U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

Memorandum

13656 7

Subject: ACTION: Preliminary Regulatory Evaluation
FMVSS No. 402, Radiator and Coolant Reservoir Caps,
Venting of Motor Vehicle Coolant Systems

Date: MAY 31 2001

From: William H. Walsh
Associate Administrator
for Plans and Policy

Reply to
Attn. of:

To: Docket No. NHTSA-01-9765-2

Thru: John Womack
Acting Chief Counsel June 1, 2001

Please submit the attached copy of the "Preliminary Regulatory Evaluation, FMVSS No. 402, Radiator and Coolant Reservoir Caps, Venting of Motor Vehicle Coolant Systems," May 2001 to the appropriate docket.

Attachment

Distribution:
Chief Counsel
Associate Administrator for Safety Performance Standards
Associate Administrator for Safety Assurance
Associate Administrator for Research and Development

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PRELIMINARY REGULATORY EVALUATION

National Highway
Traffic Safety
Administration

FMVSS No. 402
Radiator and Coolant Reservoir Caps Venting of Motor Vehicle Coolant Systems

Office of Regulatory Analysis and Evaluation

Plans and Policy

May 2001

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EXECUTIVE SUMMARY

We (NHTSA) are proposing a new Federal Motor Vehicle Safety Standard (FMVSS) No. 402 regulating new radiator caps and coolant reservoir caps, and new motor vehicles (including passenger cars) with such caps. This standard will result in fewer scalding-type injuries that occur when people attempt to remove caps from motor vehicle radiators or coolant reservoirs that are under high pressure and contain hot fluids. The standard would apply to new motor vehicles (except motorcycles and trailers) with a gross vehicle weight rating (GVWR) of 4,536 kilograms (10,000 pounds) or less and a liquid-based cooling system for their engines, and to radiator caps and coolant reservoir caps recommended for use on the engine cooling systems in the motor vehicles subject to this standard.

We would require that, when correctly fitted, the caps lock and remain locked when the radiator or cooling reservoir system is at and above 14 kilopascals (kPa) or 2 pounds of pressure per square inch (psi). We further propose that, at the option of the vehicle manufacturer, a manually-operated pressure release mechanism may be provided that has a venting outlet that directs the venting of the fluids in a manner (i.e., downward and toward the center of the vehicle) that reduces the likelihood of it contacting the person operating the manual pressure release. This would not only prevent the venting of liquid or steam in such a way that it sprays toward a person's face, hands or upper body, but would also reduce the likelihood that a person's feet or legs could be sprayed.

We propose that the new standard apply to new light vehicles manufactured on or after the first September 1st two or more years after the publication of the final rule. We also propose the same effective date for replacement radiator caps and reservoir caps for use on those vehicles. There would not be any prohibition on the manufacture and sale of caps (manufactured after the new standard's effective date) that are designed to fit on pre-standard vehicles.

The annual incremental cost of new and replacement radiator caps and coolant reservoir caps for the passenger car and light truck fleet is estimated at $14 million. The total medical cost savings and work loss savings are an estimated $72 million. Estimated annual net monetary benefits are $58 million. We estimate an annual reduction of 28,271 scalding-type injuries caused by motor vehicle radiator caps and coolant reservoir caps.

Summary Table
(1998 Dollars)

Target Population	**Impact**
Estimated Number of Annual Injuries	29,759
Estimated Number of Injuries Reduced	28,271
Savings	
Medical (PDV)	$28.2 million
Work Loss (PDV)	$43.9 million
Total Savings (PDV)	$72.1 million
Costs	
New Vehicle	$10.0 million
Maintenance (PDV)	$4.1 million
Total Costs (PDV)	$14.1 million
Net Monetary Benefit (PDV)	$58.0 million

PDV = Present Discounted Value

I. INTRODUCTION

Today's motor vehicles have engines with increased horsepower, smaller radiators, higher thermostat opening temperatures, and emissions controls that produce a greater amount of heat than did the engines of motor vehicles manufactured up to the 1950s, which had relatively low horsepower and low compression engines. However, today's vehicles have less engine surface to dissipate the heat into the atmosphere than older vehicles, which had more room under the car and under the hood. A pressurized cooling system was thus developed to prevent boiling of the coolant with resulting evaporation loss at these higher operating temperatures. The radiator caps in these pressurized systems function to provide an opening so that liquid cooling fluid can be added to the cooling systems as needed and to maintain the design pressure in the system.

During operation, a motor vehicle engine becomes very hot. Motor vehicle cooling fluid (coolant) in modern engines can reach temperatures as high as 118 to 129 degrees Celsius (245 to 265 degrees Fahrenheit) and 110 to 117 kilopascals (kPa) (16-17 psi). Under such high temperatures and pressure conditions, the opening of a standard radiator cap will allow hot fluid and steam to rush out of the neck of the radiator, with the potential for severely scalding[1] the person removing the cap. When the system is under pressure, especially high pressure, the

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[1]Scalds result from contact with hot liquids and vapors. Burns are caused by contact with hot dry objects. The effects of scalds and burns are similar. In first-degree burns, the damage is limited to the outer layer of the skin, resulting in redness, warmth, an occasional blister, and tenderness. Mild sunburn is an example of a first-degree burn. In second-degree burns, the injury goes through the outer layer and involves the deeper layers of skin, causing blisters. In third-degree burns, the full thickness of skin is destroyed and a charred layer of seared tissue is exposed. The seriousness of a burn depends on the amount of skin burned, the location of the burn and the depth of the burn.

radiator cap can literally "explode" i.e., the cap can be forcibly ejected or dislodged from the neck of the radiator in some way. A person close to the radiator may be sprayed with the hot fluid or steam that is ejected, and be scalded. We know that such incidents are not uncommon because, over the years, we have received many letters from the public and medical personnel at hospital burn-care facilities reporting such incidents, and encouraging us to establish a safety standard for radiator caps. Also, we have collected data documenting these events.

We are proposing a new Federal Motor Vehicle Safety Standard (FMVSS) No. 402 regulating new radiator caps and coolant reservoir caps and new smaller motor vehicles (including passenger cars) with such caps. We believe that, if implemented, this new standard will result in fewer scalding-type injuries that occur when people attempt to remove caps from motor vehicle radiators or coolant reservoirs that are under high pressure and contain hot fluids.

FMVSS No. 402 would apply to new motor vehicles (except motorcycles and trailers) that have a gross vehicle weight rating (GVWR) of 4,536 kilograms (10,000 pounds) or less and a liquid-based cooling system for their engines. It would also apply to radiator caps and coolant reservoir caps recommended for use on the engine cooling systems in the motor vehicles subject to this standard. Nothing in the new standard would require vehicles to have reservoir caps or radiator caps.

If such new vehicles have either caps for pressurized reservoir tanks or radiator caps, the vehicles must be designed to accommodate both original equipment and replacement radiator caps and coolant reservoir caps that meet the new standard.

We further propose that, at the option of the vehicle manufacturer, a manually operated pressure release mechanism may be provided on the cooling system of a new motor vehicle that meets the new standard. We do not propose to describe the location on the vehicle for the pressure release mechanism (e.g., lever), but would specify that the vehicle on which the venting would be provided must have a venting outlet that directs the venting of any liquid or gas in a manner (i.e., downward and toward the center of the vehicle) that reduces the likelihood of it contacting the person operating the manual pressure release mechanism. This would not only prevent the venting liquid or steam from spraying toward a person's face, hands or upper body, but would also reduce the likelihood that a person's feet or legs would be sprayed. We request comments on costs for such a pressure-release mechanism.

We also propose that cap manufacturers may manufacture radiator or coolant reservoir replacement caps (which would be required to lock under any pressure above 14 kPa) with a manually-operated pressure release mechanism incorporated into the cap to quickly reduce the cooling system pressure below 14 kPa. This manually-operated pressure release mechanism would permit fluid to flow from the radiator or coolant reservoir system, thereby quickly reducing the pressure in the system faster than would occur through the normal cooling of the system. Thus, there would be no need to wait for an extended period of time before the radiator cap or the coolant reservoir cap can be removed. We propose to require that the fluids released by the operation of a pressure release mechanism in the cap be directed downward and toward the center of the vehicle. This requirement is intended to reduce the likelihood of hot fluids or steam contacting a person operating the mechanism and also limit their contact with individuals standing next to the vehicle. The mechanism (e.g., lever) to control venting may be located on the radiator cap or the coolant reservoir cap but, to prevent operation of the mechanism from venting the system in any manner or location that would injure the person actuating it, the vented fluids would not be permitted to vent or leak through the cap itself.

We propose that the locking requirement for caps should be based on pressure, instead of temperature. Although the temperature of fluid in the radiator is important, we believe the more important safety consideration in providing a solution to radiator-related scalds is the pressure in the cooling system. If there is little pressure to force liquid or steam up when the cap is removed, the risk of hot scalding fluid being ejected from the radiator filler neck or coolant reservoir would be essentially eliminated. Also, ambient temperature under the hood of a vehicle without the engine running could approach 52 degrees Celsius (125 degrees Fahrenheit) during the hot part of a summer day. Thus, adopting a temperature-based requirement might result in persons' not being able to add radiator fluid (because of a locked cap) in circumstances when there is no danger of hot liquid or steam being ejected from the cooling system during cap removal.

We propose that the cap locking pressure be established at no more than 14 kPa based on radiator pressure release tests performed by NHTSA's Vehicle Research and Test Center (VRTC) in East

Liberty, Ohio. The VRTC conducted tests that measured various radiator pressures and observed the amount of fluid that was released or expelled at each of these pressures when the radiator caps were removed. The tests indicate that, after radiator cap removal, the least amount of fluid was released when the radiator pressure was at 1 and 2 psi. Documentation of the VRTC testing has been placed in the public docket at the DOT Docket Number cited in the heading of this notice.

Data from a 1994 Stant Manufacturing, Inc., pressure cooling system tester manual indicate that the manufacturing parameters of the compression spring used in some Stant radiator caps include a tolerance of plus or minus one psi. Therefore, it appears that any proposed cap locking pressure would be limited by the tolerance of the compression spring used in the cap. We believe that in order to reduce tolerance, a more costly spring would be required. Weighing the need for safety against a desire to minimize costs of this rulemaking on manufacturers, we propose that the cap be required to lock at any pressure of 14 kPa or more.

We propose that the radiator cap and reservoir cap lock and remain locked at or above a pressure of 14 kPa. However, the proposal would not preclude any cap or vehicle manufacturer from producing a cap that locks at pressures below 14 kPa. We further propose that when the radiator system pressure drops below 14 kPa, and the radiator cap unlocks to become removable, the cap must not be removable by rotation only. We propose that, to be removed, the radiator cap must first be pushed downward in relation to the top of the cap, and then while being pushed downward, is rotated in a counter-clockwise direction. Because most people are familiar with these motions from previous experience with child-proof caps on bottles, we tentatively conclude that labels or instructions would not be necessary to inform people how the radiator cap can be removed. The coolant reservoir cap would be required to be designed so that removal of the cap would only require rotation in a counter-clockwise direction.

We propose that each radiator cap and coolant radiator cap subject to the proposed new standard be permanently marked with the symbol "DOT" as certification that the cap meets the new standard. We are not proposing any specifications for the size or the font of the letters. We propose to let cap manufacturers use their discretion in determining the best way to meet the requirement to provide the "DOT" certification. The cap manufacturer may emboss or engrave "DOT" directly onto the cap, or may place a permanent label on the cap. We propose to construe the term "permanent" in the same way as that term has been used for purposes of the certification labeling requirements described in 49 CFR Part 567, Certification.

We also propose that cap manufacturers permanently label each cap with its maximum pressure rating for the cap. This information will let consumers know the maximum pressure within the radiator or cooling reservoir system that the system is designed to withstand.

II. BACKGROUND

On October 14, 1967 (32 FR 14282), we issued an Advance Notice of Proposed Rulemaking, specifying requirements we were considering proposing for radiator caps for passenger cars, multipurpose passenger vehicles, trucks, and buses. These requirements included a means for relieving radiator pressure, such as an intermediate step before the cap is disengaged from the radiator filler neck. We also considered requirements that would have prevented the use of a replacement pressure cap having a pressure relief rating higher than the relief rating of the cap initially supplied by the vehicle manufacturer, and would have required distinct and durable markings identifying the pressure rating of the cap.

On January 25, 1972 (37 FR 1120), we suspended rulemaking on the October 1967 proposal stating, "After consideration of the available information, it has been determined that sufficient justification for regulations of the nature proposed has not been shown at this time." We believed that the problem of removing a radiator cap from a cooling system that is under pressure was being solved by the automotive industry by a warning on the cap and the two-step operation of the cap that permits pressure release prior to cap removal, or by other coolant system designs that minimized the likelihood of escaping steam and/or fluid coming in contact with an individual.

In 1992, we were petitioned to establish a new safety standard that would result in the use of thermal locking safety radiator caps. The petitioner requested the new standard to require new vehicles sold in the U.S. equipped with a water-cooled engine to be equipped with a radiator cap that automatically locks in a closed position when the temperature of the engine coolant is 52° C (125° F) or greater. The cap would automatically unlock, allowing for safe opening of the radiator, when the temperature of the engine coolant falls below 52° C (125° F). This type of radiator cap is referred to as a "thermal-locking radiator cap." The purpose of this type of cap is to prevent the chance scalding of persons who open hot radiators of motor vehicles. The petitioner stated that radiator cap scalding incidents are increasing and will continue to increase, and presented data on the number of radiator cap scalding incidents that occur annually. We were concerned that no data could be found to support or challenge the petitioner's assertion that there are over 100,000 radiator cap scalding incidents each year in the United States, and that 20,000 victims annually require treatment in hospital emergency rooms and burn care facilities. In addition, our review of highway safety literature, including the National Safety Council's "Accident Facts" failed to provide us with any meaningful information on the total annual number of radiator cap-related scalding incidents. We concluded that the petitioner did not support the claims of significant economic benefits to society in reduced medical cost.

In order to obtain information to assess the validity of the assertions in the petition, we published a "Request for Comments" document in the Federal Register, requesting comment on the feasibility of and necessity for rulemaking to prevent scalding injuries by requiring thermal locking radiator caps or other devices on motor vehicles with water cooled engines (June 10, 1993; 58 FR 32504). We asked for data that would assist us in determining the validity of the petitioner's claims.

The public comments did not provide information that established a safety need to commence a rulemaking to establish a safety standard for thermal locking radiator caps or other devices on motor vehicles with water cooled engines to prevent scalding injuries, nor did they show that there was no safety problem. In 1993, we changed the status of action on this petition from the "rulemaking phase" to the "research phase."

In the late 1970's, the Consumer Product Safety Commission (CPSC) sampled and collected hospital emergency room data on automobile product-related injuries, including injuries from radiator caps. Our review of that data yielded no meaningful information that could be applied to this rulemaking. However, we concluded that the CPSC was still the only existing and reliable source of estimates of injuries from automobile radiator caps, and CPSC's sampled hospital emergency room data could be projected to the U.S. national level. The CPSC operates a national probability survey of hospital emergency departments, the National Electronic Injury Surveillance System (NEISS), to monitor consumer products involved in injury-producing incidents. This system enables the CPSC to make national estimates of the number, type, and severity of injuries associated with specific consumer products. NEISS collects consumer product-related injury data from a current sample of 91 of the 6,127 hospitals in the United States and its territories with at least six beds that provide emergency care on a continuing 24-hour basis. NEISS collects data on three levels: surveillance of emergency room injuries; follow-up telephone interviews with injured persons or witnesses; and more comprehensive, on-site investigations with injured persons and/or witnesses. One, two, or three levels of data collection are used by the CPSC as primary data collection tools.

