

ENGINEERING ANALYSIS CLOSING REPORT

**SUBJECT: Malfunction of Electric Powered Door Locks
In Model Year 2001 Kia Optima Vehicles**

EA No.: 04-030

Date Opened: 04-NOV-04

Date Closed: NOV 7 2005

BASIS:

Preliminary Evaluation (PE) 04-050 was opened on July 7, 2004, to investigate the issues associated with nine consumer complaints received by the Office of Defects Investigation (ODI), which alleged that malfunctions of the electric-powered door locks in the subject vehicles had entrapped an occupant inside the vehicles, or had otherwise impeded normal occupant egress from the vehicles. Specifically, the consumers complained of incidents in which the door locks had failed to disengage on command, or that they had immediately relocked without external input.

The PE disclosed that the vehicle manufacturer, Kia Motors Corporation (Kia/KMC) had received 288 similar reports through consumer complaints and field reports for the population of 24,754 subject vehicles. Kia also reported that approximately 5,700 warranty claims had been filed that specifically related to driver side door latch and lock actuator assemblies. In addition, Kia reported that warranty claims had also been filed by dealers for apparent malfunctions of other components of the door latch/lock system including, for example, the electrical wiring harness/relay, the keyless remote transmitter and receiver, and the Electrical Time and Alarm Control System (ETACS) which interfaces with the electro-mechanical door lock system.

THE ALLEGED DEFECT:

The alleged defect in this investigation refers to the failure, malfunction, or performance of the electric powered door lock system installed in MY 2001 Kia Optima vehicles that may result in self-engagement or failure of the locks to disengage on command.

DESCRIPTION OF THE KIA OPTIMA DOOR LATCH/LOCK SYSTEM:

The MY 2001 Kia Optima is a four-door sedan, equipped with an original equipment electro-mechanical door latch and locking system. Each passenger door is equipped with an individual latch and manual lock control button. Each door lock can also be engaged or disengaged by an electro-mechanical actuator, and the driver door is equipped to serve as a "master" control capable of locking and unlocking all of the passenger doors. The system can also be operated via a remote key fob transmitter and a receiver located inside the vehicle.

The following are significant design characteristics and features of the subject door locks reported by Kia and as they relate to this investigation.

- The Optima doors have both manual and electrical locking functions that can be used to actuate the door locks. The doors also have an auto-locking function that sends a lock/unlock signal from either front door to all other doors.
- The lock malfunction can be a strictly mechanical problem in the driver's door, and in such a case all other doors will not be affected, and can be opened.
- If a mechanical malfunction occurs in a door latch that initiates the auto-locking function through the sensor signals to the door lock actuator, all doors will be locked. If the auto-locking signal continues to be sent, however, all other doors can be opened (excluding the one with the electro-mechanical problem).
- If an electrical malfunction occurs in one of the key elements of the door lock circuitry, the lock actuator will keep all four doors temporarily locked. However, after a time delay of approximately 15 seconds, power to the actuator is automatically terminated (via the ETACS) and all doors can then be unlocked manually.

The mechanical components of subject door latch/locking system are illustrated in Figures 1 and 1a. Principally, these are the interior and exterior door handles and the actuating rods that control the positions of the door latch mechanism, and permit opening and/or closing of the door. Similarly, the system also includes the interior lock knob that allows the door to be manually locked and unlocked through movement of the lock actuator rod.

