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Cost and Weight Added by the Federal Motor Vehicle Safety Standards for Model Years 1968-2001 in Passenger Cars and Light Trucks

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16. Abstract

The National Highway Traffic Safety Administration (NHTSA) began to evaluate the cost of its Federal Motor Vehicle Safety Standards (FMVSS) in 1975. The agency's contractors perform detailed engineering "teardown" analyses, for representative samples of vehicles, to estimate how much specific FMVSS add to the weight and the retail price of a vehicle. This process is also known as "reverse engineering." By July 2004, NHTSA and its contractors had evaluated virtually all the cost-and weight-adding technologies introduced by 2001 in passenger cars and light trucks (including pickup trucks, sport utility vehicles, minivans, and full-size vans) in response to the FMVSS. The agency is now ready to estimate the cost and weight added by all the FMVSS, and by each individual FMVSS, to model year 2001 passenger cars and light trucks, and also in all earlier model years, back to 1968. NHTSA estimates that the FMVSS added an average of $839 (in 2002 dollars) and 125 pounds to the average passenger car in model year 2001. Approximately four percent of the cost and four percent of the weight of a new passenger car could be attributed to the FMVSS. An average of $711 (in 2002 dollars) and 86 pounds was added to the average light truck in model year 2001. Approximately three percent of the cost and two percent of the weight of a new truck could be attributed to the FMVSS.

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ACKNOWLEDGEMENTS

In 1975, NHTSA proposed to evaluate the costs as well as the benefits of existing Federal Motor Vehicle Safety Standards (FMVSS). 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 FMVSS was awarded in 1977 and completed in 1978. During 1978-2001, Robert Lemmer, Bruce Spinney, Gregory Rymarz, or Mr. LaHeist managed the cost-analysis program. Mr. Spinney also developed NHTSA's "macro-analysis" for computing mark-ups from direct 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 1998-2002 Evaluation Plan and again in the 2004-2007 plan. Mr. LaHeist outlined the report in 1998-1999 and drafted text for some of the FMVSS. After Mr. LaHeist retired, Mr. Rymarz worked up initial spreadsheets and/or text for many of the remaining FMVSS in 1999-2001. I was assigned to the cost-analysis program, as well as this report, when I joined NHTSA in 2002.

EXECUTIVE SUMMARY

The National Highway Traffic Safety Administration (NHTSA) issues Federal Motor Vehicle Safety Standards (FMVSS) for new motor vehicles and equipment to reduce the number of crashes and the risk of deaths and injuries. The 100-series FMVSS are crash avoidance standards, the 200-series regulates crashworthiness, while 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 FMVSS. The initial FMVSS went into effect on January 1, 1968.

NHTSA began to evaluate the cost of the FMVSS in 1975. The agency's contractors perform detailed engineering "teardown" analyses, for representative samples of vehicles, to estimate how much specific FMVSS add to the weight and the retail price 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, and estimates the labor, variable burden, and tooling required to produce individual components and assemble them. In addition to these direct variable costs, the contractor estimates the mark-ups to the consumer's full cost.

By July 2004, NHTSA and its contractors had evaluated virtually all the cost- and weight-adding technologies introduced by 2001 in passenger cars and light trucks (including pickup trucks, sport utility vehicles, minivans, and full-size vans) in response to the FMVSS. The agency is now ready to estimate the cost and weight added by all the FMVSS, and by each individual FMVSS, to model year 2001 passenger cars and light trucks, and also in all earlier model years, back to 1968. All costs are estimated in 2002 dollars. Upon publication of this report, NHTSA will also make available to the public all the contractor studies completed to date.

The cost of a FMVSS, in this report, includes the cost of all equipment added or modified primarily for the purpose of meeting (or even exceeding) the requirements of the standard, provided these modifications took place on or after the effective date, or even before the effective date if NHTSA had a rulemaking process underway and there was a clear anticipation of the standard. (But if safety equipment was already in place well before any rulemaking process, and was not modified in response to any FMVSS, its cost will not be attributed to the FMVSS.) The cost of a FMVSS is the incremental cost over the equipment that was there before the standard and likely would have remained there without the standard. In addition, the cost of a FMVSS may change over time, as a result of more efficient design, new types of materials, or vehicle downsizing (if the weight of the equipment is proportional to the weight of the vehicle).

The report does not include technologies so recent that NHTSA has not yet completed its cost analysis, such as side air bags and head air bags. Furthermore, the report is limited to passenger cars and light trucks; the cost of FMVSS in heavy trucks, buses or motorcycles has not been estimated.

The Cost and Weight Added by the FMVSS in Model Year 2001. NHTSA estimates that the FMVSS added an average of $839 (in 2002 dollars) and 125 pounds to the average passenger car in model year 2001. Since passenger cars cost an average of $21,217 (in 2002 dollars) and weighed 3,148 pounds in model year 2001, approximately four percent of the cost and four percent of the weight of a new passenger car could be attributed to the FMVSS. An average of $711 (in 2002 dollars) and 86 pounds was added to the average light truck in model year 2001. With light trucks costing an average of $23,995 (in 2002 dollars) and weighing 4,238 pounds in model year 2001, approximately three percent of the cost and two percent of the weight of a new truck could be attributed to the FMVSS.[1] Table 1 itemizes the cost and weight added by the FMVSS, or by specific safety technologies associated with these FMVSS, to passenger cars and light trucks in model year 2001.

TABLE 1
COST (IN 2002 DOLLARS) AND WEIGHT (IN POUNDS)
ADDED BY THE FMVSS IN MODEL YEAR 2001[2]

FMVSS	DESCRIPTION	PASSENGER CARS		LIGHT TRUCKS	
		COST	WEIGHT	COST	WEIGHT
104	Windshield Wipers and Washers				
	Dual speed wipers, washers			$15.05	2.10
105	Hydraulic Brake System				
	Dual master cylinders	$10.88	0.95	11.00	0.96
108	Lamps				
	Side marker lamps	29.37	1.95	29.37	1.95
	Center high mounted stop lamps	9.74	0.85	9.74	0.85
118	Power-Operated Window				
	Circuit breaker	0.78	0.03	0.77	0.03
124	Accelerator Control System	0.47	0.02	0.47	0.02
201	Occupant Protection in Interior Impact (1968/1981 Standard)				
	Seat back padding	4.44	0.66	11.25	3.15
202	Head Restraints	30.89	5.63	30.97	3.98
203/204	Occupant Protection from the Steering Control System	27.45	1.89	27.45	1.89
207	Seating Systems				
	Seat back locks	3.22	0.79		
208	Occupant Crash Protection				
	Safety belts	124.63	18.38	137.57	18.41
	Dual air bags	396.72	26.76	382.52	26.40
	On/off switches			8.75	0.20
214	Side Impact Protection				
	Static test	51.21	24.81	29.44	23.76
	Dynamic test	129.35	37.31		
216	Roof Crush Resistance	3.47	2.93		
301	Fuel System Integrity	16.51	2.48	16.51	2.48
TOTAL		$839.13	125.44	$710.86	86.18

[1] The average cost of the 2001 passenger cars and light trucks are based on the Manufacturer's Suggested Retail Price (MSRP). The MSRP cost for the 2001 passenger car and light truck does not include price reductions such as rebates or incentives offered by the dealer and/or the manufacturer, nor does it include price additions such as added charges and optional features.

[2] Average cost and weight per model year 2001 vehicle. For example, if a safety device costs $100 and 50% of the vehicles are equipped with it; the average cost per vehicle is $50.

Those technologies that contributed most significantly to the cost and weight of a passenger car and light truck in 2001 are:

- ***<u>Safety Belts</u>***. The primary component of the occupant protection system is the safety belt. They are highly effective in saving lives and preventing serious injuries in rollovers, frontal crashes, and many types of side impacts. Safety 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 are now equipped with manual 3-point belts. These technologies add $124.63 and 18.38 pounds to passenger cars and $137.57 and 18.41 pounds to light trucks.

- ***<u>Frontal Air Bags</u>***. By the late 1990's, passenger cars and light trucks were equipped with a frontal air bag and a manual lap/shoulder belt at both the driver's and right front passenger's seating position. The air bags are designed to save lives and prevent injuries by cushioning occupants as they move forward in a frontal crash, reducing the likelihood of injury to an occupant's head, neck, face, chest, and abdomen. Dual air bags add $396.72 and 26.76 pounds to passenger cars and $382.52 and 26.40 pounds to light trucks.

- ***<u>Side Impact Protection</u>***. Vehicle side structures are substantially reinforced and padded to meet NHTSA's static crush tests and dynamic crash tests and reduce the risk of serious and fatal injury to occupants in side impact crashes. These changes add $180.56 and 62.12 pounds to passenger cars and $29.44 and 23.76 pounds to light trucks.

