

Memorandum Report

Hood Safety Catches on 1997 Jeep Grand Cherokees

December 2004

VRTC-DCD3050 (EA02-029)
Hood Latch on 1997 Jeep Grand Cherokee

This test program was performed at the Vehicle Research and Test Center (VRTC) in response to a request from the Office of Defects Investigation (ODI), National Highway Traffic Safety Administration (NHTSA). The ODI has received complaints alleging some hood secondary latches (safety catches) failed on certain model year (MY) 1997 Jeep Grand Cherokees, allowing the hood to come open without warning while driving. If the hood opens while driving, the driver's view of the road could unexpectedly become obscured, impairing the driver's ability to control the vehicle, and possibly result in a vehicle crash, personal injury and/or property damage. According to the ODI, the subject vehicles are MY 1996-98 Jeep Grand Cherokee sport utility vehicles. ODI also stated that their analysis suggested the problem might be concentrated in MY 1997 vehicles, and specifically those manufactured from August 1996 through December 1996 and/or built in a Vehicle Identification Number (VIN) serial range from 534127 through 638267.

The subject vehicles are equipped with a hood-latching system that consists of a primary hood latch and a safety catch. The primary hood latch mechanism is

mounted on the radiator cross-member support with a corresponding striker mounted on the hood. The primary hood latch mechanism is released by pulling a spring-loaded "hood release" lever mounted on the driver-side kick panel under the instrument panel near the driver's door. Figure 1 is a photograph of a typical subject vehicle. Figure 2 is a photograph of the primary hood latch mechanism of a subject vehicle.

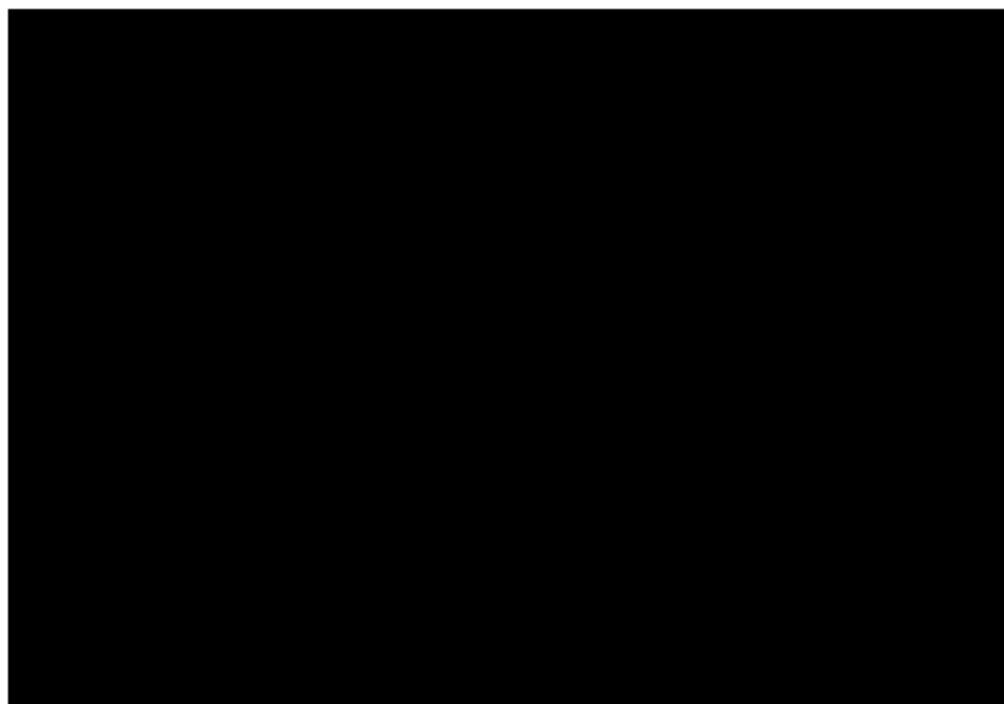


Figure 1 - MY1997 Subject Vehicle

The hood safety catch is mounted on the hood near the primary latch striker. The safety catch is opened by pulling it toward the front of the vehicle after the primary hood latch is released. The safety catch is equipped with a return spring intended to return the safety catch to its closed (safe) position after it is released. Figure 3 is a photograph of a safety catch on a subject vehicle.

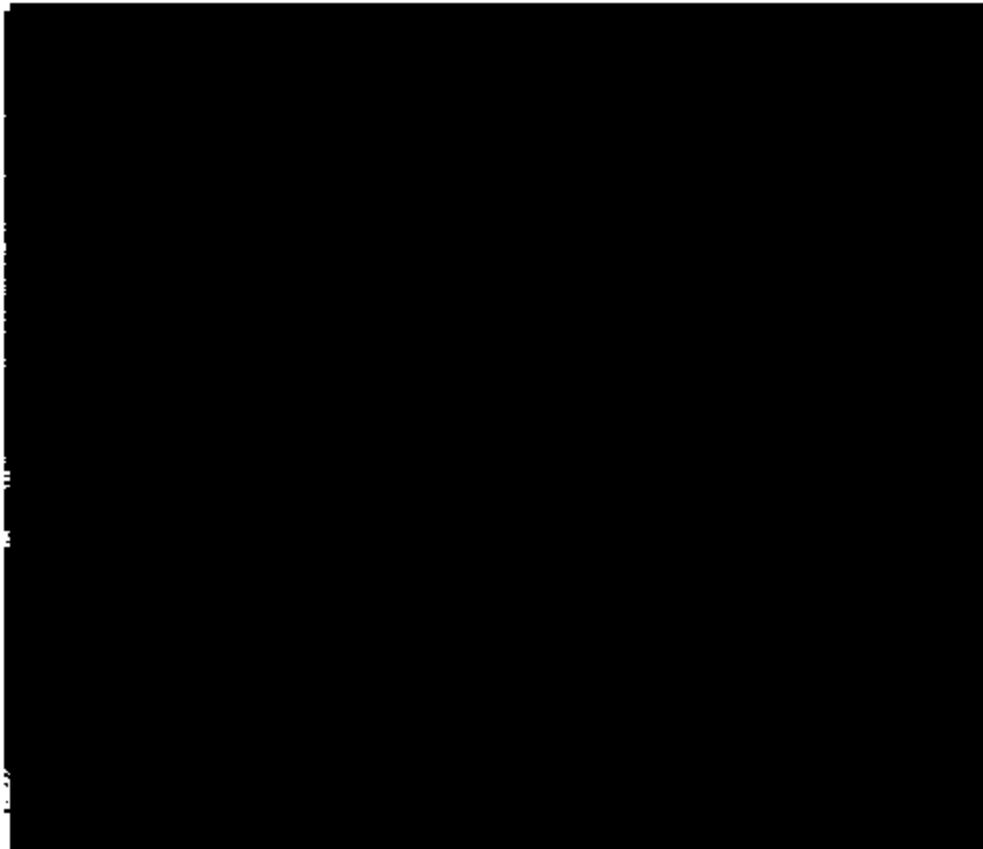


Figure 2 - Primary Hood Latch on a Subject Vehicle

According to ODI, the manufacturer reported that some of the safety catches they had inspected on subject vehicles were "sticky" and some had failed to fully return to the closed (safe) position when they were released. However, none of the catches had failed to prevent the hood from opening. They attributed the "stickiness" to high friction caused by corrosion of the hinge pivot area.

