.93 sensitivity cost for LTVs was $591.92 and the 0.96 sensitivity cost for MY 1990 LTVs was $521.12. As the progress rate goes up compared to the 0.87 progress rate, the cost per vehicle for rear-wheel ABS is lower resulting in the strange-looking result. Rear-wheel ABS was installed in 69.9 percent of LTVs in MY 1990 and only 1.9 percent of LTVs had 4-wheel ABS. Table A-4 shows the calculations of the values used in the sensitivity analysis for rear-wheel ABS. These large differences in the MY 1990 LTV rear-wheel ABS costs explain most of the differences in costs in the sensitivity analysis in Table A-2 for LTVs in MY 1990. For the 0.93 sensitivity analyses the rear-wheel ABS difference of $126.95 (Table A-4) is 90.70 percent of the difference found in Table A-2 for MY 1990 of $140.06 ($968.80 - $828.74). For the 0.96 sensitivity analyses the rear-wheel ABS difference of $176.44 (Table A-4) is 100.8 percent of the difference found in Table A-2 for MY 1990 of $175.06 ($968.80 - $793.74).

Table A-2. Sensitivity analysis of learning curve costs over time – voluntary and attributable costs (in 2019$)

Passenger Car Progress Rate	**MY 1970**	**MY 1980**	**MY 1990**	**MY 2000**	**MY 2010**	**MY 2019**
0.87	$453.58	$544.54	$866.96	$1,572.59	$2,078.32	$2,091.18
0.93	$450.72	$563.72	$880.50	$1,602.28	$2,253.79	$2,414.87
Main Analysis	$449.25	$569.62	$911.59	$1,631.95	$2,269.82	$2,427.97
0.96	$449.61	$574.04	$891.35	$1,621.46	$2,352.31	$2,602.49
No Learning	$444.87	$588.99	$978.95	$1,759.17	$2,562.46	$2,963.04
Change From Main Analysis to No Learning	0.99	1.03	1.07	1.08	1.13	1.22

LTVs Progress Rate	**MY 1970**	**MY 1980**	**MY 1990**	**MY 2000**	**MY 2010**	**MY 2019**
0.87	$226.46	$367.76	$930.02	$1,433.42	$2,009.61	$1,948.34
0.93	$222.88	$376.09	$828.74	$1,459.76	$2,177.35	$2,260.56
Main Analysis	$221.85	$378.99	$968.80	$1,493.97	$2,187.59	$2,269.21
0.96	$221.34	$380.96	$793.74	$1,476.53	$2,270.97	$2,440.48
No Learning	$219.48	$388.22	$1,016.54	$1,614.72	$2,436.75	$2,747.25
Change From Main Analysis to No Learning	0.99	1.02	1.05	1.08	1.11	1.21

Table A-3. Change in costs comparing different progress rate cost to main analysis cost – voluntary and attributable costs

Passenger Cars Progress Rate	**MY 1970**	**MY 1980**	**MY 1990**	**MY 2000**	**MY 2010**	**MY 2019**
0.87	1.01	0.96	0.95	0.96	0.92	0.86
0.93	1.00	0.99	0.97	0.98	0.99	0.99
Main Analysis	1.00	1.00	1.00	1.00	1.00	1.00
0.96	1.00	1.01	0.98	0.99	1.04	1.07
No Learning	0.99	1.03	1.07	1.08	1.13	1.22

LTVs Progress Rate	MY 1970	MY 1980	MY 1990	MY 2000	MY 2010	MY 2019
0.87	1.02	0.97	0.96	0.96	0.92	0.86
0.93	1.00	0.99	0.86	0.98	1.00	1.00
Main Analysis	1.00	1.00	1.00	1.00	1.00	1.00
0.96	1.00	1.01	0.82	0.99	1.04	1.08
No Learning	0.99	1.02	1.05	1.08	1.11	1.21