Mechanical Components of Optima Door Locking System

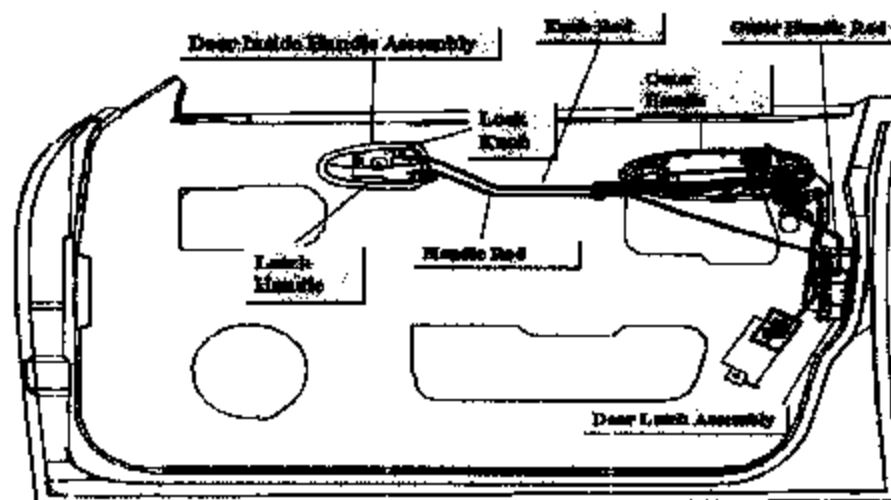


Figure 1. Mechanical Components of the Optima Door Lock System

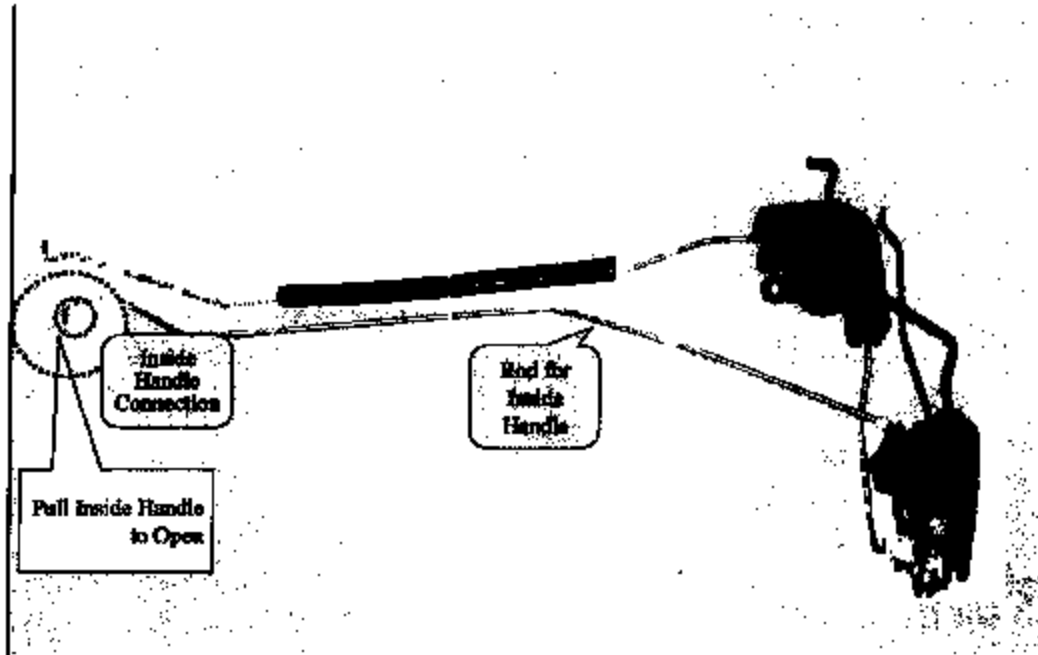


Figure 1.a. Optima Door Handle Assembly (Source: KMC)

The components of door lock assembly are illustrated in Figure 2. Primary elements of this subassembly are the interior lock/unlock knob and its actuator rod, which connects to a bellcrank assembly with an output actuator rod that manually controls the "lock" and "unlock" positions of the door latch.

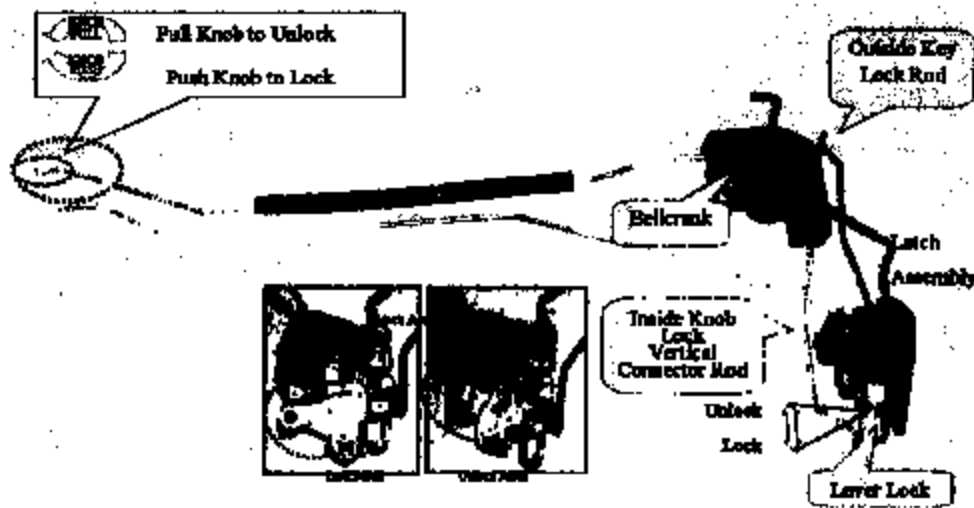


Figure 2. Optima Door Lock Assembly (Source: KMC)

Other components and sub-assemblies are also integral parts of the door latch/lock system. The installation of the lock actuator assembly is shown in Figure 3. The lock actuator assembly is the interface between the mechanical and electrical elements of the door lock system. The position of the latch pawl is translated through a linkage rod to the electrical lock actuator, which senses through a contact point whether the door is locked or unlocked.