If the corrosion-induced "stickiness" was due to a design deficiency of the catch, it should be present in all three model years. However, if the "stickiness" was due to an intermittent process or assembly control failure, the problem might be concentrated in a specific subset of the population such as a MY, date of manufacture (DOM) range, or VIN serial range. Consequently, this test program

Included MY 1996-98 Jeep Grand Cherokees. The MY 1997 vehicles included those manufactured before, during, and after the suggested DOM range and also those with VIN serial numbers before, in, and after the suggested VIN serial range. For comparison, a population of MY 1996-98 Chevrolet ST Blazer, GMC Jimmy, and Oldsmobile Bravada peer vehicles was also included.

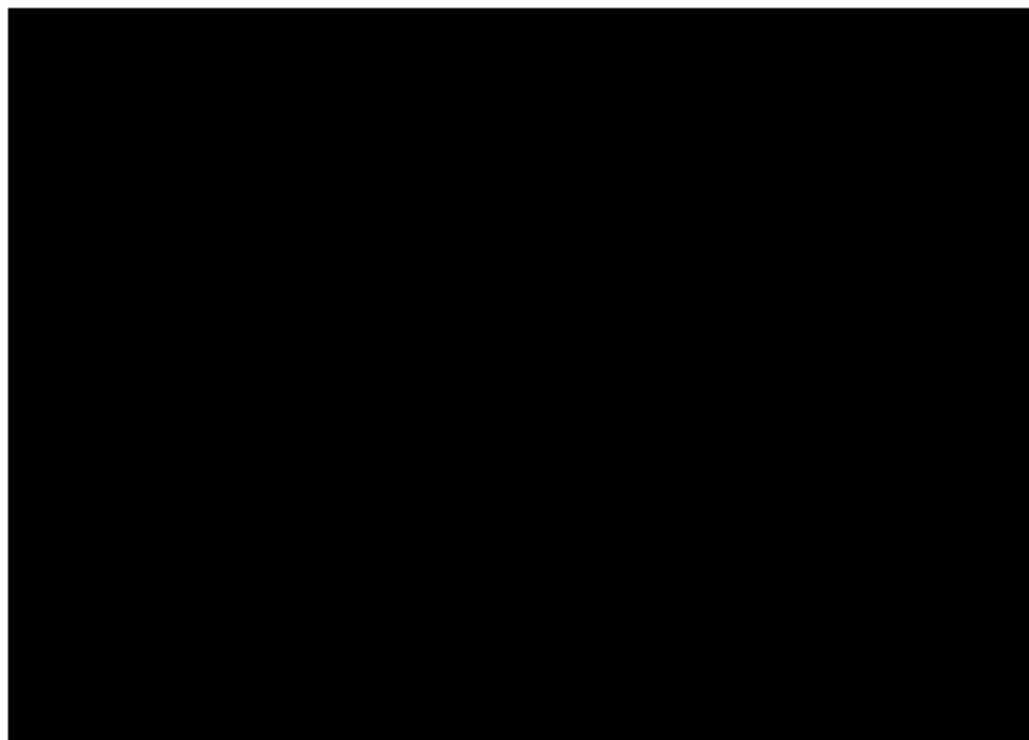


Figure 3 - Safety Catch on a Subject Vehicle

The vehicles used for this test program included those owned by consumers (POV's) and used vehicles owned by dealers at Independent resale lots (DOV's). Lists of owners of MY 1996-98 subject Jeep Grand Cherokee and peer Chevrolet ST Blazer, GMC Jimmy, and Oldsmobile Bravada vehicles were purchased from the Ohio Bureau of Motor Vehicles (OBMV). Approximately 100 owners, living within a radius of approximately 60 miles from VRTC, were arbitrarily selected from these two lists of vehicle owners. Letters were mailed to these owners informing them that VRTC might contact them by telephone within a few weeks to inquire about inspecting the

hood latch on their vehicle. The purpose of the letter was to establish credibility so that the telephone call would not be mistaken for a telemarketing scheme. If the owner agreed to an inspection, an appointment was made for the authors to inspect their POV.

Thirty-two subject vehicles were inspected. Seventeen of the 32 subject vehicles were POV's from the OBMV list. The remaining 15 used vehicles were DOV's from independent resale lots in the counties near VRTC.

Thirty-two peer vehicles were also inspected. Seventeen of the 32 peer vehicles were POV's from the OBMV list. The remaining 15 used peer vehicles were DOV's from independent resale lots in the counties near VRTC. Figure 4 is a photograph of one of the peer POV's inspected.

The design of the safety catches on the peer vehicles was different from those on the subject vehicles. The safety catch of the subject vehicles was a balanced hinge design that pivoted fore and aft, whereas the safety catch of the peer vehicles was a cantilevered pin design that pivoted laterally. Figure 5 is a photograph of a safety catch on a typical peer vehicle.

Each subject vehicle was documented and its safety catch was checked in accordance with the procedures outlined on the data sheet included in Attachment 1. The vehicle and its FMVSS label on the doorjamb were photographed.

