



U.S. Department
of Transportation


**National Highway
Traffic Safety
Administration**

Memorandum

Vehicle Research and Test Center P.O. Box B37
East Liberty, Ohio 43319
(937) 666-4511

Subject: FINAL REPORT: "2007 Lexus ES-350 Unintended
Acceleration"

Date: APR 30 2008

From: 
Michael W. Monk
Director, Vehicle Research and Test Center

Reply to NVS-310
Attn. Of:

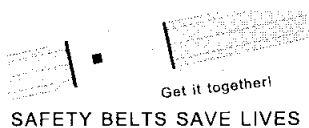
To: Kathleen DeMeter
Director, Office of Defects Investigation

NVS-210

Attached are four (4) copies of the subject report. This completes the requirements for this program.

Attachment:
Final Report

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AUTO SAFETY HOTLINE
(800) 424-9393
Wash. D.C. Area 366-0123

**VRTC MEMORANDUM REPORT EA07-010
VRTC-DCD-7113**

2007 Lexus ES-350 Unintended Acceleration

1.0 Introduction

This program was performed at the Vehicle Research and Test Center (VRTC) at the request of the Office of Defects Investigation (ODI) of the National Highway Traffic Safety Administration. ODI opened an Engineering Analysis (EA07-010) on 2007 Lexus ES-350 vehicles to investigate reports of unintended acceleration.

2.0 Objectives

- 2.1** Determine whether reported incidents of unintended acceleration were caused by a vehicle system malfunction or mechanical interference;
- 2.2** Understand and document the effects of unintended acceleration as they impact controllability of the vehicle;
- 2.3** Document potential difficulties experienced by the operator while attempting to regain control of the vehicle.

3.0 Project Tasks

3.1 Dynamic Instrumented Vehicle Testing

The Vehicle Research and Test Center obtained a Lexus ES-350 for testing (see Figure 1). The vehicle was fully instrumented to monitor and acquire data relating to yaw rate, speed, acceleration, deceleration, brake pedal effort, brake line hydraulic pressure, brake pad temperature, engine vacuum, brake booster vacuum, throttle plate position, and accelerator pedal position. Multiple electrical signals were introduced into the electrical system to test the robustness of the electronics against single point failures due to electrical interference. The system proved to have multiple redundancies and showed no vulnerabilities to electrical signal activities. Magnetic fields were introduced in proximity to the throttle body and accelerator pedal potentiometers and did result in an increase in engine revolutions per minute (RPM) of up to approximately 1,000 RPM, similar to a cold-idle engine RPM level. Mechanical interferences at the throttle body caused the engine to shut down. Mechanical interferences at the accelerator

pedal revealed that the one-piece, non-articulating accelerator pedal assembly was easily entrapped in the groove of the rubber all-weather floor mat (Figures 2 and 3) if the rubber mat was not properly secured with at least one of the two retaining hooks (Figure 4). In many observed ES-350's, the rubber mats were stacked on top of the existing carpeted floor mats, which prevented attachment of the rubber mats and facilitated the interference failure mode. A warning is embossed on the front of the floor mat that reads "Do not place on top of existing floor mats". Very few owners interviewed were able to find or read this warning (see Figure 5).

3.2 Owner Surveys

To comprehend the statistical significance of the probability for this event to occur, a survey was sent to a sample size of 1986 registered owners of a 2007 Lexus ES-350 requesting information regarding episodes of unintended acceleration. NHTSA received 600 responses for an overall response rate of 30.2%. Fifty-nine owners stated they experienced unintended acceleration. Thirty-five of those responding also reported that their vehicles were equipped with rubber Lexus all-weather floor mats and several commented that the incident occurred when the accelerator had become trapped in a groove in the floor mat. Interviews with owners revealed that many had unsecured rubber floor mats in place at the time of the unintended acceleration event, which included in some cases unsecured rubber floor mats placed over existing Lexus carpeted mats.

3.3 Analysis of the Effects of Unintended Acceleration on Vehicle Control

The safety consequences of an unsecured rubber floor mat trapping the accelerator pedal with the vehicle in gear can be severe. With the engine throttle plate open, the vacuum power assist of the braking system cannot be replenished and the effectiveness of the brakes is reduced significantly. During trapped throttle acceleration testing, several methods to defeat acceleration proved effective but not necessarily intuitive. These methods included:

- 3.3.1 Application of the brake** - Significant brake pedal force in excess of 150 pounds was required to stop the vehicle, compared to 30 pounds required when the vehicle is operating normally. Stopping distances increased from less than 200 feet to more than 1,000 feet.

