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

NHTSA

DOT HS 813 256

January 2022

Special Crash Investigations: On-Site Hazardous Materials Fatality; Vehicle: 2006 Porsche Cayenne; Location: Florida; Incident Date: June 2016

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Suggested APA Format Citation:

Crash Research & Analysis, Inc. (2022, January). *Special crash investigations: On-site hazardous materials investigation; Vehicle: 2006 Porsche Cayenne; Location: Florida; Incident date: June 2016* (Report No. DOT HS 813 256). National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 813 256		

4. Title and Subtitle	5. Report Date
Special Crash Investigations: On-Site Hazardous Materials Investigation; Vehicle: 2006 Porsche Cayenne; Location: Florida; Incident Date: June 2016	January 2022
	6. Performing Organization Code

7. Author	8. Performing Organization Report No.
Crash Research & Analysis, Inc.	CR16026

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Crash Research & Analysis, Inc. P.O. Box 302 Elma, NY 14059	11. Contract or Grant No. 693JJ919C000004

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
National Highway Traffic Safety Administration 1200 New Jersey Avenue SE Washington, DC 20590	Technical Report
	14. Sponsoring Agency Code

15. Supplementary Notes

Each crash represents a unique sequence of events, and generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicles or their safety systems. This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was submitted.

16. Abstract

This report documents the on-site investigation of a 2006 Porsche Cayenne and the deaths of its belted 46-year-old female driver and a belted 3-year-old female in a high-back booster child restraint system (CRS) in the second row. Both occupants were found deceased in the vehicle by the investigating police agency during routine patrol of the interstate highway. The Porsche was found idling on the left shoulder of the highway engaged against the guardrail. The doors and windows were closed, with the radio on. Through the course of the law enforcement investigation, it was determined that a hazardous material condition arose that involved the Porsche's 12-volt battery located under the driver's seat, its electrical system, and the production of hydrogen sulfide gas. Elevated levels of thiosulfate were detected in the driver and the passenger at autopsy. Thiosulfate is the metabolized by-product of ingested hydrogen sulfide gas, which could have been produced during an overcharging of the vehicle's battery. It was determined that an improper battery was installed in the vehicle.

17. Key Words	18. Distribution Statement
2006 Porsche Cayenne, 12-volt battery, thiosulfate, overcharging	This document is available to the public from the DOT, BTS, National Transportation Library, Repository & Open Science Access Portal, rosap.ntl.bts.gov.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	22	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Table of Contents

Special Crash Investigations
On-Site Hazardous Materials Fatality Investigation
Office of Defects Investigation
Case Number: CR16026
Vehicle: 2006 Porsche Cayenne
Location: Florida
Incident Date: June 2016

Background

This report documents the on-site investigation of a 2006 Porsche Cayenne (Figure 1) and the deaths of its belted 46-year-old female driver and a belted 3-year-old female in a high-back booster child restraint system (CRS) in the second row. Both occupants were found deceased in the vehicle by the investigating police agency during routine patrol of the interstate highway. The Porsche was found idling on the left shoulder of the highway engaged against the guardrail. The doors and windows were closed, with the radio on. Through the course of the law enforcement investigation, it was determined that a hazardous material condition arose during the vehicle's operation that involved the Porsche's 12-volt battery located under the driver's seat, its electrical system, and the production of hydrogen sulfide gas. Elevated levels of thiosulfate were detected in the driver and the child at autopsy. Thiosulfate is the metabolized by-product of ingested hydrogen sulfide gas, which could have been produced during an overcharging of the vehicle's battery. It was determined that an improper battery was installed in the vehicle.

