# School Bus Run-Off-Road and Fire
# Oakland, Iowa
# December 12, 2017


## Highway Accident Report

NTSB/HAR-19/01
PB2019-100808

National
Transportation
Safety Board

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Notation 58678
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National
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Safety Board

490 L'Enfant Plaza SW
Washington, DC 20594

**National Transportation Safety Board. 2019. *School Bus Run-Off-Road and Fire, Oakland, Iowa, December 12, 2017*. Highway Accident Report NTSB/HAR-19/01. Washington, DC.**

**Abstract:** On the morning of December 12, 2017, a school bus operated by the Riverside Community School District backed into a ditch on a rural road outside Oakland, Iowa, after picking up its first passenger, a 16-year-old female student. While the driver tried to drive the bus out of the ditch, a fire began in the engine compartment and spread throughout the bus. The driver and passenger died in the fire. The National Transportation Safety Board (NTSB) investigation focused on school bus driver fitness for duty, school bus fire safety, and school bus emergency training. The NTSB made safety recommendations to the US Department of Transportation; the National Highway Traffic Safety Administration (NHTSA); 44 states (including Iowa), the District of Columbia, and the territory of Puerto Rico; the state of Iowa; the Riverside Community School District; three school transportation associations; and seven school bus manufacturers. The NTSB also reiterated one recommendation to NHTSA and reclassified a previously issued recommendation to the three school transportation associations.



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# Acronyms and Abbreviations

| | |
|---|---|
| ADT | average daily traffic |
| AFSS | automatic fire suppression system |
| AFV | alternative-fuel vehicle |
| BSRL | Bioaeronautical Sciences Research Laboratory |
| CDL | commercial driver's license |
| CDLIS | Commercial Driver's License Information System |
| CFR | *Code of Federal Regulations* |
| CMV | commercial motor vehicle |
| ECU | electronic control unit |
| FAA | Federal Aviation Administration |
| FMCSA | Federal Motor Carrier Safety Administration |
| FMCSRs | *Federal Motor Carrier Safety Regulations* |
| FMVSS | Federal Motor Vehicle Safety Standard |
| FRA | Federal Railroad Administration |
| GVWR | gross vehicle weight rating |
| HSPG 17 | Highway State Program Guide Number 17 [NHTSA] |
| I-5 | Interstate 5 |
| I-45 | Interstate 45 |
| IAC | Iowa Administrative Code |
| IDOE | Iowa Department of Education |
| IDOT-MVD | Iowa Department of Transportation Motor Vehicle Division |
| IOSME | Iowa Office of the State Medical Examiner |
| MAP-21 | Moving Ahead for Progress in the 21st Century Act |
| MCC | microscale combustion calorimeter |
| MPD | Mesquite Police Department |
| MSBCA | Maryland School Bus Contractors Association |
| NAPT | National Association for Pupil Transportation |
| NASDPTS | National Association of State Directors of Pupil Transportation Services |
| NCST | National Congress on School Transportation |

| | |
|---|---|
| NDR | National Driver Register |
| NFPA | National Fire Protection Association |
| NHTSA | National Highway Traffic Safety Administration |
| NIST | National Institute of Standards and Technology |
| NSTA | National School Transportation Association |
| NSTSPs | National School Transportation Specifications and Procedures |
| NTSB | National Transportation Safety Board |
| PPT | physical performance test |
| RCSD | Riverside Community School District |
| SwRI | Southwest Research Institute |
| V:H | vertical distance to horizonal distance |

# Executive Summary

## Investigation Synopsis

On December 12, 2017, just before 6:50 a.m. central standard time, a 2004 International 65-passenger school bus, operated by the Riverside Community School District, was traveling south on rural 480th Street outside Oakland, Iowa. The bus driver turned onto a residential driveway for the first student pickup on his route. After the 16-year-old female student boarded, the driver reversed out of the driveway, as was his normal practice for the location, backed across 480th Street, and continued reversing until the bus's rear wheels ran off the road and dropped into a 3-foot-deep ditch. While the driver tried to drive the bus out of the ditch, a fire began in the engine compartment and spread throughout the bus. The driver and passenger died in the fire.

## Probable Cause

The National Transportation Safety Board (NTSB) determines that the probable cause of the fatal school bus run-off-road and fire in Oakland, Iowa, was (1) the driver's failure to control the bus, backing it into a roadside ditch for reasons that could not be established; and (2) the failure of the Riverside Community School District to provide adequate oversight by allowing a driver to operate a school bus with a known physical impairment that limited his ability to perform emergency duties. The probable cause of the fire was ignition of a fuel source on the exterior of the engine's turbocharger due to turbocharger overload and heat production, resulting from the blockage of the exhaust pipe by the bus's position in the ditch and the driver's attempts to accelerate out of the ditch. Contributing to the severity of the fire was the spread of flames, heat, and toxic gases from the engine into the passenger compartment through an incomplete firewall.

## Safety Issues

The investigation focused on the following safety issues:

- School bus driver fitness for duty, including physical performance tests and driver oversight by the Riverside Community School District.
- School bus fire safety, including engine fire suppression, fire-resistant materials, and federal fire safety performance standards.
- School bus emergency training, including evacuation drills and equipment.

## Recommendations

As a result of its investigation, the NTSB makes safety recommendations to the US Department of Transportation; the National Highway Traffic Safety Administration (NHTSA); 44 states (including Iowa), the District of Columbia, and the territory of Puerto Rico; the state of Iowa; the Riverside Community School District; the National Association of State Directors of Pupil Transportation Services, the National Association for Pupil Transportation, and the National School Transportation Association; and school bus manufacturers Blue Bird Corporation, Collins Industries, Inc., IC Bus, Starcraft Bus, Thomas Built Buses, Inc., Trans Tech, and Van-Con, Inc. The report also reiterates one recommendation to NHTSA and reclassifies a previously issued recommendation to the three school transportation associations.

# 1 Factual Information

## 1.1 Run-Off-Road and Postcrash Fire Narrative

About 6:30 a.m. central standard time on December 12, 2017, a 2004 International 65-passenger school bus, operated by a 74-year-old driver for the Riverside Community School District (RCSD), left the district's bus maintenance facility and dispatch lot (known as the "bus barn") at Riverside Elementary School in Oakland, Iowa. The bus traveled south on 480th Street to its first student pickup at a residence in rural Pottawattamie County, 7 miles southeast of Oakland (figure 1).[1]


**Figure 1.** Aerial view of school bus run-off-road location, with inset map showing Oakland on map of Iowa. (Source: Digital Globe Vivid Image)

By about 6:50 a.m., the scheduled pickup time, the driver had turned right into the residence's driveway. As was his standard practice at the stop, after the student boarded the bus, the driver reversed out of the driveway so he could continue on 480th Street (a gravel road). At this location, the road is bordered on the east side by a 2.5-foot-wide earthen strip and then a 3-foot-deep drainage ditch. The driver reversed the bus out of the driveway and across 480th Street (figure 2). The bus's right rear wheels crossed the earthen strip and dropped into the ditch.

When the bus's right rear wheels fell into the ditch, they lost traction; the tailpipe and rear bumper lodged against the ditch embankment, stopping the vehicle's rearward motion. The driver attempted to drive the bus forward onto the road, and a fire ignited in the engine compartment. The

[1] The residence was in the 17000 block of 480th Street.

driver used the bus radio to call the RCSD bus maintenance facility. He reported that he was stuck in a ditch at his first pickup location and that there was a fire. The fire spread into and through the bus's passenger compartment, destroying the interior and much of the exterior (figure 3).


**Figure 2.** Aerial view showing direction school bus traveled on 480th Street, path into driveway entrance, and path in reverse to crash in roadside ditch (Source: Digital Globe Vivid Image)

**Figure 3.** Burned school bus (right side) at final rest in ditch next to 480th Street, looking south. (Source: Pottawattamie County Sheriff's Office)

The driver and 16-year-old passenger died in the fire. (See appendix A for information about the National Transportation Safety Board [NTSB] launch to the scene and parties to the investigation.) Interviews with the student passenger's family, first responders, and the RCSD supervisor yielded the sequence of events for the school bus fire shown in table 1.

**Table 1.** Event timeline.

| Time | Event |
|---|---|
| 6:50 a.m. | Driver arrives at first pickup location.[a] |
| 6:55 | Driver uses radio to contact RCSD bus maintenance lot to report he is stuck in a ditch at first pickup location and bus is on fire.[b] |
| ~6:55-6:59 | RCSD supervisor calls Riverside Elementary School secretary to ask her to telephone student's house. Secretary calls brother of student's father, another RCSD bus driver, and asks him to call student's parents and inquire if student has been picked up. |
| 6:59 | Student's mother receives call from brother-in-law about bus being on fire near house, immediately goes outside to check, then alerts brother-in-law that "bus is on fire."[c] |
| 7:02 | Pottawattamie County Communications Center receives 911 call from school secretary reporting bus fire. Communications center dispatches Carson Fire Department and nearest Pottawattamie County Sheriff's Office deputy. Macedonia Fire Department personnel receive text message about fire when Carson Fire Department is dispatched. |
| 7:05 | Student's mother telephones 911. |
| ~7:10 | RCSD transportation supervisor arrives on scene from Riverside Elementary School "shortly after 7." He finds bus "fully engulfed" in fire. |
| 7:15 | Nearest Pottawattamie County Sheriff's Office deputy arrives on scene (was 24 miles from scene when dispatched).<br>(See figure 4 for photograph of fire from sheriff's office body camera video.) |
| 7:23 | Macedonia Fire Department arrives on scene. |
| 7:30 | Carson Fire Department arrives on scene. |

[a] Passenger's mother reported daughter boarded bus about 6:50 a.m.

[b] (1) RCSD transportation supervisor estimated time of call as 6:55 a.m. because another driver was preparing to leave bus barn when call came in. (2) Several bus drivers heard driver report fire over radio. One driver said accident driver sounded calm. Two drivers said they did not hear student passenger when driver reported he was in a ditch and could not get out.

[c] Brother-in-law told NTSB investigators his phone showed he called residence at 6:59 a.m.

**Figure 4.** Burning school bus (right side) in still photograph captured from body camera video. (Source: Pottawattamie County Sheriff's Office)

When interviewed by investigators from the Iowa Office of the State Medical Examiner (IOSME), the student's mother said that when she went outside and saw the bus on fire, she also observed fire in the grass in the ditch behind the bus. The driver was leaning out the driver-side window and yelled to her to get something to break the windows. According to the IOSME report, the mother told the driver to "throw [her daughter] out of the driver's side window," but he did not. She telephoned 911 and called out to her other daughter (who was inside the house) for help.

The mother and daughter retrieved a hammer, and the daughter tried to break the window directly behind the driver's window. She broke a hole in the window, which caused "thick, black smoke to come out," she told the IOSME investigators. She then attempted to break the front window on the driver's side but could not. She asked the driver where her sister was (in the bus), and the driver said he could not find her. She tried to help the driver but could not reach high enough to pull him out the window. She said that when she approached the bus, she did not see a fire in the ditch and could not see her sister. She said that she saw "fire sporadic throughout the bus and fast moving and the windows were blown out," according to the IOSME report.

The first county sheriff's deputy to arrive stated that the school bus was fully engulfed in fire when he arrived on scene (refer to figure 4). The deputy applied the fire extinguisher issued by the sheriff's department to the back of the bus, but it had no effect on the fire. He then tried to enter the school bus through the rear emergency exit door, but the flames and fire temperature stopped him. Members of the first fire department unit to arrive reported that when they approached the scene, the bus was on fire from front to rear. They immediately began fire suppression and extinguished the fire. The postcrash fire destroyed much of the school bus (figure 5).

**Figure 5.** Burned school bus (left rear) at final rest in ditch. (Source: Pottawattamie County Sheriff's Office)

## 1.2 Injuries

The bus driver and the student passenger died in the fire (table 2). Autopsy reports from the IOSME reported the cause of death for both as smoke and soot inhalation, with thermal injuries. Blood samples from the driver and the passenger were tested by NMS Labs. The driver's results showed carboxyhemoglobin at 6 percent saturation and cyanide at 0.79 micrograms per milliliter.[2] The passenger's test showed carboxyhemoglobin at 47 percent saturation and cyanide at 3.2 micrograms per milliliter.[3]

IOSME investigators documented the postfire positions of the driver and the passenger. The driver was found in the driver's seat. The passenger was found on the floor next to the driver's seat.

[2] Carbon monoxide is a product of combustion, and carboxyhemoglobin occurs when carbon monoxide binds to hemoglobin. Carboxyhemoglobin restricts the amount of oxygen carried by the blood to the tissues of the body, resulting in asphyxiation. Cyanide is a toxic byproduct of burning plastics. Carboxyhemoglobin blood levels are generally considered normal up to 3.5 percent in nonsmokers and up to 8 percent in smokers. A sample of the driver's blood was also sent to the Federal Aviation Administration (FAA) Bioaeronautical Sciences Research Laboratory (BSRL) for evaluation; toxicological testing found negative results for carboxyhemoglobin in femoral blood (the BSRL has a detection cutoff level of 10 percent).

[3] According to IOSME interviews, the student passenger did not have any medical issues or history that her family was aware of.

**Table 2.** Classification of injuries to occupants of school bus.

| Occupant | Fatal | Serious | Minor | None | Total |
|---|---|---|---|---|---|
| Driver | 1 | 0 | 0 | 0 | 1 |
| Student passenger | 1 | 0 | 0 | 0 | 1 |
| **Total** | 2 | 0 | 0 | 0 | 2 |

NOTE: Although Title 49 *Code of Federal Regulations* (CFR) Part 830 pertains only to the reporting of aircraft accidents and incidents to the NTSB, section 830.2 defines fatal injury as any injury that results in death within 30 days of the accident, and serious injury as any injury that (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date of injury; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burn affecting more than 5 percent of the body surface.

## 1.3 School Bus Driver Information

### 1.3.1 License, Employment, Training, and Driving History

The 74-year-old school bus driver held an Iowa class A commercial driver's license (CDL), issued in December 2012, with an expiration date of January 2018. The license carried endorsements for passenger (P), school bus (S), tank (N), and double/triple trailer (T), with a restriction for corrective lenses.[4] According to records from the Iowa Department of Transportation Motor Vehicle Division (IDOT-MVD), the driver was issued a persons with disabilities parking placard in September 2015.[5]

The driver was hired by the RCSD in 1999 and began driving the district's school buses in 2000.[6] He had a 5-day work week, Monday through Friday, with morning and afternoon shifts each lasting 2.25 hours, for a total of 4.5 work hours daily. His shift included pre- and post-trip

[4] An Iowa commercial class A driver's license permits the holder to operate, in commerce, a vehicle with a gross vehicle weight rating (GVWR) of 26,001 pounds or more. GVWR is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo. A passenger endorsement permits the holder to operate a vehicle designed to seat 10 or more people, including the driver.

[5] The IDOT-MVD did not have the driver's original application for the placard. The driver's medical records indicate that the placard was issued due to a spinal condition (see below). In 2015, when the driver was issued his placard under Iowa Code 321L.2, the state issued nonexpiring placards to persons with a lifelong (permanent) disability. According to the Iowa Code (accessed June 26, 2019), "person with a disability" means a person with a disability that limits or impairs his or her ability to walk: "A person shall be considered a person with a disability . . . under the following circumstances: the person cannot walk two hundred feet without stopping to rest; the person cannot walk without the use of, or assistance from, a brace, cane, crutch, another person, prosthetic device, wheelchair, or other assistive device; the person is restricted by lung disease to such an extent that the person's forced expiratory volume for one second, when measured by spirometry, is less than one liter, or the arterial oxygen tension is less than sixty mm/hg [milligrams of mercury] on room air at rest; the person uses portable oxygen; the person has a cardiac condition to the extent that the person's functional limitations are classified in severity as class III or class IV according to standards set by the American Heart Association; the person is severely limited in the person's ability to walk due to an arthritic, neurological, or orthopedic condition."

[6] He had worked for 30 years driving tractor-trailers for a gravel company in California before moving to Iowa.

duties and the 1-hour 45-minute bus route. In the 7 days before the crash, the driver drove his morning and afternoon routes on December 6, 7, 8, and 11. The crash occurred at the start of his morning route on Tuesday, December 12.

Iowa requires school bus drivers to be at least 18 years old and to pass a criminal background check as well as a preemployment drug test.[7] The Iowa Department of Education (IDOE) provides training for school bus drivers, both the required 17-hour training for newly hired drivers and the 3-hour annual in-service training for current drivers.[8] It also issues a school bus driver handbook. The driver received his annual in-service training, with content supplied by the IDOE, for the 2016–2017 school year. Included in the training was a section called "Good Information—How to Use a Fire Extinguisher"; a video presentation titled "Tail Swing Safety for School Bus Drivers"; and a section titled "Post Accident Procedures for School Bus Drivers."

The databases of the IDOT-MVD and the Commercial Driver's License Information System (CDLIS) showed that the driver had three convictions for traffic infractions (in 2013, 2014, and 2016) and a fourth for a no-injury (property-damage-only) accident in September 2017 (table 3).[9] None of the traffic infractions or the property-damage accident took place in a commercial motor vehicle (CMV). A search of the National Driver Register (NDR) problem driver pointer system did not find a listing for the bus driver.[10]

**Table 3.** School bus driver's violation history.

| Date | State | Convictions or Citations |
|---|---|---|
| September 5, 2017 | Iowa | No-injury accident |
| September 5, 2017 | Iowa | Fail to yield half of roadway |
| August 30, 2016 | Iowa | Speed (10 mph and under) in a 35–55 mph zone |
| July 7, 2014 | Iowa | Fail to obey traffic sign/signal |
| January 3, 2013 | Nebraska | Following too close |

[7] See Iowa Code 321.375. For an interstate driver, the minimum age is 21. Preemployment drug-testing is required by 49 CFR 382.301.

[8] The 17-hour *New Driver STOP Training* includes 14 hours online and 3 hours of face-to-face training.

[9] CDLIS is a nationwide computer database that enables state driver licensing agencies to ensure that each commercial driver has only one driver's license and one complete driver record. State driver licensing agencies use CDLIS to transmit out-of-state convictions and withdrawals, transfer the driver record when a CDL holder moves to another state, and respond to requests for driver status and history. The driver reported to police in his September 2017 crash that he looked down at something and when he returned his attention to the roadway, he had crossed the centerline and then struck another vehicle. The crash resulted in a citation for failure to yield half of roadway.

[10] The NDR is maintained by the National Highway Traffic Safety Administration (NHTSA), which compiles information from state licensing authorities to ensure that individual driver licensing information is complete and accessible. All 51 US jurisdictions submit information to the NDR for drivers whose licenses have been revoked, suspended, canceled, or denied, or who have been convicted of serious traffic-related offenses.

The passenger's mother reported to IOSME investigators that her daughter had expressed concern about the driver and had gone to the school principal on three occasions because the driver "backed into things and ran stop signs."[11] The mother reported that her husband had asked the driver not to turn the bus around in their driveway but instead to back out of the driveway.

The high school principal told investigators that the student passenger had complained to him in August 2017 about the bus driver having twice failed to stop at stop signs. He referred her complaint orally to the RCSD superintendent's office. No documentation related to the complaints was found with the RCSD. Also in August 2017, the bus driver reversed over a support cable on a power pole near a residential driveway while picking up two students, resulting in the power lines being torn from the house. The homeowner notified the RCSD by email, and the RCSD reimbursed the homeowner for the property damage.