We established an interagency agreement with the CPSC in July 1993 to collect radiator cap-related injury data using the NEISS. The CPSC collected injury data from October 1, 1993 through September 30, 1994. The CPSC's data collection was submitted to the NHTSA's National Center for Statistics and Analysis (NCSA) in 1995.

III. RADIATOR CAP DESIGNS

We initiated a contract study to obtain the economic cost to vehicle manufacturers and the consumer cost for current radiator caps, those caps designed to mechanically relieve relatively high temperature and pressurized coolant in vehicle cooling systems until the pressure returns to normal, and those caps that automatically lock under relatively high pressure and temperature so that they cannot be removed until the pressure and temperature return to normal levels. The contractor's report is titled, Cost, Weight and Lead Time Analysis of a Pressure and Temperature Locking Radiator Cap (HS 808 593), April 19, 1997.

The objective of the study was to assess the increased cost, if any, of providing a system that positively prevents radiator caps from being removed while the vehicle coolant temperature and pressure are relatively high and the coolant could spray on and scald the person removing the cap. The cap would not be removable until the temperature or pressure returned to normal or atmospheric pressure. It is estimated to take about 20 minutes after an engine is turned off for the cooling system pressure and temperature to return to normal levels to allow removal of the cap, if no venting system is provided. A venting system, either in the cap or as a part of the vehicle, is an option for the manufacturers. The study developed costs of current radiator caps (which are non-locking), a manually operated pressure release lever radiator cap, and pressure and temperature locking radiator caps.

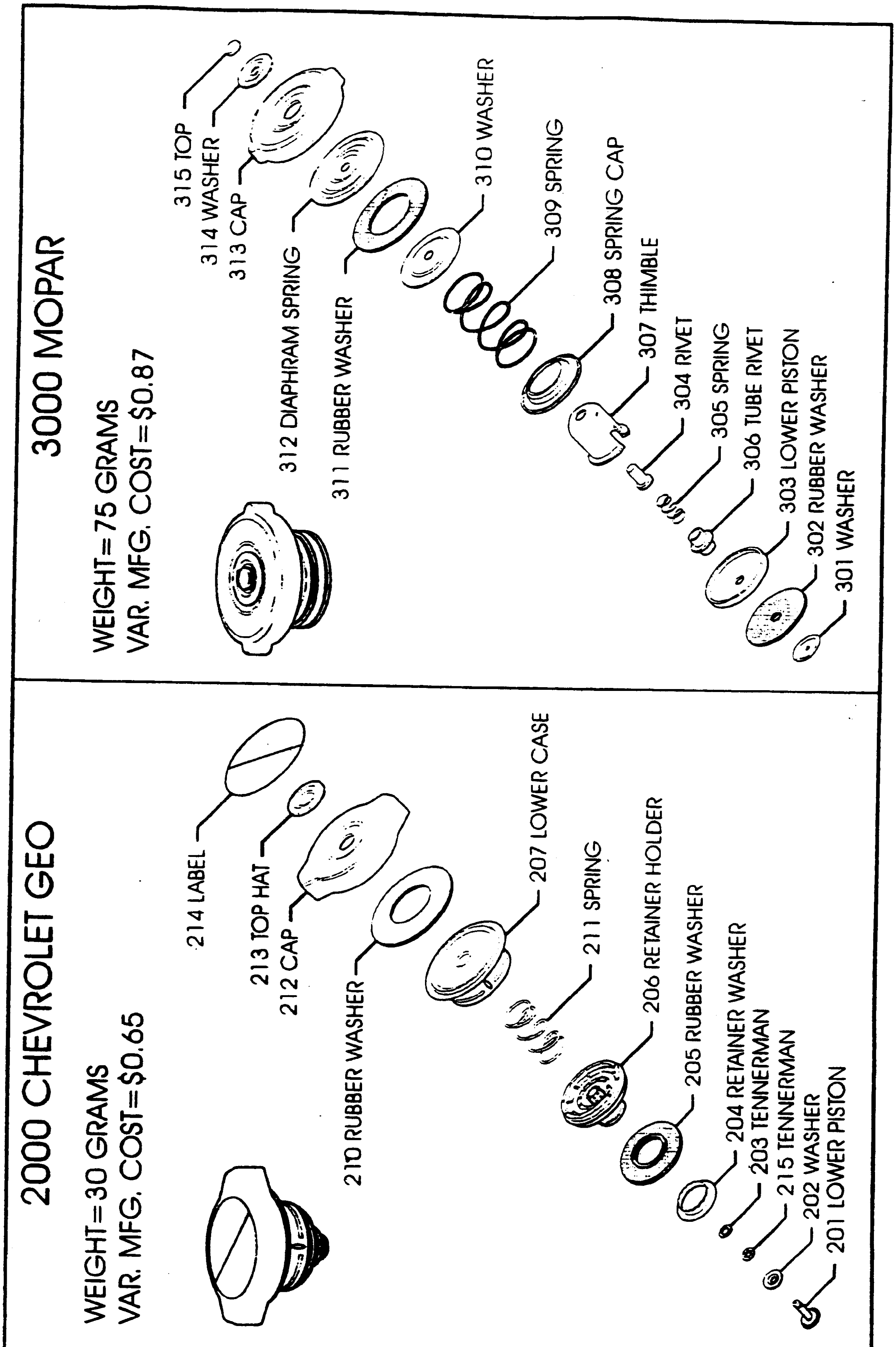
The directive of the study was to estimate the cost, weight, and lead time of 6 particular radiator caps for vehicles 4,536 kilograms (10,000 pounds) GVWR and under. The specific caps were: 1) a 1996 Geo Metro radiator cap (a sub-compact vehicle in production at that time; the Geo Metro does not have a coolant reservoir tank); 2) a coolant reservoir cap of a 1996 Dodge Intrepid (an intermediate size vehicle in production at that time), considered to be representative of all large vehicles in this study, where the coolant reservoir and the radiator are combined in a pressurized system; 3) the Lev-R-Vent produced by Stant Manufacturing, Inc. (fits the larger size vehicles and is currently in high production) which is a current replacement part for radiator or pressurized coolant reservoir systems; (the Lev-R-Vent is a mechanically actuated pressure relief system in which the pressure can be relieved prior to removing the cap); 4) the RadLoc temperature locking radiator cap (a prototype whose current size, as evaluated, would fit the larger size vehicles); 5) the Ludtke Lock 9000 pressure locking prototype cap (designed by the contractor) that can be used for either a radiator cap or coolant reservoir cap (a new design that would fit a 1996 high volume production sub-compact vehicle); and 6) the Ludtke Lock 10000 pressure locking prototype cap (designed by the contractor) that can be used as either a radiator cap or coolant reservoir cap (a new design that would fit a 1996 high volume production full car application). No pressure locking radiator caps were found to exist in current production.

All radiator caps are similar in design and construction. Exploded schematic views of the radiator caps in this analysis (2000 Chevrolet Geo, 3000 Mopar, 4000 Stant Lev-R-Vent, and 6000 RadLoc (except for the Stant No. 10241) are presented in Figures 1, 2, and 3.

The new designs for the locking radiator cap were developed by the contractor for the 1997 project. The contract study presented cost comparisons of the new pressure locking caps that can be used for radiators or coolant reservoirs, (Ludtke Lock 9000 and Ludtke Lock 1000), with the current standard radiator caps (1996 Geo Metro radiator cap and 1996 Dodge Intrepid coolant recovery tank cap). Costs are presented in Chapter VI of this analysis, Costs and Lead Time. The new designs for the Ludtke pressure locking caps were patterned after the current radiator cap designs as far as material type, size, and construction. All current radiator caps are similar in configuration, use of materials, and operation.

A cap for a pressurized coolant reservoir functions in the same environment as a radiator cap. Usually, if the coolant reservoir is pressurized, as in the case of the Dodge Intrepid, the radiator does not have a cap. The coolant in the reservoir is at the same high temperature and pressure as the radiator and the engine. Therefore, the pressure locking cap can be used either for the radiator or the pressurized coolant reservoir. Both new designs can be used for either application, the radiator or the coolant reservoir.

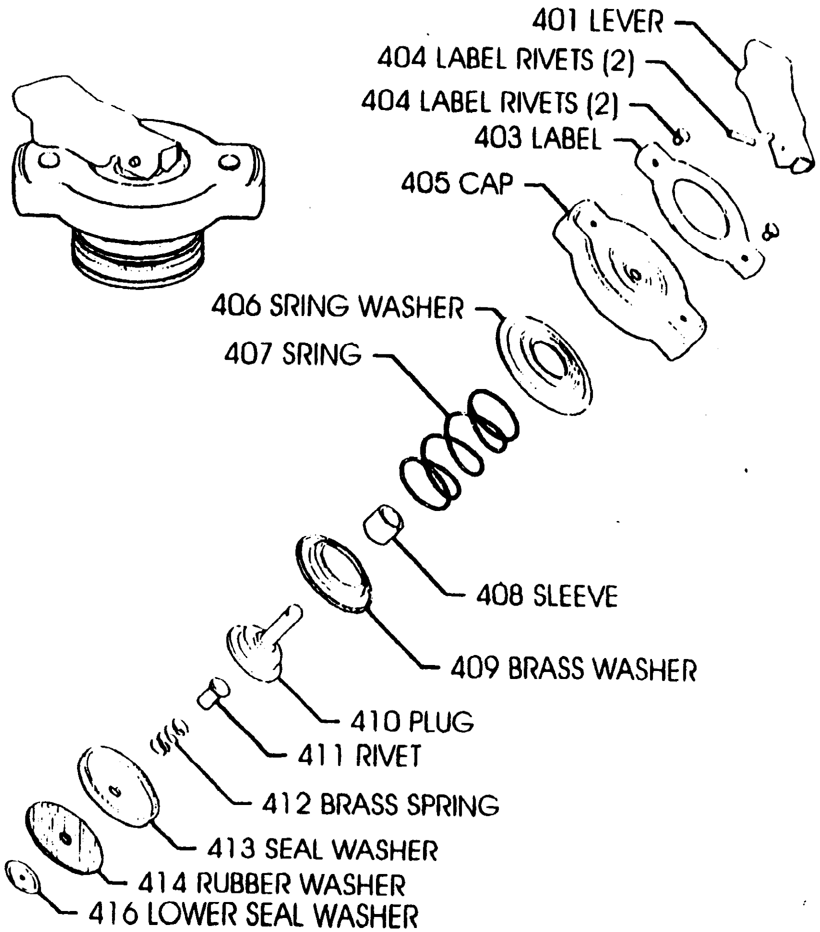
FIGURE 1



2000 CHEVROLET GEO
WEIGHT=30 GRAMS
VAR. MFG. COST=$0.65
214 LABEL
213 TOP HAT
212 CAP
210 RUBBER WASHER
207 LOWER CASE
211 SPRING
206 RETAINER HOLDER
205 RUBBER WASHER
204 RETAINER WASHER
203 TENNERMAN
215 TENNERMAN
202 WASHER
201 LOWER PISTON
3000 MOPAR
WEIGHT=75 GRAMS
VAR. MFG. COST=$0.87
315 TOP
314 WASHER
313 CAP
312 DIAPHRAM SPRING
311 RUBBER WASHER
310 WASHER
309 SPRING
308 SPRING CAP
307 THIMBLE
304 RIVET
305 SPRING
306 TUBE RIVET
303 LOWER PISTON
302 RUBBER WASHER
301 WASHER