Table A-4. MY 1990 rear-wheel ABS costs: Weights

LTVs Progress Rate	Base Cost	MY 1990 Percent with Rear-wheel ABS	Average Cost of Rear-wheel ABS per LTV	Difference From Main Analysis
0.87	$773.54	69.9%	$540.70	0
0.93	$591.92	69.9%	$413.75	-$126.95
Main Analysis 0.87	$773.54	69.9%	$540.70	0
0.96	$521.12	69.9%	$364.26	-$176.44
No Learning	$794.56	69.9%	$555.40	$14.70

Appendix B: Learning Curve Application Factors

Table B-1. Learning curve application factors for passenger cars

FMVSS	Description	Base Teardown Model Year	PC Attributable Model Year	Learning Applied to Model Years	Learning Rate
104	Windshield Wiping and Washing	1968	None	1968 – 2019	7%
105	Dual Master Cylinder	1982, but estimates prior to 1977	None	1982 – 2019	5%
105	Antilock Braking System (ABS) Four-wheel	2005	2008	1986 – 2019	13%
105	Antilock Braking System (ABS) Rear-wheel	2005	None	1987-1989	13%
105	Power Booster	1977, but previous estimates in 1966, 1968, and 1976	1972	1977 – 2019	7%
108	Side Marker Lamps	1980, but previous estimates in 1969 and 1970	1968	1982 – 2019	7%
108	Center High Mounted Stop Lamps	1986	1985	1985 – 2019	7%
108	Amber Rear Turn Signals	1982	None	1968 – 2019	7%
111	Outside Rearview Mirror	1981	1968	1968 – 2019	7%
111	Rear Visibility Cameras	2010	2012	2008 – 2019	7%
113	Hood Latch System	1968	None	1972 – 2019	7%
118	Power Windows	1982	1971	1971 – 2019	7%
118	Power Windows ARS	2009	None	1995 – 2019	7%
124	Accelerator Controls	1982	1973	1973 – 2019	7%

FMVSS	Description	Base Teardown Model Year	PC Attributable Model Year	Learning Applied to Model Years	Learning Rate
126	Electronic Stability Control	2005	2008	1998 – 2019	7%
138	Tire Pressure Monitoring System – Direct	2008	2002	2001 – 2019	7%
138	Tire Pressure Monitoring System – Indirect	2014	2002	2000 – 2019	7%
139	Tire Upgrade	2003	2007	1994 – 2019	7%
141	Minimum Sound Requirements	2013	2014	2011 – 2019	7%
201	Glove Box Latch	1968	1968	1968 – 2019	7%
201	Instrument Panel	1969	1968	1968 – 2019	7%
201	Seat Back Padding	1968	1968	1968 – 2019	7%
201	Upper Interior Protection	2001	1999	1999 – 2019	7%
202	Head Restraints Front Outboard	1978	1969	1982 – 2019	9%
202	Head Restraints Front Outboard Upgrade	2010	2009	2009 – 2019	9%
202	Head Restraints Rear	1978	None	1992 – 2019	9%
203/204	Steering Assembly	1969	1968	1968 – 2019	7%
205	HPR Windshield	1969	None	1968 – 2019	7%
207	Seat Back Locks	1986, with previous estimate in 1969	1968	1980 – 2019	7%
208	Lap belts – front seat outboard	1973, with previous estimates in 1968	1968	Not used	N.A.
208	Lap belts – front seat center	1980, with previous	None	1968 – 2012	4%

FMVSS	Description	Base Teardown Model Year	PC Attributable Model Year	Learning Applied to Model Years	Learning Rate
		estimates in 1968-74			
208	Lap belts – rear seat outboard	1980, with both earlier and later estimates	None	1972 – 1989	4%
208	Lap belts – rear seat center	1992, with several previous estimates	1968	1968 – 2007	4%
208	Lap/shoulder – front seat outboard	1992, with several previous estimates	1968	1992 – 2019	4%
208	Lap/shoulder – rear seat outboard	1990, with previous estimate in 1971	1972	1972 – 2019	4%
208	Lap/shoulder – rear seat center	2000	1994	1994 – 2019	4%
208	Automatic belt – front seat outboard – 2-pt. non-motorized passive lap with knee bolster	1975	1987	1975 - 1982	5.2%
208	Automatic belt – front seat outboard – 2-pt, non-motorized active shoulder belt with knee bolster	1987	1987	1987 - 1990	4.53%
208	Automatic belt – front seat outboard – separate passive lap belt and non-motorized active 2-pt. shoulder belt with no knee bolster	1991	1987	1991 - 1995	4%
208	Automatic belt – front seat outboard –	1987	1987	1987 – 1996	4.47%