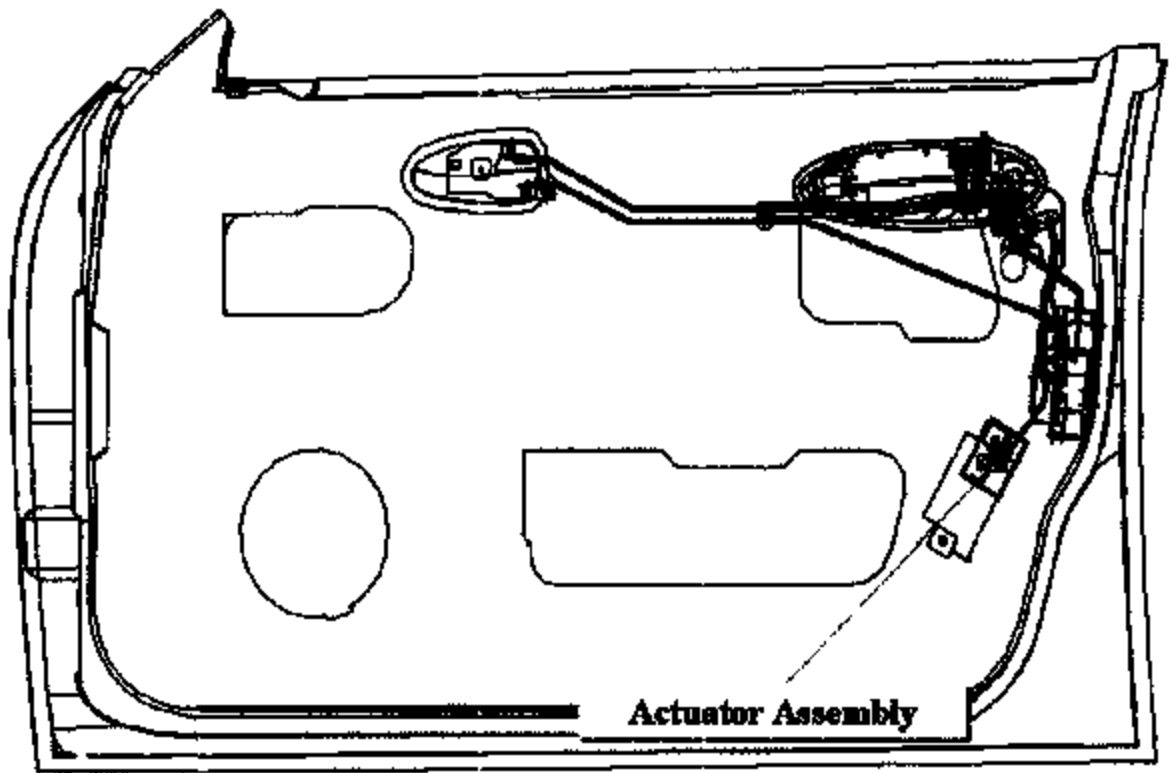


Figure 3. Installation of Lock Actuator Assembly (Source: KMC)

Figure 4 illustrates the internal views of the different positions of the actuator switch contact point when it is in the "lock" position, and when on the operational borderline between "lock" and "unlock."



**Location of Actuator switch's contact point
(LOCK position)**



**Location of Actuator switch
(located on operational borderline between
LOCK & UNLOCK)**

Figure 4. Internal Views of Lock Actuator (Source: KMC)

Figure 5 shows close-up details of the door latch assembly. Figure 6 illustrates the close-up details of an internal view of the latch assembly, noting the latch pawl lever and the rubber pawl stopper. In the latter illustration, the top of the pawl stopper is missing, allowing the pawl lever to be mispositioned and, therefore the lock actuator switch contact point will also be mispositioned.

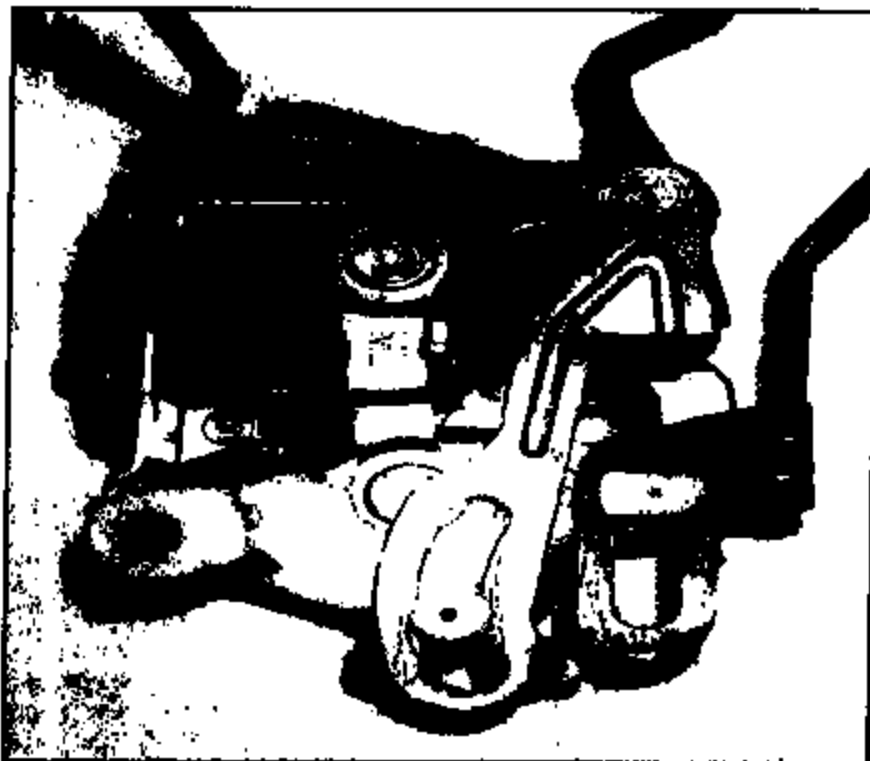


Figure 5. Close-up View of Optima Door Latch Assembly (Source: KMC)