- ***<u>Lamps</u>***. Side marker lamps and center high mounted stop lamps (CHMSL) are two new lighting systems required by FMVSS 108. Side marker lamps make it easier to see the side of another vehicle in the dark. CHMSL send an additional message to following vehicles that they must slow down. These lamps add a total of $39.11 and 2.80 pounds to passenger cars and light trucks.

- ***<u>Head Restraints</u>***. Adjustable or fixed head restraints are required at the front outboard seat positions to reduce the frequency and severity of neck injuries, specifically "whiplash", in rear-end and other collisions. Implementation of the head restraints adds $30.89 and 5.63 pounds to passenger cars and $30.97 and 3.98 pounds to light trucks.

- ***<u>Energy Absorbing Assemblies.</u>*** FMVSS 203 requires that the steering control systems yield forward to cushion the impact of a front-end crash on the driver's chest and FMVSS 204 limits the rearward displacement of the steering column into the passenger compartment after a frontal impact. These changes add $27.45 and 1.89 pounds to passenger cars and light trucks.

Historical trend of the cost and weight added by the FMVSS for model years 1968-2001. The initial FMVSS of 1968 added $169 and 18 pounds to the average passenger car in model year 1968. By model year 2001, the cost had grown to $839 (in constant, 2002 dollars) and the weight to 125 pounds. In light trucks, the cost and weight of the FMVSS grew from $107 and 11 pounds in 1968 to $711 and 86 pounds in 2001. Table 2 shows the cost and weight added by the FMVSS in vehicles of each model year from 1968 to 2001.

TABLE 2
COST (IN 2002 DOLLARS) AND WEIGHT (IN POUNDS) ADDED BY THE FMVSS FOR MODEL YEARS 1968-2001

MODEL YEAR	PASSENGER CARS		LIGHT TRUCKS	
	COST	WEIGHT	COST	WEIGHT
1968	$169.24	18.39	$106.58	10.51
1969	$216.05	33.15	$106.64	10.52
1970	$236.02	40.21	$115.95	11.07
1971	$241.47	43.35	$116.24	11.10
1972	$268.24	49.82	$142.26	15.90
1973	$291.23	63.09	$154.61	16.75
1974	$301.97	70.48	$160.79	17.59
1975	$299.54	68.64	$160.87	17.61
1976	$312.58	69.07	$162.27	17.71
1977	$306.66	66.68	$173.14	19.02
1978	$302.85	64.41	$189.14	21.46
1979	$299.58	62.33	$191.06	21.59
1980	$298.26	62.33	$195.96	21.96
1981	$297.87	61.33	$196.63	22.02
1982	$297.25	60.72	$206.92	23.68
1983	$297.61	60.38	$212.12	24.35
1984	$297.66	60.42	$214.28	24.61
1985	$298.29	60.24	$216.33	24.88
1986	$299.50	60.20	$216.81	24.94
1987	$338.32	63.14	$233.52	27.23
1988	$380.42	66.84	$232.58	27.12
1989	$421.31	70.18	$232.42	27.20
1990	$596.71	82.02	$236.15	27.70
1991	$593.10	80.13	$250.26	30.45
1992	$607.59	79.76	$294.29	34.70
1993	$650.01	82.76	$308.55	36.81
1994	$752.09	93.66	$389.49	60.69
1995	$777.93	99.96	$547.71	72.67
1996	$782.84	104.50	$612.52	77.53
1997	$838.81	125.34	$658.58	81.79
1998	$839.18	125.47	$705.27	85.73
1999	$839.16	125.46	$708.22	85.93
2000	$839.29	125.51	$709.39	86.04
2001	$839.13	125.44	$710.86	86.18

The safety technologies installed in passenger cars by model year 1968, responding to the initial FMVSS of January 1, 1968, included lap/shoulder or lap belts at all seat positions, energy-absorbing steering assemblies, dual master cylinders, and seat back locks, among others. In addition, model year 1968 passenger cars were equipped with side marker lamps, anticipating a requirement that would take effect on January 1, 1969. These technologies added $169 (in 2002 dollars) and 18 pounds to model year 1968 passenger cars.

By model year 1974, cost had increased to $302 and weight to 70 pounds. Side door beams were installed in response to the original static crush requirement of FMVSS 214. Front-outboard seats were equipped with head restraints. Safety belts were substantially upgraded: drivers and right-front passengers received integral 3-point belts with locking retractors, and rear-outboard lap belts were equipped with retractors.

Cost and weight in passenger cars changed little from 1974 to 1986, as no major new FMVSS went into effect.

Cost increased from $300 in 1986 to $752 in 1994, and weight from 60 to 94 pounds, primarily due to the automatic occupant protection requirements of FMVSS 208. The increase was gradual over that time period. Automatic protection was phased in from model year 1987 to 1990. Then, especially in 1991-94, manufacturers shifted to more effective, but more expensive types of automatic protection: from automatic belts, to driver air bags, to dual frontal air bags.

The dynamic crash test requirement of FMVSS 214 phased in a substantial upgrading and padding of side structures during 1994-97. The total cost of the FMVSS increased to $839, and their weight to 125 pounds by 2001.

Most of the FMVSS were extended from passenger cars to light trucks, but only after they had been in effect on passenger cars for some years. Many safety technologies were installed in light trucks later than in passenger cars, typically after they had been required in passenger cars but before the FMVSS were extended to light trucks. In model year 1968, safety equipment added $107 and 11 pounds to light trucks. However, most of this equipment, including lap belts and dual master cylinders, was not actually required by the FMVSS in trucks at that time, only in passenger cars.

Cost had increased to $189 by 1978 and weight to 21 pounds. By then, most light trucks had been equipped with 3-point belts and retractors at the front-outboard positions and energy-absorbing steering assemblies. Cost continued to increase gradually to $250 in 1991, and weight to 30 pounds, as more of the basic FMVSS were extended to light trucks.

The installation of frontal air bags for drivers in 1992-96, and the addition of passenger air bags in 1994-98 increased the total cost of the FMVSS in light trucks to $711 and their weight to 86 pounds by 2001.

FEDERAL MOTOR VEHICLE SAFETY STANDARDS

SECTION 1 – BACKGROUND AND METHODOLOGY

The National Highway Traffic Safety Administration (NHTSA) has a legislative mandate under Title 49 of the United States Code, Chapter 301, Motor Vehicle Safety, to issue Federal Motor Vehicle Safety Standards (FMVSS) and Regulations to which manufacturers of motor vehicles and equipment must conform and certify compliance. Chapter 301 defines a 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.[1]" 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.[2]"

NHTSA has a comprehensive program to evaluate existing motor vehicle regulations to determine their effectiveness, benefits, and costs.[3] 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 1970's, 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.

The objective of this report is to estimate the overall cost of the FMVSS and the cost of each standard with a uniform methodology. Cost and weight data for the major components of the motor vehicle equipment will be extracted from contractor and NHTSA reports and compiled into a summary report. Care will be taken to determine the economic year used for the cost data in each study. All cost data will then be brought to the most recent full economic year using the gross domestic product implicit price deflator from the Bureau of Economic Analysis. The report will also describe what vehicle modifications were made in response to the various FMVSS and explain how the cost estimates were derived. In addition, the report will estimate the total cost of meeting the FMVSS in passenger cars and light trucks, with the year-by-year breakdown of the cost and weight per passenger car and light truck from 1968 thru 2001. Finally, previously unreleased contractor studies will be made available and accessible to the public.

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, these costs tend to be negligible for most FMVSS.

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[1] Legal citation: *49 Code of Federal Regulations (CFR) 1.50* (2004).

[2] Ibid.

[3] *National Highway Traffic Safety Administration Evaluation Program Plan Calendar Years 2004-2007*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, January 2004 (DOT HS 809 699).

The Cost of a FMVSS. The cost of a FMVSS includes the cost of all equipment added or modified primarily for the purpose of complying with the standard, provided these modifications took place on or after the effective date, or even before the effective date if there was a rulemaking process underway and there was a clear anticipation of the standard. The following factors are considered when determining the cost of a FMVSS:

- If a standard essentially did not change vehicles (i.e., if the equipment was already in place well before any rulemaking process was underway and the standard essentially mandated what had already long been there), this standard does not add cost to the vehicle, and the cost of the equipment that was already there will not be attributed to the FMVSS. For example, every passenger vehicle that came under FMVSS 103 had already been equipped with a windshield defrosting and defogging system long before the standard went into effect, nor is there any evidence that these systems were upgraded to meet the standard.

- If manufacturers voluntarily put the equipment in a few years before the effective date, but after NHTSA announced plans to issue a standard, these costs will be attributed to the standard. For example, manufacturers voluntarily installed side door beams from 1969-1972 even though FMVSS 214 did not take effect until January 1973. Nevertheless, because NHTSA announced its intention to regulate side door strength in October 1968, it would appear that these "voluntary" installations were in fact undertaken in response to, or anticipation of, FMVSS 214.