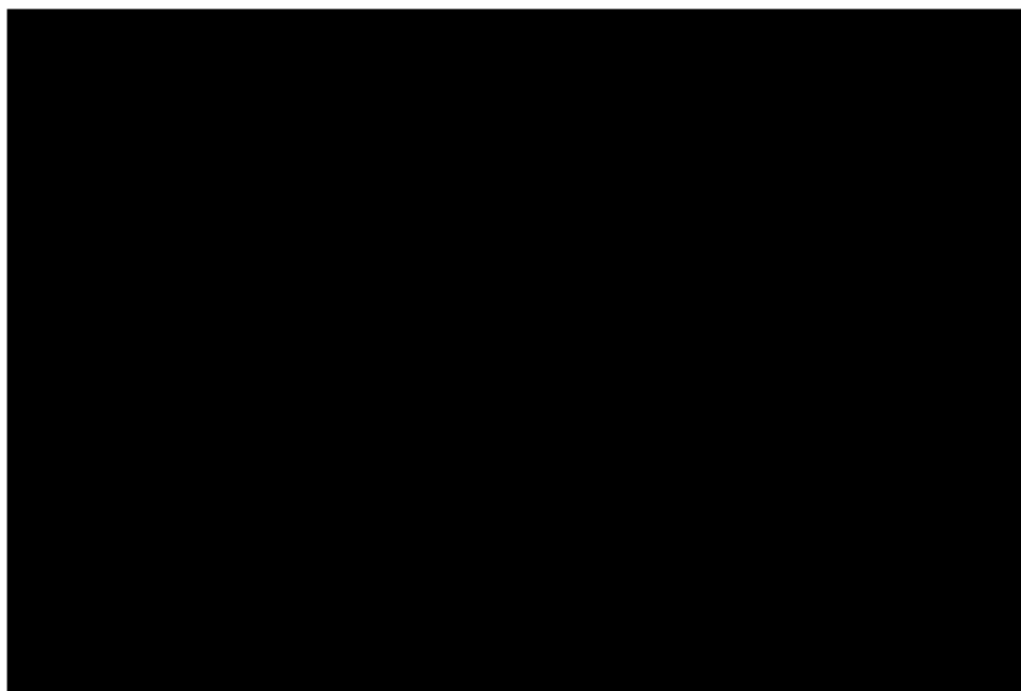


Figure 4 – NY 1996 Peer Vehicle

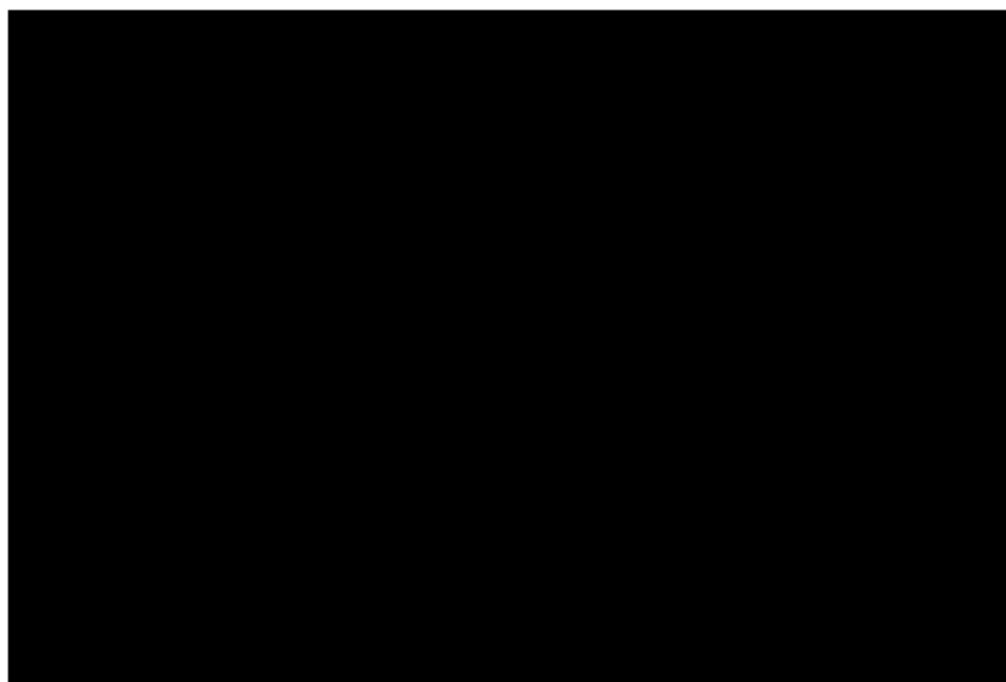


Figure 5 - Peer Vehicle Safety Catch.

After the primary hood latch release was activated, an attempt was made to raise the hood without activating the safety catch. The results were noted on the data

sheet. If the hood could not be opened because it was properly restrained by the safety catch, the safety catch was then moved to the fully open position and the hood was raised. It was then noted if the safety catch returned (return-spring force) to the closed position or stuck in a partially or fully open position when released. If the safety catch did not fully return, the hood was lowered until the primary hood latch striker contacted the primary latch. An attempt was then made to open the hood and it was noted if the hood could be opened.

As part of the subject vehicle inspections, the hood safety catch was then removed from the vehicle and placed in a plastic bag that was marked with the removal date and the VIN of the vehicle. A new OEM service replacement hood safety catch (MOPAR Parts® Part Number 55075322AC) and hood safety catch fastener (MOPAR Parts® Part Number 6502064) were then installed. The hood was closed and the operation of the primary hood latch and the safety catch were tested for proper operation.

A dimensionless metric was established to quantify the condition of the safety catches that were collected. This metric quantified the "stickiness" (efficiency) of the safety catches as a percentage with 100% representing a hypothetical safety catch that was frictionless and 0% representing a safety catch that would stick in the fully open (unsafe) position and would not return on its own to the closed (safe) condition.

Equation 1 defines the efficiency of any system that includes an energy storage component. The energy storage component of the safety catch is the return spring. The design function of the spring is to return the catch to the safe position and to prevent vibration and other forces generated during normal driving operations from moving it out of the safe position. The "work in" is the work done as the latch is moved from the closed to the open position when opening the hood of the vehicle. The "work out" is the work performed by the return spring when the latch is allowed to move from the open position back to the closed position.

$$(Eq\ 1) \quad Efficiency = \frac{Work_{(out)}}{Work_{(in)}}$$

The result of the calculation defined by Equation 1, for practical devices, is a ratio with a value always less than one. When the result of Equation 1 is multiplied by 100, the result becomes a percentage, which is easier to understand than ratios expressed by decimal numbers. Equation 2 defines the method for converting the efficiency from a ratio to a percentage. Note that for an ideal device the "work out" would be the same as the "work in" which would mean that the efficiency would be 100%. Conversely, the efficiency of a latch that stuck in the open position would be 0% since the "work out" would be zero.

$$(Eq\ 2) \quad \eta_{(percent)} = \frac{Work_{(out)}}{Work_{(in)}} \times 100$$

The "work in" can easily be determined if the force/deflection relationship is measured as the safety catch is moved from the closed to the open position. Equation 3 defines the method for calculating the work done. The result of this calculation is often referred to as "the area under the curve."