Figure 6. Close-up Internal View of Optima Latch Assembly (shown with damaged rubber pawl stopper) (Source: KMC)

In Figure 7, the door latch pawl is out of its proper position due to deterioration of the rubber pawl stopper. The control lever can not move the pawl lever and the door lock plate cannot move into its proper position. This causes the door lock actuator switch to be positioned in the operational borderline between "lock" and "unlock." In this unstable condition, the actuator switch can send a "lock" signal to the ETACS, which then sends a "lock" signal to all four doors. According to Kia's analysis, this sequence of events describes the type of malfunction that is the subject of this investigation.

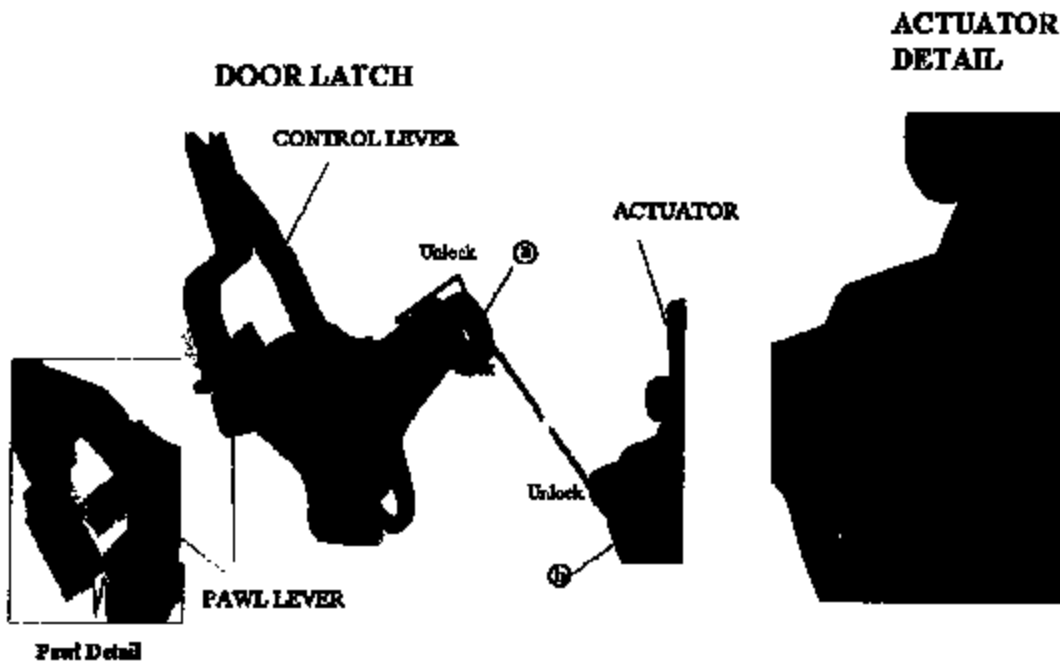


Figure 7. Details of Door Latch Components and Lock Actuator (Source: KMC)

CORRESPONDENCE:

By letter dated February 20, 2005, Kia submitted information in response to ODI's letter dated December 12, 2004. Additionally, Kia submitted supplemental documents to ODI by letter dated June 28, 2005. All of this correspondence, as well as the non-confidential information submitted under PE04-050, are contained in the public files for these respective phases of the investigation.

Kia submitted no confidential information during the EA. However, confidentiality was requested during PE04-050 for certain information regarding the procedures used in Kia tests to evaluate several relevant potential failure or malfunction scenarios.

STATUS:

| <u>Problem Experience</u> | <u>EA Opened</u> | | <u>EA Closed</u> | | <u>Total</u> |
|--------------------------------------|-------------------------|-------------------|-------------------------|-------------------|---------------------|
| | <u>ODI</u> | <u>MFR</u> | <u>ODI</u> | <u>MFR</u> | |
| <u>Owner Reports</u> | 9 | 266 | 14 | 298 | 312 |
| <u>Field Reports</u> | 0 | 40 | 0 | 42 | 42 |
| <u>Lawsuits</u> | 0 | 0 | 0 | 0 | 0 |
| <u>Property Damage Claims</u> | 0 | 2 | 0 | 2 | 2 |
| <u>Injury Incidents</u> | 0 | 0 | 0 | 0 | 0 |
| <u>Injuries</u> | 0 | 0 | 0 | 0 | 0 |
| <u>Fatal Incidents</u> | 0 | 0 | 0 | 0 | 0 |
| <u>Fatalities</u> | 0 | 0 | 0 | 0 | 0 |

POPULATION:

A total of 24,754 of the subject Kia Optima vehicles were sold in the United States.