- Even if the equipment or modification exceeded the minimum requirements of the standard, these costs will nevertheless be attributed to the standard. For example, if a model year 1987-1996 passenger car has air bags, the cost of the air bags will be fully attributed to FMVSS 208 even though at that time they could have also complied with the standard using less expensive automatic belts.

- We have only estimated costs of FMVSS that have permanent costs. If a FMVSS causes momentary redesign costs but ultimately does not result in any new equipment, we have not estimated a cost. For example, the requirements of FMVSS 101 resulted in simply relocating and changing the visual appearance of the controls and displays.

The possibility exists that manufacturers could have eventually added some of the safety equipment currently required by FMVSS even if NHTSA had never issued those FMVSS. Similarly, if an existing FMVSS were to be rescinded, manufacturers might well choose not to stop installing the safety equipment previously required by the FMVSS. However, this report will not speculate on what manufacturers might have added to or deleted from their vehicles in these purely hypothetical scenarios. If the safety equipment was originally installed during or immediately after the rulemaking process, this report will continue to attribute to that FMVSS the cost of that safety equipment, or its successors, in subsequent model years.

The cost of a FMVSS is the incremental cost over the equipment that was there before the FMVSS and likely would have remained there without the FMVSS. For example, a cost of FMVSS 105 is the difference between the costs of dual master cylinders and the single master cylinders that existed in pre-standard vehicles.

However, in the special case where a standard puts in an entirely new type of equipment, the cost of the FMVSS is the full cost of the new 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.

The cost of a FMVSS may change over time, as a result of more efficient design, new types of materials, or vehicle downsizing (if the weight of the equipment is proportional to the weight of the vehicle). For example, head restraints became less expensive due to more efficient design, and side door beams due to all of these factors, including vehicle downsizing. We are interested in tracking the costs over time when possible, but in doing so we must also keep in mind what might have happened to the vehicle over time if the FMVSS had never been issued. For example, dual master cylinders became less expensive over time, but we should note that single master cylinders might also have become less expensive.

A FMVSS can only result in added cost or no cost, never a savings. If the new equipment is less expensive, manufacturers could presumably have installed it even without the standard.

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 and models, plus design and manufacturing cultural approaches, 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
    - represent the vehicle types (passenger car, SUV, 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
    - 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
        - 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, and the second (macro-analysis) considers those elements of cost that do not vary.

- ***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.

        - ***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***. This accounting classification 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.

- o ***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.[4]

Accounting Basis for the Macro-Analysis[5]

Over the last 30 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 (GAAP). 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 6directly 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. In order to approximate this allocation process, variable costs must be isolated to the degree possible from fixed and discretionary costs.

Income statements prepared according to GAAP do not segregate cost and expense accounts based on behavior. The "Cost of Sales" account, for example, includes both variable and discretionary costs. In order 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":

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[4] Spinney, B.C., *Development of Markup Rates for Regulatory Cost Analysis that Approximate Industry Pricing Practices*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration Internal Document, February 1989, 1-2.

[5] Ibid.

- 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 below:

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 the "Big Three")

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% of net sales. The contribution margin rate of 26% on sales represents the remainder left for fixed/discretionary cost coverage. Since the template reflects company-wide operations, by definition 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% of sales and contribution margin accounts for 26%, then the markup rate on variable costs to wholesale price would be 35% (26% / 74%). The markup factor would be 1.35.

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

Variable costs * 1.35 * 1.11 ***OR*** Variable costs * 1.50

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

- ***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 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 standard.

    - Only part of the difference is attributed to the standard, while the rest of the difference is attributed to styling, product improvement, or other factors unrelated to the FMVSS. For example, with FMVSS 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 efficient and not needed for meeting the standard.

  - The contractor only performed the physical teardown of post-standard vehicles' subsystems believed to be affected by a 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 FMVSS 108, center high mounted stop lamps were added as standard equipment in model year 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 214 upgrade dynamic test requirement, some of the components partially contributed to both pre- and post-revision requirements of FMVSS 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.

- ♣ 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 201, a study of the interior components of 1982 model year trucks was conducted to determine the impact of the standard on light trucks. 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 light trucks and did not estimate the average cost increase.

- ***<u>Teardown Sample Selection</u>***. Some contractors selected a sample of motor vehicles too small to make a meaningful sales-weighted average. 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 214, an analysis of the impact of the dynamic requirements on two-door passenger cars was conducted on only two import cars representing the compact and midsize categories.

- ***<u>Inconsistency in Vehicle Sales Data</u>***. Contractors sales-weighted their data using calendar year production, calendar-year sales, or model-year registrations.

- ***Averaging the Costs Across Make-Models***. Contractors sometimes computed sales-weighted averages of the costs of the make-models they tore down in order to produce a single estimate of the cost of the FMVSS. Sales data by make-model were obtained from various sources, and "makes-models" sometimes, but not always, included vehicles of similar design but with different names (e.g., Ford Taurus and Mercury Sable). In some cases, these sales-weighted averages were based on too few models (e.g., two or three) to be statistically meaningful.

- ***Follow-Up Cost Studies***. NHTSA sometimes awarded follow-up contracts to determine if the cost of safety equipment had changed after a number of model years due to factors such as: more efficient design, vehicle downsizing, availability of new materials. These analyses were limited to teardowns of the recent model year vehicles, and did not include teardowns of pre-standard vehicles for comparison purposes.

- ***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.

- ***Different Economic Years***. All estimated costs were based on specific U.S. model production year economics that, of course, depended on when the contractor did the study.

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 price 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 registrations for each make-model studied. The volume figures for the 1965-1974 model years were obtained from Ward's Automotive Yearbook[7] and the volume figures for the 1975 model year on up were obtained from the R.L. Polk National Vehicle Population Profile.[8]

[7] Ward's Automotive Yearbook, Annual Publication, Detroit: Ward's Communications.
[8] National Vehicle Population Profile, Annual Publication, Detroit: R.L. Polk & Company.

- 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 the FMVSS 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 others reasons (consumer preference, vehicle manufacturer design choices), we will sales-weight by sales for the specific make-model in the tear down sample. For example, with FMVSS 202, vehicle manufacturers installed adjustable or nonadjustable (integral or fixed) head restraints in response to the standard.

- If the contractor has looked at a number of 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 214 side door beams in light trucks.

- ***<u>FMVSS Modifications vs. Redesigns Unrelated to FMVSS</u>***

  - 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 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 216 make-models that did not receive any overall redesign, it is plausible that any changes were specifically due to standard.

- ***Linear Interpolation When Costs Change Over Time***. If we have two cost estimates for the standard, i.e., $20 in 1980 and $10 in 1990; and, unless we have additional information that pinpoints the time of the cost reduction, we will assume a standard cost of $20 each year until 1980, a declining linear rate (in this case, $1 per year) from 1980 to 1990, and then a cost of $10 each year from 1990 onward.

- ***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 (CRB) 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 inflated to 2002 dollars. Even though a particular standard may have been studied in an earlier economic year, using the gross domestic product implicit price deflator adjustments can bring the original cost data to 2002 economics. For example, the first study done for Planning, Evaluation, and Budget was in 1978 economics. The implicit price deflator for 1978 is 45.757 and 103.945 for 2002. To bring the 1978 data to 2002 economics, the original cost estimates are multiplied by the factor of 103.945/45.757 (the ratio of the implicit price deflator for 2002 relative to that of 1978).[9] The indexes for 1976-2002 are listed on the next page:

[9] Bureau of Economic Analysis [online]; available from http://www.bea.doc.gov/bea/dn/nipaweb/AllTables.asp.

GROSS DOMESTIC PRODUCT IMPLICIT PRICE DEFLATOR (2000 BASE)	
YEAR	PRICE DEFLATOR
1976	40.196
1977	42.752
1978	45.757
1979	49.548
1980	54.043
1981	59.119
1982	62.726
1983	65.207
1984	67.655
1985	69.713
1986	71.250
1987	73.196
1988	75.694
1989	78.556
1990	81.590
1991	84.444
1992	86.385
1993	88.381
1994	90.259
1995	92.106
1996	93.852
1997	95.414
1998	96.472
1999	97.868
2000	100.000
2001	102.373
2002	103.945

SECTION 2 - FMVSS 100 SERIES

The FMVSS 100 series specify design and/or 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 101 - CONTROLS AND DISPLAYS

FMVSS 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 uniform locations with uniform labels. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses.[10]

Most motor vehicles had some form of controls and displays prior to the standard. The requirements resulted in simply relocating and changing the visual appearance of the display. While there may have been a one-time 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 102 - TRANSMISSION SHIFT LEVER SEQUENCE, STARTER INTERLOCK, AND TRANSMISSION BRAKING EFFECT

FMVSS 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 miles per hour. For vehicles equipped with manual transmissions, the standard requires a display of the shift pattern that is in the driver's field of view. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses.[11]

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[10] Legal citation: *49 (CFR) 571.101* (2004).
[11] Legal citation: *49 CFR 571.102* (2004).