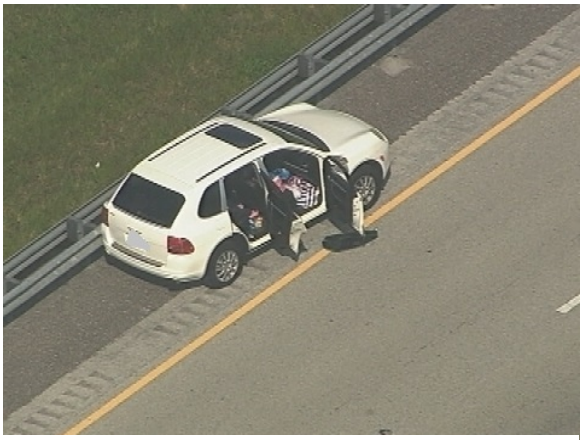


Figure 1. Aerial view of the Porsche at the incident scene (image obtained from an online news source)

Notification of the incident was provided to the National Highway Traffic Safety Administration by the medical examiner's office in August 2016. Further research was requested, and the notification was forwarded to the Crash Investigation Division (CID) where an on-site investigation was assigned to the Special Crash Investigation (SCI) team in September 2016. The SCI team initiated contact with the law enforcement agency and confirmed cooperation to inspect the vehicle on the day of assignment. The on-site portion of this investigation occurred in September 2016 and involved an inspection of the Porsche and its battery. As part of this

investigation, medical record data were obtained from the medical examiner, and investigative documents were obtained from the law enforcement agency. Porsche vehicles manufactured during this period were not equipped with event data recorders supported by the Bosch Crash Data Retrieval tool; therefore, crash data were not available. Even if the vehicle was equipped with an EDR, data may not have been recorded during the minor contact to the guardrail.

Summary

Incident Site

This incident occurred during the afternoon hours in June 2016 on an interstate highway in a rural area of Florida. The police-reported weather conditions at the incident site were clear and dry. The environmental conditions reported by the National Weather Service included a temperature of 31.1 ˚C (88 ˚F), 49 percent relative humidity, south-southeast winds at 11.1 km/h (6.9 mph), and clear skies.

The limited-access roadway was oriented primarily in the northwest/southeast direction and consisted of two lanes in each direction separated by a grass median. The roadway was straight and level. The southbound lanes were an estimated 3.7 m (12 ft) wide, separated by a broken white centerline and delineated by a solid white fog line on the right and a solid yellow fog line on the left. The left shoulder was an estimated 3.0 m (10 ft) in width and included a rumble strip. A W-beam guardrail system, consisting of I-beam posts with block outs and guardrail on each side of the posts, was located in the median immediately adjacent and parallel to the left edge of the paved shoulder. The posted speed limit was 113 km/h (70 mph).

Pre-Incident

The Porsche was driven by the 46-year-old female, and the 3-year-old female was seated in a high-back booster CRS in the second row right position. Both occupants were restrained by the vehicle's manual 3-point lap and shoulder seat belt systems. The driver was operating the vehicle with a wired earbud headphone in her left ear connected to a cell phone that was positioned on the seat cushion between her legs. The police investigation determined that the occupants were traveling on a 3.5-hour trip to a metropolitan area in the southern region of the State. Approximately 2 hours and 30 minutes prior to the discovery of this incident, the Porsche was photographed as it passed through a toll plaza. This toll plaza was located within a 30–35 minute drive of the location, where the Porsche was ultimately found on the road shoulder. The image showed the driver as the only occupant in the front row of the vehicle. During its southbound travel, a hazardous material situation developed in the Porsche that affected the occupants. Crash reconstruction indicated that the driver apparently released the accelerator and braked, thus allowing the vehicle to decelerate as the vehicle departed the left travel lane onto the shoulder.

Incident

As the vehicle came to a near-stop, the left wraparound aspect of the rear bumper fascia of the Porsche struck the guardrail. The contact between the compliant bumper fascia and the guardrail halted the Porsche's forward momentum and captured the idling vehicle. This guardrail contact did not play any role in the outcome of the incident. Over the course of about two hours, the Porsche continued to idle on the roadside. The driver and the child occupant lost consciousness and expired in their seats.