WARRANTY:

Information regarding warranty claims filed by Kia dealers as provided during PE04-050 and updated during the subject EA, are shown in the chart below. The door locks of the subject vehicles are covered by a basic five year or 60,000 mile warranty and no extended warranty coverage is available. Kia reported the following total numbers of warranty claims for various subassemblies for the driver-side door latch/lock assembly.

| Component/Assembly | Date Reported by Kia | | Total |
|------------------------------|------------------------|------------------------|-------|
| | 09/03/04 (PE04-050) | 02/11/05 (EA04-030) | |
| Latch Assembly (driver side) | 3,838 | 602 | 4,440 |
| Actuator/Door lock | 1,842 | 289 | 2,131 |
| ETACS | 564 | 81 | 645 |
| Transmitter, remote | 947 | 81 | 1,028 |
| Receiver, remote | 276 | 15 | 291 |
| Wiring Harness | 533 | 37 | 370 |
| Micro-Relay 2 | 54 | 3 | 57 |

SERVICE BULLETINS:

Kia reports that no service bulletins concerning the alleged defect were issued to its dealers.

PARTS SALES:

Kia reports that no special service or repair parts kits related to the alleged defect were developed or sold to dealers.

DESIGN, MATERIAL, AND/OR PRODUCTION MODIFICATIONS:

Kia reports that no design, material or production changes were made in any of the components that might be related to the warranty claims, field reports, or consumer complaints identified in connection with this investigation. Specifically, Kia identified no "functional changes" to any of the components of the system including the latch assembly, actuator door lock, ETACS, receiver, transmitter, wiring harness, or relay.

Kia states, however, that the supplier of the door latch assembly identified a change in the composition of the rubber compound used to fabricate the pawl stop. This "supplier-based" change was made on May 6, 2002, and did not impact the performance of the subject original equipment door locks. No other supplier-based changes were reported in Kia's responses to ODI

Information Requests, but other information was submitted as discussed in "Additional Information," below .

TESTING: Vehicle Research and Test Center (VRTC)
 East Liberty, OH

Date of Test Request: 30-MAR-05

Description: The purpose of ODI's test activity was to conduct an independent examination of the subject door latch/lock assembly, to evaluate the potential causes for self-locking conditions, and to assess whether the alleged malfunctions can simultaneously affect all of the passenger doors of the subject vehicles.

Given Kia's analysis which concluded that the door latch/lock malfunctions being considered are the result of mis-positioning of the lock actuator that may result in instability of the contact point of the actuator switch, ODI had a secondary concern that the switch might be susceptible to sending an unintended "unlock" signal to the door's actuator. This potential malfunction was seen by ODI as a potential safety issue related to passenger security within the vehicle. Therefore, ODI's tests and examinations were also intended to determine whether such conditions or events were experienced during the procedures.

VRTC acquired a subject vehicle with an odometer reading of 69,000 miles. In the as-received condition, all of the door locks operated properly. The vehicle was prepared for evaluation by removing the interior panel of the driver door, and the rubber pawl stopper was removed completely to simulate a lock failure. Various scenarios with the driver door locked/unlocked were performed and observations made of the performance and effects on the vehicle door lock system. Significant VRTC observations include the following:

- When the inside manual knob of the driver door is moved to the "unlock" position, the lock will self-actuate. In some instances the self-locking action is immediate and in other cases the self-locking action occurs after a short delay. When this occurs:
 1. the power door lock button does not unlock the driver door.
 2. the driver door cannot be opened from inside the vehicle.
 3. the outside door handle does not open the driver door, as the lock is engaged
 4. the key unlocks the door from the outside, then all four locks may self-engage
 5. the front passenger door can be unlocked by using the manual unlock knob, providing a means of vehicle egress

ADDITIONAL INFORMATION:

A technical meeting was convened on June 9, 2005 in Washington, DC, during which Kia presented further information regarding the design and function of the subject latch/lock

mechanism. In addition, Kia discussed the results of its tests of the latch/lock assembly to support its conclusions that the alleged defect does not pose an unreasonable risk to motor vehicle safety.

Kia reviewed the design and performance of the subject door latch/lock mechanism, and stated that its tests and analyses of the alleged defect support the following conclusions:

- a mechanical or electrical malfunction does not entrap the occupant inside the vehicle
- an occupant is able to exit the vehicle by use of any of the three non-affected doors, and
- a non-affected front door can be opened by operating the door switch and/or door lock knob.

As a part of its analysis of the alleged defect, Kia interviewed at least 30 consumers and stated that these results provide additional evidence that occupants were able to exit their vehicles, even when their previous complaints/reports stated they had been "trapped" due to the alleged defect. From these interviews, Kia identified the following examples of various methods used by consumers to exit the vehicle.