The standard requires that all shift levers for automatic transmissions have the same clockwise sequence: park, reverse, neutral, drive, and low gear(s). 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 be displayed in view of the driver at all times 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 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 103 - WINDSHIELD DEFROSTING AND DEFOGGING SYSTEMS

FMVSS 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, multipurpose passenger vehicles, trucks, and buses.[12]

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.[13] Table 103-1 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 103-1
AVERAGE WEIGHT AND CONSUMER COST
OF WINDSHIELD DEFROSTING AND DEFOGGING SYSTEMS
IN PASSENGER CARS

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2002)
1965 (Pre-Standard)	1.23	$9.01
1969 (Post-Standard)	1.01	$9.75

[12] Legal citation: *49 CFR 571.103* (2004).

[13] Gilmour, J.L., *Consumer Cost Evaluation of Federal Motor Vehicle Safety Standards – FMVSS 103 and 104,* Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, June 1982. (DOT HS 806 205:21-81).

A study of seven 1969 make-model light trucks indicated that the sales-weighted average weight and consumer cost of the defrosting and defogging systems was 3.05 pounds and $10.01 in 2002 dollars.[14] Although not studied, earlier model light trucks were also equipped with these systems.

Since every passenger vehicle that came under the standard was equipped with a windshield defrosting and defogging system before the standard went into effect and NHTSA has no evidence that the minimal design changes between 1965 and 1969 were made to meet the performance tests of the standard, any changes in the weight and consumer cost are not attributed to FMVSS 103.

FMVSS 104 - WINDSHIELD WIPING AND WASHING SYSTEMS

FMVSS 104 became effective on January 1, 1968 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, multipurpose passenger vehicles, trucks, and buses.[15]

Passenger Car Studies

When FMVSS 104 was issued, all passenger cars were equipped with 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.[16] Since every passenger car that came under the standard was equipped with a windshield defrosting and defogging system before the standard went into effect, their weight and consumer cost are not attributed to FMVSS 104.

Light Truck Studies

Seven 1969 make-model light trucks were also studied.[17] The windshield wiping and washing systems, which were not on pre-standard light trucks, were analyzed. 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 104-1 shows the sales-weighted average weight

[14] Gladstone, R., Harvey, M.R., and Lesczhik, J.A., *Estimation of Weight and Consumer Price Relating to the Implementation of FMVSS 201 in Passenger Cars and FMVSS 103 and 104 in Light Trucks,* Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, November 1982. (DOT HS 806 367:2-1 thru 2-6).

[15] Legal citation: *49 CFR 571.104* (2004).

[16] Gilmour, DOT HS 806 205:82-144 (1982).

[17] Gladstone, DOT HS 806 367:3-1 thru 3-23 (1982).

and consumer cost of each system, with the difference being the cost of implementing the windshield wiper requirements.

FMVSS 104-1 AVERAGE WEIGHT AND CONSUMER COST OF WINDSHIELD WIPER SYSTEMS IN LIGHT TRUCKS		
MOTOR TYPE	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Single Speed	2.23	$19.41
Multi-Speed	2.72	$23.43
DIFFERENCE	0.49	$ 4.02

For the washing systems analysis, the baseline was established as a vehicle without the system, with the components (reservoir, pump, hoses, switch and knob assembly) for the washing system directly related to the implementation of the standard. The sales-weighted average weight and consumer cost was 1.61 pounds and $11.03 in 2002 dollars.

Implementation of the windshield wiper and washer requirements of FMVSS 104 increased the average weight and consumer cost per vehicle. Table 104-2 shows the total weight and consumer cost attributable to FMVSS 104 in light trucks.

FMVSS 104-2 AVERAGE WEIGHT AND CONSUMER COST OF WINDSHIELD WIPING AND WASHING SYSTEMS ATTRIBUTABLE TO FMVSS 104 IN LIGHT TRUCKS		
SYSTEM	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Windshield Wiping	0.49	$ 4.02
Windshield Washing	1.61	$11.03
TOTAL	2.10	$15.05

FMVSS 105 - HYDRAULIC AND ELECTRIC BRAKE SYSTEMS

FMVSS 105 became effective on January 1, 1968 and specifies requirements for vehicles equipped 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 multipurpose passenger vehicles, trucks, and buses with a Gross Vehicle Weight Rating (GVWR) of 7,716 pounds or less that were manufactured before September 1, 2002
- hydraulically-braked vehicles with a GVWR greater than 7,716 pounds[18]

All hydraulically-braked passenger cars manufactured after September 1, 2000 and hydraulically- braked multipurpose passenger vehicles, trucks, and buses with a GVWR of 7,716 pounds or less that were manufactured after September 1, 2002 are part of FMVSS 135 (Passenger Car Brake Systems).

[18] Legal citation: *49 CFR 571.105* (2004).

Passenger Car Studies

Brake System Components

The brake system components specifically required by FMVSS 105 are a dual or split hydraulic service brake system, parking brake system, and brake system indicator lamp. Particular 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/or 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 pounds 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
- 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 105, effective in January 1968, represented the initial Federal effort to specify braking requirements for motor vehicles and required that passenger cars be equipped with 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. Manufacturers had extensive advance knowledge of the upgrade because a Notice of Proposed Rulemaking (NPRM) was issued as early as November 1970. FMVSS 105a was redesignated to 105-75 in February 1974, and with only minor changes in the portion applicable to passenger cars, evolved into the January 1976 requirements.

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 miles per hour
- lockup of only one wheel, not controlled by an antilock system, is permissible at speeds in excess of 10 miles per hour

It is difficult to determine what costs should be attributed to FMVSS 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 during 1965-2001 are dual master cylinders, front disc brakes, brake power assist units, and antilock brake systems (ABS). Only the cost of dual master cylinders is unequivocally attributable to FMVSS 105.

Table 105-1 shows the percentage of domestic cars with these technologies for selected model years.

TABLE 105–1
PERCENT OF DOMESTIC CARS WITH DUAL MASTER CYLINDERS, FRONT DISC BRAKES, POWER BRAKES, AND ABS BY MODEL YEAR

MODEL YEAR	PERCENT OF DOMESTIC CARS			
	DUAL MASTER CYLINDERS	FRONT DISC BRAKES	POWER BRAKES	ABS
1960	0	0	26	0
1962	9	0	26	0
1964	7	0	29	0
1966	unknown	3	35	0
1967	100	6	41	0
1968	100	13	unknown	0
1970	100	41	unknown	0
1972	100	74	68	0
1974	100	84	67	0
1976	100	99	81	0
1978	100	100	88	0
1980	100	100	unknown	0
1982	100	100	90	0
1984	100	100	96	0

TABLE 105–1 (CONTINUED) PERCENT OF DOMESTIC CARS WITH DUAL MASTER CYLINDERS, FRONT DISC BRAKES, POWER BRAKES, AND ABS BY MODEL YEAR				
MODEL YEAR	PERCENT OF DOMESTIC CARS			
	DUAL MASTER CYLINDERS	FRONT DISC BRAKES	POWER BRAKES	ABS
1986	100	100	99	1
1988	100	100	100	3
1990	100	100	100	8
1992	100	100	100	32
1994	100	100	100	57
1996	100	100	100	58
1998	100	100	100	59
2000	100	100	100	62
2001	100	100	100	62

Dual Master Cylinders. Dual master cylinders were explicitly required by FMVSS 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 light truck 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 105 requires that vehicles must be able to stop within a specified distance from 60 miles per hour 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.

Forty-one make-model passenger cars representing pre-standard, post-standard, and trend systems were studied[19], along with thirteen downsized make-model passenger cars.[20] Table 105-2 shows the sales-weighted average for the weight and consumer cost of master cylinders in 2002 dollars.

[19] Harvey, M.R., Lesczhik, J.A., and McLean, R.F., *Cost Evaluation for Nine Federal Motor Vehicle Standards, Volume 1, FMVSS 105*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, November 1979. (DOT HS 805 315).

[20] Gladstone, R., et.al., *Estimation of Weight and Consumer Price Relating to the Implementation of FMVSS 105, 108, 202, 205, & 216, in Passenger Cars and 201, 203, & 204 in Light Trucks*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, August 1982. (DOT HS 806 769:2-1 thru 2-19).

TABLE 105-2 *AVERAGE WEIGHT AND CONSUMER COST* *OF MASTER CYLINDERS IN PASSENGER CARS*		
CATEGORY	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Single (Pre-Standard)	4.38	$26.53
Dual (Post-Standard)	6.12	$38.67
Dual (Trend)	7.97	$35.95
Dual (Downsized)	3.33	$34.66

Table 105-2 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 Single Master Cylinders = $38.67 - $26.53 = $12.14

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 = ($34.66/$38.67) * $26.53 = $23.78

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

   Cost of Downsized Dual Master Cylinders – Cost of Master Cylinders (if they had remained single) = $34.66 – $23.78 = $10.88

4. Average Cost of Master Cylinders (CY), where $1977 \leq CY \leq 1981$, =

   [CY –1976] * 10.88 + [1982-CY] * 12.14

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

Weight of Post-Standard Dual Master Cylinders – Weight of Pre-Standard 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 $\leq$ CY $\leq$ 1981, =

[CY –1976] * 0.95 + [1982-CY] * 1.74

Table 105-3 shows the average weight and consumer cost of master cylinders attributable to FMVSS 105 in passenger cars by model year.