Post-Incident

During routine road patrol, two law enforcement officers from different departments were traveling southbound in their patrol vehicles when the lead vehicle observed the Porsche on the left shoulder of the highway. Both officers stopped their vehicles on the shoulder as the lead

vehicle officer conducted an inspection of the Porsche. As he approached the stopped vehicle and peered into the closed windows, he observed the driver unresponsive. This officer immediately shouted and motioned for the officers of the second patrol vehicle that there was something wrong with the driver. The Porsche was still idling, and it was observed that the vehicle's transmission was in "Drive," and that the driver's right foot was on the brake. The vehicle's doors were locked, and the windows were up. The air conditioner was turned on.

Due to the unresponsive condition of the driver and the locked status of the vehicle, the second officer proceeded to the right rear door with the intention of breaking the door glazing to gain entrance to the occupant compartment. At that point, the officer observed the child occupant in an unresponsive state in the second row right position. He proceeded to break the right front door glazing at the unoccupied position. As the glazing disintegrated, the second officer detected and was overcome by a strong chemical odor. Observing that the vehicle's transmission was still in "Drive," he reached over and placed the console-mounted shifter in "Park" and also unlocked the doors. The first officer opened the left front door. As both doors were opened, the chemical odor intensified. The officers experienced respiratory distress and eye irritation. A third officer opened the right rear door to check the status of the child passenger. Both occupants were determined to be deceased. Signs of lividity were observed in both the upper and lower extremities.

The fire department was called, and the scene was processed by hazardous material (HAZMAT) protocol. Once the odor had dispersed and the scene was declared safe, the incident was documented by the investigating law enforcement agency. Firefighting personnel used a multi-gas meter and measured that there was no indication of carbon monoxide gas in the vehicle. The identification and source of the fumes were unknown at the time. During the course of the on-scene investigation, a restart of the Porsche's engine was attempted. However, it was discovered that the battery had no voltage. It was determined that when the engine was operating, the electrical power must have been supplied solely by the vehicle's alternator.

The first arriving officers were placed in HAZMAT protocol at the scene. They removed their clothing and were decontaminated at the scene prior to transport to a regional medical center for evaluation and quarantine. The officers were released approximately 7 hours and 45 minutes after the initial discovery of the Porsche.

Due to the unknown circumstances of the incident, the Porsche was sealed and removed from the incident site by a flatbed tow truck with the deceased occupants inside. The vehicle and its occupants were taken to the medical examiner's office for removal and autopsy. During the removal of the bodies, a strong odor of sulfur (rotten eggs) was recognized. It was believed that the odor was possibly linked to the vehicle's battery. The police investigation later determined that the battery in the Porsche did not meet the manufacturer's specification for this vehicle. Further detail is discussed below in the SCI Battery Inspection section of the report.

The driver and the child were removed from the vehicle and taken for autopsy. Blood and urine samples were taken for toxicology. Elevated levels of thiosulfate were detected. Thiosulfate is the metabolized by-product of ingested hydrogen sulfide gas.

Hydrogen Sulfide

Hydrogen sulfide is a colorless gas that is very toxic and has the odor of rotten eggs. Although noticeable at first, the sense of smell deadens over time and victims may potentially be unaware of its presence. Research literature indicated that as a simple guideline, hydrogen sulfide becomes harmful to humans if the odor is detectable.

The overcharging of the vehicle's battery could have produced hydrogen sulfide. Overcharging could also boil and overflow the electrolyte (fluid) in the battery cells. Proper ventilation procedures should be adhered to when a battery is being charged.

Event Timeline

A timeline of the vehicle's movement on the day of the HAZMAT event and incident was reconstructed during the police investigation. All times and distances are referenced to the first known location of the Porsche.