### 1.3.2 Medical Information

**1.3.2.1 Certification.** The driver's medical examiner's certificate was issued in March 2017, had an expiration date of March 2019, and listed no restrictions. In the self-reporting health history section on the medical certification form, the driver indicated "yes" to a history of surgery for "back, lower" and "eyes, cataract." The report documented no abnormalities in any of the driver's body systems, and the driver "denied use of current medications" (see appendix B for the driver's medical examination history).[12] At the time of the crash, the driver's prescribed medications included the following:

- Simvastatin (to lower cholesterol and triglycerides in the blood).
- Pantoprazole (to treat excess stomach acid).
- Gabapentin (to treat nerve pain).
- Bupropion (to treat major depressive disorder and seasonal affective disorder).[13]

**1.3.2.2 Physician Records.** Records from the driver's healthcare providers document that he had more than a 10-year history of prescription medications for chronic, ongoing conditions.[14] Records from the driver's spine specialist dating from April 2014 to November 14, 2017, document a history of lumbar region progressive disc degeneration, spinal stenosis, progressive lumbar pain with radiation down the legs, and stable right lower leg weakness. The driver had a

[11] Interviews with family members and acquaintances revealed that the passenger, known to be good friends with the driver, normally sat close to him, near the front of the bus, and that the two would usually chat during the first half of the trip.

[12] His most recent medical examination to determine commercial driver fitness was conducted by a chiropractor.

[13] The driver had been using both gabapentin and bupropion for many years. Gabapentin is an antiepileptic drug used to treat nerve pain. It may cause somnolence and other psychoactive symptoms. Bupropion in an antidepressant that may also cause other neuropsychiatric symptoms. The driver was not reported to have any of the potential side effects. He had intermittently reported use of the medications during his CDL examinations and had been certified.

[14] The driver was diagnosed with high blood pressure and type 2 (noninsulin-dependent) diabetes, both controlled by diet. He had been prescribed glucose (blood sugar) testing strips.

successful lower-back spinal fusion (lumbar vertebrae L3 to L5) in January 2017 but had since developed recurrent debilitating pain radiating down both legs.

In the November 2017 visit to his spine specialist, the driver reported that he could walk if he used a cane or crutches, that he experienced pain that prevented his sitting for more than 30 minutes (or standing for more than 10 minutes), and that he was sleeping less than 4 hours a night. The physician noted that the driver exhibited stable mild right dorsiflexor weakness, with strength otherwise full and symmetric; used a four-wheeled walker for ambulation; had pain when moving from sitting to standing; and walked with about a 15-degree forward stoop.[15] Surgical intervention was recommended because physical therapy was ineffective and the driver was having difficulty ambulating and performing the activities of daily living. The driver was scheduled to have spinal surgery (to fuse lumbar vertebrae L2 and L3) on December 14 (2 days after the crash and fire).

The driver's wife told NTSB investigators that beginning in August or September 2017, he had again experienced back pain that caused him to have "a hard time getting comfortable in bed," that he had discomfort when standing, and that he could lose his balance when he was standing or walking.[16] Although he moved slowly, his wife stated that she did not believe his condition would have prevented him from evacuating the school bus in an emergency. The driver's wife reported no other health concerns for him. When interviewed by IOSME investigators on December 12, she reported that the driver's back hurt, but that he felt fine otherwise and that his back pain that day (the day of the crash) was not atypical. She said that he would occasionally fall while walking because he would lose his balance when he compensated for his back pain by bearing more weight on one leg than on the other.

**1.3.2.4 Postcrash Toxicology.** The FAA-BSRL results for the driver's blood were negative for the tested illicit drugs, positive for dextromethorphan, dextrorphan, and gabapentin, and inconclusive for bupropion.[17] Toxicological screening of the driver's urine was negative for ethanol (alcohol) and positive for acetaminophen, bupropion, dextromethorphan, dextrorphan, and gabapentin.[18]

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[15] Imaging studies showed degenerative changes in his lumbar region (discs L2–L3), as well as progressive kyphotic deformity and stenosis in the area, with progression over the previous 10 months. Kyphosis is a curving of the spine that causes a bowing or rounding of the back (see "Kypnosis," MedlinePlus; accessed June 26, 2019).

[16] She also reported that his physician had told him that he needed the surgery on December 14 because the site of his previous surgery "had slipped and was pinched."

[17] The BSRL screened for amphetamines, barbiturates, cannabinoids, methadone, opiates, phencyclidine, and over 1,300 compounds, including toxins as well as prescription and over-the-counter medications. Information about the compounds can be found on the FAA's drug information website (accessed June 26, 2019). Dextromethorphan is used as a cough suppressant in many over-the-counter cold and cough medicines. (See "DailyMed" website of National Institute of Health, US National Library of Medicine, Bethesda, Maryland; accessed June 26, 2019.) Dextrorphan is a metabolite of dextromethorphan.

[18] Acetaminophen is a mild analgesic used to treat fever and mild to moderate pain. According to the driver's wife, because of his upcoming back surgery, he had been taking over-the-counter Tylenol for pain but had not been taking prescription pain medication since December 7.

### 1.3.3 Precrash Activities

On the basis of interviews with the driver's wife and his RCSD supervisor and coworkers, combined with RCSD route information, minutes from a city council meeting, and video from a traffic camera, NTSB investigators developed a timeline of activities for the driver in the days and hours before the crash (table 4). The driver's wife stated that the driver typically woke between 4:30 and 5:00 a.m. on Monday through Friday and slept until 8:00 or 9:00 a.m. on Saturday and Sunday. She said that on the two nights before the crash (Sunday night, December 10, and Monday night, December 11), the driver had a 7.5-hour opportunity for sleep. She stated that he typically fell asleep easily, slept well (despite his back pain), and would typically awake "a couple of times" during the night to relieve himself.

**Table 4.** School bus driver's activities, December 9–12, 2017.

| Time | Driver Activity | Source |
|---|---|---|
| **Saturday, December 9, 2017** | | |
| 8:00–9:00 a.m. | Awakens | Interview |
| 10:00 a.m. | Attends sports event at local high school | |
| 3:00 p.m. | Departs sports event and drives home | |
| 10:00–11:00 p.m. | Goes to bed | |
| **Sunday, December 10, 2017** | | |
| 8:00–9:00 a.m. | Awakens, then attends church service | Interview |
| 11:30 a.m. | Departs for Lincoln, Nebraska, with grandson | |
| 3:00–4:00 p.m. | Departs Lincoln, Nebraska, for home in Carson, Iowa | |
| 9:00–10:00 p.m. | Goes to bed | |
| **Monday, December 11, 2017** | | |
| 4:30–5:00 a.m. | Awakens | Interview |
| ~6:15 a.m. | Departs house for bus barn | |
| 9:00 a.m. | Returns home after morning route | |
| 10:00–11:00 a.m. | Attends Bible study with his wife, returns home | |
| 2:45 p.m. | Departs house for bus barn | |
| ~5:00 p.m. | Returns home after afternoon route | |
| 7:30–8:04 p.m. | Attends city council meeting | Interview, meeting minutes |
| ~8:30–9:00 p.m. | Returns home, goes to bed | |
| **Tuesday, December 12, 2017** | | |
| 4:30–5:00 a.m. | Awakens | Interview |
| ~6:15–6:20 a.m. | Departs house for bus barn | |
| 6:30 a.m. | Departs bus barn to begin route | Bus schedule |
| 6:36 a.m. | Image of bus captured by traffic camera | Traffic camera |
| 6:50 a.m. | Arrives on time at first route pickup | Bus schedule, interviews |
| **After 6:52 a.m.** | **Run-off-road crash and fire** | |

The driver's wife told investigators that he took his cell phone with him on his school runs. She stated that he did not use it while driving; she further stated that she believed the school district had a policy against such use. Records from the driver's cellular service provider showed no voice (phone call) activity at or near the time of the crash. The records did, however, show outgoing text messaging activity near the time of the crash.[19] The records of the activity were unusual in that they did not show a receiving phone number. The service provider researched the activity and determined that it was not standard text messaging. Ultimately, the provider could not determine the exact nature of the activity but suggested that the driver might have been using a third-party application. The cell phone was destroyed in the postcrash fire and could not be examined.

The RCSD transportation supervisor told investigators that he had driven the afternoon bus route with the driver on December 11 (the day before the crash). He said that he wanted to see the pickup and dropoff locations because of the driver's scheduled back surgery, "just in case I had to jump in to help drive his route while he was gone." He stated that the driver used a cane when walking or getting on and off the school bus, but that he had not observed the driver using a walker. Two RCSD bus drivers and the Riverside High School principal reported seeing the driver using a walker (one said it was in September 2017). One bus driver told investigators, "Several of us had the conversation several times . . . the exact words were, 'How could he ever evacuate a bus?' Well now we know. He couldn't." The high school principal told investigators that he did not understand why the student could not get off the bus, but that he understood why the driver did not evacuate the bus: "We're talking mobility."

## 1.4 Motor Carrier Operations

### 1.4.1 Riverside Community School District

As an intrastate motor carrier, the RCSD operates seven school bus routes and employs eight full-time and five part-time school bus drivers.[20] The school district serves the cities of Oakland, Carson, and Macedonia.[21] It has six staff employees at the district level and a total of 125 employees at the schools. The bus maintenance facility and dispatch storage lot is behind the Riverside Elementary School building in Oakland.

### 1.4.2 State of Iowa Requirements

The IDOE has oversight of school districts' handling of school bus driver CDL records and qualification files, certification, training, and drug-testing.[22] The IDOE School Bus Driver

[19] Four outgoing messages were recorded: one at 6:50 a.m., one at 6:53 a.m., and two at 6:59 a.m. The records do not contain the message content.

[20] Iowa public institutions must meet state accreditation standards. RCSD operations are overseen by the Riverside School District Board of Education, made up of elected citizens who serve 4-year terms. Iowa Code 285.8 sets out school district responsibilities for school buses, routes, and bus drivers.

[21] In 2017, about 650 students were enrolled in the district's elementary, middle, and junior/senior high schools. The elementary and junior/senior high school buildings are in Oakland; the middle school is in Carson.

[22] Iowa Code 256.11 establishes state educational standards. Guidance for school districts in meeting state accreditation standards is found at Iowa Administrative Code (IAC) 281, chapter 12.

Authorization System tracks CDLs, medical certificates, and training to ensure that drivers are qualified to drive a school bus in the state.

The Iowa Administrative Code specifies physical fitness requirements for school bus drivers, as follows:[23]

> The applicant must submit annually to the applicant's employer the signed medical examiner's certificate (pursuant to 49 CFR sections 391.41 to 391.49), indicating, among other requirements, sufficient physical capacity to operate the bus effectively and to render assistance to the passengers in case of illness or injury, and freedom from any communicable disease.
>
> At the discretion of the chief administrator or designee of the employer or prospective employer, the chief administrator or designee shall evaluate the applicant's ability in operating a school bus, including all safety equipment, in providing assistance to passengers in evacuation of the school bus, and in performing other duties required of a school bus driver.

The RCSD school board has a policy, *Employee Physical Examination—Board Policy 403.1*, that requires bus drivers to present evidence of good health on being hired and every other year thereafter in the form of a physical examination report. The policy also states,

> Employees whose physical or mental health, in the judgment of the administration, may be in doubt must submit to additional examinations to the extent job-related and consistent with business necessity, when requested to do so.

Formerly, the RCSD required drivers to complete a physical performance test (PPT) consisting of the following:

- Climb and descend bus steps three times in 30 seconds.
- Alternately activate brake and throttle ten times in 10 seconds.
- Manually open and close bus door three consecutive times.
- While the vehicle is in motion, operate two hand controls on both sides of the steering wheel while maintaining vehicle control, within 8 seconds of the request.
- Starting in the driver's seat and wearing the seat belt, exit bus from rear emergency exit within 20 seconds.

The accident driver passed the PPT in August 2009 and May 2010. The RCSD stopped administering the PPT in 2011, when it hired a new transportation director.

### 1.4.3 Emergency Evacuation Drills

According to the Iowa *School Bus Drivers Handbook*, under "Reasons for Emergency Evacuation of a School Bus,"

[23] The standards are found at IAC 281–43.15.

> If any portion of a school bus is on fire, it should be stopped and evacuated immediately. Passengers should move to a point 100 feet or more from the bus and remain there until the bus driver has determined that no danger remains. If a school bus is unable to move and is close to an existing fire or highly combustible materials, the "danger of fire" should be assumed and all passengers evacuated.

The IDOE and RCSD require twice-yearly training in safe riding practices for students who are transported in school vehicles; they also have the students participate in emergency evacuation drills.[24] The IDOE does not require the school district to record the drills or report them to the department. Postcrash, RCSD bus drivers reported that they run the drills at the start and end of the school year for elementary and middle school students. The RCSD did not provide documentation of such training. High school students, according to the school principal, do not receive evacuation training.

The National School Transportation Specifications and Procedures (NSTSPs), published every 5 years by the National Congress on School Transportation (NCST), recommend actions that local school district administrations should take to promote safety in school transportation.[25] According to the most recent (2015) edition of the NSTSPs, school districts should ensure that "instruction in passenger safety, including student participation in emergency evacuation drills, is an integral part of the school and/or Head Start curriculum." The NSTSPs also recommend that school bus drivers instruct students in evacuation drills and that the instruction should include, but not be limited to, the following:

> At least once each school semester, provide all students transported to and from schools or Head Start Centers in a school bus or multifunction school activity bus with instruction in the location and operation of all emergency exits, provide supervised emergency exit drills to each student transported to or from schools or Head Start Centers in a school bus or multifunction school activity bus and provide all students with an age-appropriate safe travel curriculum consistent with the modes of travel available for each age group/grade level.

NHTSA's *Highway Safety Program Guideline Number 17* (HSPG 17) establishes recommendations for a state highway safety program "to minimize, to the greatest extent possible the danger of death or injury to school children while they are traveling to and from school and school-related events."[26] HSPG 17 also states,

> At least once during each school semester, each pupil transported from home to school in a school bus should be instructed in safe riding practices, proper loading and unloading techniques, proper street crossing to and from school bus stops and should participate in supervised emergency evacuation drills, which are timed.

[24] See IAC 281–43.40.

[25] The NCST is made up of official representatives of state departments of education, public safety, motor vehicles, and police or other state agencies having statewide responsibilities for the administration of student transportation; local school district personnel; contract operators; advisors from industry; and representatives of other interested professional organizations and groups.

[26] Title 23 *United States Code*, section 402, requires the Secretary of Transportation to promulgate uniform guidelines for state highway safety programs (a NHTSA website gives the guidelines; accessed June 26, 2019).

Prior to each departure, each pupil transported on an activity or field trip in a school bus or school-chartered bus should be instructed in safe riding practices and on the location and operation of emergency exits.

### 1.4.4 Federal Motor Carrier Safety Administration Requirements

As part of its mission of reducing crashes, fatalities, and injuries involving large trucks and buses, including school buses, the Federal Motor Carrier Safety Administration (FMCSA) monitors motor carriers (school districts included) to ensure that they have adequate safety management controls in place to comply with the *Federal Motor Carrier Safety Regulations* (FMCSRs).

As an intrastate motor carrier involved in transporting school children from home to school (and from school to home), the RCSD is subject to some, though not most, of the requirements of the FMCSRs.[27] The FMCSRs applicable to intrastate school bus operations are the CDL requirements for drivers operating CMVs (as defined at 49 CFR 385.5) and the required controlled-substance and alcohol testing of all CDL holders.[28] The FMCSA sets minimum CDL standards, including a knowledge and skills test. The state of Iowa issues CDLs to drivers in the state and according to the FMCSA, "is responsible for assessing the qualifications and validity of each of their drivers."[29] The RCSD has in place a drug-testing program, in which the school bus driver was enrolled. According to the driver's qualification file, he had undergone 13 random drug tests during his employment, with the last test in 2015. All test results were negative.

[27] The RCSD is subject to 49 CFR Parts 382 and 383 but not to all of 49 CFR Parts 300 to 399. Exceptions to the regulations also include school bus operations as defined at 49 CFR 390.5 (use of a school bus to transport only school children or school personnel from home to school and from school to home), except for the provisions of 49 CFR 391.15(e) and (f), 392.80, and 392.82. The provisions of sections 391.15, 392.80, and 392.82 refer to texting and use of a hand-held device while driving a CMV.

[28] Under 49 CFR Part 382, employers of drivers who operate CMVs requiring CDLs must ensure that the drivers undergo the following: (1) preemployment drug testing, (2) random drug and alcohol testing, (3) postaccident drug and alcohol testing, and (4) reasonable suspicion drug and alcohol testing. The FMCSRs specify requirements for return-to-duty and followup drug and alcohol testing.

[29] In addition, all CDL applicants and drivers are required to undergo medical certification examinations (by a medical examiner registered with the FMCSA) in accordance with the FMCSRs. See the FMCSA website on overview of state CDL responsibilities (accessed June 26, 2019).

## 1.5 Vehicle

### 1.5.1 General

The 65-passenger school bus, a 2004 International IC Bus model 3S530, had a GVWR of 29,800 pounds.[30] The bus was equipped with an electronically controlled Navistar diesel engine and an Allison five-speed automatic transmission.[31] It was also equipped with Navistar hydraulically operated antilock disc brakes. In addition, the bus was fitted with a Radio Engineering Industries REI-RV4001 version 2.0 camera system consisting of two interior-facing cameras (one in the rear, facing forward, and one in the driver area, facing the back), a recording system, and a hard drive.

### 1.5.2 Damage

The Pottawattamie County Sheriff's Office removed the interior cameras, recording system, and hard drive from the bus on December 12, after the fire. On December 18, the NTSB sent the recording system and hard drive to a third-party recovery company for further analysis. Because of extreme heat damage, no video files could be recovered.

All interior combustible materials (seat coverings and cushion padding, bus body liners) were destroyed by the fire. Postfire, investigators found a fire extinguisher in its storage compartment above the windshield, behind the rearview mirror; the extinguisher had not been used. All exterior nonmetallic components were consumed, including the windshield, side windows, rear window, glazing in the loading door, and fiberglass hood over the engine compartment.[32] Behind the driver area and the loading door, sections of body paint were thermally damaged and discolored, mostly above the windowsill and from the tires to the roof line. The structural supports for the roof had failed due to fire and heat damage, and the roof was buckled and deformed. The fire destroyed most of the metal window frames.[33] It also affected all major

[30] Three manufacturer safety recalls were found for the school bus, dated 2004, 2005, and 2009. The third recall (G-09501) was issued in June 2009. The recall was for a defect in the blower motors of certain heater units in entrance door stepwells or mounted on the rear wall. The recall stated that the blower could fail in low-speed operation, causing elevated temperatures that could ignite nearby combustible materials. The bus was repaired on December 11, 2009, at Cornhusker International Trucks in Omaha, Nebraska. Postfire inspection of the stepwell heater unit on the bus revealed no evidence of failure or internal combustion.

[31] (a) None of the engine compartment fluids used on the bus was classified as a flammable liquid (flashpoint less than 100°F). (b) The school bus was a 3000-series model with a DT466 engine. An electronic control unit (ECU) controlled engine timing and fuel injection. It was also capable of recording vehicle speed, engine speed, and other parameters during a triggered event. The ECU was damaged by the fire and partially dislodged from its engine mounting.