TABLE 105-3
AVERAGE WEIGHT AND CONSUMER COST
OF MASTER CYLINDERS
ATTRIBUTABLE TO FMVSS 105
IN PASSENGER CARS BY MODEL YEAR

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2002)
1966-1976	1.74	$12.14
1977	1.61	$11.93
1978	1.48	$11.72
1979	1.34	$11.51
1980	1.21	$11.30
1981	1.08	$11.09
1982-2001	0.95	$10.88

<u>Front Disc Brakes</u>. A change in the brake systems that was encouraged, although not required because of FMVSS 105, was the conversion of front brakes from a drum to a disc design. 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 105. These requirements started in 1976 about the same time as the automotive industry shifted to disc brakes; however, some cars continued to have drum brakes and still met the new requirements of FMVSS 105-75.

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 six 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 model year vehicles was 57.47 pounds and $162.01 in 2002 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 (model year 1968 and 1976 passenger cars) weighed 70.99 pounds and cost $147.24 in 2002 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 1977-1982, 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 pounds, while the consumer cost dropped to an average of $75.40 in 2002 dollars. The role of FMVSS 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.

Table 105-4 shows the overall weight and consumer cost of front brakes for the 1966/1968, 1968/1976, and 1977-1982 make-models years.

TABLE 105-4
AVERAGE WEIGHT AND CONSUMER COST
OF FRONT BRAKES IN PASSENGER CARS

CATEGORY	WEIGHT IN POUNDS	CONSUMER COST ($2002)
	Overall	
Drum (1966/68)	57.47	$162.01
Disc (1968/76)	70.99	$147.24
Disc (1977-1982)	50.36	$ 75.40

<u>Power Boosters</u>. While power boosters are not explicitly required to meet FMVSS 105, power brakes 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 105, encouraged manufacturers to use power boosters. It was difficult to stop cars within the distance and at the pedal pressure specified in FMVSS 105 unless they had power brakes. Furthermore, consumers like power boosters because they amplify the force applied by the driver to the brake pedal and allow even small drivers to achieve high levels of vehicle braking on all sizes of vehicles. Installation of power boosters should not be attributed to the standard because (1) 81% of the passenger cars already had the factory-installed power brakes by 1976, (2) the power brakes were clearly something the consumers wanted, and (3) non-power brakes continued to exist after 1976 and were meeting FMVSS 105.

Table 105-5 shows the sales-weighted average weight and consumer cost of power boosters for the 1966, 1968, 1976, and 1977-1982 make-model passenger cars.

TABLE 105-5
AVERAGE WEIGHT AND CONSUMER COST
OF POWER BOOSTERS IN PASSENGER CARS

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2002) PER POWER BRAKE	% OF CARS WITH POWER BRAKES	CONSUMER COST ($2002) PER CAR
1966	7.61	$45.28	35.31	$46.26
1968	9.27	$45.46	31.50	$41.89
1976	11.60	$54.78	80.90	$55.21
1977-1982	7.86	$40.17	84.24	$39.81

<u>Total Brake System</u>. The total brake system includes the front and rear brake assembly, master cylinder, foot pedal and linkage, power booster, warning light, proportional valve, and parking brake system. Table 105-6 shows the sales-weighted average weight and consumer cost of the total brake system for the 1966, 1968, 1976, and 1978-1982 make-models. Again, the substantial drop in the weight and consumer cost of 1977-1982 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, there is little evidence that any of these major cost changes over the years are directly related to FMVSS 105 or that these costs would have been different in the absence of the standard.

TABLE 105-6
AVERAGE WEIGHT AND CONSUMER COST
OF THE TOTAL BRAKE SYSTEM IN PASSENGER CARS

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2002)
1966	132.60	$474.67
1968	147.33	$504.70
1976	166.69	$525.25
1977-1982	117.21	$353.24

Antilock Brake Systems

Antilock Brake Systems (ABS) were developed by the motor vehicle industry and voluntarily installed by manufacturers beginning in the mid 1980's on passenger cars and light trucks. They have become accepted by consumers and are standard equipment in most new passenger cars and most light trucks. 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. ABS also enables the driver to steer the vehicle in a controlled manner while stopping. Given the potential safety benefits of ABS, the Highway Safety Act of 1991 instructed NHTSA to contemplate requiring ABS in all passenger vehicles. NHTSA published an Advance Notice of Proposed Rulemaking (ANPRM) at the end of 1993. Since many of the light trucks and passenger cars had already been equipped with ABS, the agency and others gathered crash data and evaluated the effectiveness of ABS in light trucks and passenger cars.[21,22] 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.

In 1991, NHTSA analyzed the cost of five different ABS systems in make-model passenger cars from 1988-1990.[23] Table 105-7 shows the sales-weighted average weight and consumer cost of ABS in these five models. These are the incremental weights and costs of ABS, above and beyond the pre-ABS hydraulic brake system (see Table 105-6).

TABLE 105-7
AVERAGE WEIGHT AND CONSUMER COST
OF ABS IN PASSENGER CARS

MODEL YEAR	COMPONENT	WEIGHT IN POUNDS	CONSUMER COST ($2002)
1988-90 Average of five models	Sensors/Rings	3.83	$ 45.46
	Control Unit	2.33	$166.62
	Modulator Unit	20.81	$326.23
	Wiring Harness	3.95	$ 59.25
	TOTAL	30.92	$597.56

The major ABS components shown in Table 105-7 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.

In 1994, NHTSA looked at the ABS systems in one 1992 and one 1993 passenger car.[24] Since the analysis was based on only two systems and passenger cars that were not the same make-models as any in the previous study, it is difficult to draw conclusions on cost trends. A review of 2004 make-model passenger vehicles was conducted to determine the cost of ABS as optional equipment. The prices of the ABS systems ranged from $300 to $950, with an average price of $546. Typically in the past, the sales price of performance, convenience, or luxury optional equipment widely desired by consumers has been marked up 200 to 300 percent over what it would be if it were standard equipment (i.e., over the “consumer cost” as computed by the

[21] Kahane, C.J., *Preliminary Evaluation of the Effectiveness of Rear-Wheel Antilock Brake Systems for Light Trucks,* Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, December 1993. (NHTSA Docket No. 70-27-GR-026).

[22] Kahane, C.J., *Preliminary Evaluation of the Effectiveness of Antilock Brake Systems for Passenger Cars,* Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, December 1994. (DOT HS 808 206).

[23] Fladmark, G.L. and Khadilkar, A.V., *Evaluation of Costs of Antilock Brake Systems, Volumes I and II,* Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, April 1991. (DOT HS 809 794-795: Sections 4,6,8-10).

[24] Fladmark, G.L. and Khadilkar, A.V., *Cost Estimates of Head Restraints in Light Trucks/Vans (Volume I) and Cost Estimates of Lower Cost Antilock Brake Systems (Volume II),* Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, July 1994. (DOT HS 809 797: Sections 13,15)

methods of this report). If the markups for ABS are consistent with these past trends, the average consumer costs of ABS could range from $182 to $273 and possibly indicate that the actual cost of ABS has reduced substantially since 1988-1990.

Light Truck Studies

Brake System Components

NHTSA extended FMVSS 105, effective in September 1983, for the 1984 model year pickup trucks, vans, sports utility vehicles (SUV), and other vehicle classes equipped with hydraulic brake systems. Essentially the same types of requirements that applied to passenger cars and school buses were now required for these other vehicles with hydraulic brake systems. Since 1975 or earlier, many manufacturers had gradually improved the braking capability of some of their light trucks to FMVSS 105 levels.

Dual Master Cylinders. FMVSS 105 explicitly requires a dual braking system – i.e., dual master cylinders – in all vehicles it regulates, including light trucks. For that reason, the cost of dual master cylinders in light trucks will be attributed to FMVSS 105. Even though most light trucks received dual master cylinders well before the September 1983 effective date, quite probably even as early as 1967, the regulatory process for the original FMVSS 105 was getting underway at that time. Since NHTSA has not performed any teardowns of truck master cylinders, we will assume the same cost for dual master cylinders in trucks as in passenger cars (although it is conceivable that truck systems could cost more to the extent that light trucks are usually heavier vehicles than passenger cars). Table 105-8 shows the average weight and consumer cost of dual master cylinders attributable to FMVSS 105 in light trucks.