$$(Eq\ 3) \quad Work_{(in)} = \int_{\theta_0}^{\theta_1} F(\theta) d\theta$$

The "work out" can similarly be determined if the force/deflection relationship is measured as the safety catch is allowed to return to the closed position. Equation 4 defines the method for calculating the "work out." Note that $\theta_2 = \theta_0$ if the latch returns to the fully closed position.

$$(Eq\ 4) \quad Work_{(out)} = \int_{\theta_1}^{\theta_2} F(\theta) d\theta$$

Equation 5 defines the dimensionless metric (η) that was used to quantitatively describe the condition of the safety catches that were collected during the field survey.

$$(Eq\ 5) \quad \eta = \frac{\int_{\theta_0}^{\theta_1} F(\theta) d\theta}{\int_{\theta_1}^{\theta_2} F(\theta) d\theta} \times 100$$

A specialized apparatus for measuring and recording the force/deflection relationship of the safety catches was designed, fabricated, and calibrated by VRTC. The fixture consisted of a mounting base, parallel bar actuating lever, load cell, angular potentiometer, and digital data acquisition system. Figure 6 is a photograph of this apparatus wherein some of the major components are identified.

Figure 7 is also a picture of the apparatus wherein the flexible cable and hook that coupled the safety catch hook to the load cell are more clearly visible. The flexible cable from the load cell was designed to pull on the safety catch hook in a similar manner as one may use when preparing to open the hood on a vehicle.

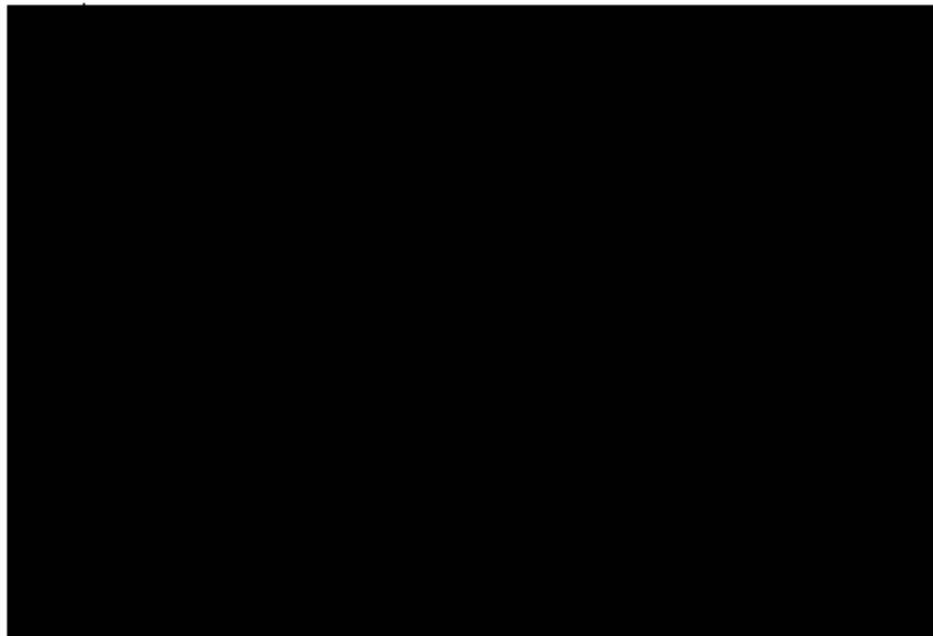


Figure 8 - Bench Test Fixture; a) Base, b) Actuating Linkage, c) Load Cell, d) Angular Potentiometer, and e) Safety Catch

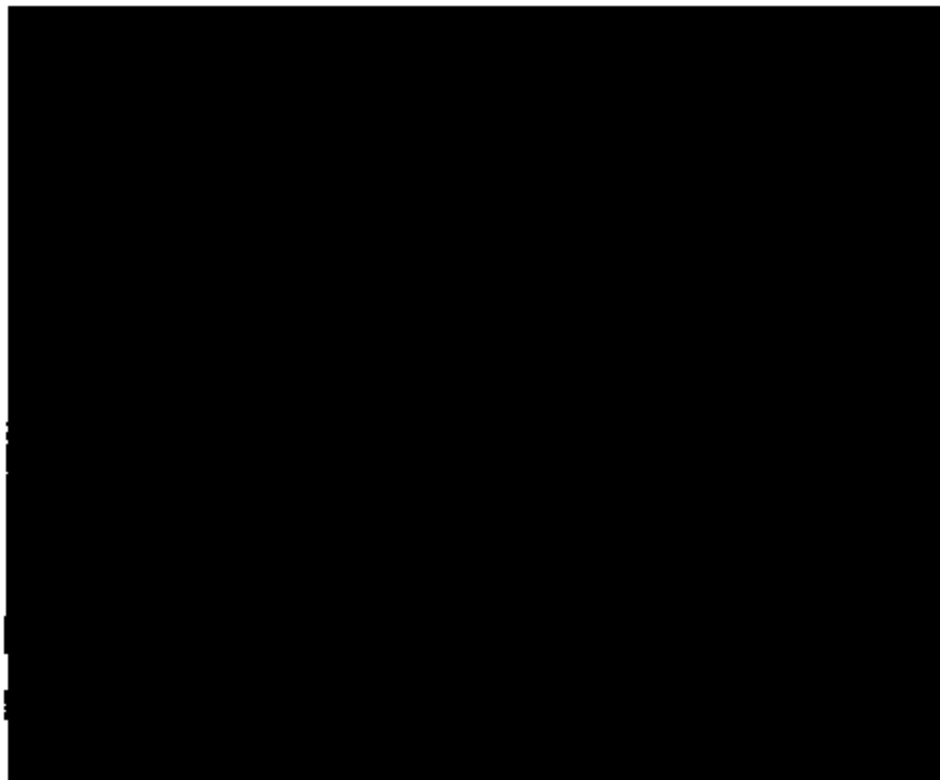


Figure 9 - Bench Test Fixture; a) Safety Catch, b) Safety Catch Pivot Pin, c) Load Cell Cable Hook, and d) Flexible Cable.

The safety catch to be tested was installed in the bench test apparatus using a new OEM service replacement fastener, which was tightened to 95 in-lb.

During testing, the load cell was used to measure the force applied at the end of the safety latch hook and the rotary potentiometer was used to measure the angular position of the safety latch hook as it moved from the closed to the open position and then to its final resting position at the end of the return stroke.

