



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

ODI RESUME

Investigation: EA 02-017
 Prompted By: PE02-020
 Date Opened: 08/16/2002 Date Closed: 08/15/2003
 Principal Investigator: LEE STRICKLAND
 Subject: BURN INJURIES DUE TO AIR BAG DEPLOYMENT

Manufacturer: FORD MOTOR COMPANY
 Products: FORD FOCUS 2000-2001
 Population: 576,700

Problem Description: CONSUMERS ALLEGE THAT DEPLOYMENT OF AIR BAGS MAY RESULT IN BURN INJURIES TO DRIVER AND/OR FIRE INCIDENTS.

FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
Complaints:	55	118	173
Crashes/Fires:	0	0	0
Injury Incidents:	55	118	173
# Injuries:	55	118	173
Fatality Incidents:	0	0	0
# Fatalities:	0	0	0
Other*:	0	0	0

*Description of Other:

Action: THIS ENGINEERING ANALYSIS HAS BEEN CLOSED.

Engineer: Leamon H. Strickland *LS*
 Div. Chief: Thomas Z. Cooper
 Office Dir.: Kathleen C. DeMeter

Date: 08/15/2003
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Summary:

All of the consumer complaints allege an incident in which deployment of the driver frontal air bag caused some type of burn injury. Most of these injuries are due to contact and/or abrasion with the air bag and are of relatively minor to moderate severity. It is possible that some drivers may have sustained burn injuries to the skin as a result of hot gases exhausting from the vents of the air bags in the subject vehicles, but the number of such incidents appears to be low. Further details of the investigation are contained in subsequent pages of this report.

Based on the above, 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 of warranted by the circumstances.

10/8/2003

BASIS:

The subject Engineering Analysis was opened as a result of upgrading Preliminary Evaluation (PE) 02-020. The PE was prompted by a screening review that disclosed the Office of Defect Investigation (ODI) had received consumer complaints containing reports of burn injuries, and in some cases allegations of fire, resulting from deployment of the driver air bags in the subject Ford Focus vehicle models produced by Ford Motor Company (Ford).

Information obtained during the PE disclosed 140 consumer allegations from all sources involving burn injuries resulting from deployment of the subject air bags. The complaints included allegations of second- and third-degree burns and reports of burned articles of clothing. Some of the complaints attributed the burn incidents to "fire," which ODI considered to be potential reports of open flames involving either driver apparel or some portion of the vehicle itself.

THE ALLEGED DEFECT:

The alleged defect in this investigation involves consumer complaints that the driver air bag installed in the subject vehicles may inflict burn injuries upon the driver as a result of its deployment, regardless of the circumstances under which that deployment may occur. In this investigation, three types of "burn" injuries are considered; those potentially resulting from thermal causes, those potentially resulting from abrasion or friction between the air bag and the driver, and those potentially resulting from chemical burns due to any product of ignition of the air bag inflator assembly.

DESCRIPTION OF THE FOCUS AIR BAG SYSTEM:

The driver frontal air bag installed in all models of Model Year (MY) 2000 and 2001 Ford Focus vehicles was manufactured and supplied to Ford by the Autoliv North America Air Bag Module Facility, located in Ogden, UT. According to Ford, the subject air bag is designed to provide effective occupant protection in moderate to severe frontal vehicle collisions. The air bag meets or exceeds all Federal regulatory provisions, and Ford claims that it is especially effective for out-of-position occupants during deployment.

The design features a new "depowered" inflator and a controlled trajectory during deployment. A radial deployment system with internal tear seams control the trajectory (direction and sequence) that reportedly reduce the severity of contact with occupants positioned in close proximity to the air bag. The exhaust vents are positioned at the "12 o'clock" position of the air bag, facing forward (toward the instrument panel) on the top surface of the deployed air bag. This location for the air bag exhaust vents is widely used within the automotive industry, and is intended to minimize the potential for interaction of a vehicle occupant with the exhaust gases. The Focus air bag design also utilizes "petal vents" to provide additional protection against occupant exposure to the exhaust gases vented during deployment. The petal vents are designed to diffuse and swirl the exhaust gases and reduce their temperature and speed as they are released. In addition, the air bag is coated to minimize the potential flow (leakage) of hot exhaust gases through the fabric and to minimize burn injuries through conduction as the driver contacts the heated fabric.