TABLE 105-8
AVERAGE WEIGHT AND CONSUMER COST
OF DUAL MASTER CYLINDERS
ATTRIBUTABLE TO FMVSS 105 IN LIGHT TRUCKS

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2002)
1982-2001	0.95	$10.88

Brake Subsystem Components. A study was conducted on eight pre-standard (1983), and their corresponding post-standard (1984), make-model light trucks from the three-major U.S. Manufacturers.[25] Costs were estimated only for those subsystems of the brake systems of light trucks that were a new or changed design in 1984. The front brake pads, rear brake systems, brake power assist, 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 light truck 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

[25] Adams, G.J., Carlson, L.E., and Firth, B.W., *Cost Evaluation of Federal Motor Vehicle Safety Standard 105-83*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, August 1985. (DOT HS 807 016).

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 105. The semi-metallic materials were used to improve brake system fade performance and durability characteristics.

Power-booster units became standard in most trucks in 1984 at the latest, largely in response to consumer demand, but conceivably also to meet stopping distance requirements of FMVSS 105 within the allowable pedal pressures. An emergency brake warning switch was added to the Ford trucks in order 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 light trucks were tested in a lightly loaded condition.

Table 105-9 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-models.

TABLE 105-9
AVERAGE WEIGHT AND CONSUMER COST
OF BRAKE SYSTEM COMPONENTS IN LIGHT TRUCKS

MAKE/MODEL	COMPONENT	MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Dodge 150	Front Pads	1983	1.21	$13.47
		1984	2.10	$20.20
	Rear Brakes	1983	50.29	$85.14
		1984	64.51	$96.81
	Servo	1984	8.54	$36.10
Dodge 350	Front Pads	1983	1.63	$18.06
		1984	2.81	$27.09
Dodge MPV	Variable Valve	1984	1.50	$28.45
Ford – All Trucks	Warning Light Emergency Brake	1984	0.03	$ 0.40
Ford F-150	Rear Shoes	1983	1.48	$16.46
		1984	1.77	$18.11
Ford F-250	Front Pads	1983	1.03	$11.48
		1984	1.23	$12.62
	Rear Shoes	1983	1.75	$19.45
		1984	1.80	$19.99
	Variable Valve	1984	2.90	$11.17
Ford F-350	Front Pads	1983	2.44	$27.34
		1984	2.91	$30.08
GMC 1500	Front Pads	1983	1.14	$12.62
		1984	1.36	$18.93
GMC 2500	Front Pads	1983	1.14	$12.62
		1984	1.36	$18.93
	Variable Valve	1984	3.04	$15.19
GMC 3500	Front Pads	1983	1.37	$15.26
		1984	1.64	$22.89
	Variable Valve	1984	3.04	$12.51

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 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 105. Since Ford accounted for 30 percent of truck sales in 1984, the 0.03 pounds and $0.40 in Ford trucks averages out to 0.01 pounds and $0.12 in all trucks. This is added to the cost and weight of dual master cylinders. Table 105-10 shows the average weight and consumer cost of brake system components attributable to FMVSS 105 in light trucks.

TABLE 105-10
AVERAGE WEIGHT AND CONSUMER COST
OF BRAKE SYSTEMS COMPONENTS
ATTRIBUTABLE TO FMVSS 105 IN LIGHT TRUCKS

COMPONENT	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Dual Master Cylinder	0.95	$10.88
Warning Light Emergency Brake Switch	0.01	$ 0.12
TOTAL	0.96	$11.00

Antilock Brake Systems

NHTSA analyzed the weight and consumer cost of four-wheel ABS systems in two SUVs.[26,27] During 1987 through 1992, ABS systems controlled only the rear wheels and were typically standard equipment on light trucks. Since 1993, it has become increasingly common for ABS systems to control all four wheels on light trucks, similar to passenger cars. The total weight and consumer cost of an ABS system in a 1990 Jeep Cherokee 4-wheel drive was calculated at 41.17 pounds and $750.88 in 2002 dollars; whereas, the total weight and consumer cost of an ABS in a 1994 Ford Explorer 4-wheel drive was calculated at 20.48 pounds and $426.68 in 2002 dollars. From this study of just two vehicles, it is not possible to compute an industry-wide average or to deduce if the lower cost for the more recent vehicle represents an industry-wide trend.

Table 105-11 shows the average weight and consumer cost of the ABS and its subsystems in these two SUVs.

[26] Fladmark, DOT HS 809 795:Section 7 (1991).
[27] Fladmark, DOT HS 809 797:Section 14 (1994).

TABLE 105-11 AVERAGE WEIGHT AND CONSUMER COST OF ABS IN TWO SUVs			
MODEL YEAR	COMPONENT	WEIGHT IN POUNDS	CONSUMER COST ($2002)
1990 Jeep Cherokee 4-wheel drive	Sensors/Rings	3.85	$ 55.02
	Control Unit	2.10	$ 95.69
	Hydraulic Unit	30.72	$547.16
	Wiring Harness	4.50	$ 53.01
	TOTAL	41.17	$750.88
1994 Ford Explorer 4-wheel drive	Sensors/Rings	2.75	$ 44.61
	Control Unit	0.85	$ 98.50
	Hydraulic Unit	15.46	$218.48
	Wiring Harness	1.41	$ 65.09
	TOTAL	20.47	$426.68

The cost of ABS is, of course, not attributable to FMVSS 105 because the standard neither explicitly requires ABS nor implicitly encourages it by including performance tests that are easier to pass with ABS than without it.

FMVSS 106 - BRAKE HOSES

FMVSS 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, multipurpose passenger vehicles, trucks, 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.[28] No cost studies of brake hoses have been performed, and none are planned by the agency.

FMVSS 107 - [Does not currently exist]

FMVSS 108 - LAMPS, REFLECTIVE DEVICES, AND ASSOCIATED EQUIPMENT

FMVSS 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, multipurpose passenger vehicles, trucks, buses, trailers, and motorcycles

[28] Legal citation: *49 CFR 571.106* (2004).

- retro reflective sheeting and reflex reflectors
- lamps, reflective devices, and associated equipment for replacement of like equipment on vehicles to which this standard applies[29]

FMVSS 108 has been amended many times; however, the most important regulations have been (1) the original standard, (2) the side marker lamp requirement, and (3) the center high mounted stop lamp (CHMSL) requirement. While this standard covers all types of lighting and reflective devices, side marker lamps and CHMSL are the only lighting developments whose cost is readily attributable to FMVSS 108 because they were added to vehicles in anticipation of, or in response to, the standard.

Passenger Car Studies

Side Marker Lamps. Prior to 1968, passenger cars 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 the 1970 model year, FMVSS 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. Most 1968 and 1969 model year passenger cars already had lamps or at least reflectors, and SAE Recommended Practice J592 discussed them as early as 1964. Nevertheless, the extent that the lamps were installed within two years of the effective date and while rulemaking was underway, we might judge that the lamps were installed "in anticipation of FMVSS 108" and attribute the full cost of the lamps to FMVSS 108.

A study of the side marker lamps or reflectors was conducted on twenty-six make-model passenger cars representing pre-standard, post-standard, and late-model systems.[30,31] The sales-weighted average for the weight and consumer cost of the pre-standard 1969 model year passenger cars was calculated at 1.46 pounds and $20.90 in 2002 dollars, which is attributed to the standard for model years 1968-69. Implementation of the side marker lamps in the post-standard 1970 model year passenger cars increased the weight to 1.95 pounds and the consumer cost to $29.37 in 2002 dollars, which is attributed to the standard for model years 1970-2001. The late model (1979-1981) passenger cars decreased in weight to 1.30 pounds and increased in consumer cost to $31.13 in 2002 dollars.

Center High Mounted Stop Lamps. CHMSL have been standard equipment on all new passenger cars sold in the United States since model year 1986 and all new light trucks since model year 1994, as required by FMVSS 108. The purpose of CHMSL is to safeguard 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

[29] Legal citation: *49 CFR 571.108* (2004).

[30] Harvey, M.R., Lesczhik, J.A., and McLean, R.F., *Cost Evaluation for Nine Federal Motor Vehicle Standards, Volume II, FMVSS 108*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, November 1979. (DOT HS 805 316).

[31] Gladstone, R., Harvey, M.R., and Lesczhik, J.A., *Estimation of the Weight and Consumer Price of Late Model Vehicle Components Relating to the Implementation of FMVSS 108, 202, 208, and 214*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, March 1982. (DOT HS 806 257:5-1 thru 5-21).

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 thirty passenger cars of model years 1986 and 1987 to determine the weight and consumer cost of CHMSL.[32,33] The sales-weighted average for the weight and consumer cost for the 1986 and 1987 model year passenger cars were calculated at 0.85 pounds and $9.74 in 2002 dollars, which are attributed to the standard.

Table 108-1 shows the average weight and consumer cost of lamps attributable to FMVSS 108 in passenger cars.