To measure the force/deflection relationship of a safety catch, the hook on the flexible cable was positioned over the end of the safety catch lever hook. The digital data acquisition system was triggered and the operating lever of the apparatus was pulled until the safety latch was in the fully open position. The lever was then pushed back to its starting position while the safety catch was allowed to return to its final resting position. In addition to collecting force/deflection data using the digital data acquisition system, all tests were recorded on videotape.

The 32 safety catches recovered during the subject vehicle inspections were each tested in the force/deflection apparatus. For comparison, twelve new OEM service replacement safety catches were also tested in the apparatus.

The data collected from the tests were used to calculate the efficiency of the safety catches. In order to address the problem of whether it was a "design or process" failure, the results of the safety catches were assembled into 10 distinctive groups. Each POV or DOV safety catch appears in more than one group, but the new safety catches only appear once as they were assigned to a unique group (Group 1).

The results of the efficiency calculations are graphically represented as notch box plots in Figure 8. The sources and number of the safety catches tested that make up a "Group" are listed above each notch box.

Each notch box depicts several pieces of statistical information. The boxes are defined on the bottom by the lower hinge and on the top by the upper hinge. This box, often referred to as the "central box," contains 50% of the data. The central box is divided into two sections, each containing 25% of the data, by the median.

Extending from the central box are lower and upper whiskers that each cover 25 % of the data. Additionally, they define the range of the data outside of the hinges and depict the lower and upper data extremes.

The limits of the box notches (notch height) mark the lower and upper 95% confidence limits of the median. Equation 6 defines the method for calculating the notch height.

$$(Eq\ 6) \quad Notch\ Height = \frac{3.14\ H}{\sqrt{N}} \quad where \quad \begin{array}{l} H = Central\ Box\ Height \\ N = Number\ of\ Data\ Elements \end{array}$$

Hinges are similar to quartiles, but unlike quartiles, which are determined by reference to the extremes, hinges are determined by reference from the median. As a result, hinges often lie closer to the median than do quartiles. This characteristic

notwithstanding, the quartiles and hinges will be the same whenever the data series is of the form defined by Equation 7.

$$(Eq\ 7) \quad N = 4n + 5 \quad \text{with} \quad n = 0, 1, 2, 3, 4, \dots, x$$

Notch box plots are very useful for visually comparing data sample sets. When the notch box plots of data sets (groups) are plotted side by side, on the same scale, visual comparisons can easily be made of the extremes, distributions, medians, and median 95% confidence ranges.

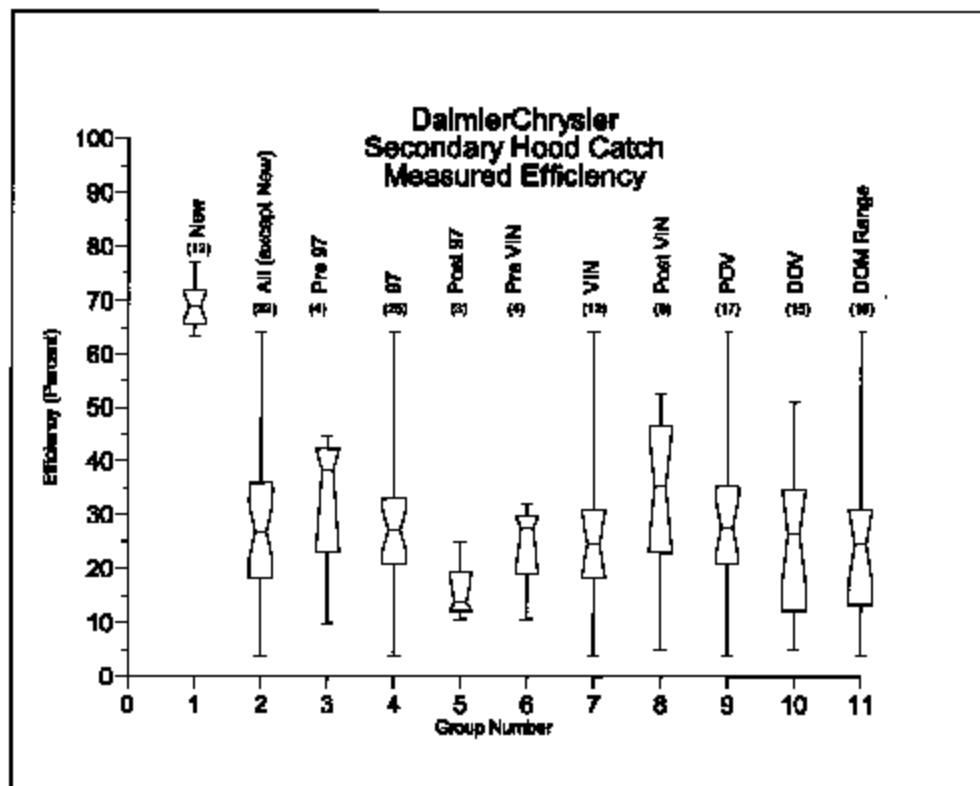


Figure 8- Bench Test Results.

A useful characteristic of a comparison of notch box plots is the fact that if the notch of any box does not overlap the notch of another box, there is a 95% statistical probability that the medians of the two populations, that the plots were based upon, will not converge no matter how many additional samples are added. Therefore, the

two populations can be judged, with 95% statistical probability, to be different and distinct from each other. Figure 9 is a notch box plot of two example data sets (groups) whose notches do not overlap.

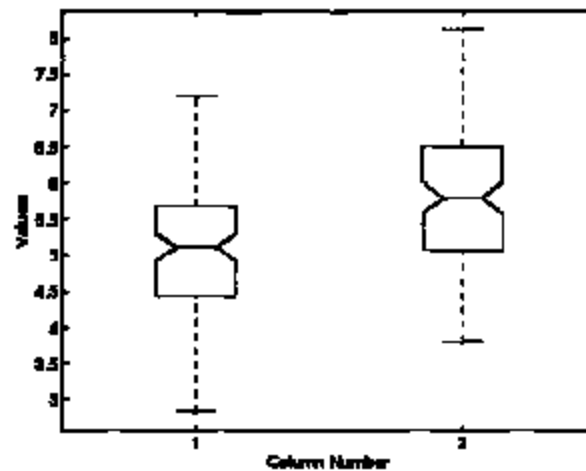


Figure 9 – Example Notch Box Plot Comparison

An examination of the information contained in Figure 8 quickly reveals that the catch efficiency of only Group 1 can be readily judged, with 95 % statistical probability, to be different and distinct from the catch efficiencies all of the other groups.