Typically, air bag inflation occurs when a pyrotechnic charge is ignited to produce gases that rapidly inflate the bag. The inflator propellant is a proprietary composition that is reported by Ford to ignite at a temperature near that of the commonly used sodium azide (approx. 2,600 degrees C), but is described as more "environmentally friendly." Inflation of the air bag produces a smoke-like, powdery residue consisting of cornstarch and talcum powder that serve as dry lubricants with the air bag in its folded and stored position before deployment.

The purpose of the air bag assembly is to provide supplemental occupant protection against impact with the interior of the vehicle (i.e., the steering wheel and windshield for the driver) during a frontal vehicular collision. In the subject vehicles, the air bag is an "advanced" design developed by Autoliv, in which the air bag inflates in a specific sequence. When deployed, the air bag begins to unfold from its stored module located in the steering wheel hub by initially inflating an inner "box." Once the inner box has fully inflated, the tear stitching, which defines the volume of the box, separates to allow the exhaust gases to flow toward the outer edges of the air bag. Additional radial tear stitching then separates and the inflation sequence continues in an outward direction toward the circumference of the air bag, rather than toward the face and chest of the driver. According to Ford, its supplier developed the air bag "...to reduce the risk of potentially serious impact injuries from air bag deployment, particularly to those drivers who are out-of-position at the time of deployment." Its inflation pattern permits the bag to deploy differently with different types and locations of driver contact in order to minimize the force of driver impact with the front surface of the air bag.

In addition to the radial deployment pattern of the subject air bags, Ford states that the inflator is designed to produce a relatively low mass of gas to inflate the bag. For this reason, the thrust of the air bag during deployment is lower than that of a similar size air bag using a higher mass inflation gas. Therefore, the pressure on the driver's chest is lower as the driver contacts the air bag during a crash. Ford also states that this is particularly true for unbelted drivers or those of smaller physical stature who may be sitting too close to the air bag.

DESIGN CHANGES:

The subject air bags were installed in all models of Focus vehicles manufactured during MY 2000 and 2001. No changes in the design of the subject air bags were made during these model years.

FAILURE/MALFUNCTION MODES:

This investigation does not concern the failure or malfunction of a vehicle component or system. Rather, the issue of concern is whether the air bag, when operating as designed, creates a risk of burn injury to the driver that rises to the level of a safety-related defect. This includes the risk of burning of clothing or other combustible material in the vehicle.

Review and analysis of the allegations of burn injuries sustained as a result of deployment of the subject air bags discloses that the driver's hands, wrists, and forearms are the primary injury locations. In cases where articles of clothing are reported to have sustained burns, these have also generally occurred on the sleeves.

ADDITIONAL INFORMATION:

Motor vehicle air bags are designed to provide protection against impact trauma injuries by rapidly deploying during a crash and providing a relatively soft cushion of occupant restraint during a crash. The airbag inflates rapidly and then deflates as the gases generated during deployment are exhausted from vents in the air bag. The deployment of an air bag is known to create a risk, although it is significantly lower than the risk resulting from occupant impact with the vehicle interior in a high-speed crash.

Occupant contact with a deployed air bag may result in injuries, including abrasions, contusions, lacerations, fractures, and burns. As a group, "burn" injuries may potentially result from friction during driver impact with the air bag (abrasions), thermal burn from hot exhaust gases and/or burning embers, and chemical burn if the air bag exhaust gases contain any product that is chemically hazardous.

Some abrasion or friction between the driver's skin or clothing and the surface of the deploying air bag is unavoidable. Also, Ford reported that the exhaust from the subject air bag is very slightly (chemically) basic; and therefore, the likelihood of chemical burn is essentially nonexistent. As a result, the primary concerns in this investigation involve the potential for heat-related (thermal) burns, and the possibility of the gases igniting a fire within the occupant compartment.

According to the website WebMD and other medical documentation¹, burn injuries are generally classified into one of four types, denoting "degrees" of severity. First degree or superficial burns are the least damaging and are typified by sunburns. Such burns do not produce blisters and damage only the top layer of skin (epidermis). First degree burns normally heal in three to six days.