TABLE 108-1
AVERAGE WEIGHT AND CONSUMER COST
OF LAMPS ATTRIBUTABLE TO FMVSS 108
IN PASSENGER CARS

CATEGORY	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Side Marker (1968-1969)	1.46	$20.90
Side Marker (1970-2001)	1.95	$29.37
CHMSL (1986-2001)	0.85	$ 9.74

Headlamp Concealment Devices. Headlamp concealment devices were a popular design feature for passenger cars during the 1960's. These devices were primarily cosmetic; however, an unsafe driving situation could arise if the concealment devices were frozen shut when headlamps were needed. FMVSS 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 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 112 was canceled on October 24, 1996 and the requirements were incorporated into FMVSS 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.[34] None of the changes in the headlamp concealment devices between 1966 and 1969 was related to the standard. The arithmetic average for the weight and consumer cost of headlamp concealment devices for the pre-standard 1966 model year passenger cars was calculated at 12.20 pounds and $114.42 in 2002 dollars. By 1969, the average weight for the post-standard passenger cars had increased to 14.01 pounds while the consumer cost decreased to $98.59 in 2002 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

[32] Carlson, L.E. and Leonard, P., *Cost Evaluation of Federal Motor Vehicle Safety Standard 108 and 207*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, May 1986. (DOT HS 807 017:15-55).

[33] Khadilkar, A.V. and Fladmark, G.L., *Cost Estimates of Center High Mounted Stop Lamps and Passenger Car Red/Amber Rear Turn Signal Lamps*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, November 1988. (DOT HS 809 793:32-68).

[34] Adams, G.J., et.al., *Cost Evaluation of Federal Motor Vehicle Safety Standards 111, 112, 118, and 124*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, November 1983. (DOT HS 806 774:31,124-134).

regulation. No cost is attributed to FMVSS 108 because most concealment devices met the requirements of the standard before its effective date of January 1,1969.

Light Truck Studies

Side Marker Lamps and CHMSL. Side marker lamps were required on light trucks at the same time as passenger cars, while CHMSL became effective on September 1, 1993 for light trucks (i.e., model year 1994). Because NHTSA has not performed teardown analyses for these systems on light trucks, and because they are similar to the systems on passenger cars, we will assume the same costs on light trucks as on passenger cars. Table 108-2 shows the average weight and consumer cost of lamps attributable to FMVSS 108 in light trucks.

TABLE 108-2
AVERAGE WEIGHT AND CONSUMER COST OF LAMPS ATTRIBUTABLE TO FMVSS 108 IN LIGHT TRUCKS

CATEGORY	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Side Marker (1968-1969)	1.46	$20.90
Side Marker (1970-2001)	1.95	$29.37
CHMSL (1994-2001)	0.85	$ 9.74

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 (HID) lights, light-emitting diode (LED) lights, and daytime running lamps (DRL). Since FMVSS 108 did not require these changes, no cost studies have been performed, and none are planned by this agency.

FMVSS 109 - NEW PNEUMATIC BIAS PLY AND CERTAIN SPECIALTY TIRES

FMVSS 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 tires for use on passenger cars manufactured after 1948. However, it does not apply to any tire that has been altered to render impossible its use, or its repair for use, as motor vehicle equipment.[35] No cost studies of new pneumatic tires have been performed, and none are planned by this agency.

FMVSS 110 - TIRE SELECTION AND RIMS FOR MOTOR VEHICLES

FMVSS 110 became effective on April 1, 1968 and specifies requirements for original equipment tire and rim selection on new 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 applies to passenger cars and to non-pneumatic

[35] Legal citation: *49 CFR 571.109* (2004).

spare tire assemblies for use on passenger cars.[36] No cost studies have been performed, and none are planned by this agency.

FMVSS 111 - REARVIEW MIRRORS

FMVSS 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, multi-purpose passenger vehicles, trucks, buses, school buses, and motorcycles. Furthermore, FMVSS 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.[37]

A study of inside rearview mirrors was conducted on sixteen pre-standard make-model passenger cars and their corresponding post-standard and trend systems.[38] Because most states required outside rearview mirrors before the implementation of FMVSS 111, they were not in the study. The sales-weighted average for the weight and consumer cost of the pre-standard 1966 model year passenger cars was calculated at 0.97 pounds and $7.67 in 2002 dollars. Implementation of the inside rearview mirrors in the post-standard 1968 model year passenger cars increased the weight to 1.12 pounds and the consumer cost to $10.81. However, estimation of the weight and consumer price in the 1982 model year passenger cars indicated a decrease in weight to 0.71 pounds and in consumer cost to $6.70 in 2002 dollars. Since the average weight and consumer cost decreased by 0.26 pounds and $0.97 in 2002 dollars between the pre-standard and long-term trend results, no cost is attributed to FMVSS 111.

***FMVSS 112* –** [Does not currently exist]

FMVSS 113 - HOOD LATCH SYSTEM

FMVSS 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 front opening hood 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, multipurpose passenger vehicles, trucks, and buses.[39]

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[36] Legal citation: *49 CFR 571.110* (2004).
[37] Legal citation: *49 CFR 571.111* (2004).
[38] Adams, DOT HS 806 774:23,25-30 (1983).
[39] Legal citation: *49 CFR 571.113* (2004).

A study of thirty-seven make-model passenger cars representing pre-standard, post-standard, and trend systems was conducted. The sales-weighted average for the weight and consumer cost of the pre-standard 1968 model year passenger cars was calculated at 3.19 pounds and $19.05 in 2002 dollars. In 1970, the weight and consumer cost in the post-standard model year passenger cars had decreased to 3.06 pounds and $15.53 in 2002 dollars. By 1971, the weight and consumer cost for the trend systems had increased slightly to 3.37 pounds and $16.90 in 2002 dollars. Since all manufacturers met the requirements of FMVSS 113 by the 1968 model year at the very latest, and likely initiated the development of dual latch systems before the FMVSS 113 rulemaking process, no cost was attributed to the standard. In fact, examination of cars for several years prior to 1968 showed that the safety standard provisions were met in all cases by the domestic industry. It was determined that there were three major reasons for hood latch design changes among the sample:[40]

- 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.
- the designs were revised for cost reduction and simplification.

The Volkswagen Beetle was the only vehicle in the sample whose change in hood latch design was definitely safety related. The Volkswagen Beetle would not have complied with the standard in 1966 because no safety catch was provided; it had dual latch systems. However, a design change was made in 1968, and a push button actuated safety catch was added. Because the safety catch was already included in the 1968 model $1^{1/2}$ years before the effective date, its development may well have been initiated before the FMVSS 113 rulemaking process; therefore, no cost was attributed to the standard.

FMVSS 114 - THEFT PROTECTION

FMVSS 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 multipurpose passenger vehicles having a GVWR of 10,000 pounds or less. It does not apply, however, to walk-in van-type vehicles.[41]

[40] McVetty, T.N., Cross, A.J., and Parr, L.W., *Cost Evaluation for Two Federal Motor Vehicle Safety Standards – FMVSS 113 Hood Latch – Passenger Cars – FMVSS 219 Windshield Zone Intrusion – Passenger Cars*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, April 1982. (DOT HS 806 187:9-18).

[41] Legal citation: *49 CFR 571.114* (2004).

While this standard would initially have had some cost implications, no cost studies have been performed, and none are planned by this agency.

FMVSS 115 - [Does not currently exist]

FMVSS 116 - MOTOR VEHICLE BRAKE FLUIDS

FMVSS 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, multipurpose passenger vehicle, truck, bus, trailer, and motorcycle that has a hydraulic brake system shall be equipped with fluid that has been manufactured and packaged in conformity with the requirements of this standard.[42] FMVSS 116 would initially have had some cost implications, along with each time it was updated; however, no cost studies have been performed, and none are planned by this agency.

FMVSS 117 - RETREADED PNEUMATIC TIRES

FMVSS 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 similar to those for new pneumatic passenger car tires. This standard applies to retreaded pneumatic tires for use on passenger cars manufactured after 1948.[43] Since FMVSS 117 does not regulate components of new passenger cars or light trucks, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS 118 - POWER-OPERATED WINDOW, PARTITION, AND ROOF PANEL SYSTEMS

FMVSS 118 became effective on February 1, 1971 (passenger cars and multipurpose vehicles) and on July 25, 1988 (trucks). 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. This standard applies to passenger cars, multipurpose passenger vehicles, and trucks with a GVWR of 10,000 pounds or less. The standard’s requirements for power-operated roof panel systems need not be met for vehicles manufactured before September 1, 1993.[44]

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

[42] Legal citation: *49 CFR 571.116* (2004).
[43] Legal citation: *49 CFR 571.117* (2004).
[44] Legal citation: *49 CFR 571.118* (2004)

opening and closing of the power windows in a parked vehicle without the ignition turned on (potential safety hazard to children or other unsuspecting persons) 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 study was conducted on six make-model passenger cars from two major domestic manufacturers that represented pre-standard, post-standard, and trend systems.[45] The small sample was due to the limited number of vehicles and the model years 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.