[32] For more details regarding fire damage, see the public docket for this investigation (https://dms.ntsb.gov/pubdms) and search for NTSB accident HWY18MH003.

[33] Near the rear of the bus, the latch mechanisms and frames of several exit windows were intact, though distorted by the heat.

mechanical systems, preventing documentation of the driver controls and electrical systems and a functional check of the hydraulic braking system.[34]

The fuel tank cap was in place, and no damage to the fuel tank was noted.[35] Because of the extent of the fire, all tires were destroyed except those on the left steer axle (front axle). The destruction of the tires caused the bus to lower onto the roadway near the front loading door (before being damaged by the fire, the inflated tires would have elevated the loading door above the roadway). No other obstructions to the front door were found; the driver had used the door to load the passenger just minutes before the crash. Only the steel wires from the bead and body plies remained on the other tires, and no reliable tread depth measurements were possible.[36] NTSB investigators visually examined the tire rims and found no defects that were not related to the crash. Damage to the front and right side of the bus is shown in figure 6.

**Figure 6.** Fire damage to bus's front and right side, including loading door, windows, roof, and engine (photographed after bus was removed to garage).

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[34] No evidence of electrical arcing was found on any wiring. The adjustable/tilting steering wheel was found to be offset at an approximate 20-degree angle to the right and melted down to the 17-inch-diameter steel hoop core. NTSB investigators found no precrash defects in the components of the steering system. The steel frame of the driver's seat was securely mounted in place and did not appear deformed. No damage was found to the two batteries in the battery box, located on the exterior of the bus below the fuse compartment. Both rear disc brake rotors were in good condition and within thickness specifications, and no cracks or warping was found. The master cylinder of the hydraulic braking system was detached from its mounting brackets. The foot treadle was in place but hanging freely from its attachment pin.

[35] About 6 inches of fuel remained in the bottom of the tank when it was inspected.

[36] (a) *Body plies* are the layers of rubber-coated cords that form the structural foundation of a tire; they provide the strength to contain tire pressure and carry a load. The tire *bead*, usually strands of wire, secures the tire to the wheel. (b) Maintenance records indicate that tires were replaced in 2009 (rear tires) and 2015 (front tires). Tire and weight rating placards that should have been mounted on the school bus were destroyed by the fire.

In the engine compartment, rubber hoses, belts, and plastic parts (such as fluid reservoirs) were missing, as was the air cleaner; many aluminum parts had sustained fire damage and melted. The alternator casing had melted and material was missing, exposing the motor and brushes. The master cylinder was detached from the firewall, and attachment points showed signs that the material had softened as a result of heat exposure and then resolidified. The transmission was in the drive position.[37] The turbocharger, on the right side of the engine compartment, was thermally discolored and exhibited no soot deposits.[38] A turbocharger (figure 7) is usually mounted near the engine and is powered by a turbine driven by the engine's exhaust gas (which causes turbochargers to become very hot). Typical intake gas temperatures for turbochargers range between 1000°F and 1200°F; temperatures can increase when the engine is under an increased load.

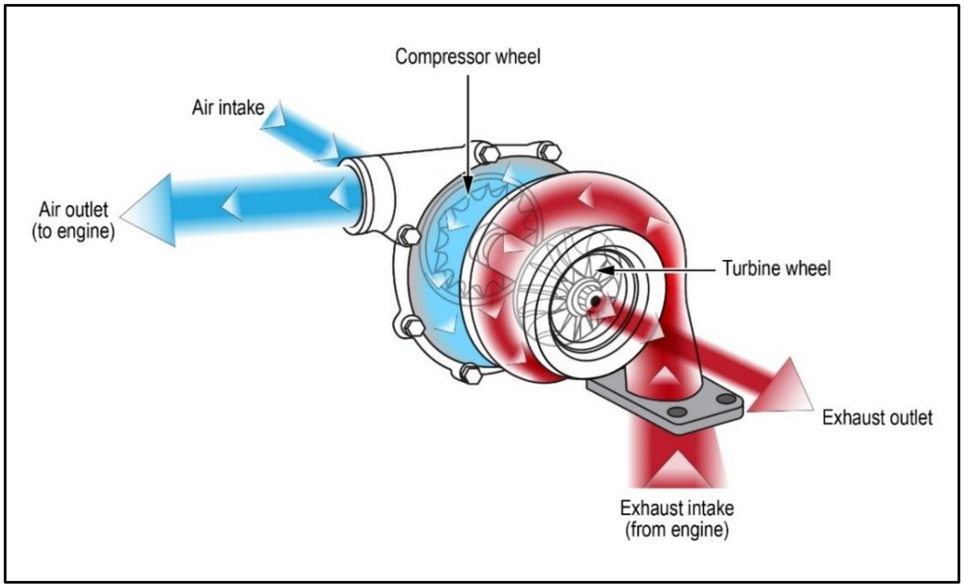


**Figure 7.** Diagram of generic diesel engine turbocharger.

The rear of the school bus's turbocharger (hot side) had small areas of reddish-brown oxidation over the entire surface. The exhaust duct exhibited similar signatures. The front end (cold side) was intact but covered with white oxidation. The intake duct was missing and found among debris on the ground after the bus was towed from the scene. The duct displayed thermal damage similar to that on the turbocharger and exhaust duct. Intake and exhaust sections examined by video borescope showed similar levels of soot, with no evidence of detonation or other signs of internal ignition. A low burn pattern was found in the area of the turbocharger.[39] The lowest point

[37] Because of fire damage, the gear shift selector was no longer mounted to the dash, although it was intact. Fire damage to the faceplate on the gear selector obscured the markings, but measurements of the shift levels on the faceplate, when compared with the levels on an exemplar bus, indicated a transmission position of D (drive).

[38] A turbocharger is a turbine-driven forced induction device that increases an internal combustion engine's efficiency and power output by forcing extra compressed air into the combustion chamber. The additional air allows the engine to burn more fuel, which creates more energy. Turbochargers are often used with diesel internal combustion engines. After the fire, the Oakland bus's turbocharger was disconnected from the exhaust system and shipped to NTSB headquarters for analysis.

[39] A fire (burn) pattern is the visible or measurable physical changes or identifiable shapes formed by a fire effect or group of fire effects. A low burn pattern is a fire pattern located at low points in a compartment.

of the pattern began at the frame and traveled midline up to the roof. The firewall in the area was relatively free of soot. The steel on the top half of the firewall was blued to the midline, and metal warpage (buckling) was present toward the top. Small areas of reddish/yellow oxidation were found, similar to the damage on the exterior of the turbocharger.

The engine block extended beyond the firewall into the driver area of the bus interior. The area was covered with a fiberglass cowling that was heavily damaged by the fire. Glass fibers were present, but a large amount of resin had burned out of the fiberglass. A hole was found on the upper right corner of the cowling. The engine block and components below the turbocharger and engine control board (forward from the firewall toward the front bumper) were intact and relatively undamaged. The blue paint on the lower part of the engine block was intact; the oil filter was also intact.[40] Between the engine block and the interior driver's area were several firewall penetrations for components such as wiring (figure 8). Components in the openings to the right of the vehicle's midline were destroyed by the fire. Electrical wiring was still present in the openings to the left of the midline, but the material used to seal the wiring inside the openings was missing and had most likely been destroyed by the fire.[41]

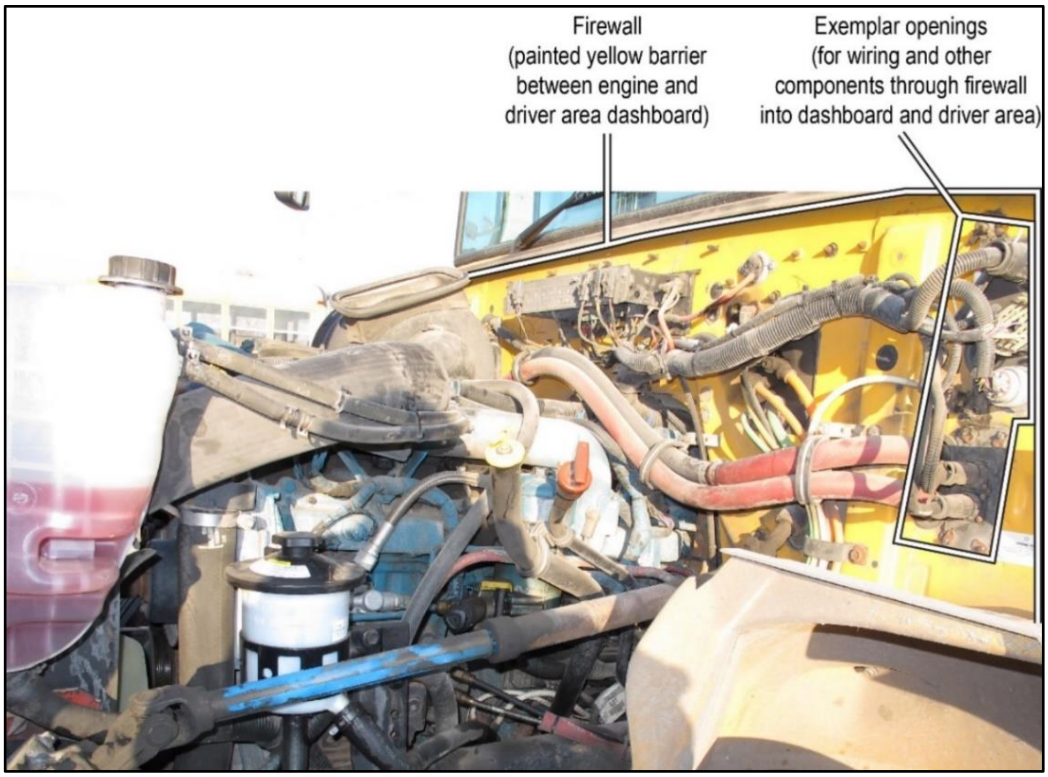


**Figure 8.** Engine compartment of exemplar bus showing firewall and openings into driver's area.

[40] For more information, see the Materials Fire Group Chairman Report in the public docket for this investigation (https://dms.ntsb.gov/pubdms); search for NTSB accident HWY18MH003.

[41] Iowa minimum school bus specifications (IAC 281–44.3[47], plus the NSTSPs) require that "all openings in the floorboard or firewall between the chassis and the passenger compartment (e.g., for gearshift selector and parking brake lever) shall be sealed."

The rear emergency exit door did not show any damage from contact with the ditch or the embankment, and the door was found to be operational after the fire. From the rear left corner of the bus to the right rear tires and below the windows, the bus's body paint showed little thermal damage. Contact damage from the ditch embankment to the right rear bumper area was documented, and the obstructed exhaust tailpipe was photographed at the scene (see figure 9 and section 1.5.3, below).[42]

**Figure 9.** Right rear bumper of bus embedded in drainage ditch embankment.

The right side of the bus's rear bumper was slightly deformed rearward and had pulled through the rivets that secured it to the bus body. The rear of the exhaust pipe was displaced upward (about 3 inches), as was the rearmost exhaust pipe support hanger (about 2 inches). The exhaust pipe had a split about 4 inches long and between 1/16 and 1/8 inch wide.

### 1.5.3 On-Scene Evidence

Dirt, earthen debris, and grass were embedded in the rear bumper and lodged between the bumper and the bus body. Debris was found in the tailpipe. A triangular depression in the backslope of the ditch contained unburned dry vegetation. The location of the depression was consistent with the position of the lower right corner of the bus's bumper. A streak of soot about 22 inches long and 5 inches wide was photographed next to the depression (figure 10). Debris samples from the tailpipe and the ditch embankment exhibited similarities and were consistent with the presence of soil and carbon soot in the fire debris.[43]

[42] The steer axle (axle 1) suspension consisted of two double-leaf spring packs mounted to the steer axle and shock absorbers. The drive axle (axle 2) suspension consisted of two 13-leaf spring packs and shock absorbers mounted to the solid drive axle. No damage was noted to the suspension in the area of axle 2.

[43] For more information, see the Materials Fire Group Chairman Report in the public docket for this investigation (https://dms.ntsb.gov/pubdms); search for NTSB accident HWY18MH003.

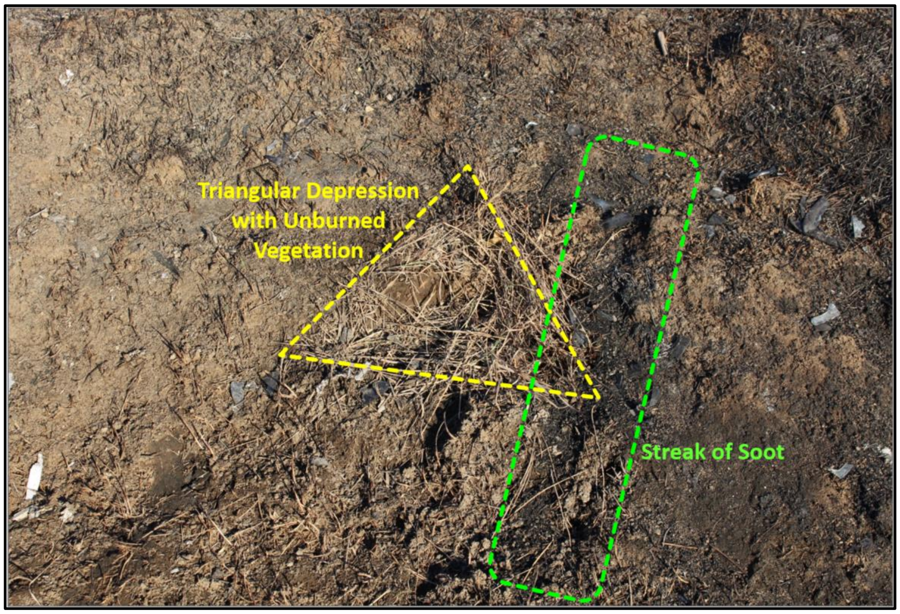


**Figure 10.** Streak consistent with soot deposit on drainage ditch backslope next to depression containing unburned vegetation.

Two distinct depressions, consistent with impressions from the bus's right rear tires, were found in the soil near the bottom of the ditch foreslope. When investigators removed the fire debris, tire imprints in the depressions were exposed (figure 11). One imprint measured about 24 inches long, 9 inches wide, and 2 inches deep and was consistent with being formed by the right rear inner tire. The imprint formed by the right rear outer tire was about 27 inches long, 9 inches wide, and 2 inches deep. Large portions of partially burned and melted tire treads were found lining the bottoms of the depressions.

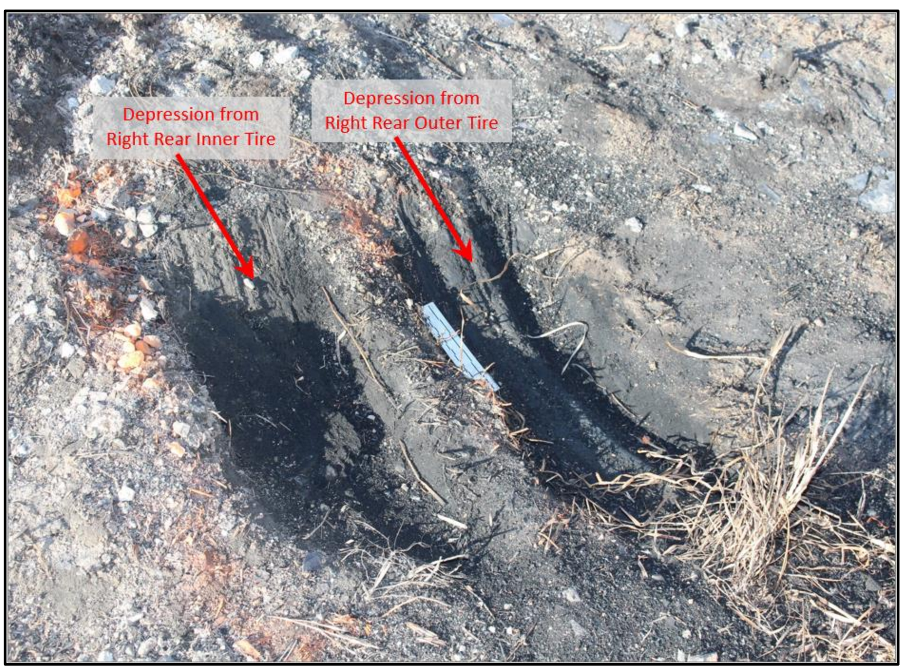


**Figure 11.** Soil depressions from rear tires on foreslope near ditch bottom.

### 1.5.4 Maintenance and Inspection

An IDOE inspection of the school bus on December 6, 2017, resulted in three out-of-service violations and six 30-day repair violations.[44] According to IDOE regulations, out-of-service violations must be repaired before a bus can be used again. The out-of-service violations were as follows:

- Right front red signal nonfunctional.
- Battery hold-down loose.
- Rear exit vandal lock warning signal not audible at driver location.[45]

The 30-day repair violations were as follows:

- Roof vent hatch warning signal malfunction—no warning signal in front.
- No registration slip available on bus.
- Inoperable emergency exit warning signal at driver location (right).
- Inoperable emergency exit warning signal at driver location (left).
- Expired chassis inspection card.
- Missing clamp on exhaust system tailpipe.

According to RCSD maintenance records and a state inspection summary, all three out-of-service violations were repaired on the day of the inspection. The postfire examination showed that the missing clamp on the exhaust pipe (a 30-day repair violation) had not been replaced. Because of the fire damage, investigators could not determine whether the other 30-day violations had been repaired.

### 1.5.5 Configuration

The interior of the school bus had 11 rows of bench seats on each side. A fire extinguisher was stored in a compartment above the windshield, behind the rearview mirror. The bus had a driver window and 11 windows on each side of the passenger area, 4 of which (2 on each side) were designated as emergency exits.[46] The bus also had a rear emergency door and two roof hatches above the aisle (figure 12).[47]

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[44] IDOE regulations give a school district 30 days to repair 30-day violations. During that time, a bus with 30-day violations can be used to transport students.

[45] The signal warns the driver if the emergency door is locked while the bus is in operation. The postfire IDOE inspection confirmed that the exit vandal lock had been remedied to an acceptable state before the fire (by removing the locking mechanism), which had also remedied a seventh 30-day violation noted in the report (but not listed above) as "emergency exit warning signal inoperable at driver location."

[46] The lower sash of the emergency windows was about 6 feet above the ground outside.

[47] The aisle measured 18 inches wide between the seat benches, and the roof hatches were 6 feet above the floor. The emergency windows (windows 4 and 8 on both sides of the bus) were 24 inches wide and 21 inches high. The rearmost seat bench on the left was a two-person seat that allowed additional aisle clearance for accessing the rear emergency door.