The information contained in Figure 8 suggests that all of the subject vehicle groups depicted (POV, DOV, MY 1996, MY 1997, MY 1998, DOM range, and VIN serial range) exhibit the "stickiness" problem. It is likely, therefore, that the "stickiness" problem is caused by the design of this type catch, and not by an intermittent process or assembly control problem.

The field inspection of the subject vehicles revealed that one MY 1997 subject vehicle (vehicle DOM and odometer reading: 12/96 and 96,210 miles, respectively) was found to have a safety catch stuck in a mostly open position, failing to prevent the hood from opening when the primary hood latch was released.

Another MY 1997 subject vehicle (11/96 DOM and 70,908 miles) had a safety catch that stuck in the fully open position after the safety catch was opened. However, when the hood was subsequently closed, the forward edge of the safety catch struck the edge of its receiver opening on the radiator support crossmember, of which the aft edge is the safety catch striker plate, moving the catch far enough to latch and prevent the hood from reopening. It is normal for a safety catch that is stuck in the fully open position to strike the crossmember in this manner. In some cases, the safety catch may not retreat enough, as this one apparently did, to prevent subsequent reopening of the hood.

One MY 1996 (12/95 and 135,602 miles) subject vehicle and one MY 1997 (11/96 and 84,468 miles) subject vehicle had safety catches that failed to fully return to the closed (safe) position when the safety catches were released; however, when the hoods were closed and the primary latches were subsequently actuated, the safety catches did prevent the hoods from opening. Apparently, these safety catches had returned far enough to engage their striker plates.

The mean efficiency of the 12 new service replacement safety catches was 69.0% with a standard deviation of 4.2%. The mean efficiency of the 32 subject vehicle safety catches was 27.8% with a standard deviation of 14.5%. This result suggests that the subject catches have deteriorated and no longer operate as smoothly and efficiently as the new replacements.

It should be noted that none of the primary hood latches of the subject vehicles showed any evidence of mechanical or operational deficiencies.

The hood safety catches of the 32 peer vehicles inspected were not removed for bench testing as had been done with the subject vehicles. Instead, the efficiencies of the safety catches of the peer vehicles were estimated by the authors and recorded on the data sheet. These estimations were made by feel and were always stated as an upper and lower bound with a typical range of 10%.

In order to ascertain the accuracy of the estimated efficiencies made during the peer vehicle inspections, two additional peer vehicles were inspected and their hood safety latches were removed for bench testing. These two catches (EO1 and EO2) were subsequently mounted in the bench test apparatus, which had been modified to accept these catches, and tested in the manner described for the subject vehicle safety catches. The efficiency range estimations made by the authors and the bench test results are graphically compared in Figure 10.

An examination of Figure 10 reveals the authors' estimates (blue bars) were very close to the bench test results noted below the bars. This validation indicates that the field estimates may be considered reliable enough for peer vehicle comparisons.

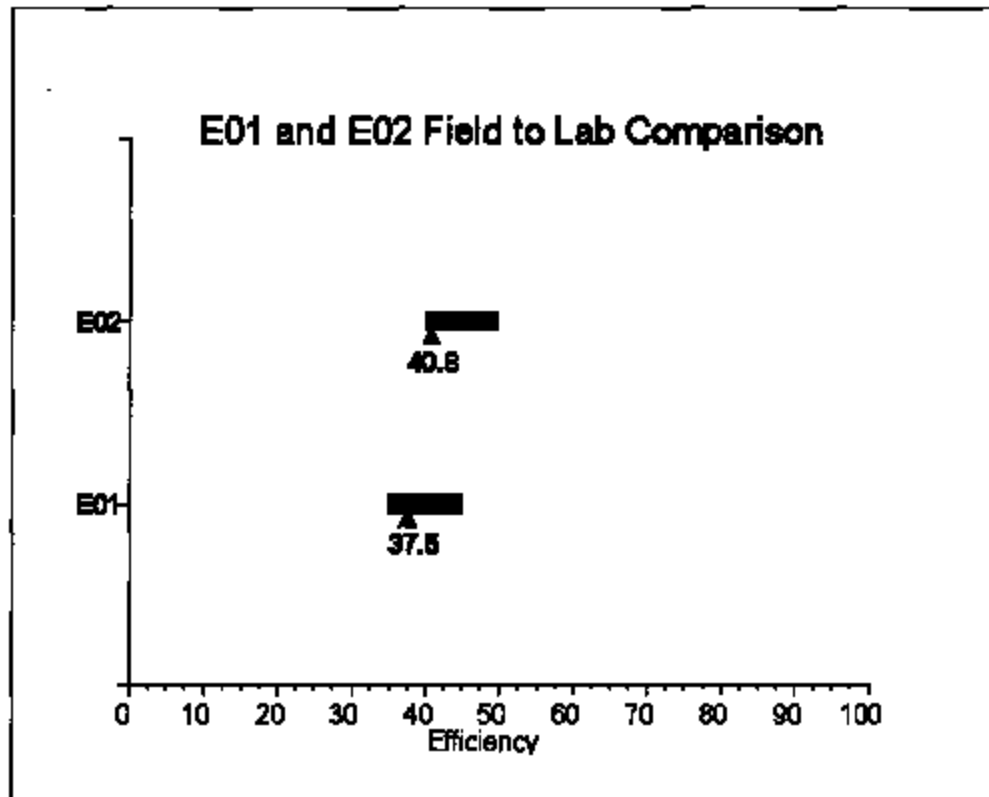


Figure 10- Field Efficiency Estimates Compared to Bench Test Result

The estimated efficiencies of the peer vehicle safety catches are graphically represented in Figure 11. The sources and the number of the safety catches that make up a "Group" are indicated at the top of each notch box plot.

An examination of the information contained in Figure 11 quickly reveals that the catch efficiency of none of the groups can be judged, with 95 % statistical probability, to be different and distinct from the catch efficiency of any other group.