4000 STANT LEV-R-VENT

WEIGHT=85 GRAMS
VAR. MFG. COST=$1.19



6000 RADLOCK

WEIGHT=80 GRAMS
VAR. MFG. COST=$1.09

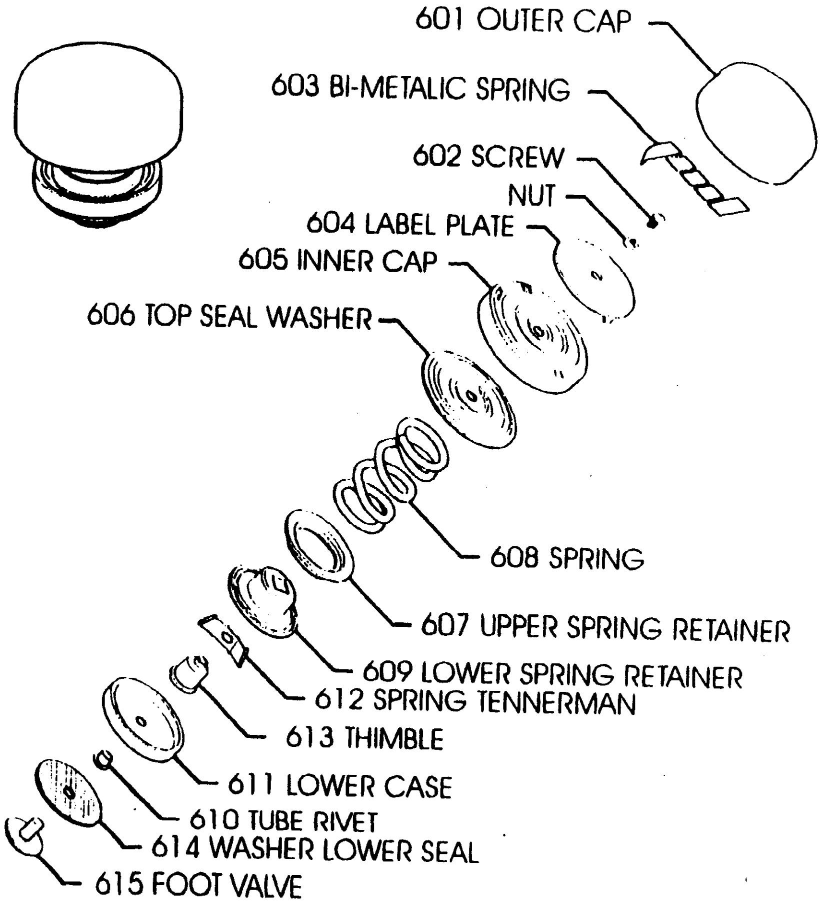


FIGURE 2

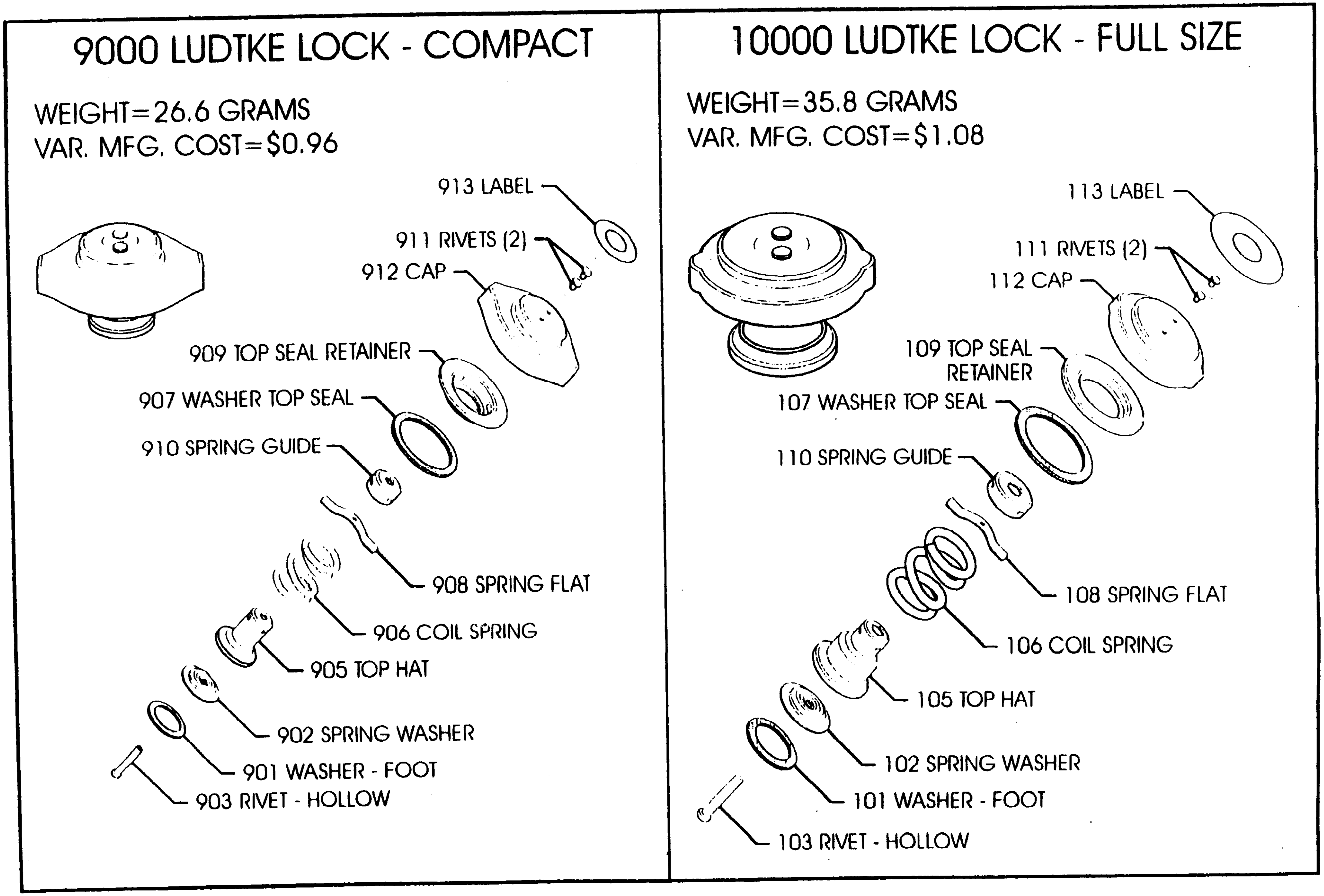

9000 LUDTKE LOCK - COMPACT
WEIGHT=26.6 GRAMS
VAR. MFG. COST=$0.96
913 LABEL
911 RIVETS (2)
912 CAP
909 TOP SEAL RETAINER
907 WASHER TOP SEAL
910 SPRING GUIDE
908 SPRING FLAT
906 COIL SPRING
905 TOP HAT
902 SPRING WASHER
901 WASHER - FOOT
903 RIVET - HOLLOW
10000 LUDTKE LOCK - FULL SIZE
WEIGHT=35.8 GRAMS
VAR. MFG. COST=$1.08
113 LABEL
111 RIVETS (2)
112 CAP
109 TOP SEAL RETAINER
107 WASHER TOP SEAL
110 SPRING GUIDE
108 SPRING FLAT
106 COIL SPRING
105 TOP HAT
102 SPRING WASHER
101 WASHER - FOOT
103 RIVET - HOLLOW

FIGURE 3

Figure 4 depicts the engine compartments for a full-size vehicle and a compact vehicle. The full-size engine compartment sketch depicts an arrangement where the radiator is pressurized but the coolant reservoir is not. The compact engine compartment sketch depicts two cooling system arrangements; the upper view shows the radiator pressurized and the system does not have a coolant reservoir. The lower view depicts a system where the reservoir is pressurized and the pressure cap is on the reservoir. In this case, the radiator does not have a cap, and coolant fill must be accomplished through the reservoir cap. In the later case, the pressure locking cap would be located on the reservoir.

Pressure increases with temperature in a sealed vehicle engine coolant system. Currently, most vehicles are designed to operate at increased temperatures to obtain higher mph efficiencies and better emissions. When the engine is turned off and cools down, the coolant system returns to atmospheric pressure.

A new pressure locking cap was developed for the sub-compact size vehicle (shown in Figure 5) and for a full-size vehicle (shown in Figure 6). The cap is attached to the radiator filler neck (or the pressurized coolant reservoir) in the same manner as the current radiator cap designs.

The operation of the locking feature of the design is as follows (shown in Figure 7): After the engine is started, the temperature and pressure of the coolant increase until the temperature reaches the design level, a fan is then automatically actuated to reduce the temperature of the coolant as it passes through the radiator to maintain the temperature at the desired level.

The relationship between temperature and pressure as they increase is presented in Figure 8. Some vehicle engines are designed to operate as high as 177° C (350° F); however, most vehicle engines are designed to operate around 93° C (200° F).

As the engine coolant pressure increases, pressure is applied against the spring washer which applies a force against the center of the spring flat through the rivet hollow. The rivet hollow part acts as a spacer between the spring flat and the spring washer. As the center of the spring flat moves up, in reaction to the force, the outer ends move down, pivoting about the spring guide. The spring flat is inserted through a slot in the spring guide during assembly. The spring flat pivots about the slots in the spring guide as the center moves up and down from the increase/decrease in coolant pressure levels. The outer ends of the spring flat move down into a depression in the filler neck as the coolant pressure increases. The radiator cap is locked in position as soon as the outer ends of the spring flat have moved down into the depression in the filler neck where the sides of the depression are vertical. Increases in pressure beyond the initial locking point increase the force of the spring flat outer ends against the bottom surface of the depression in the filler neck. When the engine is shut down and the temperature cools toward ambient and the pressure decreases towards atmospheric pressure, the outer ends of the spring flat move up and eventually reach a position where the cap can be turned and removed from the filler neck.

FIGURE 4

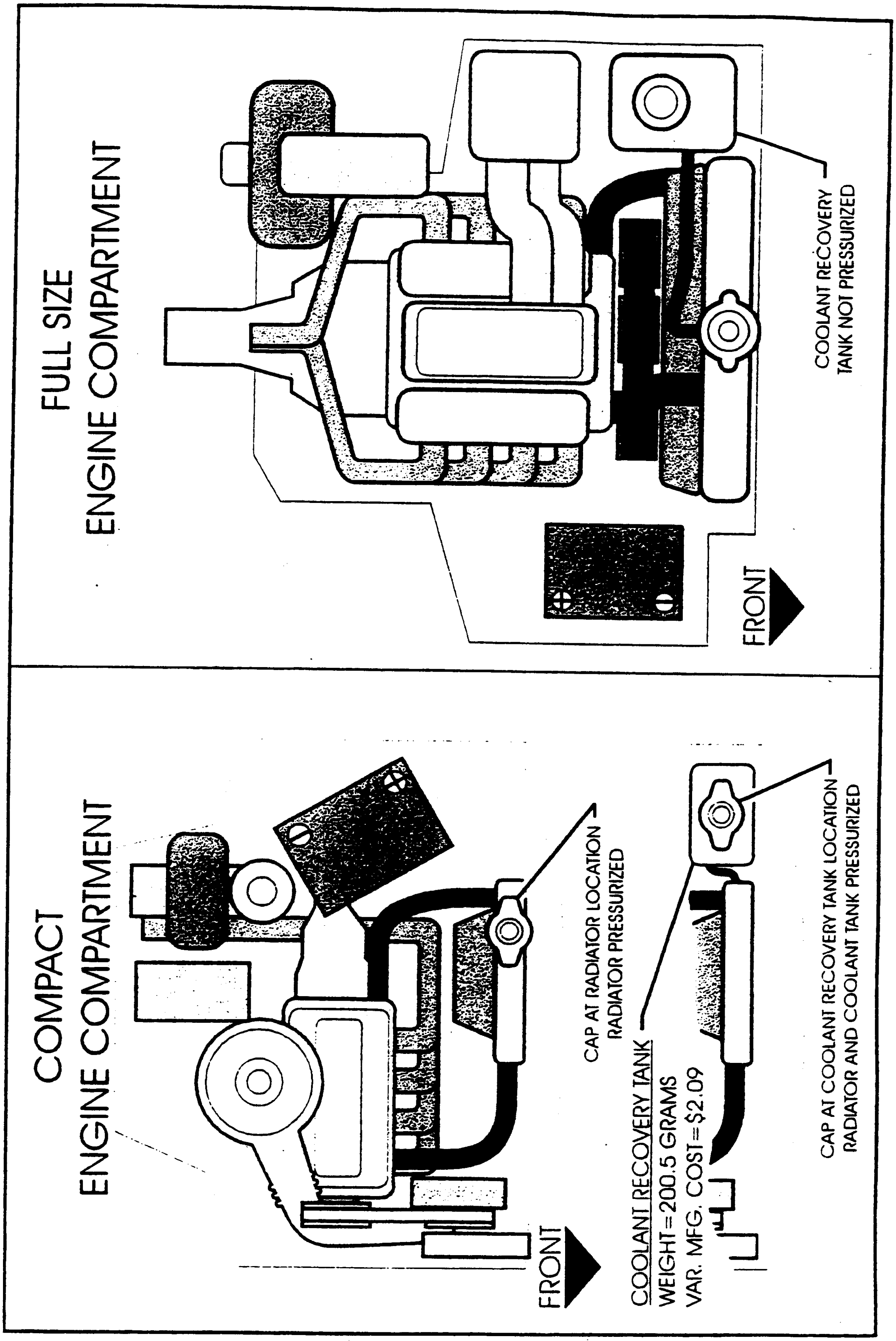

COMPACT
ENGINE COMPARTMENT
FRONT
CAP AT RADIATOR LOCATION
RADIATOR PRESSURIZED
COOLANT RECOVERY TANK
WEIGHT=200.5 GRAMS
VAR. MFG. COST=$2.09
CAP AT COOLANT RECOVERY TANK LOCATION
RADIATOR AND COOLANT TANK PRESSURIZED
FULL SIZE
ENGINE COMPARTMENT
FRONT
COOLANT RECOVERY
TANK NOT PRESSURIZED

FIGURE 5

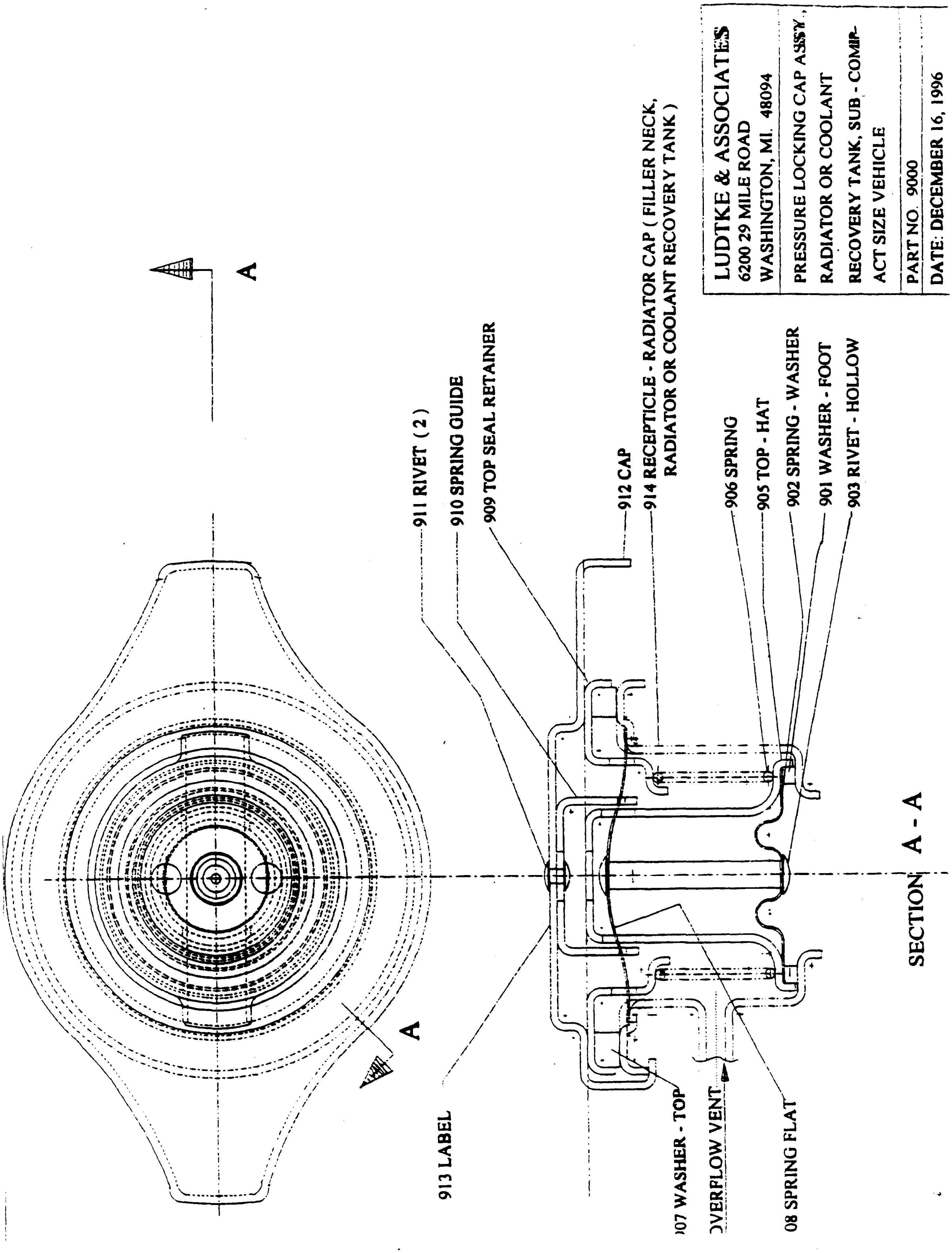
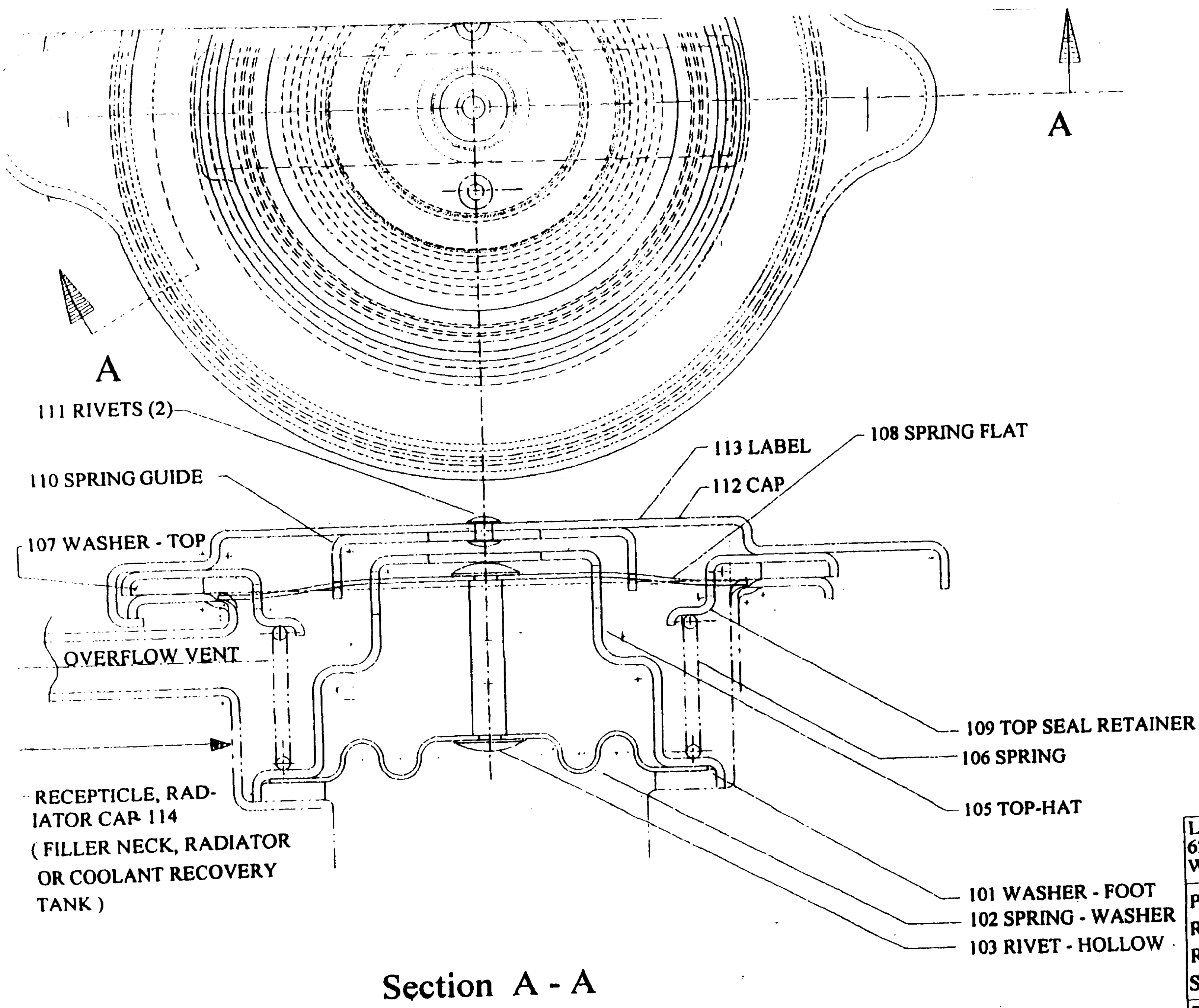
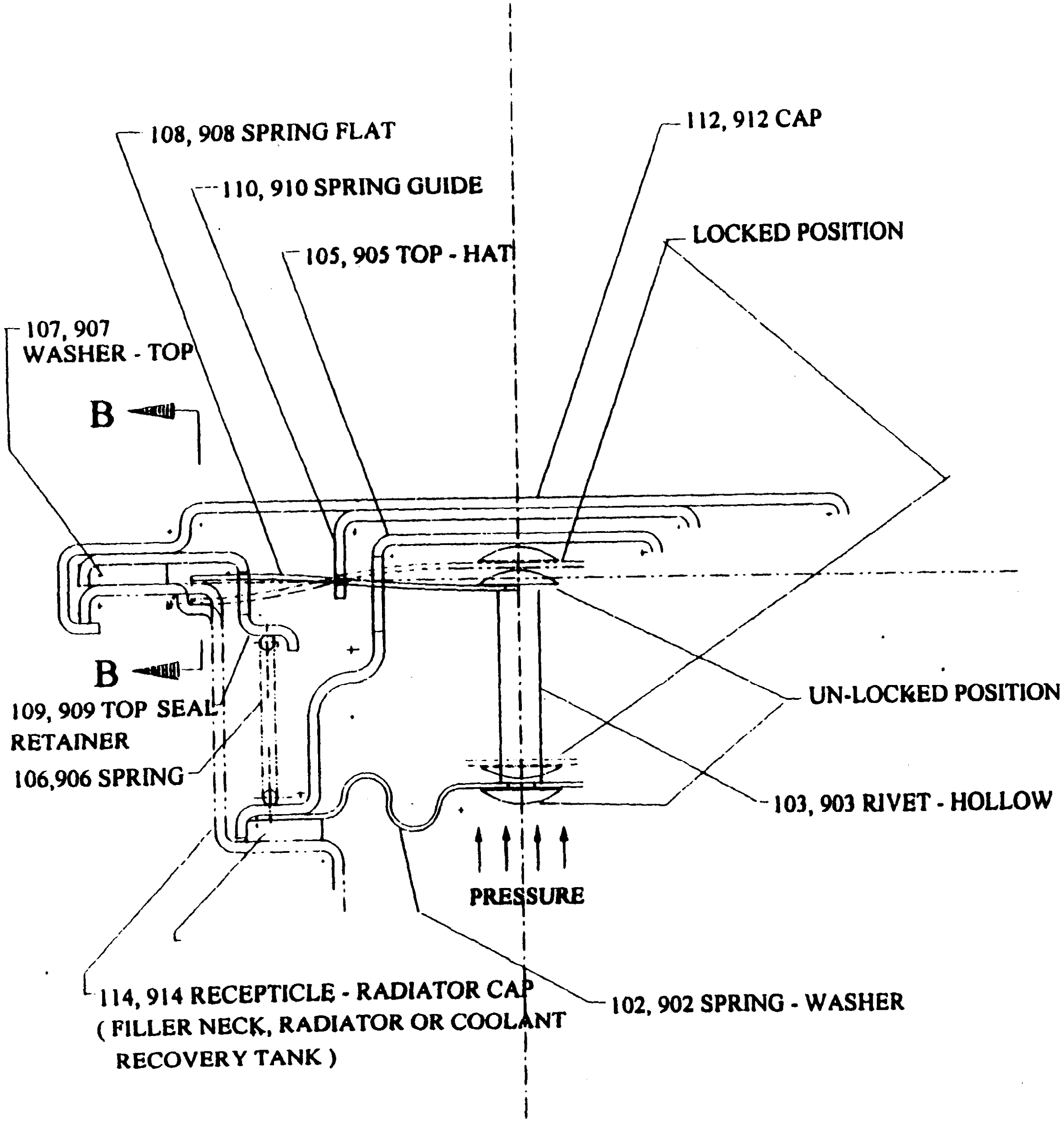