- "playing with" the locked driver's door until it opened
- using the time delay between unlocking the door and the auto-lock function
- using the switch or knob and pulling on the door handle to open the door
- lowering the driver's window and opening the door from the outside using a key
- exiting through the front passenger door
- exiting through a rear passenger door
- using the luminescent trunk release to exit through the trunk after pulling down the rear seats

In supplementary information submitted to ODI following the meeting of June 9, 2005, Kia submitted its evaluation of using the key in the outside lock of the driver's door as a mode of occupant egress. Kia reported that its studies show that this exit mode is available if the rubber pawl stopper is damaged as a result of wear or deterioration. However, if the pawl stopper is missing entirely, the force generated by turning the key cannot overcome the high level of interference between the control lever and the pawl lever, and the door cannot be opened. Instead, the door can be opened only if the key is turned while simultaneously pulling the latch handle. Kia also notes that the condition of a completely missing pawl stopper has not been encountered in a consumer vehicle, and that this condition represents a hypothetical case for evaluation only.

Kia also provided an updated discussion of relevant design and material changes, and stated that it had concluded a second change in the pawl stopper material had been identified. Specifically, Kia

“...determined that there was a material [i.e. significant] changes [sic] in the warranty claim rate for the door latch assembly as of the end of the 2001 MY; i.e., starting with the beginning of the 2002 MY.” This determination was reportedly made on the basis of a notable decrease in the warranty rates for all reasons for the driver’s door latch installed in vehicles produced after June 2001. Kia reported a warranty rate of 15.22 percent for Optima vehicles produced through June 2001, the approximate end of MY 2001 vehicles production. For the remainder of calendar year 2001, the comparable rate was 3.39 percent, representing MY 2002 production. Thus, Kia reported its conclusion that there was an additional “... change in the composition of the rubber (pawl) stoppers beginning at about the end of June 2001.”

ODI notes that the rubber pawl stopper material changes cited above are reported as “supplier-based,” and that no additional documentation regarding these changes is available. Also noted is the fact that both these changes were introduced after the end of the MY 2001 Optima production and therefore, do not apply to any of the subject vehicles as originally produced. The apparent changes to which Kia refers, affect only those MY 2001 vehicles repaired after the pawl stopper material changes were incorporated into use as service/replacement parts, as well as new MY 2002 and later production.

FAILURE/MALFUNCTION MODES:

Kia states that the root cause of malfunction of the subject door lock is deterioration due to time and use of the rubber pawl stopper in the latch, as the stopper fails to maintain proper strength and flexibility of the rubber material from which it is fabricated. This mechanical failure is cited as the root cause of malfunction of the subject lock mechanism. When the pawl stopper deteriorates or sustains a certain amount of permanent compression, it may fail to properly position the door latch pawl lever and the location of the contact point in the lock actuator lock switch becomes unstable.

As described by Kia, deterioration of the rubber pawl stopper allows the door latch pawl lever to interfere with the control lever, mispositioning the actuator switch in the functional borderline between “lock” and “unlock.” In this unstable position the actuator switch can send a “lock” message to the actuator, locking all passenger doors with the auto-lock function. A subsequent attempt to unlock the system will then unlock the doors, but it can also return the actuator switch to an unstable position, due to the deteriorated condition of the pawl stopper. If the actuator switch then reads that the lever is in the “lock” position, after approximately one second the switch will send that signal to the actuator, and the ETACS will then re-lock all four doors.

CONTRIBUTING FACTORS:

No additional factors beyond Kia’s identification of the root cause of the subject door latch/lock were found to be relevant to this investigation. There are no issues of vehicle owner actions such as service, vehicle abuse, negligence, or driver actions, that affect manifestation of the alleged defect.

MANUFACTURER'S EVALUATION OF THE ALLEGED DEFECT:

Kia states that the issues of concern in this investigation are quality issues, and that they are not safety issues that identify an unreasonable risk to motor vehicle safety.

Kia states that some of the specific potential malfunctions identified have no safety element, these being a mechanical failure of the door latch, an electronic failure of a remote transmitter or receiver, a failure of a major electronic element of a door locking component, or a malfunction of the ETACS. Kia believes that in each of these types of problems, impediment to occupant egress from the vehicle is temporary and/or transitory.

Kia further states that the mechanical/electrical door locking scenario, precipitated by deterioration of the rubber pawl stopper, is a complex series of events that culminate in activation of the auto-lock function through the ETACS to all four passenger doors.

Kia argues that incidents of self-actuation of the subject door lock mechanism do not entrap vehicle occupants, but that they are able to egress the vehicle via avenues other than the driver door. Kia's testing reportedly established that an alternative door not affected by the self-locking malfunction can be opened by operating the inside door handle and the inside manual lock knob.

Kia observes and notes that driver descriptions of "entrapment" are frequently "loose" descriptions of the actual events. In this respect, Kia states that occupants are not actually trapped inside their vehicles but instead, are unable to egress in the normal manner.