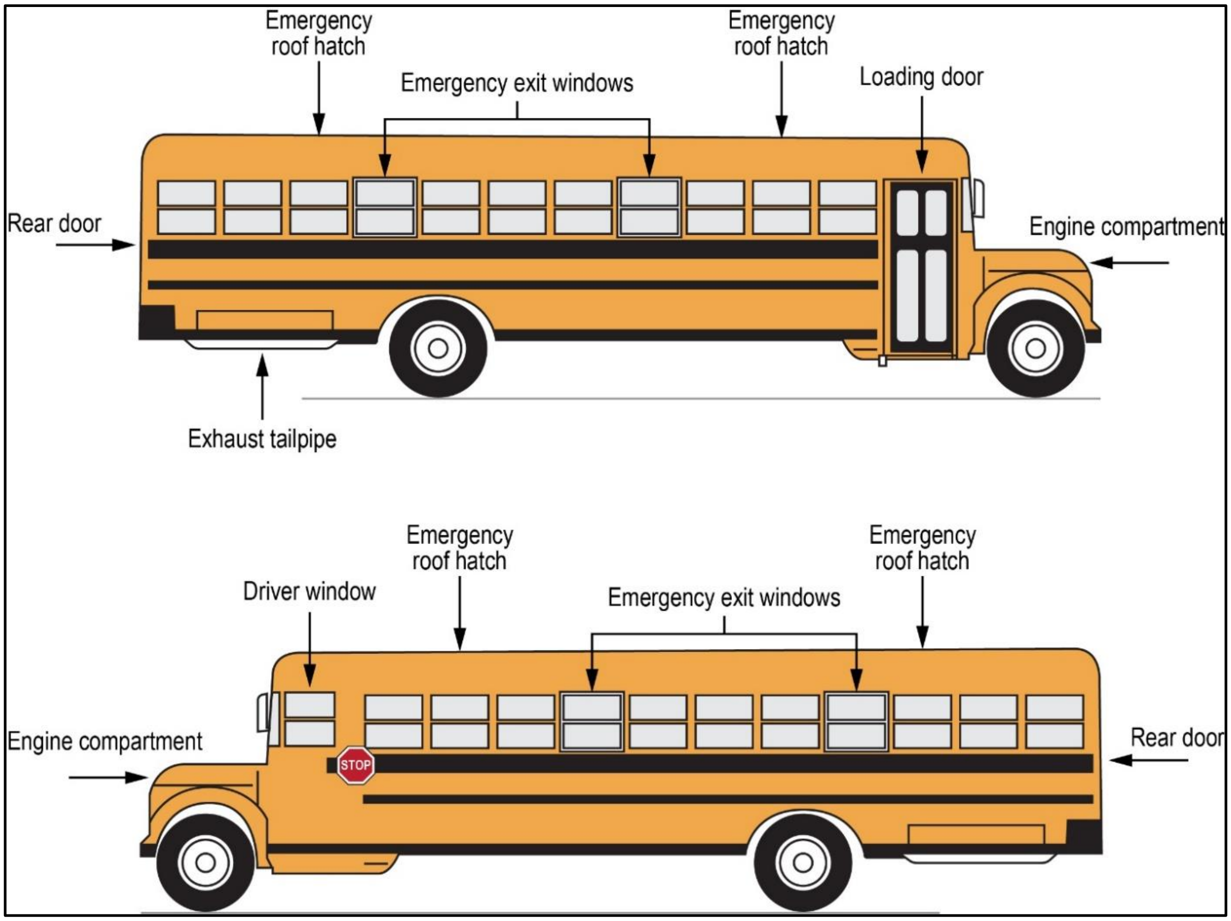


**Figure 12.** Drawing of generic school bus showing details of both sides.

The bus was equipped with a radio that communicated with the RCSD bus maintenance and dispatch lot. In an emergency, the radio could communicate directly with the local emergency dispatch center (in the Oakland area, that was the Pottawattamie County Communications Center). The radio's emergency 911 button, when pushed by the driver, would send an alert to the communications center. The driver could then speak hands-free with a police dispatcher.

On the right front side of the bus was a manual-release loading door. In a school bus equipped with a manual-release front loading door, a seated driver can open or close the door by operating a control arm handle that acts on a lever arm to exert force against the door (figure 13). To open the door, the driver would go through the following steps:

- Lift up on the spring-loaded control latch of the door handle.
- Grasp the handle of the door control arm.
- Lift up on the sliding collar attached to the handle.
- Pull the handle to release it from its locking point.
- Push the handle toward the door to open it.

**Figure 13.** Manually operated loading door at front of exemplar bus, showing hand-operated lever and connecting rod to door.

To close the door, the driver would pull up on the collar, pull the handle of the door control arm toward him- or herself, and then push the handle into the spring-loaded control latch. That would catch the handle and secure the door in the closed position (a locking feature to prevent the door from releasing while the bus was in motion).

The NSTSPs published by the NCST recommend the following specifications for manually operated loading doors on school buses:

> The entrance door shall be under the driver's control, designed to afford easy release and to provide a positive latching device on manual operating doors to prevent accidental opening. When a hand lever is used, no part shall come together that will shear or crush fingers. Manual door controls shall not require more than 25 pounds of force to operate at any point throughout the range of operation, as tested on a 10% grade, both uphill and downhill.

## 1.6 Highway Factors

The run-off-road crash and fire occurred on 480th Street, 7.1 miles east-southeast of downtown Oakland.[48] Classified as a rural minor collector road, 480th Street is a two-lane gravel road with a 12-foot-wide northbound lane and a 13.5-foot-wide southbound lane.[49] A 2.5-foot-wide

[48] A north and a south driveway on the west side of 480th Street gave access to the student passenger's residence.

[49] Lane widths on the unmarked gravel surface of 480th Street were determined by measuring from the crown of the road (the highpoint of the cross section) to either edge of the gravel, which was about 25.5 feet wide. The Pottawattamie County Secondary Roads system consists of about 1,100 unpaved roadways out of the county's total 1,500 roadway miles.

shoulder flanks the east side of the road, next to a 3-foot-deep drainage ditch parallel to the outer edge of the shoulder (figure 14). No roadside lighting is installed on 480th Street near the crash site. The speed limit is 55 mph.

**Figure 14.** Gravel surface of 480th Street at crash location (looking south), with embankment on left and driveway on right.

Where the driveway to the student's residence intersects it, 480th Street has a 4.2-percent upgrade slope northbound. As the bus driver backed out of the driveway, the bus first crossed an upslope of 6.6 percent, then an 8.7-percent cross slope (over 13.5 feet) on the 480th Street southbound lane before encountering the northbound lane's downward slope (figure 15). The cross slope of the northbound lane and shoulder is 4.5 percent downward for 14.5 feet to the edge of the drainage ditch. A 1:2.7 foreslope runs 7.5 feet into the ditch.[50]

[50] Construction and design plans related to the roadway's original construction in 1877 are no longer available. County standards for new construction of a roadway similar to 480th Street would require a 20-foot-wide roadway with 2-foot shoulders and any drainage ditch to have a 1V:3H entrance (or foreslope). Roadway slopes, ditches, and the slopes of other structures or features alongside the roadway are typically described as a ratio of vertical distance (V) to horizontal distance (H), or V:H. Therefore, a ditch described as 1V:3H would rise or drop 1 unit of measure (feet, inches, meters) for each 3 of the same unit of measurement horizontally. Drainage ditches are typically 3 feet lower than the near edge of the roadway but can vary due to erosion, aggregation, and drainage needs. For a roadway that averages fewer than 400 vehicles daily, ditch bottoms can be as narrow as 0 feet, when the ditch forms a V-shape.

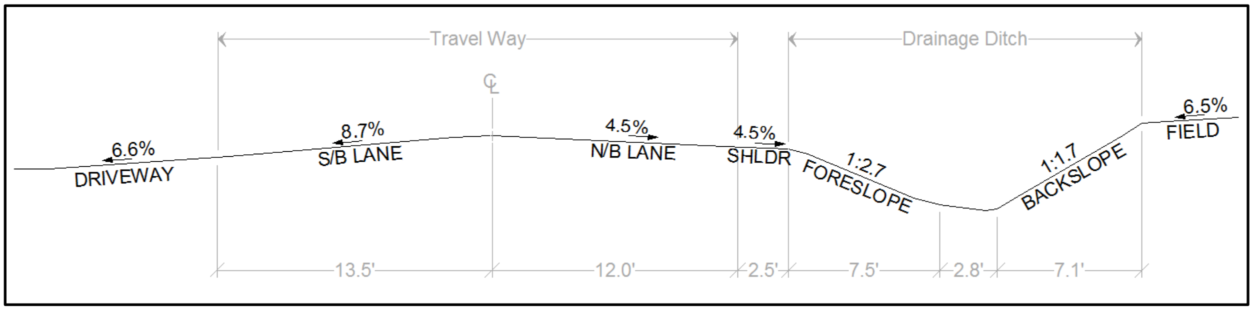


**Figure 15.** Cross section of curvature and alignment of 480th Street at crash site. (Based on Pottawattamie County Secondary Roads Department survey data)

Pottawattamie County records show the 2016 (most recent) average daily traffic (ADT) count for this part of 480th Street was 10 vehicles.[51] From 2007 through the first half of 2017, a total of four nonfatal crashes—one nonincapacitating injury, one possible injury, and two noninjury (property-damage) crashes—occurred within a 1.5-mile radius of the crash site (none on 480th Street).

## 1.7 Weather

Between 6:35 and 6:55 a.m. on the day of the crash, weather station KAIO (Atlantic Municipal Airport) in Atlantic, Iowa (about 21 miles from the crash site), reported a temperature of 14°F, clear conditions, winds from the northwest at 5 to 7 mph, and visibility unrestricted at 10 miles.[52] Astronomical data from the US Naval Observatory showed civil twilight on December 12 beginning at 7:07 a.m., with sunrise at 7:38 a.m.[53] The run-off-road crash occurred about 6:52 a.m. At the time and location of the event, the sun was at an azimuth of 113.4 degrees east of true north and at an altitude of 8.5 degrees below the horizon. The roadway gravel, the dirt shoulder, and the roadside ditch were dry.

## 1.8 School Bus Fire Protection

### 1.8.1 Federal Interior Flammability Standards and Specifications

All school buses in the United States are required to meet Federal Motor Vehicle Safety Standard (FMVSS) 302 (flammability of interior materials), established by NHTSA. FMVSS 302, adopted in 1971, specifies maximum burn rate requirements for materials used in the occupant

[51] The Iowa Department of Transportation provides Pottawattamie County with ADT figures every 4 years, either counted or calculated. The ADTs in 2012 and 2008 were 25; in 2004, the ADT was 15.

[52] Data obtained in 2018 from Weather Underground website; the site no longer shows historical data from Atlantic Municipal Airport (accessed June 26, 2019).

[53] See the US Naval Observatory data services webpage (accessed April 23, 2019). *Civil twilight* is defined to begin in the morning and to end in the evening when the center of the sun is 6 degrees below the horizon. That is the limit at which twilight illumination is sufficient, under good weather conditions, for terrestrial objects to be clearly distinguished.

compartments of motor vehicles.[54] Since its adoption, FMVSS 302 has remained essentially the same, even though other transportation industry standards, such as for rail and aircraft, have evolved over time with the use of more modern material flammability techniques (Hennessey 2017). The Oakland school bus would have been required to be equipped with seats meeting FMVSS 302 when it was manufactured in 2004.[55] NHTSA reported in January 2017 that it was undertaking a research effort to develop improved flammability tests for FMVSS 302 to make it a more robust, objective standard, including a potential test method specific to school buses. The final report was expected in June 2018 (Hennessey 2017). NHTSA has not yet published its findings.

### 1.8.2 State School Bus Interior Flammability Standards and Specifications

In 1990, the NCST adopted a large-scale test procedure for measuring flammability resistance, with performance levels for the NSTSPs exceeding those required by FMVSS 302. As of January 2019, most states had adopted the section of the body and chassis specifications of the NSTSPs called the School Bus Seat Upholstery Fire Block Test (appendix C). According to NHTSA, states are not precluded from adopting flammability resistance requirements that impose a higher performance requirement than the federal standard for vehicles procured for a state's own use.[56]

### 1.8.3 Fire Suppression Systems

The 2004 Oakland school bus was not equipped with an automatic fire suppression system (AFSS). Typically, such systems deliver a fire suppressant inside a vehicle's engine compartment when a fire sensor is activated. An AFSS uses either thermal sensors to detect heat or optical sensors to detect flame on specific ignition points or flammable agents on or near the engine block. Following detection, the system alerts the driver and automatically releases a water mist or chemical (powder) suppressant. The systems can be installed during or just after new manufacture or retrofitted into buses already in service. No national standards exist for the installation or performance of an AFSS. However, specifications have been defined for testing an AFSS, as well as voluntary performance certification, both in the United States (US Department

[54] The standard (49 CFR 571.302; accessed June 26, 2019) specifies a horizontal burn rate of not more than 102 millimeters per minute within 13 millimeters of the passenger compartment air space.

[55] Starting in 2006, in addition to meeting FMVSS 302, all school buses in Iowa are also required to be equipped with passenger seats that meet the NSTSP specifications governing passenger seating materials on school buses (appendix C).

[56] *Federal Register* 68, no. 142 (July 24, 2003): 43899 (accessed June 26, 2019).

of Transportation, American Public Transportation Association, UL) and internationally (European Union regulations, P-mark certification by industry).[57]

Several states allow for installing an AFSS in school buses as optional equipment.[58] Some states require an AFSS on alternative-fuel vehicles (AFVs), while other states require an AFSS on wheelchair-lift school buses or buses that transport special-needs students.[59] Most of those states have adopted the following NSTSP specifications for an AFSS installed in a school bus (NCST 2015, 45 and 123):

- The chassis manufacturer may provide an automatic fire extinguisher system in the engine compartment.
- Fire suppression system nozzles shall be located in the engine compartment, under the bus, in the electrical panel or under the dash, but they shall not be located in the passenger compartment. The system must include a lamp or buzzer to alert the driver that the system has been activated.
- Natural gas-powered buses may be equipped with an interior/exterior detection system. All natural gas-powered buses may be equipped with an automatic or manual fire detection and suppression system.

The NSTSPs define a fire suppression system as a fire extinguisher system that is installed in the engine compartment of a vehicle and activates automatically (in response to a fire sensor) or manually (in response to an alarm).

### 1.8.4 Fire Demonstrations

On April 16, 2018, the Stafford County (Virginia) Public Schools and the Stafford County Fire and Rescue Department held a school bus fire demonstration as a training exercise. The fire

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[57] UL (formerly Underwriters Laboratories) publishes a test specification (UL 1384; accessed June 26, 2019) for water-based automatic extinguisher units. The American Public Transportation Association publishes recommended practices for "Transit Bus Fire Safety Shutdown" and "Installation of Transit Vehicle Fire Protection Systems." In the European Union, the Economic Commission for Europe of the United Nations publishes regulation No. 107 concerning the general construction of vehicles carrying passengers (buses). The Swedish Fire Protection Association has developed guidelines for fixed fire suppression systems on buses (standard SBF 128) that include protocols for full-scale tests of extinguishing ability as well as other requirements, such as resistance to temperature extremes. The P-mark is a certification mark from SP Technical Research Institute of Sweden. It certifies that a product meets relevant standards and regulations and that the manufacturer or importer operates an approved inspection and quality-control program. Special certification rules regarding fire suppression systems in the engine compartments of buses and coaches are set forth in certification rule SPCR 183.

[58] The following states identify an AFSS as optional equipment in their state minimum school bus specifications: Alabama, Delaware, Indiana, Minnesota, Missouri, Nebraska, Nevada, New Hampshire, New Mexico, Ohio, Oklahoma, Oregon, Tennessee, Virginia, and Washington. The following states have adopted the NSTSPs and do not publish separate bus specifications, which means that an AFSS is optional school bus-approved equipment, as specified in the NSTSPs: Alaska, Kentucky, Louisiana, Maine, South Dakota, and Utah.

[59] The NSTSPs define an AFV as "a vehicle designed to operate on an energy source other than petroleum-based gasoline or diesel fuel." Such fuels include, but are not limited to, compressed natural gas, liquefied natural gas, liquefied petroleum gas or propane, and electricity. For AFVs, the following states either require an AFSS or allow an AFSS as optional equipment for AFV buses: Georgia, Idaho, Iowa, Mississippi, Montana, Nebraska, and Wyoming.

department placed a hay bale in front of a school bus and ignited it; the bus was fully engulfed in flames within 3 minutes.[60] That demonstration led to another on October 27, 2018, in Kansas City, Kansas, in which the National Association for Pupil Transportation (NAPT) partnered with the Lee Summit Fire Department to show the time it takes for flames to engulf a school bus and demonstrate realistic evacuation scenarios.

A bale of hay was set on fire inside the open front door of one bus, and by the 3-minute mark, the bus was filled with smoke, and temperatures had reached 900°F to 1,000°F (figure 16). Simultaneously, volunteers seated in another school bus (not set on fire) acted as passengers to demonstrate evacuation times. Without their seat belts, the volunteers evacuated the bus within 1 minute 16 seconds. When the demonstration was performed again, with the participants wearing seat belts, their evacuation time increased by 2 seconds. In a third demonstration, the same passengers wore their seat belts but also closed their eyes (to simulate reduced visibility due to smoke), which lengthened the evacuation time to 2 minutes 27 seconds.[61]

**Figure 16.** Extent of damage to school bus in Kansas City fire demonstration. (Source: NAPT)

[60] See news story (accessed June 26, 2019) about the Stafford County demonstration in the magazine *School Bus Fleet*.

[61] See news story (accessed June 26, 2019) about the Kansas City demonstration in *School Bus Fleet*.

## 1.9 Similar Bus Fires Investigated by NTSB

### 1.9.1 Mesquite, Texas

About 3:52 p.m. central daylight time on Wednesday, October 3, 2018, a 2019 IC conventional-style school bus operated by the Mesquite Independent School District was traveling south in the 3000 block of Lawson Road in Mesquite, Dallas County, Texas **(**figure 17). A 67-year-old driver and 54 students from Terry Middle School were on the bus. The bus was equipped with lap/shoulder belts at all seating positions, but it is not known how many occupants used them. According to the Mesquite Police Department (MPD) crash report, while the bus traveled on Lawson Road, its right rear tires dropped off the edge of the roadway. The driver steered the vehicle to the left, causing it to enter the opposing travel lane. When the driver steered the school bus back to the right, it ran off the right side of the roadway, rolled 90 degrees onto its side, and collided with a utility pole, resulting in a fire (figure 18).


**Figure 17.** Aerial photograph of crash site on Lawson Road, with inset map showing location of Mesquite on map of Texas. (Source: Texas Orthoimagery Program)

**Figure 18.** School bus at final rest after crash and fire in Mesquite, Texas. (Source: MPD)

At 3:56 p.m., the Spillman-Mesquite Police and Fire dispatch communications center received multiple 911 calls reporting the crash and that the bus was on fire. Police and fire department units were dispatched. Video from the bus's forward- and rear-facing interior cameras shows students evacuating within seconds of the vehicle coming to rest. The video shows bystanders and then law enforcement officers attempting to free a 12-year-old student (sitting in the fifth row from the rear of the bus) whose foot was caught between the bottom of the seat frame and the raised wheel-housing.