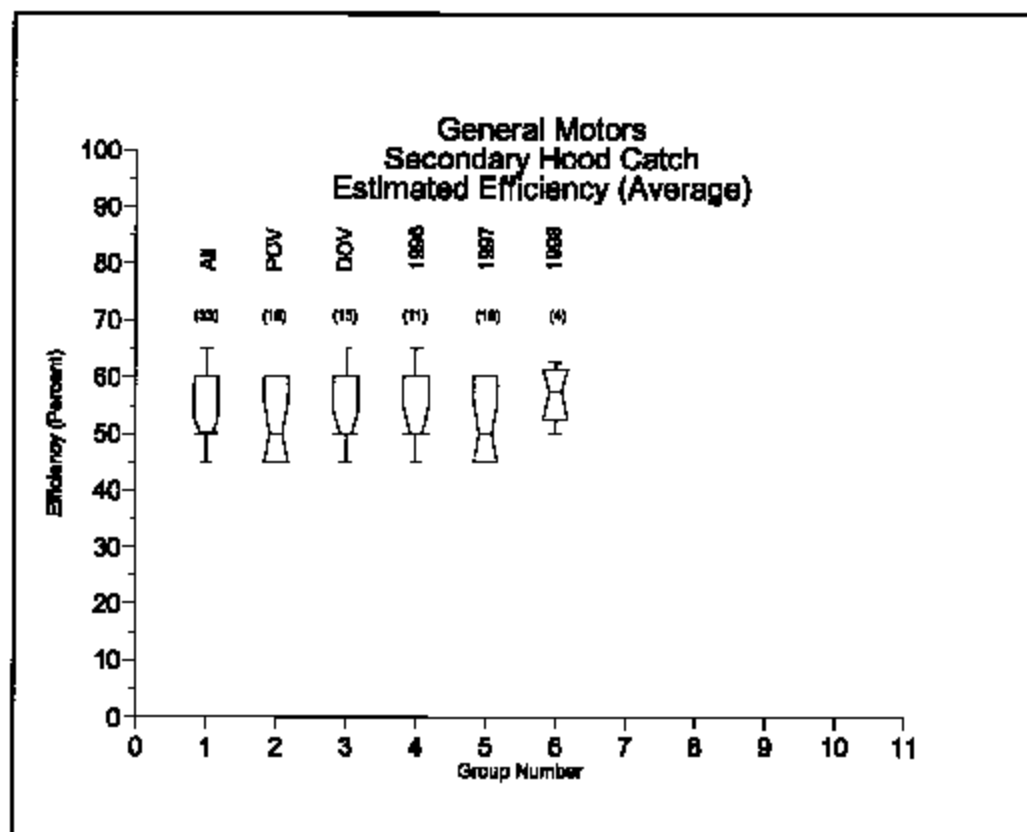


Figure 11 - Estimated Efficiencies of Peer Vehicle Safety Catches

All of the peer vehicle safety catches returned smoothly and forcefully to the closed position. The mean of the estimated efficiencies of the 32 peer vehicle safety catches was approximately 54 %.

It was noted that the new OEM service replacement safety catches appeared to be an updated design from the safety catches on the subject vehicles. Figure 12 is a photograph of both types of catches wherein the differences are clearly visible. The clearances between the base and hook at the pivot point have been increased substantially. It is suspected that this redesign was intended to prevent corrosion and debris from accumulating in the pivot area. This would reduce the likelihood of binding (stickiness) in the pivot of the subject safety catches.

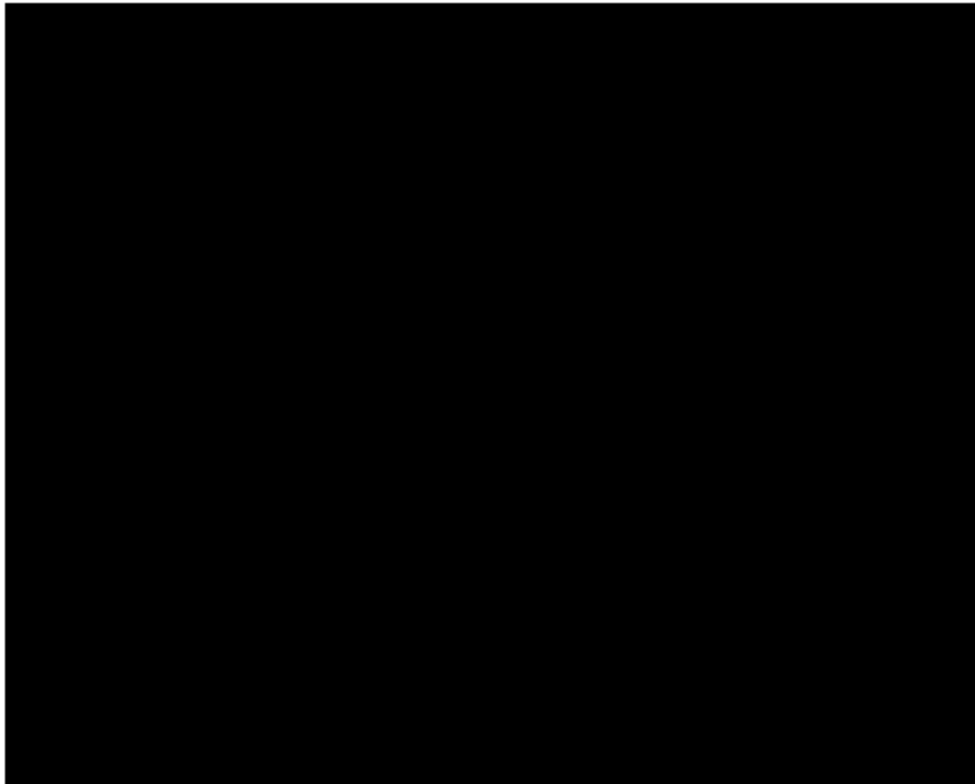


Figure 12 - Redesigned Factory Service Replacement Safety Catch on Left, Subject Safety Catch on Right. Critical Pivot Point Clearances are Listed for Both.

A piece of hinge tab was removed from the base of an exemplar new replacement catch and an exemplar subject catch, which was purchased from a local vehicle salvage yard, using a liquid-cooled abrasive saw. The piece removed from the exemplar subject catch was chosen where there was minimal corrosion and the paint coating appeared to be intact. The piece removed from the exemplar new replacement catch was chosen to match the location of the one from the exemplar subject catch. The pieces were fixed in a metallurgical mount, then ground and polished.

The polished specimens were examined using a metallographic optical microscope. The anticorrosive and paint coatings were identified and their thicknesses optically measured.

Figure 13 is a micrograph of the specimen from the exemplar new replacement catch. In this view the base material is in the bottom section of the image and the mounting medium is the coarse-textured material in the uppermost section of the image. Also visible in this view are the two layers of interest, the anticorrosive layer (probably zinc) and the outer layer of paint. The anticorrosive layer covered 100 % of the surface and was approximately 11 micrometers thick. The paint layer covered 100 % of the underlying layer and was approximately 26 micrometers thick.

The exemplar new replacement catch appeared to be of nominal design and produced via controlled processes.