Kia concludes that the information and evidence accumulated and reviewed in response to this investigation, including its tests, analyses, and evaluations of consumer inputs through complaints, field reports, and interviews, demonstrate that the malfunctions of the subject door locks do not identify an unreasonable risk to motor vehicle safety.

ODI ANALYSIS:

One of the major issues during this investigation was the apparent discrepancy between the nature of consumer complaints and the position taken by Kia that malfunctions of the subject door locks would not actually entrap an occupant in the vehicle. This concern was emphasized by the complexity of the electro-mechanical door lock system, the need to understand how the system was designed to function, and the consequences of failure of the system to function as designed.

ODI conducted a series of consumer interviews, for the purpose of gathering further specific information regarding the nature of the incidents reported as well as the actual methods used by consumers to exit the vehicles. ODI was successful in interviewing 13 vehicle owners from a list of 52 consumers to whom calls were placed. In most cases, the incidents involved reports of all doors self-locking, and the following methods were reported as means by which consumers were able to exit their vehicles:

- "played with" lock/unlock button until it unlocked successfully

- used key from outside driver door
- pulling on the inside latch handle and the inside unlock knob
- pulling on the outside latch handle and the inside unlock knob
- climbed out through open window

None of the consumers interviewed by ODI were able to confirm that all four doors remained locked after a period of time and none were able to confirm that the auto-unlock function (time delayed automatic unlock signal from the ETACS) did or did not function properly. ODI concludes that in most cases, normal vehicle egress may have been temporarily impeded but consumers were usually able to unlock a door by one of the previously identified alternative methods.

The consumer complaints and field reports received by ODI and submitted to Kia were evaluated for evidence of any type of associated trend. The numbers of incident reports were plotted against incident dates, and the results are shown in Figure 8. The graphic shows that the door lock malfunctions did not begin to occur in significant numbers until after the end of production of the subject vehicles. The numbers of incidents continued in significant numbers, reaching a peak during the third quarter of calendar year 2003. There is no consistent rate of increase in the number of incident reports through the end of calendar year 2004, and there was no spike in the number of consumer complaints following the opening of ODI's investigation.

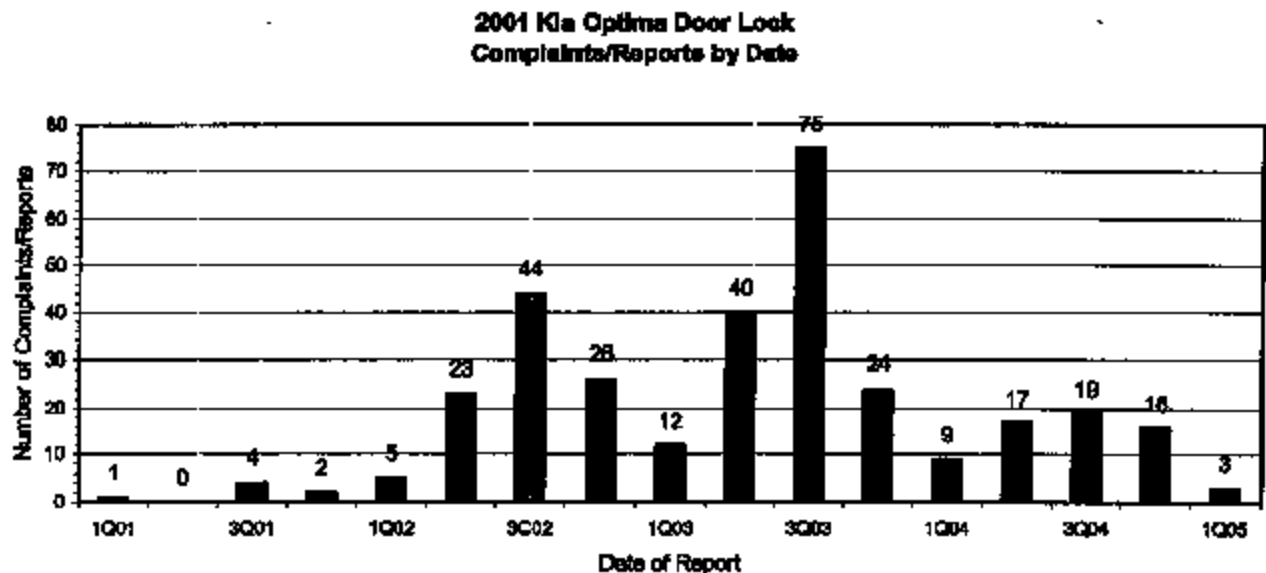


Figure 8. Self-Locking Incidents by Date of Report

The numbers of warranty claims were also plotted versus the date of claim to evaluate the existence of any detectable trend. Similar to the incident reports from consumer and field reports, the warranty claims peaked in the third quarter of calendar year 2003. A graphic of these data is shown in Figure 9.