According to the MPD report, by 4:04 p.m., the fire had engulfed the vehicle and rescuers had to evacuate. A minute later, the first Mesquite Fire Department unit arrived on scene (within 10 minutes of dispatch) and began pumping water onto the fire.[62] The trapped passenger died in the fire. The driver and four other students were transported to area hospitals for treatment. The remaining students were taken to Terry Middle School. The weather at the time of the crash was clear and the roadway was dry.[63]

### 1.9.2 Orland, California

On April 10, 2014, about 5:40 p.m. Pacific daylight time, a 2007 Volvo truck-tractor in combination with double trailers, operated by FedEx Freight, Inc., was traveling south in the right lane of Interstate 5 (I-5) in Orland, California. At the same time, a 2014 Setra motorcoach, operated

[62] Between 2006 and 2010, fire department response times, calculated as time elapsed between a fire department's receipt of an alarm and the time the first responding unit arrives on scene, was 10 minutes or less in 82 percent of the automobile fires resulting from collisions or overturn and in 64 percent of the associated deaths (Ahrens 2012).

[63] For more information, see the public docket (https://dms.ntsb.gov/pubdms) for NTSB accident HWY19IH002.

by Silverado Stages, Inc., was traveling north in the right lane of I-5. The motorcoach was transporting 42 high school students and 3 adult chaperones as part of a three-motorcoach chartered trip taking students from Los Angeles to Humboldt State University in Arcata, California. Near milepost 26, the combination vehicle moved into the left lane of the freeway, entered the 58-foot-wide median strip, and traveled into the northbound traffic lanes.

The truck-tractor collided with the front of the motorcoach, and both vehicles ran partially off the east side of I-5. A postcrash fire consumed the truck-tractor, significant portions of its trailers, and the motorcoach interior (figure 19). Both the truck and the motorcoach driver died, along with eight motorcoach passengers. Six passengers died of asphyxiation due to the inhalation of products of combustion; three were found inside the motorcoach. Two of the three did not exhibit antemortem (before death) traumatic injuries. The remaining 37 passengers received injuries of varying degrees. Ten seriously injured passengers sustained both fire-related injuries (inhalation injuries, acute respiratory failure, and second- or third-degree burns) and collision or egress injuries.


**Figure 19.** Truck-tractor double trailer and motorcoach burning after crash near Orland, California. (Source: J. Lockett)

The NTSB determined that the probable cause of the crash was the inability of the FedEx Freight truck driver to maintain control of the vehicle due to his unresponsiveness for reasons that could not be established from available information. Contributing to the severity of some motorcoach occupant injuries were high impact forces; the release of combustible fluids, leading to a fast-spreading postcrash fire; difficulties in motorcoach egress; and lack of restraint use (NTSB 2015). Among other safety issues, the Orland crash investigation focused on the lack of adequate fire performance standards for the interiors of commercial passenger vehicles.

### 1.9.3 Wilmer, Texas

On September 23, 2005, about 6:00 a.m. central daylight time, a 1998 Motor Coach Industries, Inc., 54-passenger motorcoach, operated by Global Limo, Inc., of Pharr, Texas, was traveling north on Interstate 45 (I-45) near Wilmer, Texas. The motorcoach, en route from Bellaire, Texas, to Dallas as part of an evacuation before Hurricane Rita, was carrying 44 assisted-living-facility residents and nursing staff. A passing motorist noticed that the right-rear hub of the motorcoach was glowing red and alerted the driver, who had stopped in the left lane and then proceeded to the right shoulder of I-45 near milepost 269.5.

The driver and nursing staff exited the motorcoach and observed flames coming from the right-rear wheel well. As they began evacuating passengers from the motorcoach, with assistance from passersby, heavy smoke and fire quickly engulfed the vehicle (figure 20). Twenty-three passengers were fatally injured; their causes of death were smoke inhalation and thermal injuries. Of the 21 passengers who escaped, all received injuries, many due to smoke inhalation and burns.

**Figure 20.** Damaged motorcoach on I-45 after fire near Wilmer, Texas. (Source: Dallas County Sheriff's Office)

Using video footage from local media that were filming hurricane-evacuation traffic on I-45, the NTSB reconstructed the sequence of events. A 911 call was placed at 6:07 a.m. About 6:08 a.m., 3 minutes after the motorcoach pulled onto the right shoulder of I-45, fire could be seen coming from the right rear of the vehicle. Less than 15 seconds later, the rear of the motorcoach was engulfed in flames. Three minutes later came an intense burst of fire, and by 6:15 a.m. (6 minutes 30 seconds into the video), the motorcoach was almost completely engulfed in flames.[64]

During its investigation, the NTSB identified issues with vehicle fire reporting and inconsistent data in federal accident databases, as well as a lack of fire-resistant motorcoach materials and designs. The probable cause of the fire event was determined to be insufficient lubrication in the right-side tag axle wheel bearing assembly of the motorcoach, resulting in increased temperatures and subsequent failed wheel bearings, which led to ignition of the tire and the catastrophic fire. Contributing to the rapid propagation and severity of the fire and subsequent loss of life was the lack of motorcoach fire-retardant construction materials adjacent to the wheel well (NTSB 2007).

### 1.9.4 Carrollton, Kentucky

About 10:55 p.m. eastern daylight time on May 14, 1988, a pickup truck traveling north in the southbound lanes of Interstate 71 struck head-on a church activity bus traveling south in the left lane of the interstate near Carrollton, Kentucky (figure 21). As the pickup truck rotated during impact, it struck a car traveling south in the right lane near the church bus.

**Figure 21.** Scene of crash and fire near Carrollton, Kentucky, showing burned church bus and wreck of pickup truck that struck it. (Source: *Lexington Herald-Leader*)

[64] Passersby who helped evacuate the motorcoach reported that as soon as they observed the fire in the vehicle's wheel well and pulled over to assist, black smoke had accumulated inside and was coming out the front door. A responding law enforcement officer, who was dispatched at 6:08 a.m. and was on scene in 1 to 2 minutes, observed flames already past the wheel well and moving up the side of the motorcoach, smoke pouring out the front door, and the rear windows covered by flames and smoke.

The fuel tank of the bus was punctured during the collision sequence, and a fire ensued, engulfing the bus. The bus driver and 26 passengers were fatally injured, all as a result of smoke injuries, not from the collision with the pickup truck. Thirty-four bus passengers sustained minor-to-serious injuries, and six passengers were uninjured. The pickup truck driver sustained serious injuries. Neither of the car's occupants was injured.

During its investigation, the NTSB identified safety issues with, among others, the federal safety standards used in school bus manufacture, the flammability and toxicity of school bus seating materials, and emergency egress on school buses. The probable cause of the collision was determined to be the alcohol-impaired condition of the pickup truck driver, who operated his vehicle opposite to the direction of traffic flow on an interstate highway. Contributing to the severity of the accident was the puncture of the bus fuel tank and ensuing fire in the bus, the partial blockage by the rear bench seats of the area leading to the rear emergency door, which impeded rapid passenger egress, and the flammability of the material in the bus seat cushions (NTSB 1989).

The NTSB found that the polyvinyl-chloride-covered and polyurethane-padded seat cushions provided fuel for the fire once it spread inside the bus. Hydrogen chloride is a toxic product of those materials when they burn. The NTSB concluded that exposure to hydrogen chloride and black soot most likely contributed to the inhalation injuries of those who died (as well as to the injuries of survivors). The NTSB stated in its report that, according to manufacturers, bus upholstery material was available that was less flammable and less toxic than the untreated polyvinyl chloride/polyurethane material then used in school bus seats, including fire-retardant and flame-blocking materials such as fiberglass-woven materials or aramid nonwoven blends.[65] The NTSB also reported that the National Institute of Standards and Technology (NIST) was developing acceptable criteria to slow the growth of fires in school buses. The NIST study would be directed toward currently used and state-of-the-art material assemblies for school bus seats. The NTSB recommended that NHTSA incorporate in FMVSS 302 the recommendations of NIST concerning new material acceptance criteria to reduce the rate of fire spread in all buses (Safety Recommendation H-89-4).

In January 1989, NHTSA commissioned NIST's Center for Fire Research to investigate the flammability resistance of various school bus seat assemblies. The research focused on factors such as ignitability, flame spread, rate of heat release, smoke generation, and toxicity of combustion products. In July 1990, NIST published *Assessment of the Fire Performance of School Bus Interior Components* (Braun and others 1990). The report's major findings were as follows:

- No one simple small-scale test should be used to measure fire performance of a material.
- A materials fire performance includes the examination of a combination of factors, such as ease of ignition, flame spread, rate of heat release, generation of gaseous species, smoke development, and toxicity of the combustion products. In addition, the heat exposure conditions and geometry of the school bus play a critical role.

[65] Aramids are a class of synthetic polymers that yield exceptionally strong, thermally stable fibers.

- A full-scale test procedure (testing a complete seat assembly) will provide the best basis for testing school bus seats.
- While toxicity is a concern, it appears that heat and/or smoke generated by all likely school bus seating materials could cause incapacitation before toxicity became an issue.

In November 1992, NHTSA mandated additional emergency exits for school buses. NHTSA had written to each director of pupil transportation and each school bus manufacturer, informing them of the availability of materials that are more flame resistant than NHTSA's standard requires, and that states can impose flammability standards that are more stringent than NHTSA's. On December 17, 1998, the NTSB classified Safety Recommendation H-89-4 "Closed—Acceptable Alternate Action."

In July 2003, NHTSA terminated the rulemaking it had begun in 1988 (in response to the Carrollton fire) to consider upgrading the flammability resistance requirements in FMVSS 302 for school bus interiors. NHTSA cited several reasons: because the risks presented by school bus fires pose a minimal safety problem; because its 1992 upgrade of the FMVSS 217 emergency exit requirements to allow faster evacuation from school buses had further reduced the risks posed by fire; because the bus involved in the Carrollton fire was built before upgraded federal school bus standards went into effect in 1977 and did not meet the exit and fuel system integrity requirements; because upgrading FMVSS 302 would result in significant costs; and because further research would be necessary before NHTSA could propose a test protocol, utilizing scarce agency resources.[66]

[66] *Federal Register* 68, no. 142 (July 24, 2003): 43895 (accessed June 26, 2019).

# 2 Analysis

## 2.1 Introduction

The crash sequence began when a school bus reversed out of a residential driveway onto a rural road (480th Street) outside Oakland, Iowa. After the bus crossed the roadway and shoulder, its right rear tires dropped into a ditch beside the road. A fire propagated in the engine compartment and spread to the interior of the bus. The bus driver and student passenger were fatally injured.

The analysis section of this investigative report first discusses the factors that could be excluded as not causing the crash or contributing to the fire. It then addresses the events leading to the fire, including the driver's actions before the crash, the origin and severity of the fire, and the driver's response to the emergency. The report discusses the following safety issues and makes related safety recommendations:

- School bus driver fitness for duty, including PPTs and driver oversight by the RCSD (section 2.3).
- School bus fire safety, including engine fire suppression, fire-resistant materials, firewalls, and federal fire safety performance standards (section 2.4).
- School bus emergency training, including evacuation drills and equipment (section 2.5).

As a result of its investigation, the NTSB established that the following factors did not cause or contribute to the run-off-road crash and fire:

- ***Mechanical condition*:** Investigators found no preexisting mechanical conditions on the bus that could have contributed to the crash. Damage to the bus was consistent with its right rear corner striking an earthen embankment and the subsequent fire.
- ***Driver licensing, experience, alcohol or other illicit drug impairment, and fatigue*:** The school bus driver held a current CDL, with appropriate endorsements, and had operated school buses for 17 years. His postcrash toxicology test results were negative for alcohol or illicit drugs.[67] He was operating his regular school bus on the assigned route and had ample opportunity for sleep in the days preceding the crash.
- ***Distraction*:** The driver's cell phone records showed no voice calls, but they did show unexplained messaging activity near the time of the crash. Although the cell phone service provider could not identify the source of the activity, the company confirmed that it was not standard text messaging and suggested that the driver might have used a third-party application. The cell phone was destroyed in the postcrash fire and could not be examined. Considering the lack of data, the NTSB was unable to determine whether the driver was using his cell phone before or during the run-off-road event.

[67] In this context, *illicit* refers to drugs with no medicinal value that are classified as Schedule I by the Drug Enforcement Administration: "Schedule I drugs, substances, or chemicals are drugs with no currently accepted medical use and a high potential for abuse. Some examples of Schedule I drugs are: heroin, lysergic acid diethylamide (LSD), marijuana (cannabis), 3.4-methylenedioxymethamphetamine (ecstasy), methaqualone, and peyote" (Drug Scheduling; accessed June 26, 2019).

Cell phone activity might have occurred once the driver found that he could not drive the bus out of the ditch. No other source of a possible external distraction was found.

- ***Roadway design*:** With the exception of the ditch foreslope, all geometric design features of 480th Street in the vicinity of the crash met or exceeded current county guidance (see section 1.6). The foreslope embankment was steeper than on standard high-volume roadways, but that was allowable because the roadway was low-volume, the surrounding area was clear of obstructions, and the roadway was constructed before the guidance existed. Although the depth of the ditch would have prevented the school bus from being driven forward once its rear wheels had dropped into it, the foreslope angle did not contribute to the driver backing across both travel lanes and the shoulder before entering the ditch. No roadway issues were found.

- ***Weather*:** The weather was clear, there was no precipitation, and the roadway and ditch were dry.

- ***Visibility*:** Although no streetlights were in the vicinity of the crash, illumination from the bus's backup lights and tail lights should have provided adequate roadway visibility. In addition, the driver was familiar with the pickup location.

The NTSB therefore concludes that none of the following were factors in the crash: (1) school bus mechanical condition; (2) driver licensing, experience, alcohol or other illicit drug impairment, fatigue, or distraction; (3) roadway design or conditions; and (4) weather conditions.

Emergency resources from the Pottawattamie County Sheriff's Office and responding fire departments were dispatched expeditiously. The first 911 call was received at 7:02 a.m., and responders were dispatched immediately. However, the fire had almost fully engulfed the school bus by the time the 7:02 a.m. call was received. In addition, the fire occurred in a rural location, over 20 miles from the nearest fire department and the closest law enforcement personnel. That situation is not unusual in rural areas. Therefore, the NTSB concludes that the emergency response to the crash and fire by local fire departments and law enforcement was adequate and timely.

## 2.2 Crash and Origin of Bus Fire

It is difficult to explain why the driver drove the bus off the road and into the ditch. The driver was familiar with the bus route, the configuration of 480th Street, and the driveway where the run-off-road event began. Although it was dark when the driver began to reverse out of the driveway, that condition was normal for the time of year. Moreover, the driver had regularly negotiated the driveway under similar conditions (with the roadway illuminated only by the bus's tail lights) for years. The NTSB concludes that the driver failed to control the school bus and prevent the run-off-road crash for reasons that cannot be determined from the available information.

Postfire evidence found in the ditch of distinct, rounded tire depressions lined with melted sections of tire—below the height of the surrounding undisturbed soil and with debris over the tire sections—strongly suggests that the impressions were formed by the abrasive action of spinning or rotating tires. The rounded tire depressions and tire debris are consistent with an effort by the driver to accelerate the engine and drive the bus out of the ditch. Because the right rear tires were in the ditch, they lacked traction, so that accelerating the engine would have caused them to spin. Further, laboratory examination determined that the soot near the tire impressions was consistent with the soot inside the bus's tailpipe. Soot would be expected to be expelled from the tailpipe of a diesel engine run at high revolutions per minute.

The postfire engine evidence indicates that the fire most likely originated on the engine's turbocharger.[68] Areas of clean burn, steel bluing, and metal warpage (buckling) indicate high heat. Postfire, the engine side of the firewall was relatively free of soot, indicating a clean burn, and a low burn pattern was found in the turbocharger area. Steel bluing was present from the top half of the firewall down to the midline, and metal warpage was present toward the top.[69] Thus, the part of the engine exposed to the highest temperatures was in the area of the turbocharger.

The exterior of the turbocharger most likely became superheated from the driver's repeated attempts to accelerate the bus out of the ditch while its exhaust pipe was blocked. The temperature of a turbocharger's intake for exhaust gas typically ranges between 1000°F and 1200°F, but the temperature can increase when the engine is under an increased load. It is likely that the superheated turbocharger ignited fluids in the engine compartment, such as brake, transmission, and power-steering fluids or lubricating oil. While the surface temperatures on the intake duct would have been lower than the temperature of the exhaust gas, they would still have been sufficient to ignite fluids in the engine compartment. The NTSB therefore concludes that the likely origin of the fire was the exterior of the turbocharger in the engine compartment. The NTSB further concludes that the blocked exhaust pipe, resulting in turbocharger overload with significant heat output during repeated engine acceleration, was the primary contributing factor to the initiation of the fire.

Fires originating in school bus engine compartments have been found to result from high-heat sources that ignite leaked high-pressure fluids (Meltzer and others 2016). The specific engine fuel that was the source of the Oakland bus fire could not be determined because of the extensive damage to the engine compartment. However, while none of the engine compartment fluids was classified as a flammable liquid, all fluids in the compartment would have been ignitable. Brake, transmission, and power-steering fluids on the market, as well as lubricating oil, have documented flash points and autoignition temperatures that are below the surface temperatures typically found in the turbocharger intake duct.[70] Once the fire ignited, other fluids would have contributed to the fuel load as the fire compromised the engine systems. The NTSB

[68] No electrical arcing was found in any of the electrical wiring in the engine compartment, ignition sources in the passenger compartment were eliminated, and diesel fuel was eliminated as a possible fuel source because the fuel system was intact.

[69] The lowest point of the pattern originated at the frame and traveled midline up to the front of the roof.

[70] According to the National Fire Protection Association (NFPA) document titled *NFPA 921: Guide for Fire and Explosion Investigations,* hot surface ignition temperatures for ignitable liquids can be higher than the listed autoignition temperature for that liquid. However, the flammability of a fuel depends on many factors, such as airflow, proximity to an ignition source, and the physical state of the fuel. Pressurized or aerosolized liquid fuels are more easily ignitable than pooled versions of the same liquid. That is due to the smaller mass-to-surface area ratio (small droplets require less heat to vaporize than a pool of the same liquid).

concludes that fluids in the engine compartment fueled the fire, but the initial fuel source could not be determined because of the extensive damage to the engine compartment.

In most vehicles, the engine is separated from the passenger compartment by a firewall, a structure intended to keep an engine fire from spreading into the vehicle's interior. The Oakland school bus was designed so that part of the engine extended into the driver's section. That part of the firewall was cut out, and a fiberglass cowling was installed in its place. The fiberglass cowling would have contributed to the fire's fuel load once it was exposed to heat and flame. In addition, the firewall had holes that allowed wiring to pass from the engine to the instrument panel. The holes were sealed, as required, but not with fire-resistant materials.[71] Thus, once the engine compartment caught fire, the holes allowed flames, heat, and smoke into the driver's area and passenger compartment.

The firewall at the front of the bus did not prevent the engine fire from spreading because small penetrations through the firewall were not blocked with fire-resistant material. More important, the penetration of the engine block created a large gap in the firewall that produced a direct pathway for the fire to enter the passenger area. The lack of fire-resistant material in the separation between the engine compartment and the passenger area was critical to the spread of fire and smoke into the bus's interior.

Forensic autopsy results confirmed that the driver and the passenger died from smoke and soot inhalation (breathing the products of combustion) and found that they had carboxyhemoglobin levels of 6 percent and 47 percent, respectively, with thermal injuries. The bus arrived to pick up the passenger at 6:50 a.m., and within an estimated 5 minutes, the driver had radioed that he was in the ditch and that the bus was on fire. From the on-scene evidence, the driver had spent time attempting to drive the bus out of the ditch before the fire started and he radioed for help. Four minutes after the driver's radio call, the passenger's mother reported that the bus was on fire and that she could not see her daughter inside.