FMVSS 118 was extended to light trucks effective July 25, 1988, however, voluntary installations of the power windows were appearing in light trucks as early as 1978. Because NHTSA has not performed teardown analyses of the power window components on light trucks, and because they are similar to the components on passenger cars, we will assume the same costs on light trucks as on passenger cars.

Table 118-01 shows the average weight and consumer cost of power window components attributable to FMVSS 118 in passenger cars and light trucks.

TABLE 118-01
AVERAGE WEIGHT AND CONSUMER COST
OF POWER WINDOW COMPONENTS
ATTRIBUTABLE TO FMVSS 118
IN PASSENGER CARS AND LIGHT TRUCKS

COMPONENT	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Circuit Breaker	0.04	$0.92

Based on information in the Ward's Automotive Yearbook, approximately 14% of the 1970 model year domestic passenger cars were equipped with power windows. By the 1982 model year, the number had increased to 33%. The popularity of power windows was growing, and the manufacturers had focused more attention on the cost on these systems as they filtered down from luxury cars to the intermediate range.

[45] Adams, DOT HS 806 774:24,32 (1983).

FMVSS 119 - NEW PNEUMATIC TIRES FOR VEHICLES OTHER THAN PASSENGER CARS

FMVSS 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
- 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 multipurpose passenger vehicles, trucks, buses, trailers, and motorcycles manufactured after 1948.[46] Since this standard does not regulate components of new passenger cars or light trucks, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS 120 - TIRE SELECTION AND RIMS FOR MOTOR VEHICLES OTHER THAN PASSENGER CARS

FMVSS 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 are equipped with 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 multipurpose passenger vehicles, trucks, buses, trailers, and motorcycles.[47] Since this standard does not regulate components of new passenger cars or light trucks, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS 121 - AIR BRAKE SYSTEMS

FMVSS 121 became effective on January 1, 1975 and establishes performance and equipment requirements for braking systems on vehicles equipped with air brake systems. The purpose of this standard is to insure safe braking performance under normal and emergency conditions.[48]

The Intermodal Surface Transportation Efficiency Act (ITSEA) of 1991 enacted by U.S. Congress required the Department of Transportation to initiate and enact rulemaking to improve braking performance of new commercial motor vehicles. Consequently, FMVSS 121 was amended in March 1997 and 1998 to require ABS systems on new air brake truck-tractors (Class 7 and 8) and new air brake trailers (greater than 10,000 pounds GVWR). It is important to note that even 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.

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[46] Legal citation: *49 CFR 571.119* (2004).
[47] Legal citation: *49 CFR 571.120* (2004).
[48] Legal citation: *49 CFR 571.121* (2004).

Since FMVSS 121 does not regulate components of new passenger cars or light trucks, it is outside the scope of this report. However, a study was conducted in 2000 and Table 121-1 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.[49] 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 121 apply to passenger cars or light trucks because they are equipped with hydraulic brakes, not air brakes.)

TABLE 121-1
AVERAGE WEIGHT AND CONSUMER COST
OF ABS IN AIR-BRAKED TRUCK-TRACTORS AND TRAILERS

ABS	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Truck-Tractor		
2000 Navistar International Class 7 Bendix ABS	31.71	$612.45
2000 Freightliner Class 8 Meritor/Wabco ABS	18.76	$496.36
Trailer		
2000 Great Dane Meritor/Wabco ABS	31.74	$494.85
2000 Utility International Haldex ABS	33.19	$396.06
Tractor-Trailer Connection		
	9.54	$ 96.79

FMVSS 122 - MOTORCYCLE BRAKE SYSTEMS

FMVSS 122 became effective on January 1, 1974 and specifies performance requirements for motorcycle brake systems. The purpose of the standard is to insure safe motorcycle braking performance under normal and emergency conditions. This standard only applies to motorcycles.[50] Since this standard does not regulate components of new passenger cars or light trucks, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

[49] Khadilkar, A.V., Fladmark, G.L., and Khadilkar, J., *Teardown Cost Estimates of Automotive Equipment Manufactured to Comply with Motor Vehicle Standards, FMVSS 121 (Air Brake Systems) and FMVSS 105 (Hydraulic Brake Systems), Antilock Brake Features*, Washington: U.S. Department of Transportation, National Highway Traffic Safety Administration, November 2002. (DOT HS 809 808).

[50] Legal citation: *49 CFR 571.122* (2004).

FMVSS 123 - MOTORCYCLE CONTROLS AND DISPLAYS

FMVSS 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 equipped with handlebars, except for motorcycles that are designed and sold exclusively for use by law enforcement agencies.[51] Since this standard does not regulate components of new passenger cars or light trucks, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS 124 - ACCELERATOR CONTROL SYSTEMS

FMVSS 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, multipurpose passenger vehicles, trucks, and buses.[52]

Accelerator control systems were difficult to analyze because changes were being made to the carburetor systems to meet EPA fuel conservation and emissions systems standards at the same time FMVSS 124 went into effect. However, the standard was met by having two energy sources, an inner and outer accelerator return spring, which were capable of returning the throttle to the idle position.

A study was conducted on eighteen make-model passenger cars from four major manufacturers that represented pre-standard, post-standard, and trend systems.[53] Analysis of each system identified an increase in the weight and consumer cost from the six pre-standard make-models to the six post-standard make-models. While a comparison of the post-standard and trend systems indicated that four out of the six make-models decreased in cost, three out of those four make-models were from the same manufacturer (GMC). The lack of evidence to support a significant trend, therefore, justifies the use of 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 pounds and $0.45 in 2002 dollars; the post-standard was calculated at 0.04 pounds and $0.91; the trend systems were calculated at 0.03 pounds and $0.74.

NHTSA has not performed teardown analyses of the accelerator control systems on light trucks; however, because they are similar to the systems on passenger cars, we will assume the same costs on light trucks as on passenger cars.

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[51] Legal citation: *49 CFR 571.123* (2004).
[52] Legal citation: *49 CFR 571.124* (2004).
[53] Adams, DOT HS 806 774:24,33-38 (1983).

Table 124-1 shows the actual weight and cost increments of accelerator control systems attributable to FMVSS 124 in passenger cars and light trucks.

TABLE 124-1 AVERAGE WEIGHT AND CONSUMER COST OF ACCELERATOR CONTROL SYSTEMS ATTRIBUTABLE TO FMVSS 124 IN PASSENGER CARS AND LIGHT TRUCKS		
CATEGORY	WEIGHT IN POUNDS	CONSUMER COST ($2002)
Pre-Standard	0.02	$0.45
Post-Standard	0.04	$0.91
DIFFERENCE	0.02	$0.47

FMVSS 125 - WARNING DEVICES

FMVSS 125 became effective on January 1, 1974 and establishes shape, size, and performance requirements for reusable day and night 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 pounds.[54] Since this standard does not regulate components of new passenger cars or light trucks, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS 129 - NEW NON-PNEUMATIC TIRES FOR PASSENGER CARS

FMVSS 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.[55] Since this standard does not require new passenger cars or light trucks to have the optional non-pneumatic tires, no cost studies have been performed, and none are planned by this agency.

FMVSS 131 - SCHOOL BUS PEDESTRIAN SAFETY DEVICES

FMVSS 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.[56] Since this standard does not regulate components of new passenger cars or light

[54] Legal citation: *49 CFR 571.125* (2004).
[55] Legal citation: *49 CFR 571.129* (2004).
[56] Legal citation: *49 CFR 571.131* (2004).

trucks, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS 135 – LIGHT VEHICLE BRAKE SYSTEMS

This standard specifies requirements for vehicles equipped 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 multipurpose passenger vehicles, trucks, and buses with a GVWR of 7,716 pounds 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 multipurpose passenger vehicles, trucks, and buses with a GVWR of 7,716 pounds or less manufactured before September 1, 2002, may meet the requirements of this standard instead of FMVSS 105.[57] No cost studies have been performed.

FMVSS 138 – TIRE PRESSURE MONITORING SYSTEMS

FMVSS 138 became effective on August 5, 2002 and specifies performance requirements for tire pressure monitoring systems. The purpose of the standard is to prevent significant under-inflation of tires and the resulting safety problems by warning the driver when a tire is significantly under-inflated. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses with a GVWR of 10,000 pounds or less, except those vehicles with dual wheels on an axle.[58] No cost studies have been performed.

FMVSS 139 – NEW PNEUMATIC RADIAL TIRES FOR LIGHT VEHICLES

FMVSS 139 became effective on June 5, 2003 and specifies tire dimensions, test requirements, labeling requirements, and defines load ratings. The purpose of the standard is to create more stringent tire performance requirements and require improved labeling of tires to assist consumers in identifying tires that may be the subject of a safety recall. This 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 pounds or less and that were manufactured after 1975.[59] No cost studies have been performed.

[57] Legal citation: *49 CFR 571.135* (2004).
[58] Legal citation: *49 CFR 571.138* (2004).
[59] Legal citation: *49 CFR 571.139* (2004).