LUDTKE & ASSOCIATES
6200 29 MILE ROAD
WASHINGTON, MI. 48094
PRESSURE LOCKING CAP ASSY., RADIATOR OR COOLANT RECOVERY TANK, SUB - COMPACT SIZE VEHICLE
PART NO. 9000
DATE: DECEMBER 16, 1996
A
A
911 RIVET (2)
910 SPRING GUIDE
909 TOP SEAL RETAINER
912 CAP
914 RECEPTICLE - RADIATOR CAP (FILLER NECK, RADIATOR OR COOLANT RECOVERY TANK)
906 SPRING
905 TOP - HAT
902 SPRING - WASHER
901 WASHER - FOOT
903 RIVET - HOLLOW
913 LABEL
907 WASHER - TOP
OVERFLOW VENT
908 SPRING FLAT
SECTION A - A

FIGURE 6

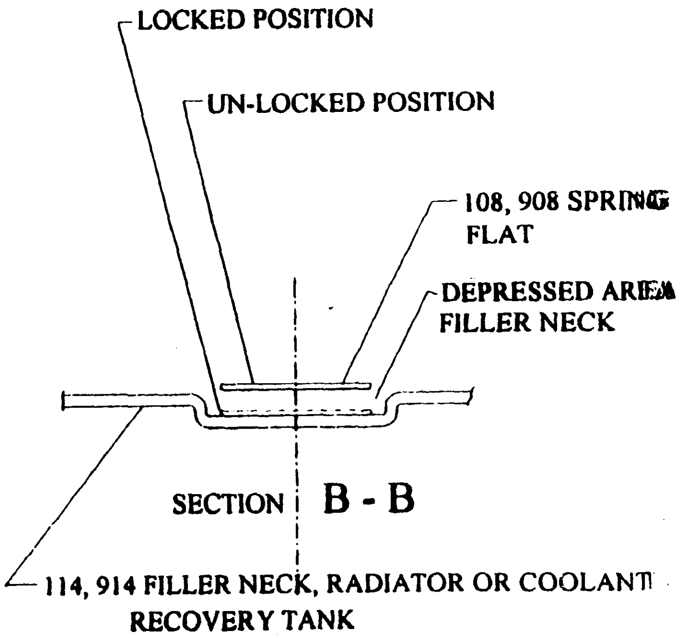


Section A - A

LUDTKE & ASSOCIATES 6200 29 MILE ROAD WASHINGTON, MI 48094
PRESSURE LOCKING CAP RADIATOR OR COOLANT RECOVERY TANK - FULL SIZE VEHICLE
PART NO. 10000
DATE: NOVEMBER 22, 1996



SECTION A - A



SECTION B - B

FIGURE 7

LUDTKE & ASSOCIATES
6200 29 MILE ROAD
WASHINGTON, MI 48094

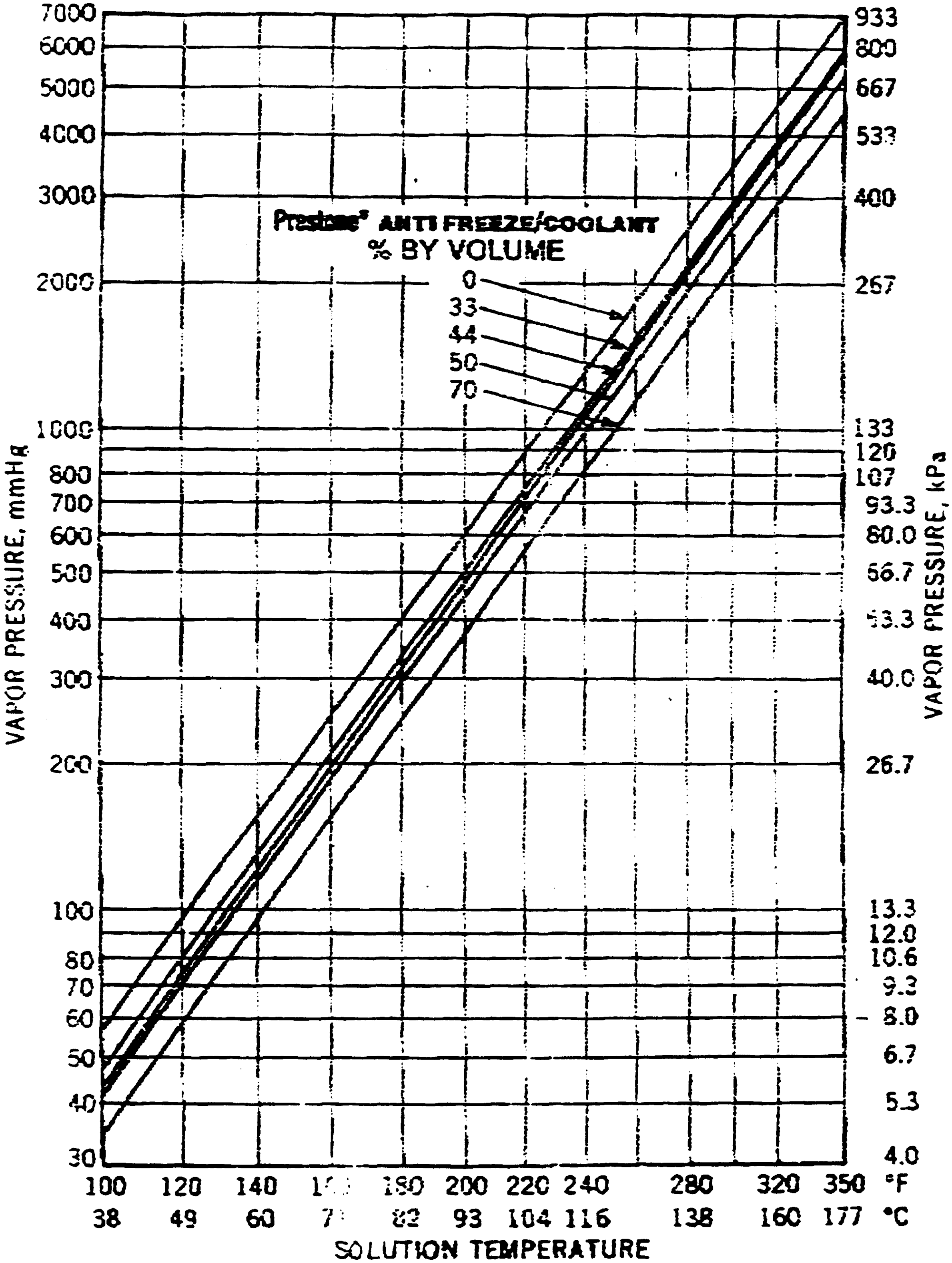
LOCKING, NON-LOCKING POSITION - 108, 908 SPRING FLAT & 101,901 WASHER FOR PRESSURE LOCKING RADIATOR CAP, PART #'S 9000 & 10000

PART NO. 11000

DATE: NOVEMBER 23, 1996

FIGURE 8

VAPOR PRESSURES OF AQUEOUS
Prestone® ANTI FREEZE/COOLANT
AT VARIOUS TEMPERATURES



The spring washer acts as a diaphragm across the filler neck opening in the radiator, or coolant reservoir tank. The spring washer and the washer foot, in combination, seal off the coolant. These two parts are forced against the shoulder in the filler neck by the spring. If the coolant pressure increases to a certain point above the operating pressure, then the spring washer moves up away from the filler neck shoulder, creating a gap and relieving pressure. The coolant that passes through the gap is vented out through a relief tube to the ground (the same method as in current radiator cap designs).

The RadLoc radiator cap design is similar to other radiator caps except for an additional bi-metal flat wire coil spring that is mounted under a dome cap. The inner cap is the same as the "cap part" of a "typical radiator cap" and functions in the same manner. One end of the flat wire coil is straightened out to form a tab that prevents its end from turning when heat is applied to the bi-metal material. The other end of the flat wire coil straightens out to form a tab that is bent. The increase in temperature from the coolant, as the engine warms up, causes the coil bi-metal flat wire bent tab to rotate until the tab enters a slot at the edge of the inner cap which in turn prevents the inner cap from being turned for removal.

IV. TARGET POPULATION

1. Consumer Product Safety Commission, National Electronic Injury Surveillance System Data

In November 1997, the NCSA published a technical report, DOT HS 808 598, titled "Injuries Associated with Specific Motor Vehicle Hazards: Radiators, Batteries, Power Windows, and Power Roofs" that compiled the data from the CPSC's injury data collection effort. The technical report includes estimates of the number of persons injured as a result of incidents involving motor vehicle radiators.

The NEISS data are collected from a current sample of 91 hospitals of the 6,127 hospitals in the United States and its territories with at least six beds that provide emergency care on a 24-hour/day basis. These data are used to estimate the number of persons nonfatally injured and treated in hospital emergency rooms nationwide. Each injury case study treated in one of the 91 hospitals is assigned that hospital's sample weight and the weights are then summed across all hospitals involved.

Injury estimates based on NEISS data are conservative for the following reasons. First, an indeterminate number of injuries are not captured in the NEISS sample. NEISS does not collect injury data from other medical care facilities (walk-in clinics, etc.) or from physicians in private practice. Secondly, an undeterminable number of injured persons that were treated at NEISS emergency rooms during the study period may not have been included by the NEISS data collectors. This is mostly due to missing or incomplete information in the emergency room report regarding details of the incident, and are generally believed to be a very small number compared to the far larger first category of fully identifiable, relevant cases excluded altogether from the NEISS sample.

The data in Tables 1 through 11 provide national estimates of the number of persons injured due to hazards associated with motor vehicle radiators based upon NEISS data. During the 12-month period from October 1, 1993 through September 30, 1994, an estimated 19,638 persons were injured nationwide as a result of incidents involving motor vehicle radiators. Of the 19,638 persons, about 77 percent (15,118 persons) were injured nationwide as a result of activities associated with radiator caps. Nearly 73 percent of the radiator cap injuries (11,024 out of 15,118) occurred during the removal or attempt to remove the cap from the radiator. Twenty-five percent of the radiator cap injuries (3,764 out of 15,118) were described as resulting from the radiator cap "exploding," i.e., the cap being forcibly ejected or dislodged from the neck of the radiator in some way. In most of these cases, we believe an attempt was being made to remove the radiator cap and this, along with excessive radiator pressure, may have contributed to the radiator cap ejection. The remaining 2 percent of radiator cap injuries (330 out of 15,118) resulted from persons attempting to place the cap on the radiator, or because a loose, not tightened, or badly fitting cap allowed the radiator to boil over. An additional 1,403 persons were injured from involvement with the radiator reservoir (most likely pressurized reservoirs) (Table 1).