Although the front door, rear door, and four exit windows were available for egress, neither the driver nor the passenger exited the bus. The driver spoke with the passenger's mother while he leaned out his window, which would have given him access to an outside air source. However, he never moved from his seat and did not evacuate the bus. That indicates that he might have been immobile and unable to extricate himself, even though an autopsy did not find that he sustained injuries from the crash.

Postfire, the passenger was found next to the driver's seat. The school bus traveling in reverse and entering the ditch would not have caused the passenger to end up in the driver's area. Moreover, although the passenger had received emergency training in middle and elementary school on how to evacuate through the bus's rear door and side emergency windows, she did not escape through either opening. The NTSB determined after the fire that the emergency windows had not been opened and that the rear door was accessible and operable.

[71] The Iowa Administrative Code, which includes the NSTSPs, specifies only that penetrations through the firewall of a school bus must be sealed.

In addition, the passenger did not evacuate through the front loading door. Although the fire propagated quickly inside the bus once it penetrated from the engine compartment, the driver and passenger still had time to evacuate when the driver radioed about the fire. The passenger's family reported no medical issues that would have prevented her from evacuating the bus after it entered the ditch and before the driver reported the fire. Interviews with family members and acquaintances revealed that the passenger, known to be good friends with the driver, normally sat close to him, near the front of the bus, and that the two would normally chat during the first half of the trip.

The NTSB considered all these circumstances when assessing why the passenger would not have evacuated the bus. The information available about her position on the floor next to the driver's seat, combined with her failure to respond when her mother called her from outside the bus, suggests that the passenger, rather than evacuate on her own through the front or rear doors or the emergency windows, might have chosen instead to remain in the bus and was attempting to help extricate the driver when she was fatally overcome by the products of combustion. The NTSB concludes that the passenger was possibly attempting to assist the school bus driver, whose limited mobility due to medical conditions might have prevented him from evacuating the bus, and she did not perceive the immediate danger before being overcome by smoke and superheated gases as a result of the fire.

## 2.3 School Bus Driver Fitness for Duty

### 2.3.1 Medical Issues

The NTSB examined possible causes for the driver's lack of response to the fire emergency. After excluding his experience with the vehicle or the route, impairment from alcohol or illicit drugs, and distraction, investigators considered whether reduced mobility from his medical conditions could explain why the driver did not evacuate the school bus in response to the fire. Many factors can affect a person's response to an emergency. However, a school bus driver's inability to extricate himself and those in his care in a fire emergency, when there is no physical barrier to escaping the fire, is extremely concerning. NTSB investigators focused on the following elements to assess whether the driver was incapable of responding in the emergency:

- Medical condition, medications, and physical mobility.
- Reports from supervisors and coworkers on his pre-event mobility.
- Interviews with witnesses to the events preceding the fire.

The 74-year-old driver had a history of high blood pressure, high cholesterol, depression, diabetes, gastric reflux, and low back pain treated with spinal fusion surgery. He was found qualified for a CDL during an examination on March 6, 2017, and he held a medical certificate valid for 2 years. However, after the examination, the driver's degenerative disc disease worsened, resulting in mild right dorsal ankle flexion weakness and debilitating back pain that meant he could not walk without a cane or a walker. The driver understood his diagnosis of degenerative disc disease, had seen a specialist, and was scheduled for back surgery 2 days after the crash.

Investigators examined the driver's medical history and found that his medical conditions were well controlled. They found no evidence that the driver experienced significant side effects from the drug gabapentin. Therefore, the NTSB concludes that although the school bus driver had progressive chronic pain and stable mild right dorsal flexion leg weakness, there was no evidence that the driver's back pain or leg weakness or other medical conditions and medications, including the drug gabapentin, would have affected his ability to perform the driving functions required (while sitting) to operate the school bus.

Although the driver was physically capable of driving the bus, witnesses to the postcrash fire (the passenger's family) stated that when they approached the bus, the driver was in his seat and leaning his head out the driver-side window. The driver's cause of death was smoke and soot inhalation, with thermal injuries. The autopsy found no evidence that he had been injured in the crash.

### 2.3.2 Physical Performance Tests

The driver's severe, progressive chronic back pain affected his daily life, causing him difficulty in standing and walking, and could have impaired his ability to evacuate the bus or help the passenger. Although the driver could board and exit the bus under normal conditions—and had, in fact, boarded normally earlier that morning—he did so while using his cane, under normal, low-stress conditions, and with as much time as he needed. When the driver needed to evacuate the bus after the crash, conditions were neither normal nor low stress. The bus was in the ditch, the driver was aware that it was on fire, and a student was on board.

The NTSB was unable to assess the speed of the fire's spread into the passenger compartment, which might have reduced the time available for the driver to evacuate. Given those factors and the driver's documented reduction in mobility, including his use of mobility aids, the NTSB concludes that it is likely that the bus driver's progressive chronic back disease, which caused severe chronic pain, impaired his ability to evacuate the school bus himself or to assist the passenger to evacuate.

As noted earlier, the Iowa Administrative Code specifies that school bus drivers must have sufficient physical capacity to "render assistance to the passengers in case of illness or injury." The code also specifies that an employer or prospective employer has discretion to "evaluate the applicant's ability in operating a school bus, including all safety equipment, in providing assistance to passengers in evacuation of the school bus . . . ."

The RCSD transportation supervisor, the school principal, and the driver's coworkers were aware of his physical impairment. Although he held a 2-year medical certificate, the district took no action to ensure that he could perform all the duties of a school bus driver after his physical condition worsened, such as refer him for a medical clearance or remove him from duty. RCSD policy allowed the administration to require a driver to submit to additional examination if his or her physical or mental health was in doubt. Until 2011, the RCSD had required its drivers to pass tests of their physical ability (PPTs).

A number of states use PPTs to determine whether a school bus driver is physically able to assist passengers in an emergency.[72] The NTSB recognizes that the school bus transportation industry suffers from a driver shortage.[73] The NTSB is also aware that many medically certified school bus drivers with safe driving records have physical limitations that could prevent them from passing a PPT. However, the consequences of a driver not being able to evacuate a school bus or assist passengers in an emergency cannot be ignored. Acute medical conditions in school bus drivers should be addressed expeditiously to ensure safe transportation for students and prevent fatalities from crashes that are survivable, such as the one in Oakland.

Although the RCSD had a policy that required employees to submit to additional examinations if school administrators judged that their physical or mental health might be in doubt, after discontinuing the use of PPTs in 2011, the RCSD had no written policies or procedures for tracking the capacity of its drivers to physically carry out emergency duties and ensure safe school bus operation. Although the RCSD was aware of the bus driver's acute medical impairment, the district did not require him to obtain clearance from a doctor stating that he had received medical care to alleviate his physical impairment. Nor did the RCSD use a PPT to evaluate the driver's abilities. The NTSB concludes that the use of PPTs on both a routine and an as-needed basis can help identify physically unfit drivers who have a valid medical certificate but who might not be able to perform required safety duties, especially in an emergency.

### 2.3.3 Driver Oversight

When a school district, as an intrastate motor carrier, identifies a physical impairment that could affect a driver's ability to operate a school bus and could lead to a crash or result in the driver's inability to safely render assistance—such as an inability to walk without a cane or move quickly in an emergency—the district should require the driver (even if he or she has a medical certificate) to demonstrate physical ability or provide a doctor's clearance for duty. While school bus drivers undergo federally required medical examinations and can be medically certified for 2 years, medical conditions can occur during the interval between examinations that render the driver incapable of performing critical emergency duties. The state of Iowa permits school districts to require PPTs of drivers to demonstrate and document that they are able to conduct critical school bus duties.

The NTSB has investigated fatal crashes in which commercial drivers, including school bus drivers, obtained medical certificates even with disqualifying medical conditions, such as in recent crashes in Anaheim, California, and Baltimore, Maryland (NTSB 2016, 2018). The Oakland crash and fire underscores that school districts should not rely only on a medical certificate when a driver appears to be ill (or fatigued). Districts should also make certain that their transportation supervisors and others in positions of authority can take steps to require a driver to provide medical

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[72] Six states (Arizona, Florida, Indiana, New York, South Carolina, and West Virginia) and at least one school transportation company require drivers to complete a PPT. Ten states (Alabama, Colorado, Iowa, Kansas, Kentucky, Louisiana, Michigan, Oregon, Utah, and Washington) allow local districts to administer the tests but do not require them. Thirty-four states and the District of Columbia do not have a publicly stated policy regarding PPTs.

[73] See a fall 2016 study by the NAPT and an article in *School Bus Fleet* from November 2016 (both accessed June 26, 2019).

clearance for duty when he or she shows signs of a potentially disqualifying medical condition or acute physical impairment.

The school bus driver in this crash displayed a worsening physical condition and had to use a cane or a walker. The RCSD was aware of the driver's condition and that he was scheduled for surgery 2 days after the crash. The high school principal informed the RCSD of passenger complaints regarding the driver's ability, yet no complaints were documented. The RCSD had a responsibility to exercise effective driver oversight that would ensure both the medical fitness and the physical ability of a driver to perform the tasks associated with normal or emergency operation of a school bus. The NTSB therefore concludes that if the RCSD had adhered to the requirements of its transportation policy regarding the physical abilities of school bus drivers and had not allowed the accident driver to operate a bus until he was medically cleared and fit for duty (or could pass a PPT), the fatal outcome of what should have been a survivable run-off-road, low-speed crash might have been avoided.[74]

The RCSD had a responsibility to recognize the safety risk in dispatching a physically impaired driver on a route when, as is always the case, an emergency could arise that would require him to assist his passengers. Therefore, the NTSB concludes that the RCSD exercised poor oversight of driver safety by allowing a driver with known, significantly limited mobility to operate a school bus and by not removing a driver from duty who was unable to perform required safety duties.

Since the fatal run-off-road crash in Oakland, the RCSD has implemented procedures to improve its oversight of school bus drivers. Emergency evacuation drills are now documented; bus drivers are developing new instructional presentations for teachers (teachers instruct students before the drills); all students (elementary through high school) are participating in evacuation drills in school buses, with drivers present; and students are being drilled in how to open a bus's front door, exit windows, rear or side door emergency exits, and roof hatches. A transportation advisory committee consisting of students, parents, and RCSD representatives has been created to address concerns, and a driver complaint checklist now documents the tracking and resolution of issues. The training of drivers and transportation supervisors has been updated, and annual training certificates are placed in driver files. The district has reinstated the PPT for drivers at the time of hire and annually; the tests can also be administered at the superintendent's request. Finally, the RCSD has stated that it will install global positioning systems in the buses to monitor bus speed and obedience to stop signs and provide real-time, in-route information to parents.

### 2.3.4 Driver Medical Referrals

The circumstance of unsafe medical conditions being overlooked by the school bus carrier in the Oakland crash is strikingly similar to the circumstances of a 2016 school bus crash in Baltimore. In that case, the NTSB found that the driver was unable to safely operate the bus due to a medical condition (a seizure disorder) that was known to his employer and his coworkers. In the Baltimore crash, the bus driver had a disqualifying medical condition. In the Oakland crash,

[74] As described earlier (section 1.4.2), RCSD school board policy 403.1 required bus drivers to present evidence of good health in the form of a physical examination report, at the time of hiring and every other year thereafter.

the driver had an acute medical condition that was known by, or should have been known by, the motor carrier. Yet both drivers were permitted to operate school buses and transport children.

Coworkers of the Oakland bus driver told NTSB investigators that they had observed firsthand that he had medical problems and could not walk without a cane or a walker. They expressed concerns about the driver's ability to move around or control the bus. According to the IDOT-MVD, a concerned person can submit a signed, written request for an evaluation of a driver who has a physical, mental, or visual impairment, regardless of age. The IDOT's Office of Driver Services reviews requests and determines the appropriate course of action, including medical or vision evaluation and other tests. It is unclear whether the Oakland driver's supervisor, his coworkers, or other school system employees who witnessed or knew of his severe impairment were aware that they could refer him to the IDOT-MVD for evaluation. In light of the driver's significant, noticeable medical condition, the absence of a referral by school staff or coworkers could point to a general lack of awareness about the regulations concerning a bus driver's medical fitness and the procedures for reporting a medically unfit driver.

A school bus driver should not operate a school bus, and a motor carrier should not allow a school bus driver to operate a school bus, while the driver's ability or alertness is so impaired, or so likely to become impaired, through fatigue, illness, or any other cause, as to make it unsafe for him or her to begin or continue to operate a bus. The RCSD was an intrastate operator, but some Iowa school districts contract with interstate (national) companies to provide school bus transportation. Interstate motor carriers that provide school bus transportation services are prohibited by federal regulations from operating a CMV when a driver is impaired, including by a medical condition, even if the driver has a valid medical certificate. As specified at 49 CFR 392.3,

> No driver shall operate a commercial motor vehicle, and a motor carrier shall not require or permit a driver to operate a commercial motor vehicle, while the driver's ability or alertness is so impaired, or so likely to become impaired, through fatigue, illness, or any other cause, as to make it unsafe for him/her to begin or continue to operate the commercial motor vehicle.

Therefore, the NTSB concludes that awareness training for Iowa school district personnel, including but not limited to bus drivers, transportation directors, supervisors, and superintendents, would increase awareness of the federal and state regulations regarding commercial driver fitness and the avenues available for reporting drivers who have medical conditions that might make it unsafe for them to operate a school bus.

### 2.3.5 Safety Recommendations

PPTs can help identify medically unfit drivers who have valid medical examination certificates but who might not be able to perform the duties of a school bus driver, especially in an emergency. The Iowa Administrative Code specifies physical fitness requirements for school bus drivers, which include having sufficient physical capacity to operate a bus effectively and to render assistance to passengers in case of illness or injury. However, the state code leaves it to the discretion of the chief administrator (or a designee of the employer or prospective employer) to evaluate the ability of a school bus driver to operate safety equipment and assist passengers. Each state may be different in the discretion given to school districts for instituting PPTs.

The NTSB recognizes the RCSD for reinstating the PPTs for its drivers on hiring, annually, and as needed. School bus drivers can experience health-related changes, either temporary or permanent, in their ability to physically perform the duties of their job. As this crash demonstrates, changes can occur between annual or biennial driver examinations. Given the special requirements related to evacuation and assistance of students that apply to school bus drivers, the NTSB believes that requiring school bus drivers nationwide to complete a PPT regularly or when there is a concern about their abilities to meet the physical requirements of the job enhances the safety of students and drivers alike and, further, that school systems without such programs are missing a safety opportunity. Accordingly, the NTSB recommends that the 44 states that do not currently require PPTs, the District of Columbia, and Puerto Rico revise their school bus driver requirements so that all drivers must pass a PPT on hiring and at least annually, and also whenever a driver's physical condition changes in a manner that could affect his or her ability to physically perform school bus driver duties, including helping passengers evacuate a bus in an emergency.[75]

As discussed in the NTSB's special investigation report addressing the Baltimore crash (NTSB 2018), all state licensing agencies accept third-party reporting of drivers who have medical conditions that might impair their ability to safely operate a vehicle. In the Baltimore report, the NTSB noted that "school bus drivers with potentially hazardous medical conditions are of concern nationwide. Every state allows individual reporting of medically unsafe drivers to the state licensing agency." The NTSB recommended that the National Association of State Directors of Pupil Transportation Services (NASDPTS), the NAPT, the National School Transportation Association (NSTA), the American School Bus Council, and the Maryland School Bus Contractors Association (MSBCA) inform their members of the circumstances of the Baltimore school bus crash and lessons learned from the crash investigation to help raise awareness of the avenues available to report school bus drivers with medical conditions that may make it unsafe for them to operate a school bus (Safety Recommendation H-18-16). For the MSBCA, Safety Recommendation H-18-16 was classified "Closed—Acceptable Action" on October 16, 2018. For the NASDPTS, the NAPT, and the NSTA, the current status of Safety Recommendation H-18-16 is "Open—Initial Response Received." For the American School Bus Council, the current status of Safety Recommendation H-18-16 is "Open—Await Response."

In June 2018, the NSTA published an article in its newsletter informing all its members of the circumstances of the Baltimore crash and the lessons learned to raise awareness of driver reporting. The NSTA discussed the Baltimore crash safety recommendation in July 2018 at its annual conference, and then in November 2018, hosted a webinar covering driver fitness for duty. In June 2018, the NASDPTS sent a copy of the NTSB's special investigation report on the Baltimore crash to its members and encouraged them to review it. In July 2018, the MSBCA published a letter on its website informing its members of the Baltimore crash to raise awareness of reporting methods for school bus drivers who have medical conditions that might make it unsafe for them to operate school buses.

[75] The states subject to the recommendation are Alabama, Alaska, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Hawaii, Idaho, Illinois, Iowa, Kansas, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Dakota, Tennessee, Texas, Utah, Vermont, Washington, Wisconsin, and Wyoming; and the commonwealths of Kentucky, Massachusetts, Pennsylvania, and Virginia.

In October 2018, the NASDPTS surveyed its state directors to assess existing state requirements and guidelines in many of the areas related to updating school bus driver qualification requirements and programs and discussed the results at its annual conference. Also in 2018, the electronic newsletter of the NASDPTS published a link to the NTSB press release and media reports about the Baltimore crash investigation. The NAPT presented a keynote address at its October 2018 annual conference, informing all members about the Baltimore crash circumstances and the NTSB's safety recommendations. On the basis of a review of the work those associations have done to raise awareness of reporting methods, as discussed in the report addressing the Baltimore crash, the NTSB classifies Safety Recommendation H-18-16 as "Closed—Acceptable Action" for the NASDPTS, the NAPT, and the NSTA. For the American School Bus Council, the status of Safety Recommendation H-18-16 remains "Open—Await Response."

The NTSB is concerned that school districts are overlooking medical conditions that would impair a driver's ability to safely operate a school bus in order to maintain school bus transportation services. A driver should be physically fit for the demands of the position, which include not only driving the school bus but also possessing the dexterity and physical strength to operate the emergency exits for an evacuation, to lift and deploy a fire extinguisher, and to assist one or more passengers who are incapacitated and need egress assistance. The NTSB recommends that the state of Iowa inform its school districts of the circumstances of the Oakland school bus crash and fire and the lessons learned from the investigation, and that it publicize to its staff the methods available for individually reporting school bus drivers who have medical conditions that might affect their ability to safely operate a school bus.

## 2.4 School Bus Fire Safety

### 2.4.1 Fire Data

In 2006, the NTSB held a public hearing on motorcoach fires in support of its investigation of a fire near Wilmer, Texas, that resulted in 23 fatalities (NTSB 2007). During the hearing, the FMCSA testified that—recognizing the difficulty of obtaining meaningful data on motorcoach and bus fires—it had contracted with the John A. Volpe National Transportation Systems Center to gather data and studies on motorcoach fires, set up a database or spreadsheet system to structure the data, and analyze the motorcoach and bus fire problem, including causes, frequency, and severity.

The Volpe Center published two reports documenting and analyzing motorcoach fires between 1995 and 2008. The reports found that, though fatality and injury reductions may be small on average, active and passive fire suppression systems (such as improved flammability standards for interior materials) could help avert the most severe consequences in an extreme or catastrophic bus fire (Meltzer, Ayres, and Truong 2009).