Observation	Elapsed Time (Hours: Minutes)	Distance
Porsche observed at the toll booth entering the southbound interstate	00:00	0.0 km (0.0 miles)
Driver makes a cell phone call and leaves a voice mail regarding her trip	00:11	Unknown
A cell phone ping determines the location of the Porsche is in the vicinity of the incident site	00:35	20.4 km (12.7 miles)
Porsche idling on the roadside and approached by investigating officer	Approx. 02:35	20.4 km (12.7 miles)

The activities of the driver and the movement of the Porsche are not known prior to the time it was observed at the interstate toll booth. There was no noted distress, uneasiness, or concern in the voice mail message left by the driver. Over the next 24 minutes, the HAZMAT event developed. The driver may have lost consciousness, allowing the vehicle to drift to the left shoulder. Alternatively, she may have begun to feel the ill effects of the hydrogen sulfide fumes of the event and attempted to stop the vehicle. The vehicle came to rest on the left roadside against the guardrail, where the driver was ultimately overcome. The incapacitated driver and child succumbed to the fumes over the course of the next two hours.

2006 Porsche Cayenne

Description

The 2006 Porsche Cayenne (Figure 2), manufactured in June 2005, was identified by the Vehicle Identification Number WP1AA29P86Lxxxxxx. Its digital odometer reading was 228,691 km (142,106 miles). The all-wheel drive platform was configured on a 286 cm (112.6 in) wheelbase and was powered by a 3.2-liter V6 gasoline engine that was linked to a 6-speed automatic transmission. The service brakes were a power-assisted front/rear disc system with ABS. The gross vehicle weight rating was placarded at 2,945 kg (6,493 lb). Front and rear gross axle weight ratings were 1,385 kb (3,053 lb) and 1,650 kg (3,638 lb rear), respectively. The curb weight was 2,160 kg (4,763 lb). The manufacturer's recommended tire size was P235/65R17 at all four axle positions. At the time of the SCI inspection, the Porsche was equipped with four Continental Cross Contact tires of the recommended size.

The interior of the Porsche was configured with two rows for the seating of up to five occupants (2/3) with a rear cargo area. The front bucket seats featured leather upholstery, reclining seat backs, and adjustable head restraints. At the time of the SCI inspection, the driver seat had been removed during the police investigation and was loosely situated in the left front interior space. The second row seat was a split bench with forward folding seat backs with adjustable head restraints in all three positions. All head restraints were adjusted to the full-down position. Manual restraint systems consisted of 3-point lap and shoulder seat belts for all seat positions. Both seat rows were configured with retractor pretensioners. Supplemental restraint systems consisted of certified advanced 208-compliant (CAC) driver's and passenger's frontal air bags, front seat-mounted side impact air bags, and roof side rail-mounted inflatable curtain (IC) air bags.

Figure 2. Front left image of the Porsche Cayenne

Figure 3. Sideswipe damage to the left aspect of the rear bumper fascia

Exterior Damage

The exterior damage to the Porsche was limited to the wrap around aspect of the bumper fascia aft of the left rear axle (Figure 3). The damage consisted of a linear abrasion and minor displacement to the lower fascia below the body structure at the C–D pillar. The damage was

consistent with sideswiping contact to the guardrail. Dimensionally, the damage measured 48 cm (19.0 in) in length and began 33 cm (13.0 in) aft of the left rear axle. The elevation of the abrasion measured 74 cm (29.0 in) above the ground. This damage was cosmetic in nature and did not involve any structure of the vehicle. The collision deformation classification assigned to the damage pattern was 12LBLS2.

Interior Damage

Inspection of the interior was unremarkable for damage. The battery well was located in the occupant compartment under the driver seat. The driver seat had been removed by the police during their investigation.

At the inspection, loose change was found in the center console and in a cup. Some of the coins appeared oxidized and appeared to have reacted chemically with an undetermined agent. The cause of their altered appearance remains unknown.

Vehicle History

A vehicle history report indicated that the Porsche was purchased used by the driver in May 2016. The driver was the sixth owner of the vehicle. The odometer reading at the time of the driver's purchase was not reported. The last reported odometer reading of the Porsche was 227,252 km (141,208 miles) in March 2016 as the vehicle was listed for sale in a dealer inventory.

The only reported maintenance beyond routine oil and filter service were two separate checks of the electrical system. These services occurred in May 2006 at approximately 13,679 km (8,500 miles) and in April 2007 at approximately 30,256 km (18,800 miles). Both services were performed by a registered Porsche dealer. There was no reported documentation of service to the vehicle's battery.