Figure 14 is a micrograph of the specimen from the exemplar subject catch. In this view the base material is also in the bottom section of the image and the mounting medium is also the coarse-textured material in the uppermost section of the image. Also visible in this view are the two layers of interest, the anticorrosive layer (probably zinc) and the outer layer of paint. The anticorrosive layer covered approximately 50 % of the surface and was approximately 4 micrometers thick. The paint layer covered 100 % of the underlying layer and was approximately 19 micrometers thick.

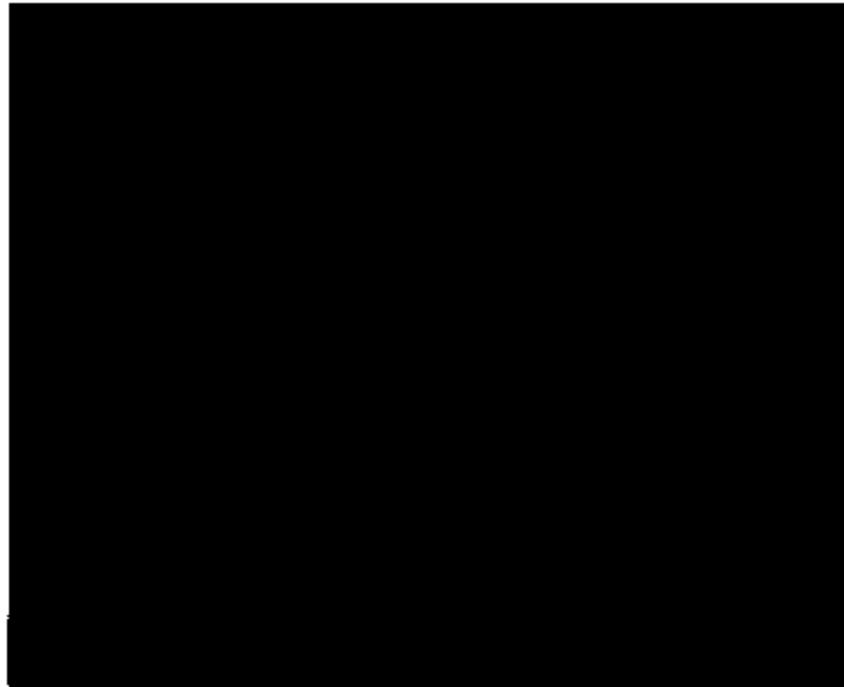


Figure 13 – Section of Tab from Exemplar New Replacement Catch.

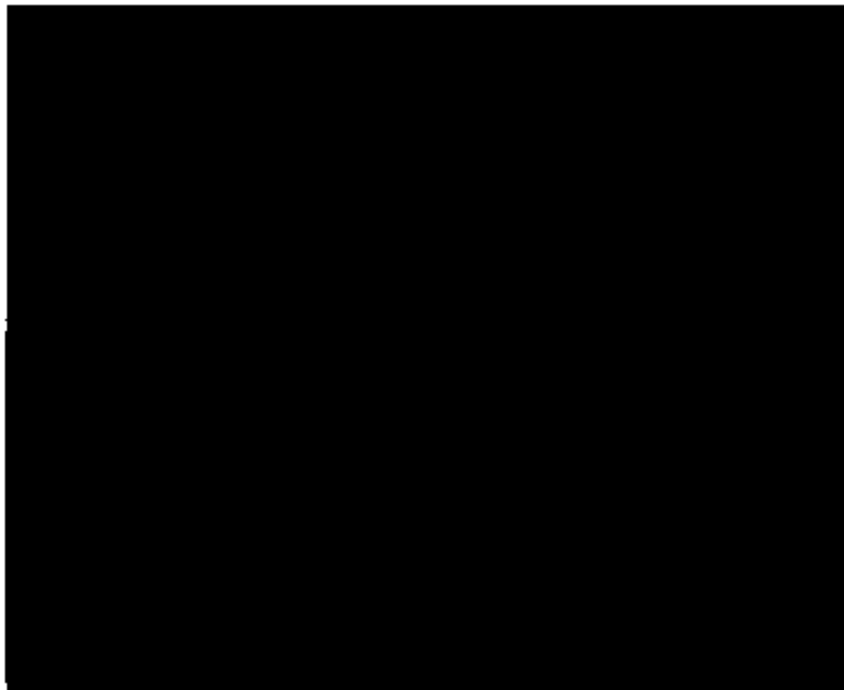


Figure 14 – Section of Tab from Exemplar Subject Catch

The exemplar subject catch appeared to have been produced via an uncontrolled process and its corrosion protection would probably be marginal for "under-the-hood" service.

Even though the subject safety catches appeared to be prone to corrosion, it is the opinion of the authors that the likelihood of these safety catch failures would have been considerably reduced if the safety catches on the subject vehicles had been properly lubricated during routine maintenance.



Thad A. Gardner

VRTC Defects Analysis Group



James H. Hague

VRTC Defects Analysis Group

Attachment 1

Sample Vehicle Data Sheet

Date: _____

Veh. Test N° _____

DCD3050 Vehicle Survey Data Sheet

Owner Name _____ Address _____ Ph# _____

Model year (EPA label): _____ Make: _____ Model: _____ Trim line: _____

VIN: _____ Mfr date: _____

Odometer: _____ Transmission: Auto() Manual ()

Photograph the vehicle viewing the left front and left side of the vehicle. Photograph the FVMS9 label on the driver side doorjamb. From the driver seat, operate hood release pull handle. Did primary hood latch release?

Yes () No ()

From front of the vehicle, after releasing the primary hood latch, try raising the hood without operating the secondary hood catch. Can the hood be raised?

Yes () No ()

Open the hood (by releasing the secondary hood catch if required). Does the secondary hood catch fail to return (sticks partially or completely open)?

Yes () No ()

If the secondary hood catch fails to return on its own (sticks partially or completely open), lower the hood slowly until the striker rests on the primary hood latch and attempt to raise the hood again without releasing the secondary hood catch. Can the hood be raised?

Yes () No ()

Photograph the secondary hood catch and the surrounding area. Photograph the area where the primary hood latch is mounted and the secondary latch engages when closed. Note any observations about the condition of the secondary hood catch or the environment in which it is mounted. Slowly lower the hood and note where the secondary hood catch first engages the cross member. Note any alignment issues with either the primary hood latch, or the secondary hood catch. If there is any wear or damage to the plastic coating of the secondary hood catch, note where it is and attempt to photograph this.

If the hood can be raised without operating the secondary hood catch, or if the secondary hood catch does not move freely, remove the secondary hood catch. Identify the removed catch with the VIN#. Replace the secondary latch with a new component. Secondary hood catch replaced?

Yes () No ()

NOTES: