Journal of the National Academy OF Forensic Engineers®

http://www.nafe.org
ISSN: 2379-3252

Vol. XIX No. 1 June 2002

Forensic Engineering Review: Causes of Sudden Unexpected Vehicle Acceleration

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A disturbing number of drivers have experienced accidents in which their vehicle "runs away" or suddenly accelerates. This article will address some of the reasons for this phenomenon, including mechanical malfunctions, human factors issues, and design defects. Some vehicle makes and models with particularly high rates of sudden acceleration incidents are highlighted.

What do drivers report?

Drivers who experience a sudden acceleration incident typically report an unexpected loud "revving" noise from the engine coupled with a sensation of unusually high acceleration. This may occur in DRIVE or REVERSE. Because the driver does not expect their vehicle to accelerate, the acceleration seems particularly strong. Many drivers report an acceleration "like I have never felt before." Tire marks on the pavement often confirm a high-power acceleration, and rule out "skid" marks from braking.

Most drivers report that they are "absolutely positive" their right foot was on the brake, but the vehicle accelerated anyway. In nearly every incident of this type, the driver attempts to steer clear of obstacles, and ultimately crashes. Drivers usually respond instinctively, by attempting to brake and steer. Most of these incidents are over in a matter of seconds, and some have fatal results for occupants or pedestrians. It is interesting to note that drivers faced with an unexpected sudden acceleration almost never shut off the ignition or shift the transmission out of gear, because there is too little time to think and respond in such an emergency situation.

Post-crash inspections

In most cases, a mechanical examination of the crashed vehicle does not uncover any mechanical problem with the throttle system or cruise control. This can be puzzling, since the only way an engine can produce high power is for the throttle to open. Opening the throttle requires either a) the driver to depress the gas pedal, or b) the cruise control to actuate the throttle.

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In some cases, I have found physical evidence to explain the incident. These have included:

- Mechanical interference between the gas pedal and floor mat, causing the pedal to become stuck;
- Deterioration or damage in a throttle cable or cruise control cable, causing excessive friction in the throttle system;
- Excessive friction in the throttle shaft and/or associated linkage;
- Use of improper or damaged throttle cables, causing binding or kinking;
- Mechanical interference between the throttle linkage and adjacent components, caused by design defect or improper service; and
- Problems with the throttle return springs, including missing springs, stretched springs, incorrect springs, or incorrect spring attachment point.

These mechanical problems have explained only about one quarter of the sudden acceleration incidents I have investigated. Understanding the others requires consideration of multiple factors.

Some common elements

Sudden acceleration incidents seem to occur most frequently in vehicles with automatic transmissions and under certain conditions:

- At a car wash or parking garage;
- With a driver who is unfamiliar with the vehicle;
- On a few selected vehicle models, and;
- On vehicles without a brake-shift interlock.

Why would such incidents occur at a car wash? Some researchers have seized on a theory involving electro-magnetic radiation from car-wash equipment, causing interference with the vehicle's cruise control electronics. To my knowledge, this theory has not been confirmed, and would not explain those incidents that occur away from electrical equipment. Other investigators have looked into possible electrical wiring problems, and found that certain kinds of electrical malfunctions can cause the cruise control servo to open the throttle, in some makes and models.

Pedal misapplication

Is it possible that a driver may experience sudden acceleration by stepping on the wrong pedal? And if that were true, why would it occur at a higher rate under certain conditions and on certain vehicles? Let us consider the pedal misapplication theory in light of the following factors.

At a car wash or parking garage, an attendant may deliver a car to its owner, and the engine is often left running. The attendant may adjust the driver's seat from its usual position, or may step into the vehicle and drive without adjusting the seat to a comfortable position. If a driver is unfamiliar with the layout of the gas and brake pedals, or if the gas and brake pedals have an unusual layout, the unfamiliar driver is more likely to step on the wrong pedal than the regular driver, particularly if the seating position is incorrect. If the attendant adjusts the driver's seat for his own comfort, the seat may be left out of position for the regular driver, contributing to a pedal misapplication.