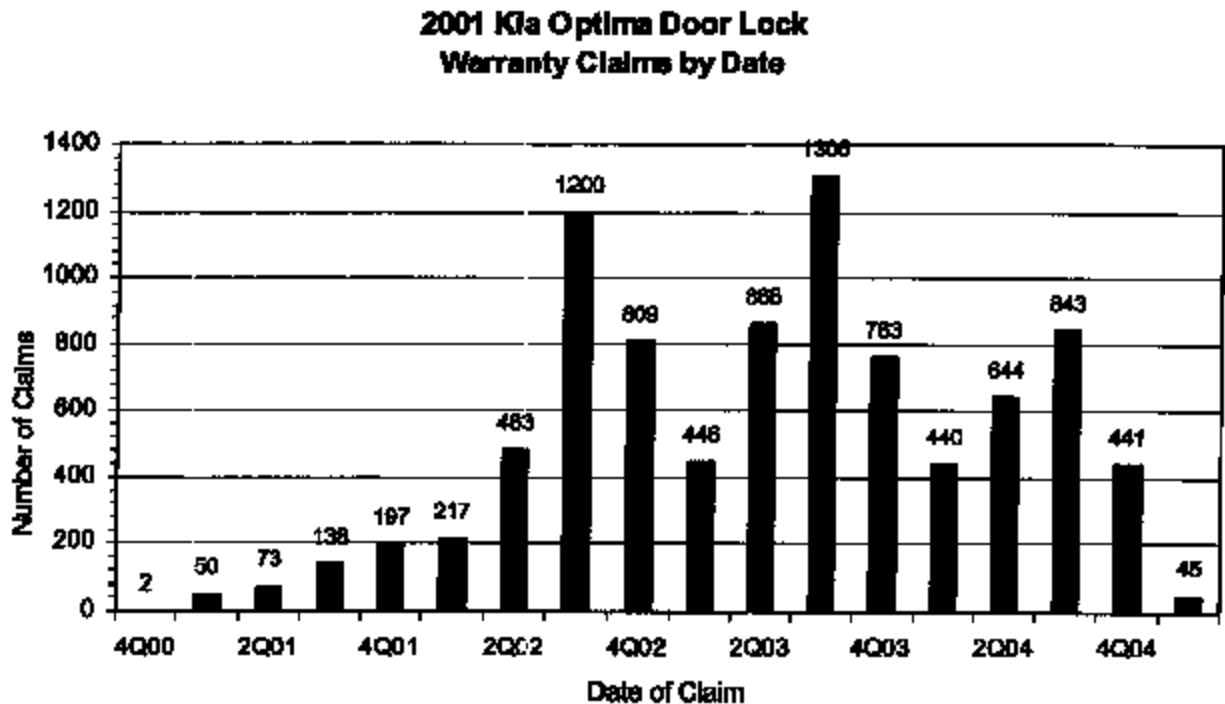


Figure 9. Warranty Claims by Date of Claim

ODI's analysis of the issues in this investigation are predicated on a general acceptance of Kia's identification of pawl stopper deterioration as the primary cause of the door lock system malfunctions being considered.

The change in the rubber pawl stop material made in May 2002, described by Kia as "supplier-based," was apparently made without Kia's prior knowledge or approval. Kia exercised no apparent control over this engineering change that may have improved the functional performance of the door lock system. Similarly, Kia did not document an earlier change in the pawl stopper material that may have been made in June 2001. Kia states that this change probably accounts for improved performance of the door lock system, as reflected by a decrease in the warranty rates. ODI notes that such changes are usually controlled and documented, and issued with parts distribution controls that may include purging of existing stocks, and tracking of the improved components through replacement part inventories and vehicle installations.

Kia documents no internal inquiry into this issue prior to the opening of PE04-050. The evidence indicates that tests conducted by Kia and other evaluations of the potential for self-locking of all

occupant doors were apparently conducted in response to ODI's inquiry. This is noted even though the subject door lock system had a record of very high failure/warranty rates extending back to calendar year 2002.

Kia's evaluation of the implications of simulating deterioration of the rubber pawl stopper by removing it completely is not challenged by ODI. It is understood that the kinematics of a complicated system of mechanical linkages may be altered by a small change in a single physical dimension within that system of links, and that the overall mechanical efficiency of the system may be compromised by such a change. Further, it is not seen as a necessary issue of contention when considered in the context of all other information disclosed during this investigation.

REASON FOR CLOSING:

Notwithstanding the concerns articulated in this report, the evidence fails to disclose a malfunction with a clear and consistent pattern of compromise to motor vehicle safety. ODI believes that malfunction of the subject door lock system may impede the normal egress of a vehicle occupant but that it does not entrap that occupant. ODI also believes that the high warranty claim rate for the subject door lock system clearly documents the door lock system as deficient in an overall sense. Coincidentally, the high incidence of malfunctions has not been accompanied by a definitive history of demonstrated safety-related implications.

Based on the above, the further expenditure of agency resources on this investigation does not appear to be warranted. The closing of this investigation does not constitute a finding by NHTSA that a safety-related defect does not exist. The agency may take further action if warranted by the circumstances.


Safety Defects Engineer

11/07/05
Date

I Concur


Vehicle Integrity Division

11/7/05
Date


Director,
Office of Defects Investigation

11-7-05
Date