In 2009, NHTSA funded the NIST's Building and Fire Research Laboratory to conduct research with the following goals (Huczek and Blais 2015; Johnsson and Yang 2012):

1. Understand the development of motorcoach fires and their subsequent spread into passenger compartments.
2. Evaluate and identify bench-scale material flammability test methods.

3. Test the effectiveness of fire-hardening of motorcoach exterior components around the wheel well.
4. Assess tenability inside the passenger compartment in the event of a wheel well fire.

The research found that in flammability testing under FMVSS 302, only one interior material (back of the seat rest) failed by exceeding the permitted horizontal burn rate by 25 percent.[76] All components (except the interior wall panel), however, failed the FAA flammability requirements, and all components failed the Federal Railroad Administration (FRA) flammability requirements. Moreover, the seat components and parcel rack door burned "significantly more easily than comparable components approved for use in aircraft and railcars." Seats and parcel racks were found to constitute most of the combustible interior mass of a motorcoach in tests involving tire fires. Researchers did not examine the relationship between improved material flammability performance and fire spread in the passenger compartment.

Tests found that (1) penetration of a tire fire into the passenger compartment occurred after flames impinged on windows and broke the glass, and (2) tire fires can penetrate into the passenger compartment in less than 5 minutes through broken windows.[77] Tests of three types of fire-hardening materials found that replacing exterior combustible components with sheet metal delayed fire penetration through windows by 30 minutes. Using an intumescent coating on the exterior near the tires delayed fire penetration by 20 minutes.[78]

The report concluded that thermally untenable conditions were reached in less than 6 minutes at local areas in the rear of a motorcoach after fire penetration.[79] Untenable conditions "were attained with a limited fuel loading suggesting that the conditions and timing observed in this experiment were not the most conservative."[80] With a uniform smoke layer, hydrogen chloride caused untenable toxicity in the rear of the motorcoach at just under 9 minutes. Tests of carbon monoxide combined with hydrogen cyanide and tests of oxygen vitiation both caused untenable conditions from front to rear just over 11 minutes after fire penetration. The report noted that "thermal conditions were generally more severe at earlier times than toxic, irritant, or asphyxiant

[76] Flammability tests were conducted on four combustible interior motorcoach components: interior wall panels, parcel rack doors, seat fronts, and seatbacks. Typical interior materials from seat, wall, and ceiling constructions in model year 2000 motorcoaches were used.

[77] Temperatures in the wheel well and along the axles were sufficiently high to have the potential to ignite or damage any combustible materials underneath the motorcoach, but the floor and interior areas near the fire were protected by stainless-steel sheet metal and a layer of insulation.

[78] The report defined *intumescent coating* as "a polymer that swells and creates a char barrier to heat and mass transfer when heated by flame." Further: "An effective char barrier can limit pyrolysis [decomposition brought about by high temperatures] of the combustible material underneath and prevent fuel (combustible material) vapors that are generated from escaping and burning."

[79] Other locations in the rear and middle of the coach were measured as untenable within 8 minutes, and the motorcoach front was measured as thermally untenable after 11 minutes.

[80] The combination of three pairs of seats and partial trim installation constituted sufficient fuel loading to cause flashover in the rear half of the passenger compartment less than 11 minutes after fire penetration.

gas conditions” and that when combined in a fire, “the incapacitating effects of thermal and toxic gas effects would shorten tenability time and time to escape.”[81]

In November 2016, the FMCSA published another Volpe study that combined sources to update and expand on the 2009 Volpe analysis. The new study evaluated school bus fire risk, used indicators of future fire risk based on regulatory compliance data, and estimated the effects on fire safety of recent technology changes, including automatic fire detection and suppression (Meltzer and others 2016).[82] According to Volpe’s 2016 report, slightly more than one school bus fire occurs per day, with an average of 379.4 reportable fires per year.[83] Volpe reported that for school bus fires of known origin, 68 percent originated in the engine compartment. In addition, major school bus manufacturers recall thousands of buses each year because of fire safety concerns such as fuel leaks, turbocharger failures, and electrical shorts. Although some states track school bus “thermal events” (in 2016, for example, South Carolina reported 108 bus thermal events between fiscal years 1995–1996 and 2016–2017 [SCDE 2016]), the Volpe report clarifies that the lack of a comprehensive, centralized national database makes it difficult to produce an accurate statistical analysis of the annual frequency of school bus fires.

The NTSB’s report on the 1988 crash and fire in Carrollton, Kentucky, stated that “the national statistics suggest that the incidence of fire in school buses is relatively rare”; but the NTSB’s bigger concern even then was that “the fires could spread to the occupant spaces of school buses and cause injuries and death” (NTSB 1989). Although Volpe found in 2016 that about one school bus fire occurs every day, it concluded that the actual occurrence of school bus fires could be far greater than the number of records collected, because reporting might not accurately capture the fires. Among the possible reasons are that school bus fires can occur on secondary roadways, the fire damage might not meet an arbitrary monetary threshold, or the fires might be extinguished before anyone is injured.[84]

Nevertheless, school bus travel is one of the safest forms of transportation in the United States. Every day, nearly 600,000 buses carry more than 25 million students to and from school or school activities. Children are safer traveling in school buses than in any other vehicle. Although school buses are extremely safe, the NTSB continues to investigate school bus crashes in which fatalities and injuries occur (NTSB 2018) and has investigated two fatal school bus fires in less than a year in which a run-off-road crash was survivable but a passenger died in a postcrash fire.

[81] ISO 13571:2007, “Life-Threatening Components of Fire—Guidelines for the Estimation of Time Available for Escape Using Fire Data” (International Organization for Standardization, Geneva, Switzerland) contains guidance for calculating incapacitation and time for escape from the life-threatening components of fires.

[82] The report includes vehicle models newer than 1980 that were involved in fires from 2004 to 2013. The research relied on the US Fire Administration’s National Fire Incident Reporting System database and the FMCSA’s Motor Carrier Management Information System database. Additional data sources included NHTSA’s Fatality Analysis Reporting System and State Data System, plus state police accident reports for selected states; a joint FMCSA and NHTSA bus fire analysis database; and new reports (Meltzer, Ayres, and Truong 2012).

[83] Note that school buses are not typically in operation 365 days a year, due to the school schedule.

[84] According to Volpe, such fires are less likely to be documented by employers, insurance companies, or government entities.

Enhancements to school bus design—such as installed AFSSs and enhanced interior flammability standards—could help prevent crashes and reduce the severity of, or eliminate, postcrash fires.

### 2.4.2 Fire Suppression Systems

In the Oakland fire, visibility inside the school bus deteriorated within minutes of the driver radioing that the bus was on fire. When the student's mother approached the bus and called to the driver, she could not see her daughter inside the bus, and thick, dark smoke was observed venting from the window the passenger's sister broke shortly afterward. Preventing the spread of a fire and lengthening the time available for egress are two ways of increasing the survivability of vehicle fires.

In 2012, the Moving Ahead for Progress in the 21st Century Act (MAP-21) instructed NHTSA to research motorcoach fires and methods to prevent them.[85] The Southwest Research Institute (SwRI) in San Antonio, Texas, was contracted to develop and validate procedures and metrics to evaluate current and future detection, suppression, and exterior fire-hardening technologies that could prevent or delay fire penetration into the passenger compartment of a motorcoach and thereby increase passenger evacuation time.[86]

Fire suppression systems installed in the engine compartment work to suppress engine fires by detecting fire and releasing fire-suppressant chemicals into the engine area. The systems automatically intervene, without driver action, and are especially important if a driver is incapacitated by a crash. If the Oakland school bus had been equipped with such a system, the system most likely would have slowed or stopped the growth and spread of the fire and its progression into the passenger compartment. SwRI tested currently available fire suppression systems for motorcoaches that can be installed in school buses, either at the time of manufacture or in later retrofitting, to prevent or delay fire penetration into the passenger compartment.

MAP-21, while directed at motorcoach fire safety, helped pave the way for the testing of fire suppression systems that have been shown to prevent or mitigate the spread of fire into a passenger compartment and that are now widely available and already installed in school buses. The 2016 Volpe report, along with school bus fires reported by the school bus transportation industry, proves that the largest percentage of school bus fires originate in the engine compartment. Motorcoach and other commercial bus manufacturers have already made AFSSs standard

[85] Section 32704(a) of MAP-21, Public Law 112-141 (July 6, 2012), directed the Secretary of the US Department of Transportation to "conduct research and testing to determine the most prevalent causes of motorcoach fires and the best methods to prevent such fires and to mitigate the effect of such fires, both inside and outside the motorcoach." Research and testing were to include automatic fire suppression systems.

[86] SwRI developed objective tests, methods, and metrics for analyzing engine compartment fire detection and suppression/extinguishment systems and the flammability/fire-hardening of exterior materials between the wheel well and the passenger compartment.

equipment on buses equipped with wheelchair lifts, while some states, such as Florida, Georgia, Pennsylvania, and New York, require fire suppression systems for paratransit buses.[87]

Not only are AFSSs being installed in commercial passenger buses, but school bus manufacturers are installing the systems today, school districts are implementing them in their fleets, and many states permit the installation of the systems as optional equipment in school buses (with established minimum specifications for the systems often adopted directly from the NSTSPs).[88] Florida, Georgia, Pennsylvania, and New York require fire suppression systems for all school buses used to transport special-needs passengers, and most states also require fire suppression systems for AFV school buses.[89] Moreover, private school bus transportation contractors are including the systems in buses operated under state transportation contracts. For example, National Express, which owns and operates tens of thousands of buses in this country and abroad, signed a contract in 2017 with a manufacturer to install fire suppression systems in all its new buses. AFSSs are already in use throughout the country and are available for installation today. The NTSB concludes that a fire suppression system in the engine compartment could have prevented the fire from spreading into the passenger compartment.

### 2.4.3 Fire-Resistant Materials

FMVSS 302 (refer to section 1.8) specifies the fire-resistance requirements for materials used in the occupant compartments of motor vehicles, including school buses. The standard is intended to reduce deaths and injuries caused by vehicle fires. However, flammability testing under FMVSS 302 uses a small-scale fire to represent a fire originating in the passenger compartment from sources such as matches or cigarettes. The test thus does not represent the most common causes of school bus fires, most of which begin in the engine and can ignite after a crash. The NTSB found that the standard is outdated. NHTSA has yet to publish its research regarding improvements for test procedures to evaluate the flammability of interior materials. The current standard for school buses remains less stringent than the flammability standards applied in other modes of transportation under US Department of Transportation safety oversight, such as aviation and rail.

Combustible polymers, plastics, and fabrics are the first materials to ignite in a vehicle fire, have high heat release rates, and produce high levels of toxic gas—all of which greatly increase the fire hazard (Patronik 2008; Tewarson, Quintiere, and Purser 2005). The NTSB has stated in previous investigations that in addition to real-world ignition sources, an adequate safety standard for the flammability of interior materials should take into account materials that represent the main fire load in current vehicle design. A flammability standard for materials used in high-occupancy passenger vehicles such as school buses should include a wide spectrum of fire performance properties, including heat release rate, smoke production, ignition resistance, and the tendency to

[87] See 2011 article on improving the fire safety of buses and coaches published in *Metro* magazine (accessed June 26, 2019).

[88] See 2018 article in *School Bus Fleet* about need for measures to prevent school bus fires (accessed June 26, 2019).

[89] See *Metro* magazine article cited above.

form flaming droplets. The 2009 NIST test found that motorcoach interior materials designed to meet FMVSS 302 do not meet the more stringent FAA and FRA requirements (such as vertical burn rate, heat release, and smoke density) and that in a motorcoach fire, the time from fire penetration to untenable conditions in the vehicle interior was from 5 to 9 minutes (Huczek and Blais 2015; Johnsson and Yang 2012).[90] The same can be said of school bus interiors that meet FMVSS 302. Combustible materials in the interior of a school bus, including the foam in the seats, might pass FMVSS 302 when tested in a horizontal position. However, the rate at which flame spreads greatly increases when the materials are installed vertically, such as in seatbacks (Briggs and Hunter 2004; NFPA 2016; Spearpoint and others 2005; Hirschler and others 2007).

As the NTSB stated in its report on the 2014 motorcoach fire in Orland, California (NTSB 2015), an upgraded FMVSS flammability standard must consider real-world ignition scenarios and vehicle design and construction. The American Public Transportation Association—which represents the bus, rapid transit, and commuter rail industries—publishes a buying guide that specifies fire safety features for all new transit buses, including fire-detection systems, firewalls, and fire-retardant/low-smoke materials for passenger-compartment and insulation materials. Volpe's 2009 report concluded that the federal safety standards for commercial passenger vehicles (including school buses) pertaining to the flammability of interior components should meet the standards for other commercial passenger transport modes, such as aircraft, railcars, and transit buses (Meltzer, Ayers, and Truong 2009).[91]

The NSTSP flammability standards set a maximum burn rate for floor coverings and use the fire block test for seat upholstery in school buses (see appendix C). The fire block test requires that the time from ignition to flameout (extinguishment) should be less than 8 minutes, that the flame should not spread from seat to seat, and that the weight loss of the seat from a fire should not exceed 10 percent of the pretest padding and upholstery. However, as has been seen in recent school bus fires (including the one in Oakland) and in demonstration fires, smoke can overwhelm most of a school bus from a flame at the front loading door in less than 2 minutes. In addition, the toxic gases produced in a fire by a typical vinyl seat and cushion can spread quickly.

The initiating events of school bus fires include component overheating, electrical system malfunctions, engine compartment leaks, and collisions, such as in the rollover crash in Mesquite, Texas. Regardless of how a fire starts, the longer vehicle construction materials can impede the spread of flames into and through the passenger compartment, the better the chance that the occupants will survive. In its report on the fire that consumed a church activity bus (a school bus) in Carrollton, Kentucky, the NTSB stated its concern about the flammability and toxicity of materials in school bus interiors (NTSB 1989). Although the seats in the Carrollton bus complied with FMVSS 302, the materials used in the seats were sufficiently flammable to allow the fire to spread rapidly throughout the vehicle. Those fatally injured died as a result of smoke inhalation, not from injuries sustained in the bus's crash with a pickup truck. Thirty years later, the NTSB is

[90] Human tenability limits (in fires) are exceeded when exposure conditions are such that occupants can no longer save themselves (Purser 2016).

[91] See (a) 49 CFR 25.853, Airworthiness Standard for Flammability of Seat Cushions; (b) 49 CFR 238.103, Fire Safety, Flammability, and Smoke Emission Tests; and (c) *Federal Register* 58, no. 201 (October 20, 1993): 54250.

still addressing the applicability of FMVSS 302 to the interior of school buses to prevent the rapid spread of fire and smoke.

The NTSB found during the Oakland investigation that small penetrations through the firewall (although sealed according to school bus specifications) were not blocked with fire-resistant material.[92] More important, the firewall did not prevent the spread of fire from the engine compartment because the engine block's penetration into the passenger compartment was covered only in fiberglass cowling that provided no fire protection or containment and acted as fuel load.

In aviation, federal regulations require that the "design and construction of the engine and materials used must minimize the probability of the occurrence and spread of fire during normal operation and failure conditions, and must minimize the effect of such a fire" (14 CFR 33.17[a]). The regulations also require that an aircraft engine component that acts as a firewall must be (1) fireproof and (2) constructed so that no hazardous quantity of air, fluid, or flame can pass around or through the firewall.[93] The intent of the regulation is that the firewall will "contain, isolate, and withstand a fire" as well as "prevent any source of flammable material from feeding an existing fire," so that the firewall will protect the occupants from an engine fire long enough to carry out an emergency evacuation of the aircraft.

In the Oakland fire, penetrations from the engine compartment created a firewall gap and a direct pathway for the fire to enter the passenger area. The NTSB concludes that the lack of a complete firewall between the school bus engine compartment and the passenger compartment led to the rapid spread of superheated gases, smoke, and fire into the passenger compartment; and the interior components of the bus were flammable when exposed to ignition sources greater than those used in tests under FMVSS 302 and in fire block tests.

### 2.4.4 Safety Recommendations

FMVSS 302 applies to all vehicles, regardless of the number of passengers and the time needed for egress in a fire. However, the FMVSS 302 performance tests cannot predict a material's fire performance (combustion behavior) when exposed to a large ignition source, such as a fire propagating from the engine compartment. To increase the likelihood of passenger survivability and delay flashovers (fire rapidly spreading across a gap), requirements are needed for the

[92] As noted earlier, Iowa's requirements for school buses specify only that firewall penetrations be sealed.

[93] In July 2002, the FAA issued Advisory Circular 33.17-1A, setting forth acceptable methods of complying with the requirements of 14 CFR Part 33. If a component's primary function is that of a firewall, the circular states: "Acceptable evidence that the fire is contained would be if the firewall component does not develop a burn through hole, does not fail at any attachment or fire seal point around its periphery, does not cause backside ignition and does not continue to burn after the test flame is removed." *Hazardous quantity* is defined as "an amount of flammable liquid, vapor or other material which could sustain a fire of sufficient severity and duration to significantly increase the overall fire hazard or result in a hazardous condition." *Hazardous condition* is defined as "any hazardous engine effect listed in 14 CFR 33.75(g)(2), or any other result of exposure to fire which would prevent the continued safe operation or shutdown of the engine."

flammability and smoke-emitting properties of the materials used in high-occupancy commercial passenger vehicles, including school buses.

The NTSB (2015) has found that the current criteria for testing the flammability and smoke emissions of the materials used in the interiors of motor vehicles are inadequate, and that significant upgrades of FMVSS 302 are needed to improve the safety of today's high-occupancy commercial passenger vehicles, including school buses. The standard should establish a more stringent set of flammability requirements to reduce the propagation of passenger compartment fires and permit longer evacuation times. As a result of previous investigations, the NTSB has issued recommendations aimed at identifying a means of increasing postcrash occupant survivability, such as the use of fire-retardant materials that can extend the time available for escaping a vehicle. In aviation, for example, NTSB recommendations have led to improvements in postcrash occupant protection (NTSB 2001).

FMVSS 302 is outdated and less stringent than the flammability standards applied in other modes of transportation under US Department of Transportation oversight, such as aviation and rail (NIST 2012). Just as in airplane and passenger train fires, the danger to school bus passengers is not limited to exposure to flames. The side effects of a fire, such as inhaling products of combustion, can be equally deadly. In its report on the motorcoach fire in Orland, California, the NTSB concluded that FMVSS 302 does not adequately account for modern vehicle interior components or conditions experienced in real-world vehicle fires, nor does it include specific fire-resistant material standards appropriate for large commercial vehicles (NTSB 2015). As a result, the NTSB made the following recommendation to NHTSA:

> Revise FMVSS 302 to adopt the more rigorous performance standards for interior flammability and smoke emissions characteristics already in use throughout the US Department of Transportation for commercial aviation and rail passenger transportation. (H-15-12)

Safety Recommendation H-15-12 is currently in "Open—Acceptable Response" status. NHTSA reported to the NTSB in December 2015 that it "was evaluating standards already in use in other transportation modes, such as commercial aviation and rail passenger transportation," and that it intended to "initiate a new research project to inform our decision to upgrade FMVSS No. 302. Components of that research will include vehicle interior material flammability and smoke emissions characteristics." Then in 2017, NHTSA publicly announced that a research effort titled *Test Procedures for Evaluating Flammability of Interior Materials* was under way and that final results were expected to be published in June 2018. The NHTSA announcement included a work plan to also consider supplementary methods specific to school buses. No results have yet been published. The NTSB concludes that the Oakland fire, along with other school bus fires reported nationally and as shown in school bus fire demonstrations, illustrates that once a school bus compartment is breached (even when an exterior fire enters the bus), a fire spreads quickly, and smoke, toxic gases, and heat make the interior untenable for occupancy.