We believe the that preliminary unadjusted target population (the target population will be adjusted in Chapter V. Section c.) for this proposed rule, using only the following CPSC/NEISS data, is 16,191 injuries (14,788 injuries from radiator caps and 1,403 injuries from radiator reservoirs treated at an emergency room). This includes all cases except those involving a loose cap (330 injuries).

According to the NEISS data, the radiator caps causing injuries were installed on automobiles in 91 percent of the cases, on pickup trucks in approximately 7 percent of the cases, and on trucks and vans in the remaining 2 percent of cases. Eight percent of the vehicles involved were pre-1975 models, 26 percent were 1975-1979 models, 34 percent were 1980-1984 models, 31 percent were 1985-1989 models, and less than 1 percent were model years 1990-1994 (Table 2). Not all 1994 vehicles were taken into account since the CPSC data collection ended in September 1994. We are not aware of any cooling system design changes introduced after 1990 that would have significantly affected the number of radiator-related injuries. One possible reason for the small number of injuries involving newer vehicles (model years 1990-1994) is that newer vehicles experience fewer mechanical failures.

In the NEISS data (Table 3) eighty-six percent of persons injured by motor vehicle radiator caps were males. Two percent of persons injured by radiator caps were less than 15 years of age, 40 percent were ages 15-29 years, 37 percent were ages 30-44 years, 17 percent were ages 45-59 years, and 4 percent were 60 years of age or older (Table 4).

Scalding-type burns from hot radiator fluid or steam released from the radiator injured nearly 91 percent of those whose injuries involved radiator caps. Injuries from chemical and thermal burns accounted for 7 percent of the injuries; and contusions, abrasions, lacerations or fractures, caused by striking against some part of the vehicle in reaction to hot radiator fluid, accounted for 2 percent of the injuries. A small number of persons were poisoned by accidental ingestion of the coolant (less than 0.5 percent) (Table 5).

The NEISS data indicated that the face (including eyeball, eyelid, eye area, and nose) was the most injured body region for 38 percent of persons whose injuries involved radiator caps, followed by the lower arm (26 percent), the upper trunk (18 percent), the hand/wrist (including finger) (13 percent), and all other regions, including upper arm (5 percent) (Table 6). Four percent of persons whose injuries involved radiator caps received injuries over 25 percent of their bodies (Table 7).

Approximately 88 percent of the persons whose injuries involved radiator caps had moderately severe injuries, primarily first and/or second degree scalding-type burns that did not generally require hospitalization. Ten percent of the persons were seriously injured. The remaining 2 percent of persons received minor injuries (Table 8).

Approximately 93 percent of persons injured were treated and released without hospitalization; the remaining 7 percent were hospitalized due to more serious injuries (Table 9). Persons injured who required hospitalization tended to be those with the more serious injuries. Sixty-four percent of persons seriously injured from contact with radiator caps were hospitalized (929), while only 1 percent of those persons moderately injured were hospitalized (184) (Table 10).

The highest number of injuries involving radiator caps (44 percent) occurred in June, July and August. Eleven percent of persons were injured from contact with radiator caps during the winter, 20 percent occurred in the spring, and 25 percent took place in the fall (Table 11).

Table 1. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Body Type of Motor Vehicle October 1993 - September 1994*

Type of Radiator Involvement	Body Type of Motor Vehicle				
	Auto	Van	Pickup	Truck	Total
Radiator Cap	13,711	373	955	79	15,118
Percent	91%	2%	6%	**	100%
Removal	9,824	373	748	79	11,024
Ejection[1]	3,704	0	60	0	3,764
Closure	119	0	147	0	266
Other[2]	64	0	0	0	64
Radiator Reservoir	1,403	0	0	0	1,403
Percent	100%	0	0	0	100%
Radiator Hose	1,655	524	75	116	2,370
Percent	70%	22%	3%	5%	100%
Other Radiator[3]	141	6	7	34	188
Unspecified Radiator[4]	217	12	14	0	243
Other Cooling System[5]	316	0	0	0	316
TOTAL	17,443	915	1,051	229	19,638
PERCENT	89%	5%	5%	1%	100%

Source: Injuries Associated with Specific Motor Vehicle Hazards: Radiators, Batteries, Power Windows, and Power Roofs, USDOT, DOT HS 808 598, July 1997, p. 9.

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[1] Exploded, popped off.

[2] Cap on radiator, but loose, not tightened, or bad fit.

[3] Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[4] Cut by/fell on, etc., or injury indirectly due to radiator.

[5] Heater, heater hose, water pump, thermostat, etc.

*Percentages may not add to 100% due to rounding.

** Less than 1%

Table 2. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Model Year of Involved Vehicle October 1993 - September 1994*

Type of Radiator Involvement	Vehicle Model Year					
	Pre 1975	1975 - 1979	1980 - 1984	1985 - 1989	1990 -1994	Total
Radiator Cap	1,228	3,893	5,143	4,728	126	15,118
Percent	8%	26%	34%	31%	1%	100%
Removal	1,168	3,311	3,325	3,094	126	11,024
Ejection[1]	60	582	1,607	1,515	0	3,764
Closure	0	0	147	119	0	266
Other[2]	0	0	64	0	0	64
Radiator Reservoir	0	279	377	689	59	1,403
Percent	0	20%	27%	49%	4%	100%
Radiator Hose	229	618	525	979	19	2,370
Percent	10%	26%	22%	41%	1%	100%
Other Radiator[3]	0	39	58	91	0	188
Unspecified Radiator[4]	0	61	91	91	0	243
Other Cooling System[5]	0	0	316	0	0	316
TOTAL	1,457	4,890	6,510	6,578	203	19,638
PERCENT	7%	25%	33%	34%	1%	100%

Source: Ibid., p. 10.

[1]Exploded, popped off.

[2]Cap on radiator, but loose, not tightened, or bad fit.

[3]Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[4]Cut by/fell on, etc., or injury indirectly due to radiator.

[5]Heater, heater hose, water pump, thermostat, etc.

* Percentages may not add to 100% due to rounding.

Table 3. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Gender October 1993 - September 1994*

Type of Radiator Involvement	Gender		
	Male	Female	Total
Radiator Cap	13,074	2,044	15,118
Percent	86%	14%	100%
Removal	9,153	1,871	11,024
Ejection[1]	3,626	138	3,764
Closure	231	35	266
Other[2]	64	0	64
Radiator Reservoir	1,403	0	1,403
Percent	100%	0	100%
Radiator Hose	2,328	42	2,370
Percent	98%	2%	100%
Other Radiator[3]	154	34	188
Unspecified Radiator[4]	226	17	243
Other Cooling System[5]	316	0	316
TOTAL	17,501	2,137	19,638
PERCENT	89%	11%	100%

Source: Ibid., p. 13.

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[1] Exploded, popped off.

[2] Cap on radiator, but loose, not tightened or bad fit.

[3] Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[4] Cut by/fell on, etc., or injury indirectly due to radiator.

[5] Heater, heater hose, water pump, thermostat, etc.

* Percentages may not add to 100% due to rounding.

Table 4. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Age October 1993 - September 1994*

Type of Radiator Involvement	Age of Person					
	0-14	15-29	30-44	45-59	60+	Total
Radiator Cap	320	5,973	5,609	2,561	655	15,118
Percent	2%	40%	37%	17%	4%	100%
Removal	294	2,960	4,911	2,266	593	11,024
Ejection[1]	26	2,747	698	231	62	3,764
Closure	0	266	0	0	0	266
Other[2]	0	0	0	64	0	64
Radiator Reservoir	22	748	471	141	21	1,403
Percent	2%	53%	34%	10%	2%	100%
Radiator Hose	149	854	1,104	131	132	2,370
Percent	6%	36%	47%	6%	6%	100%
Other Radiator[3]	0	52	102	0	34	188
Unspecified Radiator[4]	17	49	66	111	0	243
Other Cooling System[5]	0	0	316	0	0	316
TOTAL	508	7,676	7,668	2,944	842	19,638
PERCENT	3%	39%	39%	15%	4%	100%

Source: Ibid., p. 12.

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[1]Exploded, popped off.

[2] Cap on radiator, but loose, not tightened or bad fit.

[3]Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[4]Cut by/fell on, etc., or injury indirectly due to radiator.

[5]Heater, heater hose, water pump, thermostat, etc.

* Percentages may not add to 100% due to rounding.

Table 5. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Injury Diagnosis October 1993 - September 1994 *

Type of Radiator Involvement	Injury Diagnosis				
	Burns	Other Burns[1]	Poisoning[2]	Other Injury[3]	Total
Radiator Cap	13,704	1,083	35	296	15,118
Percent	91%	7%	**	2%	100%
Removal	9,973	776	35	240	11,024
Ejection[4]	3,524	184	0	56	3,764
Closure	207	59	0	0	266
Other[5]	0	64	0	0	64
Radiator Reservoir	1,313	56	0	34	1,403
Percent	94%	4%	0	2%	100%
Radiator Hose	2,217	106	0	47	2,370
Percent	94%	4%	0	2%	100%
Other Radiator[6]	0	0	34	154	188
Unspecified Radiator[7]	0	0	0	243	243
Other Cooling System[8]	316	0	0	0	316
TOTAL	17,550	1,245	69	774	19,638
PERCENT	89%	6%	**	4%	100%

Source: Ibid., p.14.

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[1]Chemical or thermal burns.

[2]Due to ingesting radiator antifreeze.

[3]Contusions, abrasions, lacerations or fractures.

[4] Exploded, popped off.

[5] Cap on radiator, but loose, not tightened or bad fit.

[6] Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[7] Cut by/fell on, etc., or injury indirectly due to radiator.

[8] Heater, heater hose, water pump, thermostat, etc.

*Percentages may not add to 100% due to rounding.

** Less than 1 %.

Table 6. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Most Injured Body Region October 1993 - September 1994*

Type of Radiator Involvement	Most Injured Body Region					
	Face	Lower Arm	Upper Trunk	Hand/ Wrist	All Other[1]	Total
Radiator Cap	5,677	3,874	2,782	2,032	753	15,118
Percent	38%	26%	18%	13%	5%	100%
Removal	3,715	2,910	2,162	1,685	552	11,024
Ejection[2]	1,929	841	561	237	196	3,764
Closure	33	123	0	110	0	266
Other[3]	0	0	59	0	5	64
Radiator Reservoir	532	541	0	15	315	1,403
Percent	38%	39%	0	1%	22%	100%
Radiator Hose	800	456	769	184	161	2,370
Percent	34%	19%	32%	8%	7%	100%
Other Radiator[4]	34	34	0	86	34	188
Unspecified Radiator[5]	80	0	0	163	0	243
Other Cooling System[6]	116	0	182	18	0	316
TOTAL	7,239	4,905	3,733	2,498	1,263	19,638
PERCENT	37%	25%	19%	13%	6%	100%

Source: Ibid., p. 15.

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[1]Face includes eyeball, eye area, and nose; Hand/Wrist includes finger; Upper Trunk includes shoulder and elbow.

[2] Exploded, popped off.

[3] Cap on radiator, but loose, not tightened or bad fit.

[4] Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[5] Cut by/fell on, etc., or injury indirectly due to radiator.

[6] Heater, heater hose, water pump, thermostat, etc.

* Percentages may not add to 100% due to rounding.

Table 7. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Most Injured Body Region October 1993 - September 1994*

Type of Radiator Involvement	Most Injured Body Region[1]			
	Lower Trunk	25%+ of Body	All Other	Total
Radiator Cap	461	646	659	15,118
Percent	3%	4%	4%	100%
Removal	405	470	568	11,024
Ejection[2]	56	176	91	3,764
Closure	0	0	0	266
Other[3]	0	0	0	64
Radiator Reservoir	0	210	0	1,403
Percent	0	15%	0	100%
Radiator Hose	106	35	129	2,370
Percent	5%	2%	5%	100%
Other Radiator[4]	0	34	0	188
Unspecified Radiator[5]	0	0	48	243
Other Cooling System[6]	153	0	0	316
TOTAL	720	925	836	19,638
PERCENT	4%	5%	4%	100%

Source: Ibid., p. 16.

[1] 25%+ of Body includes two categories of overall injury to the body: 25-50% and more than 50%; All Other includes head, ear, upper and lower leg, knee, foot and toe.

[2] Exploded, popped off.

[3] Cap on radiator, but loose, not tightened or bad fit.

[4] Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[5] Cut by/fell on, etc., or injury indirectly due to radiator

[6] Heater, heater hose, water pump, thermostat, etc.

*Percentages may not add to 100% due to rounding.

Table 8. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Injury Severity October 1993 - September 1994*

Type of Radiator Involvement	Injury Severity			
	Minor	Moderate	Serious	Total
Radiator Cap	396	13,266	1,456	15,118
Percent	2%	88%	10%	100%
Removal	313	9,559	1,152	11,024
Ejection[1]	83	3,377	304	3,764
Closure	0	266	0	266
Other[2]	0	64	0	64
Radiator Reservoir	48	1,050	305	1,403
Percent	3%	75%	22%	100%
Radiator Hose	87	2,178	105	2,370
Percent	4%	92%	4%	100%
Other Radiator[3]	120	68	0	188
Unspecified Radiator[4]	163	80	0	243
Other Cooling System[5]	0	316	0	316
TOTAL	814	16,958	1,866	19,638
PERCENT	4%	86%	10%	100%

Source: Ibid., p. 17.

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[1] Exploded, popped off.

[2] Cap on radiator, but loose, not tightened or bad fit.

[3] Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[4] Cut by/fell on, etc., or injury indirectly due to radiator.

[5] Heater, heater hose, water pump, thermostat, etc.

* Percentages may not add to 100% due to rounding.

Table 9. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Medical Disposition October 1993 - September 1994*

Type of Radiator Involvement	Medical Disposition		
	Treated and Released	Hospitalized	Total
Radiator Cap	14,005	1,113	15,118
Percent	93%	7%	100%
Removal	10,069	955	11,024
Ejection[1]	3,606	158	3,764
Closure	266	0	266
Other[2]	64	0	64
Radiator Reservoir	1,403	0	1,403
Percent	100%	0	100%
Radiator Hose	2,300	70	2,370
Percent	97%	3%	100%
Other Radiator[3]	188	0	188
Unspecified Radiator[4]	243	0	243
Other Cooling System[5]	316	0	316
TOTAL	18,455	1,183	19,638
PERCENT	94%	6%	100%

Source: Ibid., p. 18.

[1] Exploded, popped off.

[2] Cap on radiator, but loose, not tightened or bad fit.

[3] Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[4] Cut by/fell on, etc., or injury indirectly due to radiator.

[5] Heater, heater hose, water pump, thermostat, etc.

* Percentages may not add to 100% due to rounding.

Table 10. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement, Injury Severity and Medical Disposition October 1993 - September 1994

Type of Radiator Involvement & Injury Severity	Medical Disposition		
	Treated and Released	Hospitalized	Total
Radiator Cap[1]	14,005	1,113	15,118
Minor	396	0	396
Moderate	13,082	184	13,266
Serious	527	929	1,456
Radiator Reservoir	1,403	70	1,403
Minor	48	0	48
Moderate	1,050	0	1,050
Serious	305	0	305
Radiator Hose	2,300	70	2,370
Minor	87	0	87
Moderate	2,178	0	2,178
Serious	35	70	105
All Other Radiator[2]	747	0	747
Minor	283	0	283
Moderate	464	0	464
Serious	0	0	0
TOTAL	18,455	1,183	19,638
Minor	814	0	814
Moderate	16,774	184	16,958
Serious	867	999	1,866

Source: Ibid., p. 19.

[1] Cap removal, ejection, closure; loose or badly fitting cap.

[2] Other and unspecified radiator; other cooling system.