Second degree burns involve the entire top layer of skin (epidermis) and some portions of the dermis (second layer of the skin). These injuries are also referred to as partial-thickness burns, and are sub-categorized as superficial and deep partial-thickness burns. Superficial partial-thickness burns cause blistering, are painful, and generally heal within three weeks. The skin underneath the blister is moist and red. Deep partial-thickness burns are dry and may appear ivory or pearly white. They require longer than three weeks to heal and usually produce severe scarring. Skin grafts are usually recommended for deep second degree burns.

Third degree burns are full thickness injuries that destroy the epidermis and dermis. They are dry, and have a dark leathery appearance. Third degree and full thickness second degree burns larger than 3 centimeters in diameter are best treated with surgery, immediate skin grafting, and long term use of compression garments to minimize severe scarring.

¹ Solem, Lynn, M.D. and Clayton, Matthew, M.D. *No Ice, No Butter; Management of Burns*. Postgraduate Medicine 1995; Vol.97 No 5.

Fourth degree burns are most serious. This category of burn extends completely through the skin and injures muscle and bone. Fourth degree burns always require medical treatment.

COMMUNICATIONS WITH THE MANUFACTURER:

Information relevant to this investigation was requested and received from Ford during the Preliminary Evaluation phase. Under the EA, NHTSA requested additional information from Ford by letter dated December 16, 2002. Ford's response was submitted to NHTSA by letter dated January 31, 2003.

VEHICLE POPULATION:

The manufacturer reported that a total of 576,670 subject MY 2000-2001 vehicles were sold in the United States. The driver air bags installed in all of the subject vehicles are identical in design and materials.

PROBLEM EXPERIENCE:

Consumer complaints and field reports of all types were submitted by Ford to NHTSA. These reports and data were merged with those submitted by consumers directly to NHTSA, and the following net statistics were derived:

Total number complaints of burn injuries: 173

Number allegations of "fire" or third degree burns: 34

Number of allegations of fatal incidents/fatalities: 0/0

The above count of "fire or third degree burns" is based on language used in consumer descriptions of the events. This information is discussed further in the **ODI EVALUATION** section of his report.

WARRANTY:

Data for warranty, extended warranty, goodwill adjustments, and zone/field adjustments were not requested in the subject investigation. The nature of the alleged defect is such that these data are not considered relevant or useful.

SERVICE BULLETINS:

Ford issued no technical service bulletins or other type of service literature regarding the subject air bags to its dealers or consumers.

ACCIDENT INVESTIGATION DATA:

In support of this investigation, searches of the NHTSA's National Center for Statistics and Analysis (NCSA) accident investigation and data files were conducted. The purpose of the searches was to review the experience of reported air bag burn injuries and reported injuries of any kind to the head, neck, and facial areas of the body in the subject Focus models when compared to other models considered to be peers. NCSA compiled data for a peer class consisting of 20 passenger car models for MY 2000 and 2001, based on comparability of gross

vehicle weights. Some of the more popular models in the peer class are Chevrolet Cavalier, Dodge Neon, Ford Escort, Honda Civic, Nissan Sentra, Toyota Celica and Corolla, and Volkswagen Jetta.

The National Automotive Sampling System (NASS) Crashworthiness Data System (CDS) was queried for air bag-related burn injuries in MY 2000-2001 Focus and peer vehicles during calendar years 1998-2002. The search identified eight relevant injuries, all sustained by drivers and all injuries involving upper body extremities. Of the eight injuries, three occurred in the subject Focus vehicles. Because varied numbers of air bag deployments occurred among the four other peer models in which burn injuries also occurred, burn injuries per deployment were calculated to allow direct comparison. Although the Focus had three of the total of eight burn injuries, its rate per deployment was the same or less than the rates of the peer vehicle models where burn injuries also occurred. When compared to the aggregate of the peer class selected, however, the Focus shows the higher burn injury rate because no air bag-related burn injuries were identified for 17 of the 20 peer vehicle models. NCSA also reports that the subject Focus models had more air bag deployments than any of its peers, but that this finding corresponded to the higher population of Focus models than any of its peers in the sample. Finally, there is the qualifier that the raw numbers found in the CDS data searches are quite small. The significance of the comparative results must, therefore, be viewed with this in mind.