- 3.3.2** Turning off the ignition - In place of an ignition key, the ES-350 uses an ignition button that removes the ability to instantaneously shut off the engine in the event of an emergency while the vehicle is in motion (see Figure 6). It was found that depressing and holding the button will eventually turn off the engine after three seconds. Through the survey it was learned that the button delay operation is not widely known by owners and because of this, drivers found themselves unable to turn off the engine when the vehicle was in motion. The owner's manual makes general mention of the operation, but there is no indication of the three second hold requirement.
- 3.3.3** Placing the vehicle in Neutral - Many owners complained that the neutral gear position in the gated shift pattern was not immediately obvious, leading to unsuccessful attempts to disengage the engine from the drive wheels. On the labeled shift diagram located on the console, the Neutral "N" marking is in closest proximity to the "Sport" mode upshift gate (see Figure 7).
- 3.3.4** Activation of Electronic Stability Control (ESC) - It was discovered that if an emergency maneuver is executed that activates the Electronic Stability Control, such as steering around a sharp curve while traveling at an excessive speed, the electronic throttle is temporarily electronically closed by the vehicle control module regardless of the accelerator pedal position. With the throttle plate closed, vacuum quickly returns to the brake booster and provides a significant increase in braking capability (see Figure 8). Additionally, ESC has the capability to automatically apply hydraulic pressure to the service brakes to aid in slowing the vehicle. When the emergency maneuver is concluded however, the ESC system returns to a passive state, and the throttle again returns to an open condition leading to further unwanted acceleration.

4.0 Summary

- Mechanical interferences at the accelerator pedal revealed that the accelerator pedal assembly was easily entrapped in the groove of the rubber all-weather floor mat if the rubber mat was not properly secured with at least one of the two retaining hooks.
- A survey was sent to 1986 registered owners of a 2007 Lexus ES-350 requesting information regarding episodes of unintended acceleration. Of the 600 people that responded, 59 stated that they experienced unintended acceleration and 35 complained of pedal interference with the Lexus rubber all-weather floor mats.
- With the engine throttle plate open, the vacuum power assist of the braking system cannot be replenished and the effectiveness of the brakes is reduced significantly.
 - Brake pedal force in excess of 150 pounds was required to stop the vehicle, compared to 30 pounds required when the vehicle is operating normally.
 - ESC activation may restore vacuum to the brake booster, providing a significant increase in braking capability, but only until ESC activity ceases.
- The owner survey indicated the 3 second delay in the operation of the ignition button is not widely known by owners and because of this, drivers found themselves unable to turn off the engine when the vehicle was in motion.
- Many owners complained that the neutral gear position in the gated shift pattern was not immediately obvious, leading to unsuccessful attempts to disengage the engine from the drive wheels.



Figure 1 – 2007 Lexus ES-350



Figure 2 – Lexus All-weather Floor Mat with Retaining Hook Holes at the Bottom



Figure 3 – Accelerator Pedal Trapped at Full Throttle by Unsecured Rubber Floor Mat



Figure 4 –Floor Mat Retaining Clip and Carpet Receiving Eyelet

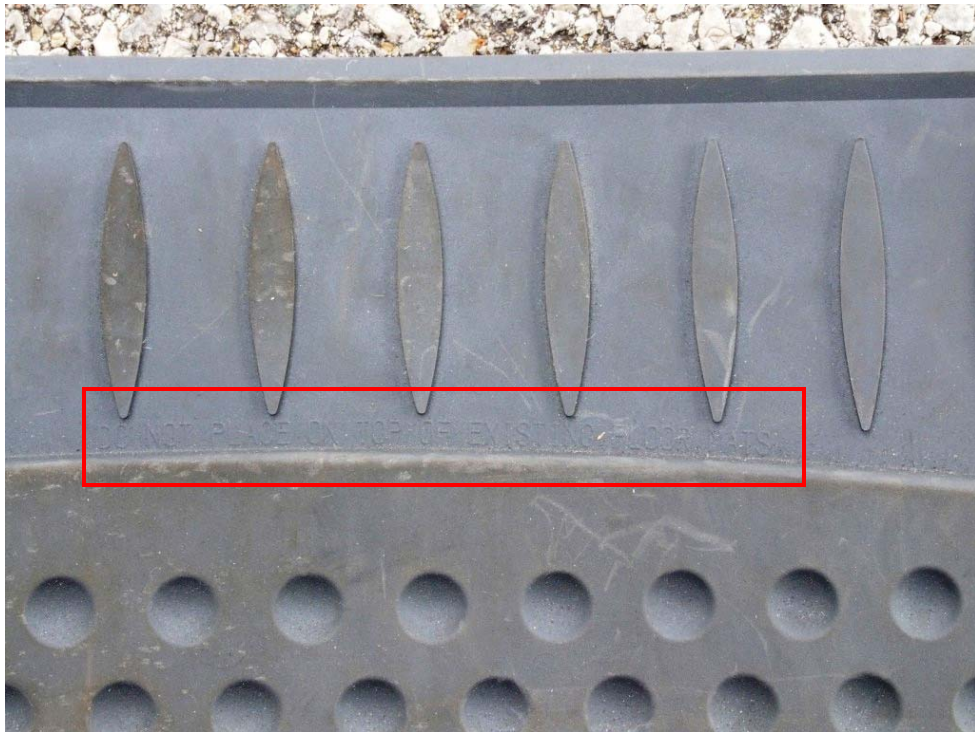


Figure 5 – Embossed Warning On Floor Mat States “Do Not Place On Top of Existing Floor Mats”