FMVSS	Description	Base Teardown Model Year	PC Attributable Model Year	Learning Applied to Model Years	Learning Rate
	3-pt. non-motorized with no knee bolster				
208	Automatic belt – front seat outboard passive lap belt with 2-pt. motorized shoulder belt and knee bolster	1987	1987	1981 - 1996	5.12%
208	Air bag - driver	2007, plus 1987 and 1992-1996	1985	2007 – 2019	7%
208	Air bag – passenger	2007, plus 1992-1996	1987	2004 – 2019	7%
208	Pretensioners and load limiters – front seat	1999	None	1995 – 2019	4%
208	Pretensioners and load limiters – rear seat	1999	None	1998 – 2019	4%
208	Adjustable anchors	1999	1995	1989 – 2019	4%
208	Manual on-off Switch	1998	None	1998 – 2009	7%
214	Side Door Beams	1979	1970	1969 – 2019	7%
214	Dynamic Test	1996	1989	1986 – 2019	7%
214	Side Air Bags – Front Torso Bags	2001	2005	1996 – 2019	7%
214	Side Air Bags – Combination Bags	2001	2005	1999 – 2019	7%
214	Side Air Bags – Window Curtains	2001	2005	1998 – 2019	7%
214	Side Air Bags – Rear Torso Bags	2001	None	2004 – 2019	7%
216	Roof Crush Initial Standard	1974	1974	1974 – 2019	7%
216	Roof Crush Upgrade	2013	2012	2004 – 2019	2%

FMVSS	Description	Base Teardown Model Year	PC Attributable Model Year	Learning Applied to Model Years	Learning Rate
225	LATCH - Lower Anchors and Tethers for Children	2012	2000	2001 – 2019	7%
226	Ejection Mitigation - Rollover Sensor	2005	2011	2003 – 2019	7%
226	Ejection Mitigation - Window Curtain	2005	2012	2012 – 2019	7%
301	Fuel System Integrity 1976-78	1976	1976	1976 – 2019	2%
301	Fuel System Integrity - 2007-2009	2008	2007	1996 – 2019	2%
401	Interior Trunk Release	2002	2002	2000 – 2019	7%

Table B-2. Learning curve application factors for LTVs

FMVSS	Description	Base Teardown Model Year	LTV Attributable Model Year	Learning Applied to Model Years	Learning Rate
104	Windshield Wiping and Washing	1969	None	1968 – 2019	7%
105	Dual Master Cylinder	1982, but estimates prior to 1977	None	1982 – 2019	5%
105	Antilock Braking System (ABS) Four-Wheel	2005	2008	1989 – 2019	13%
105	Antilock Braking System (ABS) Rear-Wheel	2005	None	1987 – 2003	13%
105	Power Booster	1977, but previous estimates in 1966, 1968, and 1976	1972	1977 – 2019	7%
105	Brake Warning Light	1984	1984	1968 – 2019	7%
108	Side Marker Lamps	1980, but previous estimates in 1969 and 1970	1968	1982 – 2019	7%
108	Center High Mounted Stop Lamps	1986	1991	1991 – 2019	7%
108	Amber Rear Turn Signals	1982	None	1972 – 2019	7%
111	Outside Rearview Mirror	1981	None	1968 – 2019	7%
111	Rear Visibility Cameras	2010	2012	2008 – 2019	7%
113	Hood Latch System	1968	None	1972 – 2019	7%
118	Power Windows	1982	MPVs 1978	1978 – 2019	7%