Table 11. Estimates of Persons Injured by Involvement with Motor Vehicle Radiators By Type of Radiator Involvement and Season of the Year October 1993 - September 1994*

Type of Radiator Involvement	Season of the Year				
	Fall	**Winter**	**Spring**	**Summer**	**Total**
Radiator Cap	3,742	1,702	2,981	6,693	15,118
Percent	25%	11%	20%	44%	100%
Removal	2,937	1,254	2,151	4,682	11,024
Ejection[1]	679	342	824	1,919	3,764
Closure	128	106	0	32	266
Other[2]	0	0	0	64	64
Radiator Reservoir	196	159	185	863	1,403
Percent	14%	11%	13%	62%	100%
Radiator Hose	436	181	968	785	2,370
Percent	18%	8%	41%	33%	100%
Other Radiator[3]	85	0	35	68	188
Unspecified Radiator[4]	65	17	113	48	243
Other Cooling System[5]	0	0	136	180	316
TOTAL	4,524	2,059	4,749	8,637	19,638
PERCENT	23%	11%	23%	44%	100%

Source: Ibid., p. 20.

[1] Exploded, popped off.

[2] Cap on radiator, but loose, not tightened or bad fit.

[3] Fan, fan belt, grill, fumes from overheating, radiator fluid got into eyes, unintentional ingestion of radiator fluid, etc.

[4] Cut by/fell on, etc., or injury indirectly due to radiator.

[5] Heater, heater hose, water pump, thermostat, etc.

*Percentages may not add to 100% due to rounding.

2. Johns Hopkins University Baltimore Regional Burn Center Data

In 1998, we requested information from the Johns Hopkins University Baltimore Regional Burn Center (Johns Hopkins) on persons injured (receiving scalding-type burns extensive enough to require treatment in hospital emergency rooms) from interactions with motor vehicle radiator caps. We requested information on the date of injury, age, gender, extent of burns, severity of injury, hospital outcome (surgery, discharge, etc.), length of hospital stay, cost of hospitalization, and any other relevant information.

Johns Hopkins provided us with data on 48 patients who were admitted with scalding-type burns from radiator caps during the period July 1, 1987 to June 30, 1998, and who required an in-patient stay at its institution (Tables 12 through 17). The data included admissions by year and month, patient age, gender, total body surface area (TBSA) as a percentage of the entire body, severity of burn (i.e., first, second, or third degree), admission date to hospital, discharge date, hospital length of stay (in days), total number of surgical procedures for skin grafting, and total hospital room charges.

There were roughly the same number of admissions per year (five or six) for the years 1988 through 1995, with the exceptions of 1987 (one admission) and 1994 (no admissions) (Table 12). From 1996 through 1998 there were two or three patients admitted each year. There were 40 male patients and 8 female patients, ranging in age from 0.8 to 86 years. Nearly half of the patients were between 16 and 35 years of age, and 17 percent of the patients were between 21 and 25 years of age (Table 13).

The highest number of admissions for radiator scalding injuries occurred in the summer months. About 65 percent of the scalding-type injuries from radiator caps took place during June, July and August. The remaining injuries were distributed among the spring and fall. There were no patients admitted to Johns Hopkins during winter months (January, December and February) (Table 14).

The percent of total body surface area burned ranged from 1 percent to 25 percent, with 90 percent of patients burned between 1 to 14 percent of TBSA (Table 15).

Table 12. Radiator Cap Scalding Injuries: Johns Hopkins University Baltimore Regional Burn Center Patient Admissions, By Year, July 1, 1987 - June 30, 1998

Year	Number of Admissions
1987	1
1988	6
1989	6
1990	5
1991	6
1992	6
1993	5
1994	0
1995	5
1996	3
1997	2
1998	3
TOTAL	48

Source: Johns Hopkins University, Baltimore Regional Burn Center, Baltimore, Maryland.

Table 13. Radiator Cap Scalding Injuries: Johns Hopkins University Baltimore Regional Burn Center Age Ranges of Patients Admitted, July 1, 1987 - June 30, 1998

Age Range	Number of Patients
0 - 10	2
11 - 15	1
16 - 20	5
21 - 25	8
26 - 30	4
31 - 35	5
36 - 40	3
41 - 45	3
46 - 50	4
51 - 55	4
56 - 60	4
61 - 65	2
66 - 70	1
71 - 75	1
76 - 80	0
81 - 85	0
86 - 90	1
TOTAL	48

Source: Johns Hopkins University, Baltimore Regional Burn Center, Baltimore, Maryland.

Table 14. Radiator Cap Scalding Injuries: Johns Hopkins University Baltimore Regional Burn Center Patient Admissions, By Month, July 1, 1987 - June 30, 1998

Month	Number of Admissions
January	0
February	0
March	2
April	1
May	4
June	6
July	12
August	13
September	4
October	4
November	2
December	0
TOTAL	48

Source: Johns Hopkins University, Baltimore Regional Burn Center, Baltimore, Maryland.

Table 15. Radiator Cap Scalding Injuries: Johns Hopkins University Baltimore Regional Burn Center Percent of Total Body Surface Area Burned Patients Admitted, July 1, 1987 - June 30, 1998

Percent of Total Body Surface Area	Number of Patients
1	2
2	2
3	6
4	4
5	3
6	3
7	1
8	2
9	2
10	6
11	2
12	3
13	4
14	3
15	0
16	0
17	1
18	1
19	0
20	1
21	0
22	1
23	0
24	0
25	1
TOTAL	48

Source: Johns Hopkins University, Baltimore Regional Burn Center, Baltimore, Maryland.

3. University of California San Diego Regional Burn Center Data

In 1998, the University of California San Diego Regional Burn Center (UCSD) provided us with data on eight patients admitted with scalding-type burn injuries from radiator incidents for the period January 1996 to August 1997 (Table 16). The average age of the patients admitted was 41, the average length of hospital stay was 6 days, and on average, 6 percent of the patient's total body surface area was burned.

Table 16. Radiator Burn Injuries: University of California San Diego Regional Burn Center January 1996 - August 1997

Gender	Age	Total Body Surface Area Burned (percent)	Length of Stay on Floor	Length of Stay in Intensive Care Unit	Cost/Hospitalization[1]	Length of Stay/ Total Body Surface Area Burned
M	36	5	8		$16,000	1.6
F	39	2.9	3		$6,000	1.034483
M	58	3	8		$16,000	2.666667
M	29	2	5		$10,000	2.5
M	46	19	13	2	$36,000	0.769474
M	49	10	1		$2,000	0.1
F	39	7	7		$14,000	1
F	31	1	2		$4,000	2
AVERAGE	40.9	6.24	5.88		$13,000	1.461328

Source: University of California San Diego Regional Burn Center.

[1] Cost is the hospital room charge only.

4. Adjustments to Johns Hopkins and UCSD Data to Project National Burn Center Hospitalization Cases

We used the Johns Hopkins and the UCSD data to project an estimated national average of burn center patients by calculating the estimated annual average number of patients within the Baltimore primary metropolitan statistical area (PMSA) and San Diego metropolitan statistical area (MSA) and applying a factor to reach a national estimate. We believe most burns of this type from the Baltimore and San Diego areas are treated at the Johns Hopkins Regional Burn Center and San Diego Regional Burn Center, although some burns may be treated elsewhere. Therefore, we believe that this is a conservative baseline estimate. Johns Hopkins reports that during the 11-year period from July 1, 1987 to June 30, 1998, there were 48 patients admitted with scalding-type burns from radiator caps that required an in-patient stay. The estimated population of the Baltimore PMSA (from which most of the cases were taken) in 1998 is 2,475,000, and the estimated national population for 1998 is 270,116,000[2]. Applying the burn incidence of the Baltimore PMSA to the national population results in an estimated 11-year total of 5,239 scalding-type burns from radiator caps, or an estimated 476 radiator cap scalding cases annually throughout the United States requiring burn center hospitalization.

We also examined UCSD data for the 20-month period from January 1996 to August 1997, and made another estimate of the national incidence of radiator cap scald injuries requiring hospitalization. We used UCSD's eight reported radiator scalding-type injuries during this

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[2] Based on data from the Statistical Abstract of the United States, 1998, U.S. Census Bureau, the Official Statistics, September 16, 1998.

period requiring hospital stays and applied it to the estimated 1998 population for the San Diego MSA of 2,723,000. Then, we projected the scalding burn hospitalization incidence from the San Diego MSA to the national population, and arrived at an estimated annual national incidence of radiator cap scalding-type burn injuries of 476 cases, the same number derived from the Johns Hopkins data. Based on the estimates from Johns Hopkins and UCSD, we project a national annual average of 476 radiator cap scalding cases requiring burn center hospitalization. The Johns Hopkins and UCSD data provided no estimates of how often people scalded by interactions with radiators were treated at hospital emergency rooms, doctors' offices or clinics, or had other medical treatment that did not involve hospitalization.

5. CPSC Injury Cost Model[3]

The CPSC developed the Injury Cost Model (ICM) to estimate the cost of consumer product injuries to society. The ICU uses NEISS data to make national estimates of the number, type, and severity of injuries associated with specific consumer products, such as radiator caps. The CPSC estimates that, nationally, in FY 1994, there were 16,287 radiator cap related injuries that were treated at doctors' offices or clinics, 17,548 radiator cap related injuries treated at emergency departments, and 1,887 similar cases admitted to the hospital either directly or

[3] U.S. Consumer Product Safety Commission, Estimating the Cost to Society of Consumer Product Injuries: The Revised Injury Cost Model, January 1998. U.S. Consumer Product Safety Commission, Updating the Injury Cost Model: 1987-1996 NHIS Data Extraction, June 1999.

through the emergency department, for an estimated national total of 35,722 radiator cap related injury cases (Table 17).

Table 17. FY 1994 Estimated Weighted Cases of Medically Treated Nonfatal Radiator Cap Injuries By Place of Treatment

Patient Treatment Location	Estimated Weighted Cases
Doctor/Clinic	16,287
Emergency Dept.	17,548
Hospital-Adm via ED	1,132
Hospital-Adm Direct	755
TOTAL	35,722

Source: Consumer Product Safety Commission, Injury Cost Model, as Applied to Radiator Cap Injuries.

Number of NEISS non-admitted records: 346
Number of NEISS hospital-admitted records: 30

The estimated number of consumer product injuries attributed to radiator cap incidents based on the ICM (35,722 injuries) is higher than our unadjusted target population (16,191 injuries using the CPSC NEISS data for October 1993 to September 1994). This is because our unadjusted target population estimate of 16,191 injuries includes only persons injured and treated for injuries in hospital emergency rooms, and excludes doctor and clinic cases. The ICM includes a greater number of medical treatment settings including: 1) injury survivors treated only in non-hospital settings other than ambulatory surgery centers (e.g., physician's offices and clinics, health centers, school clinics, and company clinics); 2) non-admitted survivors treated in ambulatory surgery centers (alternative to hospital admission for medical conditions that require surgical intervention but are not so invasive that they require more than a few hours of post-operative rest and observation before patients can be discharged); 3) hospital-admitted survivors not admitted through the emergency room (the two typical situations of this type are hospital admission from a non-emergency room health care treatment setting or admission to a burn center or other specialized acute care facility that does not have an emergency room); 4) hospital-admitted survivors admitted via the emergency room; 5) injury survivors treated and released from the emergency room.

6. NHTSA Adjusted Target Population Based on CPSC Injury Cost Model (ICM) and NEISS Data

We used the ICM NEISS data to calculate the radiator cap related injury target population (since it captures radiator cap injuries treated in a variety of medical settings) instead of the burn center model (which reports only incidents that require hospitalization). We correlated radiator cap related scalding-type injury estimates from the ICM to our target population (based on NEISS data), and arrived at an adjusted estimate of injuries, as follows. We added the following ICM estimated weighted injury cases from Table 19: 17,548 (emergency department) + 1,132 (hospital-admission via emergency department) + 755 (hospital-admission direct) = 19,435 ICM hospital and emergency room cases. We then calculated the ratio of 16,287 ICM doctor/clinic cases from Table 19 to 19,435 ICM hospital and emergency room cases = 0.838. To arrive at our adjusted target population, we multiplied the number of radiator cap and reservoir cap related injuries from Table 1 by the ratio of ICM doctor/clinic cases to ICM hospital and emergency room cases, as follows: 16,191 (11,024 radiator cap removal injuries + 3,764 radiator cap ejection injuries + 1,403 radiator reservoir injuries) x 1.838 = 29,759 total radiator cap injuries. To calculate the number of doctor/clinic cases, we deduct 16,191 injuries from 29,759 total injuries and arrive at 13,568 doctor/clinic injury cases.

The Agency has no data on which to measure the effectiveness of radiator and reservoir caps that meet the proposed requirements. If you prevent people from opening the cap, when there is a danger of being scalded, we believe that the only cases where the new radiator and coolant reservoir caps will not perform are when the cap becomes defective over time, or when tools are used to remove the cap and it is damaged. Assuming a 95 percent effectiveness, once the vehicle fleet is completely equipped with the new caps, we estimate that the reduction in the total annual number of radiator burn injuries will be 29,759 x .95 = 28,271 injuries.

V. BENEFITS

1. Medical Costs

a. Burn Center Costs, Johns Hopkins and UCSD

Johns Hopkins provided us with fiscal year hospital room cost data for the years 1987 - 1998 on persons injured with scalding-type burns who required an in-patient stay at its institution (Table 18).

Table 18. Johns Hopkins University Baltimore Regional Burn Center Patients Admitted with Scalding-type Burns from Radiator Caps Fiscal Year Data July 1, 1987 - June 30, 1998

Age	Gender	Total Body Surface Area (TBSA%)	Admit Date	Discharge Date	Hospital Length of Stay (Days)	Total Hospital Room Charges $ Actual	Adjusted Total Hospital Room Charges $ 1998[1]
86	F	12.0[2]	07-20-87	07-31-87	11	8,963.52	16,619.00
17	M	7.0	06-14-88	06-17-88	3	2,829.45	4,913.88
47	M	8.0	07-07-88	07-10-88	3	1,830.04	3,178.21
60	M	10.0	07-17-88	07-19-88	2	1,666.30	2,893.85
46	M	14.0	08-10-88	08-13-88	3	3,290.16	5,713.99
62	M	10.0	09-06-88	09-10-88	4	2,557.93	4,442.33
31	M	12.0	10-26-88	10-27-88	1	1,180.23	2,049.69
53	M	22.0	06-08-89	06-20-89	12	10,486.41	16,921.25
21	M	13.0	07-04-89	07-06-89	2	4,578.04	7,387.29
28	M	3.0[3]	07-06-89	07-06-89	1	860.57	1,388.65
21	M	6.0	07-17-89	07-19-89	2	1,748.49	2,821.43
26	M	18.0	07-22-89	08-01-89	10	7,131.17	11,507.12
22	M	13.0	11-14-89	11-16-89	2	1,345.21	2,170.68
31	M	10.5	05-08-90	05-10-90	2	1,307.34	1,939.72

[1]Based on Bureau of Labor Statistics Data, Consumer Price Index, Medical Care, U.S. Dept. of Labor, Series ID CWUR0000SAM.

[2]Third degree burn over 7.0% TBSA.

[3]Third degree burn over 1.0% TBSA.