Most drivers are in the habit of performing certain tasks in a particular pattern or sequence. For example, I usually unlock the door, get into the seat, close the door, put on my seat belt, start the engine, step on the brake, shift into gear, and apply the gas pedal. If a driver enters his vehicle and the engine is already running, his normal sequence and pattern is disrupted, and the driver may be at a higher-than-normal risk for a pedal misapplication. If the engine is running and the seat position has been adjusted, the risk of pedal misapplication is compounded. These human factors observations are based on my own experience in approximately 30 sudden acceleration incident investigations.

Summarizing factors that may increase the likelihood of sudden acceleration due to pedal misapplication, they are:

- Engine left running
- Incorrect or unfamiliar seating position
- Driver is unfamiliar with the layout of the gas and brake pedals
- Gas and brake pedals have an unusual layout
- Vehicle is not equipped with a brake-shift interlock

Brake-shift interlock

Most passenger cars and light trucks built since the early 1990s have a safety feature called a brake-shift interlock that prevents the driver from shifting the transmission out of PARK unless the brake is depressed. This safety feature effectively prevents accidents that occur when a driver may inadvertently apply his/her foot to the gas pedal instead of the brake when shifting from PARK into DRIVE or REVERSE. The brake-shift interlock does not prevent inadvertent shifting from NEUTRAL to DRIVE or REVERSE.

One notable model to have a brake-shift interlock installed as a safety recall campaign was the Audi 5000. After a disproportionately high number of sudden acceleration reports on this model in the 1980's, it was found that the unusual physical layout of the steering column, brake and gas pedal positions in the

Audi 5000 caused some drivers to step on the gas pedal when they thought they were stepping on the brake. After those cars were recalled in 1987 and retrofitted with a brake-shift interlock, sudden acceleration reports dropped dramatically. Most manufacturers incorporated the brake-shift interlock as standard equipment by 1992.

Government and auto manufacturer positions

Following the rash of sudden acceleration incidents with Audi 5000 in the 1980's, The National Highway Traffic Safety Administration (NHTSA) undertook a lengthy investigation into the cause of such incidents. NHTSA concluded that there are multiple factors explaining sudden acceleration, but the bulk of these incidents were caused by pedal misapplication. NHTSA outlined several factors causing sudden accelerations, noting that vehicles with unconventional gas and brake pedals positions had a far higher incidence of sudden acceleration incidents than other vehicles with more conventional pedal locations. They recommended installation of a brake-shift interlock as an effective safety feature to prevent most sudden acceleration incidents.

The auto industry abbreviated NHTSA's findings to conclude that sudden acceleration is caused by driver error. To support that position, some manufacturers promoted their own tests suggesting that a vehicle's brakes could always overpower the engine and stop a vehicle, even if the throttle were to become stuck in the open position. By sticking with their story that sudden acceleration is caused by pedal misapplication, and by suggesting that no malfunctions have ever been discovered as a cause, the industry has attempted to avoid dealing with the subject of unconventional vs. standard gas and brake pedal layouts.

Jeep Recalls

After a NHTSA investigation into sudden acceleration incidents reported in Jeep Cherokees and Grand Cherokees, recall No. 97I002000 was issued in 1997. All Jeep Cherokees from 1984 through 1995, including Jeep Grand Cherokees, were affected.

The recall modification involved the installation of a brake-shift interlock, which was installed as original equipment beginning with the 1996 model year. The recall advises as follows:

> *"1984-95 Jeep Cherokee and Grand Cherokee Multipurpose passenger vehicles equipped with automatic transmissions. This is not a safety recall in accordance with Federal Regulation 573. However, it is deemed a safety improvement campaign by the agency. Drivers can mistakenly step on the accelerator pedal when they intend to step on the brake pedal. Pedal misapplication by a driver can cause unintended acceleration. Dealers will install a shift interlock on the automatic transmission of these vehicles."*

Carwash association alert

The International Carwash Association sent an alert to its members in June 1995, entitled:

> Problems with "Lurching" Jeep Cherokees Persist
> *"ICA Headquarters has received calls in recent months from car wash operators around the country who have experienced problems with Jeep Cherokees lurching forward unexpectedly when coming off the line."*

Does unconventional pedal layout cause pedal misapplication?

In order to determine the relationship between pedal layout and pedal misapplication, I measured the pedal positions in eleven passenger vehicles, and determined the number of complaints for sudden acceleration in those vehicles.