FMVSS	Description	Base Teardown Model Year	LTV Attributable Model Year	Learning Applied to Model Years	Learning Rate
			Trucks 1988		
118	Power Windows ARS	2009	None	1995 – 2019	7%
124	Accelerator Controls	1982	1973	1973 – 2019	7%
126	Electronic Stability Control	2005	2008	1999 – 2019	7%
138	Tire Pressure Monitoring System – Direct	2008	2002	2001 – 2019	7%
138	Tire Pressure Monitoring System – Indirect	2014	2002	2000 – 2019	7%
139	Tire Upgrade	2003	2007	1994 – 2019	7%
141	Minimum Sound Requirements	2013	2014	2013 – 2019	7%
201	Glove Box Latch	1979	1971	1979 – 2019	7%
201	Instrument Panel	1979	1971	1971 – 2019	7%
201	Seat Back Padding	1979	1980	1980 – 2019	7%
201	Upper Interior Protection	2001	1999	1999 – 2019	7%
202	Head Restraints Front Outboard	1978	1990	1982 – 2019	9%
202	Head Restraints Front Outboard Upgrade	2010	2009	2009 – 2019	9%
202	Head Restraints Front Center Seat	2010	None	2004 – 2019	9%
202	Head Restraints Rear	1978	None	1992 – 2019	9%
203/204	Steering Assembly	1969	1980	1968 – 2019	7%
205	HPR Windshield	1969	None	1968 – 2019	7%
206	Door locks - Sliding doors on LTVs	1975	2006	1968 – 2019	7%

FMVSS	Description	Base Teardown Model Year	LTV Attributable Model Year	Learning Applied to Model Years	Learning Rate
208	Lap belts – front seat outboard	1973, with previous estimates in 1968	1968	1972 – 1980	4%
208	Lap belts – front seat center	1980, with previous estimates in 1968-74	none	1968 – 2019	4%
208	Lap belts – rear seat outboard	1980, with both earlier and later estimates	None	1972 – 1991	4%
208	Lap belts – rear seat center	2003, with several previous estimates	None	1968 – 2007	4%
208	Lap/shoulder – front seat outboard	1989, with several previous estimates	1972	1972 – 2019	4%
208	Lap/shoulder – front seat center	2010	None	2002 – 2019	4%
208	Lap/shoulder – rear seat outboard	1990, with previous estimate in 1971	1987	1987 – 2019	4%
208	Lap/shoulder – rear seat center	2010	2004	1998 – 2019	4%
208	Air bag - driver	2007	1992	2007 – 2019	7%
208	Air bag – passenger	2007	1994	2004 – 2019	7%
208	Pretensioners and load limiters – front seat	1999	None	1995 – 2019	4%
208	Pretensioners and load limiters – rear seat	1999	None	1998 – 2019	4%
208	Adjustable anchors	1999	1995	1990 – 2019	4%

FMVSS	Description	Base Teardown Model Year	LTV Attributable Model Year	Learning Applied to Model Years	Learning Rate
208	Manual on-off Switch	1998	None	1997 – 2011	7%
214	Side Door Beams	1994	1991	1991 – 2019	7%
214	Side Air Bags – Front Torso Bags	2001	2005	1998 – 2019	7%
214	Side Air Bags – Combination Bags	2001	2005	1999 – 2019	7%
214	Side Air Bags - Window Curtains	2001	2005	2000 – 2019	7%
214	Side Air Bags – Rear Torso Bags	2001	None	2010 – 2019	7%
216	Roof Crush Upgrade	2013	2013	2004 – 2019	2%
225	LATCH - Lower Anchors and Tethers for Children	2012	2001	2001 – 2019	7%
226	Ejection Mitigation - Rollover Sensor	2005	2011	2002 – 2019	7%
226	Ejection Mitigation - Window Curtain	2005	2012	2007 – 2019	7%
301	Fuel System Integrity 1976-78	1976	1977	1977 – 2019	2%
301	Fuel System Integrity - 2007-2009	2008	2007	1996 – 2019	2%

Notes:

The third column shows the model year for which the original teardown estimates were developed.

The fourth column shows the first-year costs that were attributable to the FMVSS.

The fifth column shows the years for which the learning curve was applied. In some cases, these years are earlier than the attributable year, because learning was applied to voluntary compliance

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