Age	Gender	Total Body Surface Area (TBSA%)	Admit Date	Discharge Date	Hospital Length of Stay (Days)	Total Hospital Room Charges $ Actual	Adjusted Total Hospital Room Charges $ 1998
20	M	12.0	05-09-90	05-11-90	2	1,722.87	2,556.24
38	F	13.5	08-18-90	09-10-90	23	23,891.15	35,447.59
.8	F	24.5	08-18-90	09-10-90	23	22,799.08	33,827.28
28	M	3.0	11-24-90	11-26-90	2	1,153.13	1,577.14
14	M	4.0	03-02-91	03-03-91	1	702.92	961.39
34	M	2.0	07-02-91	07-02-91	1	1,881.25	2,573.00
71	M	3.0	07-23-91	07-24-91	1	1,699.58	2,324.52
32	M	5.25	08-06-91	08-07-91	1	958.83	1,311.40
3	F	4.0	08-09-91	08-10-91	1	854.04	1,168.08
17	M	14.5	10-26-91	11-1-91	6	4,036.81	5,521.17
47	F	9.5	03-29-92	04-17-92	19	14,167.71	18,038.42
18	M	3.0	05-01-92	05-02-92	1	551.88	702.66
65	M	10.0	07-12-92	07-25-92	13	8,224.22	10,471.13
43	M	17.0	07-30-92	08-15-92	16	10,538.84	13,418.12
38	M	13.5	09-02-92	09-04-92	2	1,645.32	2,094.83
25	M	0.5	09-16-92	09-17-92	1	703.10	895.19
35	M	20.0	06-07-93	06-07-93	1	2,471.65	2,969.92
23	M	3.0	06-09-93	06-10-93	1	2,954.95	3,550.65
23	M	4.0	08-12-93	08-13-93	1	2,626.57	3,156.07

Age	Gender	Total Body Surface Area (TBSA%)	Admit Date	Discharge Date	Hospital Length of Stay (Days)	Total Hospital Room Charges $ Actual	Adjusted Total Hospital Room Charges $ 1998
47	M	6.0	08-23-93	08-25-93	2	5,698.88	6,847.73
29	M	10.0	10-06-93	10-07-93	1	1,288.30	1,548.01
52	M	1.0	04-24-95	04-26-95	2	1,848.74	2,030.42
21	M	5.0	08-07-95	08-09-95	2	4,767.84	5,236.38
36	F	3.0	08-10-95	08-16-95	6	9,530.03	10,466.56
69	M	6.0	08-26-95	08-30-95	4	3,550.34	3,899.24
18	F	4.0	10-08-95	10-09-95	1	800.60	879.28
44	M	10.0	08-01-96	08-06-96	5	5,273.86	5,593.63
60	M	11.5	08-08-96	08-09-96	1	1,190.27	1,262.44
53	M	14.0	08-23-96	09-04-96	12	16,308.92	17,297.77
22	M	9.0	07-20-97	07-22-97	2	1,933.16	1,994.29
56	M	5.0	09-19-97	09-21-97	2	1,505.47	1,553.08
44	F	8.0[4]	05-13-98	05-28-98	15	25,438.06	25,438.06
53	M	2.5	06-22-98	06-24-98	2	6,178.32	6,178.32
56	M	11.0	06-30-98	07-02-98	2	6,325.57	6,325.57
TOTAL COST							323,062.67

Source: Johns Hopkins University Baltimore Regional Burn Center, Baltimore, Maryland.

[4]Third degree burn over 2 % TBSA; surgery required.

The length of hospital stay for these patients ranged from 1 day to 23 days, with 64 percent of patients admitted for 1 or 2 days (Table 19). The length of stay in the hospital for the remainder of the patients were fairly evenly distributed between 3 and 23 days.

Table 19. Radiator Cap Scalding-type Injuries: Johns Hopkins University Baltimore Regional Burn Center Length of Stay in Burn Center, July 1987 - July 1998

Length of Stay in Burn Center	
Number of Days	**Number of Patients**
1	15
2	15
3	3
4	2
5	1
6	2
10	1
11	1
12	2
13	1
15	1
16	1
19	1
23	2
TOTAL	48

Source: Johns Hopkins University, Baltimore Regional Burn Center, Baltimore, Maryland.

We can estimate the 1998 national annual burn center charges based on the total cost per case at Johns Hopkins and the UCSD. Total hospital room charges for the 48 cases at Johns Hopkins amounted to $323,062 in 1998 costs, or an average of $6,730.46 per case. We can estimate the average national cost using Baltimore costs as follows: $6,730.46 x 476 national annual cases = $3,203,703.70. To convert the cost in Baltimore to the national average cost, we apply the ACCRA health cost index, $3,203,703.70/.919[3] = $3,486,076.00 estimated annual national burn center total hospital room cost.

Total hospital room charges for the 8 cases reported by UCSD amounted to $108,681.31 (Table 16 total cost/hospitalization adjusted by 1998 CPI; medical care), or an average of $13,585.16 per case. We can estimate the average national cost based on San Diego costs as follows: $13,585.16 x 476 national annual cases = $6,466,536.10. To convert the cost in San Diego to the national average cost, we apply the ACCRA health cost index, $6,466,536.10/1.209[4] = $5,348,665.00 estimated annual national burn center total hospital room cost.

Based on the above analyses, the estimated annual number of burn center injuries is 476 nationally, and the estimated hospital cost for these injuries ranges from $3,486,076 to $5,348,665. The burn center costs include only hospital room charges and do not include physician costs and other charges.

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[3] ACCRA (American Chamber of Commerce Researchers Association) Cost of Living Health Index for Baltimore is 91.9. The national average cost is 100.

[4] ACCRA Cost of Living Health Index for San Diego is 120.9

It should be noted that there are many more patients with minor burns resulting from radiator cap scalding that are treated and discharged or are treated as outpatients, and are not included in the above estimated projections, based on data from Johns Hopkins and UCSD. It is difficult to estimate the costs associated with these types of injuries since hospitals generally do not collect these data or provide cost component breakouts for all expenses incurred during the hospital stay or outpatient treatment as a result of the injury.

b. Consumer Product Safety Commission, Injury Cost Model

The Consumer Product Safety Commission calculated an estimate of their Injury Cost Model (ICM) as applied to radiator cap injuries for 1994 (Table 20). The ICM contains injury cost estimates that can be used with NEISS data to estimate injury costs along the various dimensions of the NEISS sample. The dimensions include diagnosis (a description of the nature of injury and body part injured), victim age and gender, type of product involved and, through supplemental investigation, injury cause.

Table 20. FY 1994 Estimated Cost Components For Medically Treated Nonfatal Radiator Cap Injuries 1994 By Place Of Treatment (1998 Dollars)

Patient Treatment Location	Estimated Weighted Cases	Medical	Work Loss	Pain and Suffering	Legal and Liability	Total
Doctor/Clinic	16,287	$485	$1,720	$22,736	$87	$25,028
Emergency Dept	17,548	$786	$1,710	$25,075	$96	$27,667
Hospital-Adm via ED	1,132	$30,940	$35,423	$154,104	$765	$221,233
Hospital-Adm Direct	755	$30,940	$35,423	$154,104	$765	$221,233
AVERAGE		$2,241	$3,495	$30,823	$127	$36,687
TOTAL	35,722	$80,066,408	$124,848,770	$1,101,047,588	$4,533,389	$1,310,496,155

Source: Consumer Product Safety Commission, Injury Cost Model, as Applied to Radiator Cap Injuries.

Number of NEISS non-admitted records: 346
Number of NEISS hospital-admitted records: 30

In the ICM, the Medical Cost component includes: the original hospital and retreatment cost components, plus health insurance claims processing; costs of emergency medical treatment and ambulance transport (including air ambulances); hospital, physician and rehabilitation costs including post-discharge costs for hospital admitted cases; and ancillary costs for prescriptions, medical equipment and supplies, allied health services, home health services, nursing home care, and home health care. Because data are lacking, this component omits costs for trauma-induced mental health treatment of victims and their families.

The Work Loss Cost component includes the original foregone earnings, visitor forgone earnings, and disability components. It includes the value of: 1) victims' lost wage work and household work, as well as fringe benefits; 2) any lost schoolwork; and, 3) the work, family and friends lost while caring for, transporting, and visiting the injured. Finally, this component includes employer productivity losses, most notably the costs when supervisors spend time juggling schedules or recruiting and training replacements for injured workers.

The Quality of Life and Pain and Suffering Cost component places a dollar value on the intangible losses that result from an injury. These include pain, suffering, and lost quality of life.

The Product Liability Insurance and Litigation Costs component includes the original product liability insurance administration and litigation cost components. It includes the administrative costs of compensating product liability insurance claims related to injury, as well as attorney fees, court costs; plaintiff, defendant, and witness time; and out-of-pocket expenses (e.g., for transportation) that arise in litigation related to liability and compensation. NHTSA is not including the Quality of Pain and Life and Suffering Cost and the Product Liability Insurance and Litigation Costs in its cost calculations. Litigation and liability costs are excluded because third parties are generally not involved in radiator cap burn cases. It is usually the owner or driver of the vehicle that is injured and litigation is unlikely to occur. Quality of life costs are excluded because they are actually valuations rather than economic costs, and are subject to controversy as to their true value.

We estimate the national hospital cost per case for radiator cap scalding-type injuries by dividing the total ICM medical costs (excluding doctor/clinic) of $72,167,213 ($80,066,408 - (16,287 x $485)) by 19,435 ICM hospital and emergency room cases to arrive at an average ICM medical cost of $3,713.26 per case. Multiply 13,568 doctor/clinic cases (29,759 total injuries - 16,191) by $485 doctor/clinic medical cost per case to arrive at $6,580,480, the total cost of doctor/clinic injuries. We then multiply 16,191 injury cases by $3,713.26 per case for hospital care to arrive at $60,121,392, the total cost of hospital care. Adding $60,121,392 (hospital care cost) and $6,580,480 (doctor/clinic cost) we arrive at a total unadjusted medical care cost of $66,701,872 in 1998.

Work loss costs are calculated in a similar manner. We estimate the national work loss per case by dividing the ICM work loss costs (excluding doctor/clinic) of $96,835,130 ($124,848,770 - (16,287 x $1,720)) by 19,435 ICM hospital and emergency room cases to arrive at an average ICM work loss cost of $4,982.51 per case. We multiply 13,568 doctor/clinic cases by $1,720 doctor/clinic work loss cost per case to arrive at $23,336,960, the total cost of doctor/clinic cases. Then, we multiply 16,191 cases by $4,982.51 per unit cost to arrive at an unadjusted cost of $80,671,819. Finally, adding $80,671,819 and $23,336,960, we arrive at a total unadjusted work loss cost of $104,008,779 in 1998.

Medical cost savings and work loss savings will be adjusted in Section VII Cost/Benefit, for vehicle age, present discount value, and 95 percent effectiveness.

A new database is in the process of being developed, the ABA/TRACS registry, (the American Burn Association and the trauma registry of the American College of Surgeons) which is likely to become a major source of information on burn epidemiology and trends in burn treatment outcomes. The TRACS burn registry is expected to include in its coding system, the Tenth Revision of the International Statistical Classification of Diseases, Injuries, and Causes of Death, (ICD), the E-code which is the supplementary classification of external cause of injury that is specific to burn injury attributed to motor vehicle radiators and radiator caps. The TRACS registry is projected to be available sometime in 2001.

VI. COSTS AND LEAD TIME

1. Costs

The new designs for the locking radiator caps developed by the contractor for the study are presented in Table 21. These designs were patterned after the current radiator cap designs in terms of material type, size, and construction. All current radiator caps are similar in configuration, use of materials, and operation. This is because they all have the same function and are mass produced. The costs for these caps can be compared to make an assessment as to the cost of implementing manually operated pressure release caps and/or the positive locking radiator caps. These costs would represent the economic impact on the automotive industry and the consuming public, if these types were implemented. The costs are developed on the basis that the cap design would be installed on the annual production for the entire U.S. vehicle fleet. The costs for the caps are based on an annual production of 250,000 units. The costs include the variable manufacturing costs of each part, sub-assembly and final assembly and the tooling costs and capital equipment costs required to make the caps. The capital equipment costs are those that the capital equipment represents if the equipment had to be purchased to go into production. Most radiator cap manufacturers already have the necessary equipment. The variable manufacturing costs are also marked up by representative industry markups to assess the costs to the vehicle assembler (manufacturer), the vehicle dealer, and the vehicle purchaser. Given a production-ready design, it is estimated that temperature and pressure locking radiator caps could be manufactured for the motor vehicle industry in 12 months. A manufacturer can introduce multiple sizes at the same time.

Table 21. Cost, Weight, and Lead Time of Temperature and Pressure Locking Radiator and Coolant Recovery Tank Caps

(1996 Dollars)

Item	Weight Grams	Material Cost	Labor Cost	Variable Burden	Estimated Variable Cost	Cap Mfr's Price to Vehicle Mfr.	Wholesale	Retail	Lead Time
Chevrolet Geo Metro (Radiator Cap)	30.0	.18	.21	.26	.65	.92	1.22	1.35	N/A
Dodge Intrepid (Coolant Recovery Tank Cap)	75.0	.25	.26	.36	.87	1.23	1.63	1.81	N/A
Slant Lev-R-Vent (Radiator Cap)	85.0	.33	.39	.47	1.19	1.68	2.23	2.47	N/A
RadLoc (Temperature Locking Radiator Cap)	80.0	.33	.34	.42	1.09	1.54	2.05	2.27	11 months
Prototype (Pressure Locking Radiator Cap)	26.6	.21	.33	.42	.96	1.35	1.80	2.00	11 months
Prototype (Pressure Locking Coolant Recovery Tank Cap)	38.5	.34	.33	.41	1.08	1.52	2.02	2.24	11 months

Source: Cost, Weight and Lead Time Analysis of Pressure and Temperature Locking Radiator Caps, NHTSA Technical Report No. DOT HS 808 593, Washington, April 1997.

As indicated in this analysis in Section III, Radiator Caps, the contract study presented cost comparisons of the pressure and temperature locking Ludtke 9000 and Ludtke 10000 caps along with the current Geo Metro cap and the Dodge Intrepid cap. These cost estimates are presented in Table 20. We estimate that the maximum retail cost increase for switching from the current radiator caps ($1.35 for the Chevrolet Geo Metro radiator cap) to a pressure-locking radiator cap ($2.00 for a Ludtke 9000 prototype pressure-locking radiator cap) would be $0.65. Changing from a current coolant reservoir cap ($1.81 for the Dodge Intrepid coolant reservoir cap) to a pressure-locking coolant reservoir cap ($2.24 for a Ludtke 10000 prototype pressure-locking coolant reservoir cap) would add $0.43 in retail cost.

Injury data from the NCSA Technical Report[5] indicate most radiator cap-related problems occur near the tenth year of vehicle life. This information was confirmed by public comment from Stant Manufacturing, Inc., a manufacturer of radiator caps, indicating that original equipment caps remain in use for a period of approximately ten years. Therefore, we assume that, on average, the radiator caps and coolant reservoir caps will need to be replaced in ten years. Tables 22 and 23 present 1999 sales of passenger cars and light trucks of 16,890,535, and 1999 sales adjusted for survival probability in year ten (0.721 passenger cars, 0.816 light trucks[6]) of 12,956,345. Table 24 presents the cost of new and replacement radiator caps and coolant caps.

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[5] Injuries Associated with Specific Motor Vehicle Hazards: Radiators, Batteries, Power Windows, and Power Roofs, NHTSA Technical Report No. DOT HS 808 598, Washington, July 1997.

[6] Updated Vehicle Survivability and Travel Mileage Schedules, NHTSA Technical Report No. DOT HS 808 339, Washington, 1995, pp. 7, 9.

Based on current vehicle designs, we estimate that 75 percent of the new vehicle fleet will use pressure-locking radiator caps (valued at a cost increase of $0.65) and 25 percent of the new vehicle fleet will use coolant reservoir caps (valued at a cost increase of $0.43).

The $7,709,025 total cost increase for replacement caps is adjusted at a 7 percent discount factor in year ten (0.5258) to arrive at the present value of the total maintenance cost increase of $4,053,405 for radiator caps and coolant reservoir caps in year ten. The estimated cost of radiator caps and coolant reservoir caps for new passenger cars and light trucks is $10,049,869. Therefore, if this proposed rule were made final, we estimate that the total cost to the public would be $10,049,869 in higher radiator cap and coolant reservoir cap prices for the passenger car and light truck fleet, plus $4,053,405 in lifetime maintenance costs, for a total annual incremental cost of $14,103,274.