Figure 1 displays the relative pedal positions for all eleven vehicles superimposed. These pedal positions are displayed as if viewed from above. The horizontal reference is the centerline of the driver's seat, and the vertical reference is the front of the driver's seat.

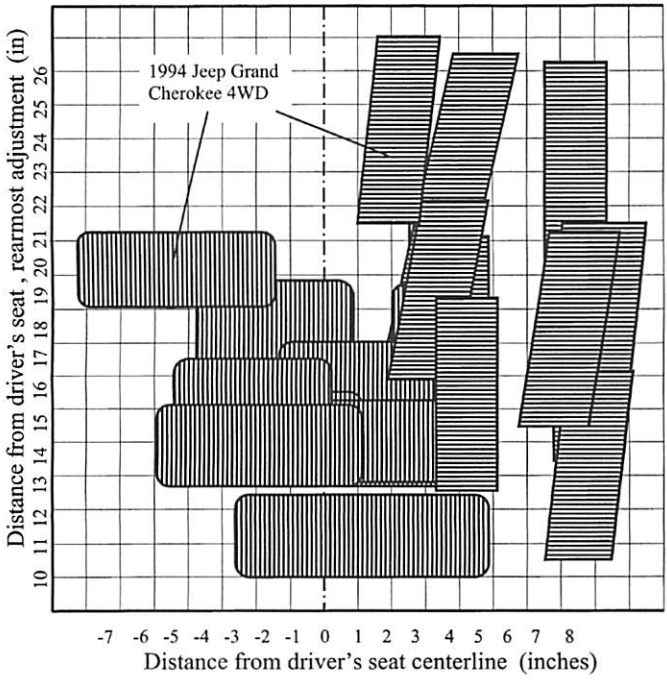

Figure 1
Brake and gas pedal positions relative to the driver's seat

The vehicles measured include:

1985 Audi 5000S
1993 Plymouth Acclaim
1992 Dodge Caravan
1994 Jeep Grand Cherokee 4X4
1990 Oldsmobile Toranado
1989 Jeep Cherokee 4X4
1985 Ford Bronco
1988 Volkswagen Vanagon
1993 Ford Explorer
1994 Jeep Cherokee 2WD
1988 BMW 325

As shown in Figure 1, the Jeep Grand Cherokee 4X4 pedals are positioned farther to the left than any of the other models in this group. Most models position the gas pedal well to the right of the seat centerline. Of these models, the Jeep Grand Cherokee places the gas pedal closest to the seat centerline. The gas pedal on the Jeep Grand Cherokee is located at a position where most drivers would expect to find a brake pedal.

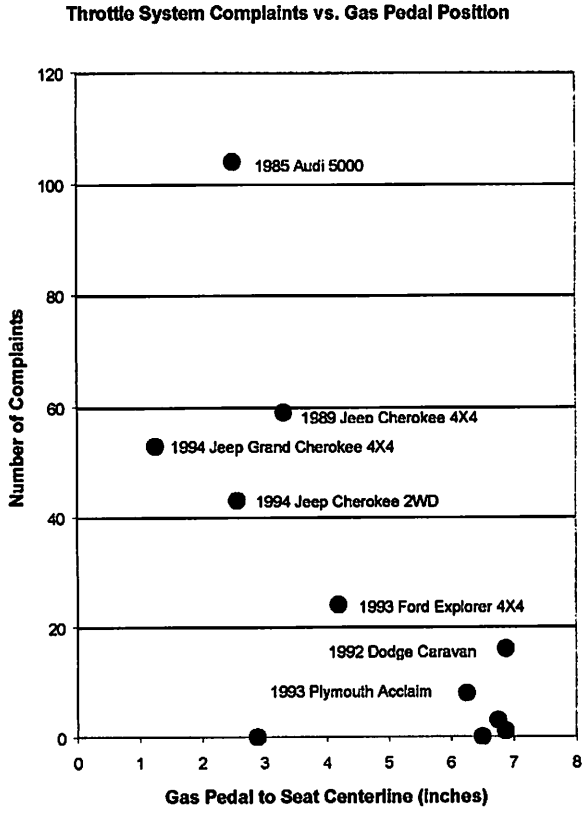

Figure 2
Number of sudden acceleration complaints vs. gas pedal position

Complaint Analysis

For each of the vehicles listed above, the NHTSA database was queried for complaints relating to throttle linkage, cables and pedals. These complaints are associated with sudden acceleration incidents. The total number of sudden acceleration complaints was plotted against the gas pedal-to-seat centerline distance for all eleven vehicles.