Figure 6 - Push Button Ignition Replaces Conventional Key



Figure 7 – Shift Gate with Diagram

Lexus ES350 Performance Test

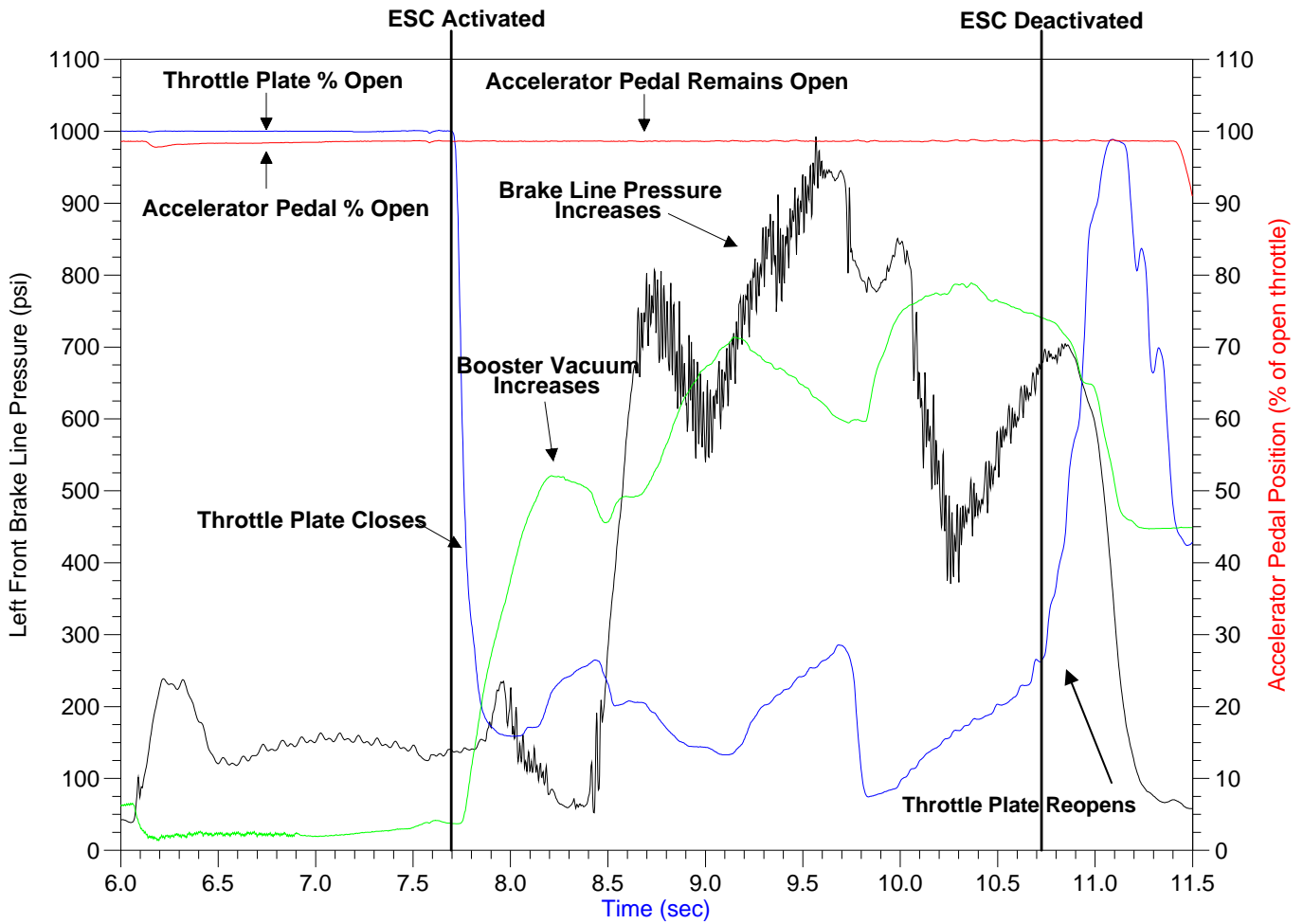


Figure 8 – Data Acquired from Lexus During Testing Indicates Engine Throttle is Overridden During ESC