The police investigation determined that the driver experienced periodic electrical problems after her purchase of the vehicle. Thirteen days after the purchase, the Porsche was reportedly towed back to the dealer for a failure to start. Notably, the dealer initially reported to the police that it was not towed there and that they had no record of servicing it. When pressed by the investigator, the dealer did recall it was towed in, but reported that it was serviced for a problem with the thermostat. A receipt found in the vehicle indicated that the driver had the Porsche jump-started by a mobile auto service 16 days after her purchase. Throughout this time period, the dealer reported that the driver had scheduled multiple appointments to bring the Porsche in for a check-up. However, she continually canceled and then rescheduled the appointments. This HAZMAT event occurred 19 days after the purchase of the vehicle.

NHTSA Recall and Investigations

At the onset of the SCI investigation, a query of NHTSA's recall database www.nhtsa.gov/recalls with the Porsche's Vehicle Identification Number revealed that there were no unrepaired recalls. A similar query at the time of this final report indicated that there were two unrepaired recalls for this particular vehicle. Neither recall pertained to the battery or electrical system of the vehicle. A fuel pump recall was opened on January 28, 2018, and a

transmission selector recall was opened on June 26, 2019; both were several years after the date of this incident.

Manual Restraint Systems

The 2006 Porsche was equipped with 3-point continuous loop seat belts for the five designated seat positions. All seat belt systems were configured with sliding latch plates. The front row lower anchorages were mounted to the outer aspect of the seat frames. The D-rings were adjustable with both set to the full-up positions. The driver's seat belt webbing retracted onto an emergency locking retractor (ELR) while the front row right and second row seat belts retracted onto switchable ELR/automatic locking retractors. All retractors were configured with pretensioners. Although the driver and the second row right child were belted, the minor severity crash did not result in occupant motion; therefore, there was no loading evidence to the seat belt systems. The minor severity sideswipe crash did not actuate the pretensioners.

Supplemental Restraint Systems

The Porsche was equipped with a CAC frontal air bag system that consisted of dual-stage driver's and passenger's frontal air bags, a front row right occupant classification sensor, seat belt retractor pretensioners, seat belt buckle switches, and seat track position sensors. It was also equipped with front-row, seat-mounted side impact air bags and roof side rail-mounted IC air bags. The minor severity sideswipe crash did not trigger deployment of the air bags or actuation of the pretensioners.

SCI Battery Inspection

The battery specified for the 2004-2006 Porsche Cayenne with the 3.2-liter V6 engine is a Group Number 94R, Model No. 450RC/950CCA, based on the Battery Council International's "Battery Replacement Book." The battery was located in a well below the floor under the driver seat (Figure 4), mounted longitudinally with the negative terminal positioned forward. A polymer cover concealed the battery tray; however, the cover contained a filter on the top surface. The overall dimensions of the well were approximately 45 cm long x 19 cm wide x 19 cm deep (17.8 in x 7.5 in x 7.5 in). The well vented to the atmosphere outside the vehicle by a single 6 mm (0.25 in) port at the forward aspect. The vent is shown by the arrow in the image below (Figure 5).