NCSA also queried the New York State (NYS) crash database for calendar years 1999-2000 for numbers of injured occupants in MY 2000-2001 Ford Focus and peer vehicles in which the air bag deployed and any kind of burn injury was the most severe injury reported. The subject Focus vehicles exhibited burns per deployment rate of eight percent, as compared to any of the individual peer vehicles which exhibited rates of 0 to 3.6 percent. In raw numbers, the Focus accounted for seven burn reports out of a total of 87 for the 21 vehicles in the group. Similarly, the Focus exhibited a higher rate of burns per deployment than the aggregate group of 20 peer models.

A third NCSA query investigated the NYS crash database for calendar years 1999-2000, for injured drivers of the subject Focus models and peer vehicles, in which an air bag deployed and any kind of head, face, eye, or neck injury was the most severe injury reported for the driver. In these data, the subject Focus models exhibited an injury per deployment rate of 14.9 percent as compared to rates for the individual peer models ranging from 0 to 37.5 percent. The comparable rate for the aggregate of the 20 peer models is 23.5. An additional finding from this query shows that when head injuries are excluded (in case head injuries might include some non-air bag related cases), the rate for the subject Focus models is 12.6 percent, compared to the rates of the individual peer models of 0 to 25.0 percent. This also compares to the rate for the aggregate of all peer models of 14.1 percent.

MANUFACTURER'S EVALUATION OF THE ALLEGED DEFECT:

The manufacturer states that allegations of burn injuries sustained as a result of air bag deployments in the subject vehicles do not demonstrate the existence of a safety-related defect. Ford reiterates that air bag deployments are not risk-free events, and that the risk of injuries

caused by the air bag is far less than the risk of injuries in a crash when an air bag is not available.

Ford also addresses the severity of burn injuries reported and the relationship between the severity and likely cause of the injury. Many of the complaints reviewed in this investigation contained language quantifying the severity of such injuries, usually stated in terms of "degree." Diagnosing burn severity requires evaluation by trained medical personnel and Ford states that because such assessments are an inexact science, the diagnosis of a single injury may vary even from one medical observer to another. In addition, Ford states that as more time passes between the injury occurrence and a medical evaluation, it becomes increasingly difficult to determine whether the injury is the result of abrasion or thermal causes.

Ford states that burn injury severity, when made by qualified medical personnel, includes consideration of the depth of damage sustained by the human skin/tissue, as well as the body surface area injured. Ford also states that while any air bag-induced injury is regrettable, the burns allegedly associated with air bag deployments in the subject vehicles are localized and non-life threatening. Ford believes they may be regarded as minor burn injuries because they cover a small portion of the body, the vast majority affecting only the hands, wrists, or forearms.

Ford considers "self-diagnosis" by complainants in the subject investigation to be subjective, and points out that no medical evidence is available to substantiate such claims in 50 percent of the complaints where a burn severity rating is assigned.

Questionable burn severity assessments are also pointed out in Ford's review of the complaints. A number of consumer statements and/or other evaluations indicate that the injuries were the result of "chemical burns." Ford points out that the non-azide inflator used in the subject air bag produces only a small amount of corrosive or chemically active effluent (i.e., sodium hydroxide) capable of causing chemical burns, and that although the subject deployments may cause minor irritations of the skin and/or eyes, there are no toxic components in the exhaust gases.

Ford also points out that claims of burns on the back side of the forearms are most likely not thermally related because of their relative distance away from the air bag vents when the arms are located in a normal driving position. Ford believes such events are more likely the result of "air bag slap" which may occur as the unfolding air bag wraps over the top of the arm upon reaching maximum inflation volume and pressure.

Ford cites a 1995 study of air bag-related injuries that found that 63.5 percent of the injuries sustained by drivers during air bag deployments were the result of abrasions.² Ford therefore concludes that a driver injured by an air bag deployment is significantly more likely to sustain

² Antosia, R.E., Partridge, R.A., and Virk, A.S. *Air Bag Safety*. *Annals of Emergency Medicine* 1995; 25; 794-8.

abrasion-type burns than temperature-related burns. In consideration of this fact, together with the difficulty of determining the severity of the injury and the absence in many cases of prompt medical evaluation, Ford argues that the majority of the alleged burns are not temperature-related, but the result of abrasion or friction.