Figure 2 indicates a strong correlation between gas pedal position and sudden acceleration reports. In general, those vehicles with the gas pedal near the seat centerline have the highest number of sudden acceleration complaints.

Figure 3 summarizes the sudden acceleration complaints across the 1993 through 1997 model years for the Jeep Grand Cherokee, Jeep Cherokee, Ford Explorer and Dodge Ram. For each vehicle, the number of complaints has been

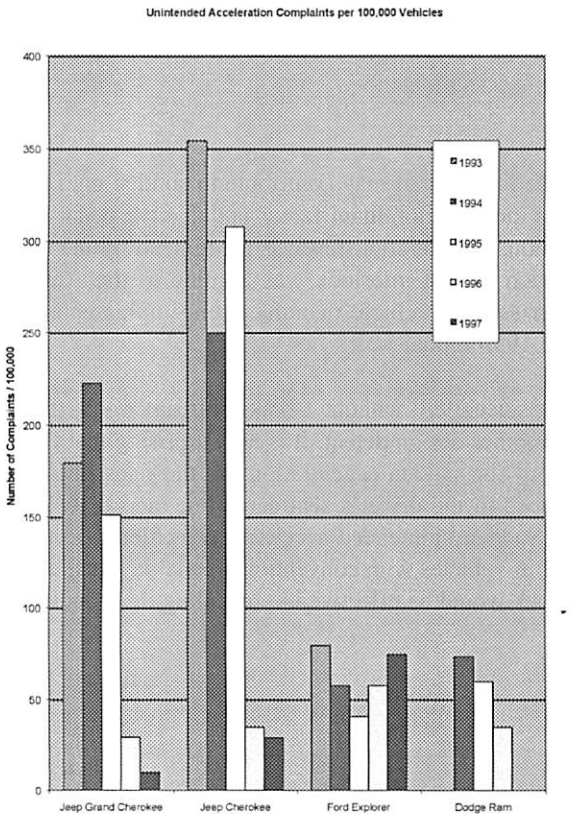

Figure 3
Rate of sudden acceleration complaints for 4 models over 5 years

divided by the number of vehicles sold. The resulting chart plots complaints per 100,000 vehicles across the five model years and four vehicles.

The data in Figure 3 leads to two striking conclusions:

a. 1993-95 Jeep Cherokee and Grand Cherokee models have an unusually high number of sudden acceleration complaints relative to comparable sport utility vehicles, and;

b. When Jeep added a shift-interlock in the 1996 model year, the sudden acceleration complaints were reduced dramatically.

The disproportionately high number of sudden acceleration reports in pre-1996 Jeep Cherokee and Grand Cherokee models is the result of two design defects. First, the location of the gas pedal is near the centerline of the driver's seat, where most drivers expect to find the brake pedal. This defective layout causes some drivers to step on the gas when they intend to step on the brake. Secondly, the absence of a shift interlock causes this unintentional pedal misapplication to result in accidents. The presence of a shift interlock would eliminate most sudden acceleration accidents.

Conclusions

There are multiple factors that may contribute to sudden unexpected acceleration incidents. The most predominant factor is defective pedal layout, causing pedal misapplication. This relationship was recognized by the auto industry in the late 1980s, when a shift interlock was applied to the Audi 5000 in a recall. All Japanese passenger vehicle manufacturers implemented shift interlocks in or before the 1990 model year.

For vehicles built since 1990 without a brake-shift interlock, the absence of this safety feature is another design defect. It is not surprising that those vehicles with the poorest record for sudden acceleration are the ones in which the gas pedal is positioned close to the driver's seat centerline, and that do not have a brake-shift interlock. Sudden unintended acceleration incidents occur at a somewhat lower frequency in vehicles with conventional pedal layouts, and the installation of a shift interlock would be effective in preventing those incidents as well.