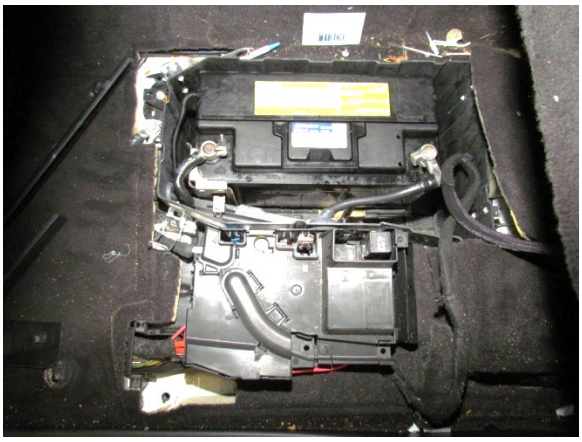


Figure 4. Battery positioned in the well under the driver's seat

The battery found in the vehicle at the time of this incident was an AC-Delco 60 Series Group 49 (Figure 6), Model No. 130RC/825CCA. It was in the possession of the medical examiner at the time of the SCI inspection. Its nominal dimensions were 36 cm long x 18 cm wide x 19 cm high (14 in x 7 in x 7.5 in). It fit in the battery well without alteration. Note that this battery was the wrong Group number. The correct Group number was 94R. The battery installed in this Porsche was specified for the 2003-2006 Porsche Cayenne equipped with the 4.5-liter V8 engine. This battery had two vents located on the ends of its top cap.

Swab samples of the top surface of the battery, battery well, and driver seat were taken during the SCI inspection. These samples were forwarded to NHTSA for analysis. The results of the swab tests are not known.

Figure 5. Overhead view of the battery well in the Porsche with the battery removed

Figure 6. Image of the AC-Delco 60 series Group 49 12-volt battery found in the Porsche

Police Inspection

The police inspection of the vehicle occurred six days after the event. The driver's seat was removed, and the battery compartment was opened. The report stated that the battery had "exploded." The top of the battery was wet, and it appeared to have overflowed. A pH test found the liquid to be acidic. Only one of the battery's vents was connected to the vent port in the battery compartment. This connection vented to the atmosphere beneath the vehicle. The second vent port on the battery vented to the battery well and, over time, to the occupant compartment of the Porsche.

A Porsche mechanic connected a diagnostic scan tool to the vehicle. The only code present indicated that there was a "Battery Issue."

Porsche/AC-Delco Inspection

The medical examiner contacted the vehicle's manufacturer regarding the circumstances of the event. A meeting between the medical examiner and the technical representatives of Porsche, AC-Delco, and a private consulting firm occurred in August 2016. Porsche submitted an inspection protocol to the medical examiner that involved inspecting the Porsche's battery, placing an exemplar battery in the vehicle, then starting and running the engine for up to three hours. This exemplar battery was a Group 49 battery (duplicate to the one removed from the Porsche), not the Group 94R battery that was specified for the vehicle.

Inspection of the AC-Delco battery removed from the Porsche determined that it weighed approximately 17.7 kg (39.08 lb) and had a measured reading of 1.8 volts. The exemplar battery supplied by the AC-Delco representative weighed approximately 20.8 kg (45.8 lb). The battery voltage was 11.8 volts prior to the starting of the vehicle and was 14.1 volts while the engine was running. There were no noted fault messages on the instrument cluster display.

After operating the vehicle for approximately 10 minutes, the Porsche and AC-Delco representatives and the consultant reported to the medical examiner that "they had a conflict" and had to terminate the inspection. They refused to explain any further and left the medical examiner without further comment.

2006 Porsche Cayenne Occupant

Driver Demographics

Age/sex:	46 years/female
Height:	Unknown
Weight:	Unknown
Eyewear:	None
Seat type:	Bucket seat with adjustable head restraint
Seat track position:	Unknown, seat was removed prior to SCI inspection
Manual restraint usage:	Restrained by the 3-point lap and shoulder seat belt
Usage source:	On-scene images
Air bags:	Frontal, seat-mounted side impact, and IC air bags available; none deployed
Alcohol/drug data:	Positive for benzodiazepines and diphenhydramine
Egress from vehicle:	Deceased; removed by medical examiner
Transport from scene:	Medical examiner to the medical examiner's office
Medical treatment:	None; fatal

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Elevated level of thiosulfate, 6.1	040099.9	Vehicle battery	Certain

Source: medical examiner report.

Driver Kinematics

The driver was seated in the power-adjustable driver's seat in an unknown track position with the seat back slightly reclined and the head restraint adjusted to the full-down position. The driver was restrained by the manual 3-point lap and shoulder seat belt system. On-scene images of the driver seated in the vehicle obtained from the medical examiner's office show that the seat belt webbing was positioned across her hips and her left anterior shoulder and chest. A wired earbud was placed in her left ear, connected to a cell phone.