Ford acknowledges that temperature-related burns may result from positioning of the hands on the steering wheel in the vicinity of the air bag vents, but Ford believes that many of the allegations in this investigation are not of this nature. Ford reports that high-speed infrared imaging determined the exit temperature of the gas at the inflator to be in the range of 720 to 750 degrees C. The nominal temperature of the exhaust gases at the petal vents has not been measured or calculated because of their highly transient nature and the difficulty in measuring it.

The matter of potential thermal-related burn injuries as a result of deployment of the subject air bags was evaluated during the developmental phase of the subject air bags. This subject was addressed by Autoliv, supplier of the subject air bags to Ford, and the results were documented in a study published well before the subject Focus model went into production. The study, commissioned by Autoliv, was conducted by ONERA, the French National Establishment for Aerospace Research, and was based on mathematical modeling as opposed to test simulations of the thermodynamics involved in an air bag deployment. The ONERA study found only slight differences between the newer inflator type used in the subject air bags and the sodium azide inflators that prevalent during the 1990s, when evaluated by skin temperatures induced in thick and thin-skin types during exposure to the air bag material and exhaust gases.

Ford states that the subject air bags provide effective occupant protection in moderate to severe frontal crashes, and that the vehicles surpass all regulatory crash performance criteria, including those for out-of-position occupants. Ford also asserts that the potential for contact burns that may occur as a result of air bag deployment are far outweighed by the protection afforded by the air bags against more severe trauma that may result from a crash. Ford concludes that there is no safety-related defect in the air bag system of the subject vehicles.

ODI EVALUATION:

In response to consumer allegations of "fires" as a consequence of deployment of the subject airbags, and to obtain more details about incidents involving alleged third degree burns, ODI attempted to contact all 33 complainants who made such allegations. From the list of 33 consumers who made such reports, the following results were realized:

Consumers interviewed	12
Insufficient information to contact consumers	12
Consumer contacts attempted unsuccessfully	9

Of the consumers interviewed, the following results were obtained:

- No reports of fire involving the vehicle were identified
- One report of burning embers in the air bag exhaust was not verified
- Several reports of "smoke" were identified, described as white, gray, and/or powdery

- Three reports of orange or red flames were identified, typically described as a “flash,” which self-extinguished in five seconds or less
- The typical report of burns involved the driver’s hands or forearms, or clothing covering the forearms
- Burn severities were diagnosed by emergency medical technicians, hospital emergency room staff, and/or private physicians
- Two cases were diagnosed as “chemical burns” by medical personnel.
- Medical treatments typically consisted of creams, ointments, moisturizers and/or bandages
- No surgeries were required

This and other information reviewed during the course of this investigation suggests that the medical treatments reportedly received by consumers are not consistent with the severity of third degree burn injuries that completely destroy both layers of skin. Several consumers compared their burn injuries to sunburns. As noted above, the potential for chemical burns is virtually nonexistent, and the “smoke” observed by some consumers during air bag deployment is apparently the dust of cornstarch or talcum powder used on the air bag surfaces.

The following are significant findings of this investigation:

- Air bag-related burn injuries sustained by drivers of the subject vehicles primarily affected the hands, wrists, and forearms. The likelihood of burns to other areas of the body is low.
- Most of these injuries are due to contact and/or abrasion with the air bag and are of relatively minor to moderate severity.
- It is possible that some drivers may have sustained burn injuries to the skin as a result of hot gases exhausting from the vents of the air bags in the subject vehicles, but the number of such incidents appears to be low.
- In rare cases, air bag exhaust gases in the subject vehicles may have been hot enough to damage or burn articles of clothing or accessories worn by some drivers.
- Abrasion-type burns, resulting from contact of the driver with the air bag, are a recognized potential consequence of air bag deployment in all vehicles, and are not limited to the subject vehicles.
- In circumstances reported in the incidents surveyed, there is no indication that position of the driver’s hands on the steering wheel made it more or less likely that burns were sustained.
- In general, comparisons of the incidence of Focus air bag-related burn injury reports with similar reports for a group of 20 peer vehicles shows the Focus to be somewhat over-represented. However, the absolute numbers of such incidents are very small for all vehicle models.

CONCLUSION:

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.