We request comments on costs for a manually-operated pressure release mechanism that may, at the option of the vehicle manufacturer, be provided on a new motor vehicle that meets the new standard. This mechanism would be used to reduce pressure inside the radiator or the coolant reservoir to normal, and would be separate from the radiator drain valve or the reservoir drain valve, which are used to drain liquids, and expose the radiator or reservoir to ambient air pressure. The mechanism would be a venting outlet that directs the venting of the liquid or gas in a manner that prevents it from contacting the person operating the manual pressure release.

We also request comments on costs for a manually-operated pressure release mechanism incorporated into the radiator or reservoir cap to quickly reduce the cooling system pressure below 14 kPa. The discharge resulting from the pressure release mechanism must not contact the person operating the release mechanism. The lever on the cap would not open the closed system to ambient air. The vented steam or fluid would not vent through the cap.

Table 22. Estimated Surviving 1999 Passenger Car and Light Truck Fleet in Ten Years

Vehicles	1999 Sales	Survival Probability in Year Ten*	Adjusted 10-Year Fleet
Passenger Cars	8,698,217	0.721	6,271,414
Light Trucks	8,192,318	0.816	6,684,931
Total	16,890,535		12,956,345

Source: Updated Vehicle Survivability and Travel Mileage Schedules, NHTSA Technical Report No. DOT HS 808 339, Washington, 1995, pp.7, 9.

Table 23. Cost of Radiator Cap and Coolant Cap for Vehicle Fleet

	Total Fleet	Radiator Caps 75 Percent of Fleet	Coolant Caps 25 Percent of Fleet
New Vehicles	16,890,535	12,667,901	4,222,634
Year 10	12,956,345	9,717,259	3,239,086
Cost of Cap		$0.65	$0.43
New Vehicles		$8,234,136	$1,815,733
Year 10 Surviving Fleet		$6,316,218	$1,392,807

Table 24. Cost of Radiator Cap and Coolant Cap Adjusted for 7 Percent Discount Factor in Year Ten and Total Cost

	Total Cost Radiator Cap	Total Cost Coolant Cap	7 Percent Discount Factor in Year Ten	Total Cost Radiator Cap Present Value	Total Cost Coolant Cap Present Value	Radiator and Coolant Cap Total Cost
New	$8,234,136	$1,815,733	-	$8,234,136	$1,815,733	$10,049,869
Replacement	$6,316,218	$1,392,807	0.5258	$3,321,067	$732,338	$4,053,405
Total Cost				$11,555,203	$2,548,071	$14,103,274

2. Lead Time

We propose that FMVSS No. 402 apply to new light vehicles manufactured on or after the first September 1st two or more years after the publication of the final rule. We also propose the same effective date for replacement radiator caps and reservoir caps for use on those vehicles. There would not be any prohibition on the manufacture and sale of caps (manufactured after the new standard's effective date) that are designed to fit on pre-standard vehicles. We do not believe that this proposed rule involves any new technology, or performance specifications that manufacturers cannot meet with existing design, tooling, or manufacturing capabilities. If this proposal were made final, we would encourage manufacturers to comply as soon as possible.

VII. COST/BENEFIT

We estimate that the annual incremental cost of new and replacement radiator caps and coolant reservoir caps for the passenger car and light truck fleet, adjusted for survivability in year ten (0.721 for passenger cars, 0.816 for light trucks) with a 7 percent discount factor (.5258) applied in year ten, and for radiator and coolant reservoir caps on new vehicles is $14,103,274. Assuming 95 percent effectiveness, the benefits of such caps would be an estimated total annual reduction of 28,271 scalding-type burn injuries, of which 452 are burn center hospitalizations. The present value of these injuries over the life of a new vehicle fleet is an estimated 13,270 (7 percent discount rate). Medical costs associated with radiator cap and coolant reservoir burns are an estimated $66,701,872, which we adjust to $28,184,724 for vehicle age, present discount value, and 95 percent effectiveness. We estimate work loss costs of $104,008,779 which we adjust to $43,948,673 for vehicle age, present discount value, and 95 percent effectiveness. We estimate that the total medical cost savings and work loss savings are $72,133,397 (Table 25).

In summary, the net impacts of this rulemaking are an estimated annual monetary benefit of $58,030,123 ($72,133,397 - $14,103,274) and a reduction of 28,271 injuries annually caused by new motor vehicle radiator caps and coolant reservoir pressure caps. A summary of the costs and benefits of regulating new radiator caps and coolant reservoir caps, and motor vehicles (except motorcycles and trailers) that have a GVWR of 4,536 kilograms (10,000 pounds) or less and a liquid-based cooling system for their engines is presented in Table 26.

Table 25. Vehicle Age Distribution, Discount Factors, and 95 Percent Effectiveness Applied to Medical Cost Savings, Work Loss Savings, and Total Savings

VEHICLE MODEL YEAR	VEHICLE AGE PERCENT DISTRIBUTION NEISS DATA ADJUSTED	VEHICLE AGE DECIMAL DISTRIBUTION NEISS DATA ADJUSTED	PRESENT DISCOUNT VALUE FACTOR	VEHICLE AGE X PDV FACTOR	MEDICAL COST SAVINGS DOLLARS	WORK LOSS SAVINGS DOLLARS	TOTAL SAVINGS DOLLARS
1	0.228	0.002	0.9667	0.0022	66,701,872.00	104,008,779.00	170,710,651.00
2	0.228	0.002	0.9035	0.0021			
3	0.228	0.002	0.8444	0.0019			
4	0.228	0.002	0.7891	0.0018			
5	0.228	0.002	0.7375	0.0017			
6	6.544	0.065	0.6893	0.0451			
7	6.544	0.065	0.6442	0.0422			
8	6.544	0.065	0.6020	0.0394			
9	6.544	0.065	0.5626	0.0368			
10	6.544	0.065	0.5258	0.0344			
11	6.558	0.066	0.4914	0.0322			
12	6.558	0.066	0.4593	0.0301			
13	6.558	0.066	0.4292	0.0281			
14	6.558	0.066	0.4012	0.0263			
15	6.558	0.066	0.3749	0.0246			
16	5.154	0.052	0.3504	0.0181			
17	5.154	0.052	0.3275	0.0169			
18	5.154	0.052	0.3060	0.0158			
19	5.154	0.052	0.2860	0.0147			
20	5.154	0.052	0.2673	0.0138			
21	1.516	0.015	0.2498	0.0038			
22	1.516	0.015	0.2335	0.0035			
23	1.516	0.015	0.2182	0.0033			
24	1.516	0.015	0.2039	0.0031			
25	1.516	0.015	0.1906	0.0029			
	100.0			0.4448	29,668,130.88	46,261,761.11	75,929,891.98
					.95	.95	.95
					28,184,724.33	43,948,673.05	72,133,397.38

Table 26. Summary of Benefits and Costs

Monetary Benefits	Impact
Medical Cost Savings	$28,184,724
Work Loss Savings	$43,948,673
Total Savings	$72,133,397
Costs	
New Vehicle Costs	$10,049,869
Maintenance Costs	$4,053,405
Total Costs	$14,103,274
Net Impacts	
Net Monetary Benefit	$58,030,123
Total Radiator Burn Injuries Reduced	28,271
Discounted Present Value of Reduced Injuries in Current Fleet	13,270

VIII. SMALL BUSINESS IMPACTS

The Regulatory Flexibility Act of 1980 (Public Law 96-354) requires agencies to evaluate the potential effects of their proposed and final rules on small businesses, small organizations and small governmental jurisdictions. Business entities are defined as small by standard industry classification for the purposes of receiving Small Business Administration assistance. One of the criteria for determining size, as stated in 13 CFR 121.601, is the number of employees in the firm; another criteria is annual receipts. For establishments primarily engaged in manufacturing or assembling passenger automobiles, and special purpose motor vehicles which are for highway use, and transportation equipment, not elsewhere classified, the firm must have less than 500 employees to be classified as a small business. At this time, there are only a few manufacturers of radiator caps which are small businesses. We believe that this rulemaking will not have an adverse effect on small businesses. We request comments on the impact of this rulemaking on small businesses.

IX. CUMULATIVE IMPACTS

Section 1(b) II of Executive Order 12866 Regulatory Planning and Review requires the agencies to take into account to the extent practicable "the costs of cumulative regulations". To adhere to this requirement, the agency has decided to examine both the costs and benefits by vehicle type of all substantial final rules with a cost or benefit impact effective from MY 1990 or later. In addition, proposed rules should also be identified and preliminary cost and benefit estimates provided. A this time, there are no major outstanding proposals that have quantified costs and benefits.

Costs include primary cost, secondary weight costs and the lifetime discounted fuel costs for both primary and secondary weight. Costs will be presented in two ways, the cost per affected vehicle and the average cost over all vehicles. The cost per affected vehicle includes the range of costs that any vehicle might incur. For example, if two different vehicles need different countermeasures to meet the standard, a range will show the cost for both vehicles. The average cost over all vehicles takes into account voluntary compliance before the rule was promulgated or planned voluntary compliance before the rule was effective and the percent of the fleet for which the rule is applicable. Costs are provided in 1997 dollars, using the implicit GNP deflator to inflate previous estimates to 1997 dollars.

Benefits are provided on an annual basis for the fleet once all vehicles in the fleet meet the rule. Benefit and cost per average vehicle estimates take into account voluntary compliance.

Table 27. COSTS OF RECENT PASSENGER CAR RULEMAKINGS
(Includes Secondary Weight and Fuel Impacts)
(1997 Dollars)

Description	Effective Model Year	Cost Per Affected Vehicle $	Cost Per Average Vehicle $
FMVSS 114, Key Locking System to Prevent Child-Caused Rollaway	1993	$8.99 - 18.65	$0.50 - 1.03
FMVSS 214, Dynamic Side Impact Test	1994 - 10% phase-in 1995 - 25% 1996 - 40% 1997 - 100%	$65.77 - 640.56	$59.54
FMVSS 208, Locking Latch Plate for Child Restraints	1996	$0.85 - 17.07	$2.29
FMVSS 208, Belt Fit	1998	$3.25 - 16.28	$1.20 - 1.73
FMVSS 208, Air Bags Required	1997 - 95% 1998 - 100	$479.52 - 579.42	$479.52 - 579.42
FMVSS 201, Upper Interior Head Protection	1999 - 10% 2000 - 25% 2001 - 40% 2002 - 70% 2003 - 100%	$35.96	$35.96
FMVSS 225, Child Restraint Anchorage Systems	2001 - 20% 2002 - 50% 2003 - 100%	$2.87 - $6.74	$5.78
FMVSS 208, Advanced Air Bags	two phases 2003 to 2001	$23 to 128	Depends on method chosen to comply

Table 28. BENEFITS OF RECENT PASSENGER CAR RULEMAKINGS
(Annual benefits when all vehicles meet the standard)

Description	Fatalities Prevented	Injuries Reduced	Property Damage Savings $
FMVSS 114, Key Locking System to Prevent Child Caused Rollaway	None	50-99 Injuries	Not Estimated
FMVSS 214, Dynamic Side Impact Test	512	2,626 AIS 2-5	None
FMVSS 208, Locking Latch Plate for Child Restraints	Not estimated	Not estimated	None
FMVSS 208, Air Bags Required Compared to 12.5% Usage in 1983	4,570 - 9,110	AIS 2-5 85,930 - 155,090	None
Compared to 46.1% Usage in 1991	2,842 - 4,505	63,000 - 105,000	
FMVSS 201, Upper Interior Head Protection	575 - 711	251 - 465 AIS 2-5	None
FMVSS 225, Child Restraint Anchorage Systems – Benefits include changes to Child Restraints in FMVSS 213	36 to 50*	1,231 to 2,929*	None
FMVSS 208, Advanced Air Bags	117 to 215**	584 to 1,043 AIS 2-5**	Up to $85 per vehicle*

* Total benefits for passenger cars and light trucks

** Total benefits for passenger cars and light trucks, does not count potential loss in benefits if air bags are significantly depowered.

Table 29. COSTS OF RECENT LIGHT TRUCK RULEMAKINGS
(Includes Secondary Weight and Fuel Impacts)
(1997 Dollars)

Description	Effective Model Year	Cost Per Affected Vehicle $	Cost Per Average Vehicle $
FMVSS 202, Head Restraints	1992	$44.64 - 108.29	$5.28
FMVSS 204, Steering Wheel Rearward Displacement for 4,000 to 5,500 lbs. unloaded	1992	$5.76 - 28.52	$1.02 - 1.93
FMVSS 208, Rear Seat Lap/Shoulder Belts	1992	$65.95	$0.39
FMVSS 114, Key Locking System to Prevent Child- Caused Rollaway	1993	$8.99 - 18.65	$0.01 - 0.03
FMVSS 208, Locking Latch Plate for Child Restraints	1996	$0.85 - 17.07	$2.29
FMVSS 108, Center High-Mounted Stop Lamp	1994	$14.34 - 21.68	$14.79
FMVSS 214, Quasi-Static Test (side door beams)	1994 - 90% 1995 - 100	$64.17 - 80.48	$59.48 - 74.71
FMVSS 216, Roof Crush for 6,000 lbs. GVWR or less	1995	$23.63 - 212.05	$0.85 - 8.40
FMVSS 208, Belt Fit	1998	$3.59 - 16.98	$6.13 - 8.27
FMVSS 208, Air Bags Required	1998 - 90% 1999 - 100	$479.52 - 579.42 dual air bags	$478.52 - 597.42 dual air bags
FMVSS 201, Upper Interior Head Protection	1999 - 10% 2000 - 25% 2002 - 70% 2003 - 100%	$35.62 - 78.00	$54.97
FMVSS 225, Child Restraint Anchorage Systems	2001 - 20% 2002 - 50% 2003 - 100%	$2.87 - $6.74	$5.78
FMVSS 208, Advanced Air Bags	two phases 2003 to 2001	$23 to 128	Depends on method chosen to comply

Table 30. BENEFITS OF RECENT LIGHT TRUCK RULEMAKINGS
(Annual benefits when all vehicles meet the standard)

Description	Fatalities Prevented	Injuries Reduced	Property Damage Savings $
FMVSS 202, Head Restraints	None	470 - 835 AIS 1 20 - 35 AIS 2	None
FMVSS 204, Steering Wheel Rearward Displacement for 4,000 to 5,500 lbs. unloaded	12 - 23	146 - 275 AIS 2-5	None
FMVSS 208, Rear Seat Lap/Shoulder Belts	None	2 AIS 2-5	None
FMVSS 114, Key Locking System to Prevent Child Caused Rollaway	None	1 Injury	Not Estimated
FMVSS 208, Locking Latch Plate for Child Restraint	Not estimated	Not estimated	None
FMVSS 108, Center High Mounted Stop Lamp	None	19,200 to 27,400 Any AIS Level	$119 to 164 Million
FMVSS 214, Quasi-Static Test (side door beams)	58 - 82	1,569 to 1,889 hospitalizations	None
FMVSS 216, Roof Crush for 6,000 lbs. GVWR or less	2 - 5	25-54 AIS 2-5	None
FMVSS 208, Belt Fit	9	102 AIS 2-5	None
FMVSS 208, Air Bags Required Compared to 27.3% Usage in 1991	1,082 - 2,000	21,000 - 29,000 AIS 2-5	None
FMVSS 201, Upper Interior Head Protection	298 - 334	303 - 424	None
FMVSS 225, Child Restraint Anchorage Systems – Benefits include changes to Child Restraints in FMVSS 213	36 to 50*	1,231 to 2,929*	None
FMVSS 208, Advanced Air Bags	117 to 215**	584 to 1,043 AIS 2-5**	Up to $85 per vehicle*

* Total benefits for passenger cars and light trucks

** Total benefits for passenger cars and light trucks, does not count potential loss in benefits if air bags are significantly depowered.