The sequence of events that preceded her death did not cause displacement of the driver from her seat position or result in injury other than the inhalation injury attributed to the thiosulfate from the vehicle's battery. The impact with the median barrier guardrail produced an insignificant longitudinal force (12 o'clock) to the Porsche and did not displace the driver.

The exposure to the thiosulfate rendered her unconscious as she remained in her seat position with her right foot positioned on the brake pedal. The driver was found in her seat, with her head tilted back against the head restraint and her mouth open. Lividity was present in her extremities; therefore, death had occurred prior to the officers discovering the vehicle on the shoulder of the interstate. Toxicology determined elevated levels (6.1) of thiosulfate. Due to limited data on this chemical and its effects to humans, the medical examiner ultimately defaulted to an

undetermined cause of death in September 2016. The case was closed with no evidence of foul play.

Second Row Right Child Occupant Demographics

Age/sex:	3 years/female
Height:	Unknown
Weight:	Unknown
Eyewear:	None
Seat type:	Split-bench
Seat track position:	Non-adjustable
Manual restraint usage:	High-back booster child restraint system, restrained by the vehicle's 3-point lap and shoulder seat belt
Usage source:	On-scene images
Air bags:	IC air bag available; not deployed
Alcohol/drug data:	None
Egress from vehicle:	Deceased; removed by medical examiner
Transport from scene:	Medical examiner to medical examiner's office
Medical treatment:	None; fatal

Second Row Right Child Occupant Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Elevated level of thiosulfate, 1.1	040099.9	Vehicle's battery	Certain

Source: medical examiner report.

Second Row Right Child Occupant Kinematics

The child occupant was seated in a high-back belt positioning booster seat in the second row right position of the Porsche. The child was restrained by the vehicle's manual 3-point lap and shoulder seat belt, with the shoulder belt positioned across her chest and right shoulder.

The child was overcome by the toxic gas emitted from the vehicle's battery. The minor sideswipe impact sequence with the median barrier guardrail was longitudinal in nature (12 o'clock direction of force). It did not displace the child from her seated position in the CRS. The vehicle came to rest engaged against the guardrail.

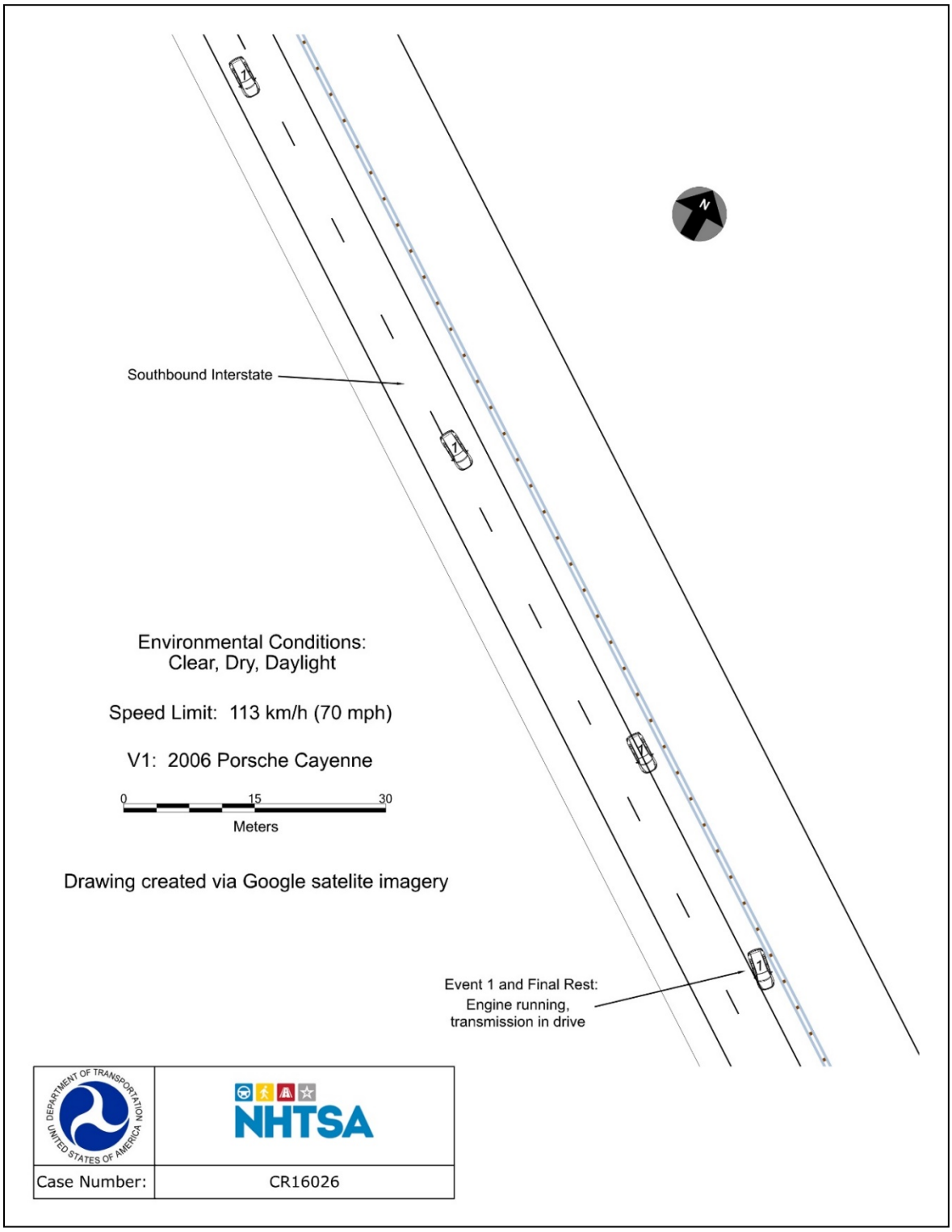
The first arriving officer on-scene observed the child occupant positioned in the CRS and restrained by the seat belt system and unresponsive. There was evidence of lividity in the extremities, and she was determined to be deceased. Due to the circumstances of this event and as a safety precaution to the first responders, the vehicle was sealed by a tarp at the scene and towed via a flatbed truck to the medical examiner's office with the bodies of both occupants remaining inside. Toxicology identified exposure to thiosulfate with a value of 1.1. Similar to the driver, the ME concluded the cause of death to be undetermined.

Determinations

Based on the SCI inspection, as well as the investigations of law enforcement and the medical examiner, it was determined that:

- The battery in the Porsche at the time of the event did not meet the manufacturer's specifications for a Porsche Cayenne equipped with the 3.2-liter V6 engine.
- The battery in the vehicle met the specifications for a Porsche Cayenne equipped with the 4.5-liter V8 engine.
- The installed battery had two vent ports. One port vented to the atmosphere beneath the vehicle. The second port vented directly to the battery well, and ultimately to the occupant compartment, due to the battery's location beneath the driver seat.
- The battery appeared to have an overcharging event which overflowed the electrolyte and produced hydrogen sulfide gas. Based on the occupants' outcome, the gas appeared to have infiltrated the occupant compartment.
- The disparity in the weight of the vehicle's battery and the exemplar battery indicated that the vehicle's battery may have boiled dry.
- The driver possibly recognized that she was in distress and attempted to stop the Porsche on the left shoulder prior to losing consciousness, thus precipitating contact with the guardrail. Alternatively, the driver may have released the accelerator and allowed the vehicle to coast and drift to the left without input due to her incapacitation, precipitating contact with the guardrail.
- Rendered unconscious, the driver and the second row occupant succumbed to the toxic hydrogen sulfide fumes while the Porsche idled on the roadside.

Incident Diagram



DOT HS 813 256
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U.S. Department
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**National Highway
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15484-010722-v2