As part of its 2017 research effort, NHTSA contracted with SwRI to perform testing. SwRI presented its findings to date at the SAE International Government Industry Meeting in

Washington, DC, in April 2019.[94] SwRI reported that it had used the microscale combustion calorimeter (MCC) to test 29 materials used in motor vehicle interiors, motorcoach interiors, and school bus seats; thin materials were also included to test at least one that would fail FMVSS 302 (manila file folder cardboard).[95] The materials were tested using both FMVSS 302 and ASTM standard D7309.[96]

SwRI reported that its statistical analysis "showed that failure in the FMVSS 302 test can be predicted based on two MCC parameters and specimen thickness and density." SwRI had established an equivalent MCC pass/fail criteria along with an alternative criterion, independent of thickness. SwRI stated that work is in progress to address challenges with the MCC method and to develop a laboratory procedure. SwRI is expected to present additional information at the Interflam conference in July 2019.[97] The NTSB is closely following SwRI's work as well as NHTSA's progress with Safety Recommendation H-15-12, and reiterates Safety Recommendation H-15-12 to NHTSA.

Engine fire suppression systems or mitigation through fire-resistant materials offers large safety benefits in helping prevent unnecessary death or injury from bus fires, as the NTSB has addressed in previous reports and recommendations. Even without a fire suppression system, had the Oakland school bus been equipped with a complete firewall or with fire-resistant materials between the engine and the passenger compartment, the spread of fire and smoke into the bus's interior would have been reduced or slowed. Exposure of the occupants to smoke and heated gas would have lessened, and the time available to evacuate the bus would have increased. As a result, the two fatalities might have been prevented.

Therefore, the NTSB recommends that NHTSA require all new school buses to be equipped with fire suppression systems that at a minimum address engine fires. The NTSB further recommends that the US Department of Transportation require in-service school buses to be equipped with fire suppression systems that at a minimum address engine fires. Firewalls should act as complete protective barriers in the event of a fire. The NTSB therefore recommends that NHTSA develop standards for newly manufactured school buses, especially those with engines that extend beyond the firewall, to ensure that no hazardous quantity of gas or flame can pass through the firewall from the engine compartment to the passenger compartment.

It will take time to enact FMVSS regulations requiring fire suppression systems on school buses and enhancements to barriers between passenger compartments and the engines. But school bus manufacturers can take action on these safety improvements now. Therefore, the NTSB

[94] According to the SwRI website (accessed June 26, 2019), a material flammability group in the Fire Technology Department performs tests to evaluate the ignition, flame spread, heat release rate, smoke production rate, and toxic potency characteristics of materials and assemblies.

[95] The tested materials were 10 motor vehicle interior materials; 8 motorcoach interior materials; 6 school bus seat materials; and 5 thin materials.

[96] ASTM standard D7309 is the standard test method for determining flammability characteristics of plastics and other solid materials using microscale combustion calorimetry. ASTM International, formerly the American Society for Testing and Materials, develops and publishes technical standards for a wide range of materials.

[97] The Interflam conference is an international conference and exhibition on fire science and engineering. For more information, see the Interflam conference website (accessed June 26, 2019).

recommends that as standard equipment on all newly manufactured school buses, Blue Bird Corporation, Collins Industries, Inc., IC Bus, Starcraft Bus, Thomas Built Buses, Trans Tech, and Van-Con, Inc., install fire suppression systems that at a minimum address engine fires.

To achieve a higher level of firewall protection, school bus manufacturers need to prevent the spread of fire through sealed openings that have no fire resistance, as well as make fireproof school buses that have an engine that extends through the firewall into the passenger compartment. Any opening or penetration of the engine firewall could be sealed with close-fitting, fireproof grommets or bushings, or be coated with or use fire-resistant materials. The NTSB therefore recommends that Blue Bird Corporation, Collins Industries, Inc., IC Bus, Starcraft Bus, Thomas Built Buses, Trans Tech, and Van-Con, Inc., ensure that, for any opening or penetration of the engine firewall, no hazardous quantity of gas or flame can pass through the firewall from the engine compartment to the passenger compartment in newly manufactured school buses.

## 2.5 School Bus Emergency Training

A critical component of school bus safety is emergency training of school bus drivers and passengers and emergency drills involving both drivers and students. Proper response in an emergency depends on the quality of training, the types of drills (which should supplement classroom instruction), and the frequency of refresher training and drills.

### 2.5.1 Drivers

The state of Iowa oversees the licensing and training of school bus drivers, with training requirements set by the IDOE. The Oakland driver, who was hired in 1999, received 12 hours of new-driver training. He then received 3 hours of in-service refresher training every year from 2000 through 2017. The RCSD requires school bus evacuation training for students twice a year. Some bus drivers told investigators that the emergency training was done. However, the RCSD has no records of the training, nor is the district required to record or report completion of the training to the IDOE. Before the Oakland fire, the RCSD transportation supervisor stated that the evacuation training of students was performed by any bus driver available that day. RCSD high school students were considered to have received the training through elementary and middle school. After the ninth grade, they were not given refresher training or drills on how to evacuate a school bus.

Proper training with consistent practice helps prevent a poor or panicked response in an emergency. The driver delayed the response to the emergency situation by using the radio to call the bus maintenance facility for help, rather than alerting emergency responders directly by pushing the radio's 911 button. Although the driver reported that the bus was stuck in a ditch, gave the bus's location, and stated that a fire had started, no call was made to 911 until the Riverside Elementary School secretary reported the fire to the Pottawattamie County Communications Center dispatcher minutes later. The Iowa school bus driver handbook specifically instructs drivers that if any part of a school bus is on fire, it should be evacuated immediately. It could not be determined during the investigation whether, after the fire began in the engine compartment and before he used the radio to report the fire, the driver attempted to evacuate himself or the passenger, as instructed by the handbook. What is known is that the driver did not, and most likely could not, get out of his seat to evacuate the bus during the emergency—indicating the severity of his immobility when the fire began.

Had the driver used the 911 button to contact emergency services rather than reporting his situation to the RCSD bus barn, dispatch of emergency services would probably have been immediate. Pushing the 911 button would have switched the driver directly to an emergency dispatcher at the county communications center. First responders did not delay once they received the 911 call. However, an estimated 7 minutes elapsed between the call to the bus maintenance lot and the call to 911. First came the driver's radio call to the supervisor, then the call from the supervisor to the school secretary, then the calls to the bus passenger's uncle (another bus driver) and from the uncle to the passenger's mother, and finally the call to 911 from the school secretary.

The NTSB recognizes that the fire was in a rural location and at a distance from the nearest fire department. The fire department arrived on scene 21 minutes after it was dispatched, but even if they had been notified earlier, the firefighters most likely would not have reached the burning bus in time to save the lives of the occupants. However, timely notification of emergency responders is critical when dealing with vehicle fires, and continued refresher training can remind school bus drivers that their emergency radio will call 911 directly. The NTSB concludes that the school bus driver's decision to use the radio to call the bus transportation supervisor instead of activating the 911 emergency button delayed notification to emergency responders.

### 2.5.2 Passengers

Research has shown that under the stress of an evacuation, passengers do not always use the most appropriate exit. Passengers in emergency situations are less able to cope with new equipment and information if it is not intuitive or does not match their expectations. Their natural inclination is to leave by the exits they recognize, such as the loading door at the front of a bus (ICE Ergonomics Ltd. 1996). Training in school bus evacuation teaches students to use the front loading door as their first option in an emergency. As described in section 1.5.5, opening a manually operated door requires several steps and up to 25 pounds of force. A student who is not trained in the procedure might not be able to open the door in an emergency without driver assistance. If a driver is incapacitated or unable to open a manual door, it is important to prepare students for evacuation through any available exit. No obstructions to the front door of the Oakland bus were found postfire, and the driver had used the door to load the passenger minutes before.

To achieve safe and effective evacuation with minimal panic, passengers must have a basic understanding of how the exits function, especially given that they might have to use them in poor lighting (it was still dark outside in the Oakland fire) or in smoke-filled environments. Nationally (as discussed in section 1.4.3), NHTSA's HSPG 17, along with the NSTSPs, advises school transportation providers to train students on how to operate all emergency exits, which include the front door. The emergency evacuation training given and the drills practiced by the RCSD before the Oakland fire did not include how to operate the manual release on the front door in the event of driver incapacitation, despite the front door being the often-used first means of egress from a school bus.[98]

The NTSB has previously addressed the training of school bus passengers for emergency egress, as well as training on the use of all available exits. A safety issue identified in the NTSB's investigation of a 2001 school bus crash in Omaha, Nebraska, was the lack of emergency preparedness of the students in the bus (NTSB 2004).

On Saturday, October 13, 2001, about 2:00 p.m. central daylight time, a school bus carrying 27 Seward High School students and 3 adults (excluding the driver) was traveling west through a work zone on US Route 6 in Omaha. As the bus entered the work zone lane shift at the approach to a bridge, it encountered an eastbound motorcoach carrying Norfolk High School students. Although the buses did not collide, the westbound bus departed the roadway to the right and struck a W-beam barrier on the approach to the bridge, steered momentarily to the left, then steered abruptly back to the right, striking the W-beam again and, finally, striking a three-rail barrier between the guardrail and the concrete bridge railing. The bus passed through the remains of the barrier, rode up onto the bridge's sidewall, and rolled 270 degrees clockwise as it fell about 49 feet, landing on its left side in a 1-foot-deep creek below the bridge. Three students and one adult sustained fatal injuries. The remaining passengers and the bus driver sustained injuries ranging from serious to minor.

Although federal and Nebraska state laws require twice-yearly school bus evacuation drills for all students who ride school buses, very few of the students on the accident bus had received such training.[99] The circumstances of the Omaha crash demonstrated that pretrip safety information can be critically important for students who ride buses sporadically, since they may be less familiar with a bus's general layout and escape routes than regular riders. The NTSB concluded that had the Seward School District conducted emergency evacuation drills for all students, the passengers' ability to open emergency exits and evacuate the vehicle in an emergency would have been greatly improved.

After the Oakland fire, the RCSD made significant changes to its evacuation training program. School bus evacuation training is now recorded for all RCSD school buildings. The evacuation training is now given to students at all age levels twice a year. The classroom part of the training instructs students about exits and how to operate them, including a manual-release front door. All students also learn to operate the exits during the second part of the training, which consists of evacuation drills after a classroom presentation. The NTSB concludes that emergency training, including training on how to conduct emergency drills with students, is a vital safety exercise that should be incorporated into the annual training curriculum for school bus drivers. The

[98] As noted earlier in the report, safety features on the door release handle must be manipulated or overcome before the front door can be opened. The safeguards were put in place to prevent the inadvertent or deliberate opening of the front loading door while a school bus is in motion. Without proper use of the manual door release, the front door will not open.

[99] NTSB interviews with student passengers revealed that only one student had received school bus emergency evacuation training while in high school and that only four students had received any form of training in school bus emergency evacuation in either elementary or middle school. According to the Seward School District's transportation supervisor, although two evacuation drills were conducted each school year, none of the accident bus's passengers had received such training because most rode buses only for special events.

NTSB also concludes that despite the front loading door being the often-used first means of egress, students might not be trained in how to evacuate through a manually operated loading door if their driver becomes incapacitated.

### 2.5.3 Safety Recommendations

In addition to other training that is required by federal, state, and local regulations, RCSD bus drivers undergo internal training to familiarize them with their specific duties and the school bus systems. The onboard radio system, which communicates with the Pottawattamie County Communications Center, is equipped with an emergency 911 button that when pushed, immediately alerts the communication center and allows the driver to speak directly to a 911 dispatcher, hands free. However, the training is not standardized, and not all drivers have been trained to use the radio's emergency 911 button.

The NTSB recommends that the state of Iowa educate its school districts on the circumstances of the Oakland school bus crash and fire, and provide guidelines to drivers on how to present thorough evacuation training to students; require twice-yearly documented school bus evacuation training and drills (including showing students how to open a manually operated loading door); and verify that training is available to all potential bus passengers, including students, teachers, and other school district employees who might act as chaperones or substitute school bus drivers. In addition, the NTSB recommends that the RCSD, during its annual school bus driver training, advise drivers on how to use the onboard 911 button in the event of an emergency.

Furthermore, according to school bus manufacturers contacted by the NTSB, in the last 15 years, over 70,000 school buses were manufactured equipped with a manual control on the front loading door. Those buses are still in production. Therefore, the NTSB recommends that the NASDPTS, the NAPT, and the NSTA recommend that their members verify that students are educated on how to operate the manual-release handle for front loading doors on school buses during evacuation training and drills.

# 3 Conclusions

## 3.1 Findings

1. None of the following were factors in the crash: (1) school bus mechanical condition; (2) driver licensing, experience, alcohol or other illicit drug impairment, fatigue, or distraction; (3) roadway design or conditions; and (4) weather conditions.

2. The emergency response to the crash and fire by local fire departments and law enforcement was adequate and timely.

3. The driver failed to control the school bus and prevent the run-off-road crash for reasons that cannot be determined from the available information.

4. The likely origin of the fire was the exterior of the turbocharger in the engine compartment.

5. The blocked exhaust pipe, resulting in turbocharger overload with significant heat output during repeated engine acceleration, was the primary contributing factor to the initiation of the fire.

6. Fluids in the engine compartment fueled the fire, but the initial fuel source could not be determined because of the extensive damage to the engine compartment.

7. The passenger was possibly attempting to assist the school bus driver, whose limited mobility due to medical conditions might have prevented him from evacuating the bus, and she did not perceive the immediate danger before being overcome by smoke and superheated gases as a result of the fire.

8. Although the school bus driver had progressive chronic pain and stable mild right dorsal flexion leg weakness, there was no evidence that the driver's back pain or leg weakness or other medical conditions and medications, including the drug gabapentin, would have affected his ability to perform the driving functions required (while sitting) to operate the school bus.

9. It is likely that the bus driver's progressive chronic back disease, which caused severe chronic pain, impaired his ability to evacuate the school bus himself or to assist the passenger to evacuate.

10. The use of physical performance tests on both a routine and an as-needed basis can help identify physically unfit drivers who have a valid medical certificate but who might not be able to perform required safety duties, especially in an emergency.

11. If the Riverside Community School District had adhered to the requirements of its transportation policy regarding the physical abilities of school bus drivers and had not allowed the accident driver to operate a bus until he was medically cleared and fit for duty (or could pass a physical performance test), the fatal outcome of what should have been a survivable run-off-road, low-speed crash might have been avoided.

12. The Riverside Community School District exercised poor oversight of driver safety by allowing a driver with known, significantly limited mobility to operate a school bus and by not removing a driver from duty who was unable to perform required safety duties.

13. Awareness training for Iowa school district personnel, including but not limited to bus drivers, transportation directors, supervisors, and superintendents, would increase awareness of the federal and state regulations regarding commercial driver fitness and the avenues available for reporting drivers who have medical conditions that might make it unsafe for them to operate a school bus.

14. A fire suppression system in the engine compartment could have prevented the fire from spreading into the passenger compartment.

15. The lack of a complete firewall between the school bus engine compartment and the passenger compartment led to the rapid spread of superheated gases, smoke, and fire into the passenger compartment; and the interior components of the bus were flammable when exposed to ignition sources greater than those used in tests under Federal Motor Vehicle Safety Standard 302 and in fire block tests.

16. The Oakland, Iowa, fire, along with other school bus fires reported nationally and as shown in school bus fire demonstrations, illustrates that once a school bus compartment is breached (even when an exterior fire enters the bus), a fire spreads quickly, and smoke, toxic gases, and heat make the interior untenable for occupancy.

17. The school bus driver's decision to use the radio to call the bus transportation supervisor instead of activating the 911 emergency button delayed notification to emergency responders.

18. Emergency training, including training on how to conduct emergency drills with students, is a vital safety exercise that should be incorporated into the annual training curriculum for school bus drivers.

19. Despite the front loading door being the often-used first means of egress, students might not be trained in how to evacuate through a manually operated loading door if their driver becomes incapacitated.

## 3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the fatal school bus run-off-road and fire in Oakland, Iowa, was (1) the driver's failure to control the bus, backing it into a roadside ditch for reasons that could not be established; and (2) the failure of the Riverside Community School District to provide adequate oversight by allowing a driver to operate a school bus with a known physical impairment that limited his ability to perform emergency duties. The probable cause of the fire was ignition of a fuel source on the exterior of the engine's turbocharger due to turbocharger overload and heat production, resulting from the blockage of the exhaust pipe by the bus's position in the ditch and the driver's attempts to accelerate out of the ditch. Contributing to the severity of the fire was the spread of flames, heat, and toxic gases from the engine into the passenger compartment through an incomplete firewall.

# 4 Recommendations

## 4.1 New Recommendations

As a result of its investigation, the National Transportation Safety Board makes the following new safety recommendations.

**To the US Department of Transportation:**

> Require in-service school buses to be equipped with fire suppression systems that at a minimum address engine fires. (H-19-3)

**To the National Highway Traffic Safety Administration:**

> Require all new school buses to be equipped with fire suppression systems that at a minimum address engine fires. (H-19-4)

> Develop standards for newly manufactured school buses, especially those with engines that extend beyond the firewall, to ensure that no hazardous quantity of gas or flame can pass through the firewall from the engine compartment to the passenger compartment. (H-19-5)

**To the states of Alabama, Alaska, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Hawaii, Idaho, Illinois, Iowa, Kansas, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Dakota, Tennessee, Texas, Utah, Vermont, Washington, Wisconsin, and Wyoming; the commonwealths of Kentucky, Massachusetts, Pennsylvania, and Virginia; the District of Columbia; and the territory of Puerto Rico:**

> Revise your school bus driver requirements so that all drivers must pass a physical performance test on hiring and at least annually, and also whenever a driver's physical condition changes in a manner that could affect his or her ability to physically perform school bus driver duties, including helping passengers evacuate a bus in an emergency. (H-19-6)

**To the state of Iowa:**

> Inform your school districts of the circumstances of the Oakland school bus crash and fire and the lessons learned from the investigation, and publicize to your staff the methods available for individually reporting school bus drivers who have medical conditions that might affect their ability to safely operate a school bus. (H-19-7)

> Educate your school districts on the circumstances of the Oakland school bus crash and fire, and provide guidelines to drivers on how to present thorough evacuation

training to students; require twice-yearly documented school bus evacuation training and drills (including showing students how to open a manually operated loading door); and verify that training is available to all potential bus passengers, including students, teachers, and other school district employees who might act as chaperones or substitute school bus drivers. (H-19-8)

**To the Riverside Community School District:**

During your annual school bus driver training, advise drivers on how to use the onboard 911 button in the event of an emergency. (H-19-9)

**To the National Association of State Directors of Pupil Transportation Services, National Association for Pupil Transportation, and National School Transportation Association:**

Recommend that your members verify that students are educated on how to operate the manual-release handle for front loading doors on school buses during evacuation training and drills. (H-19-10)

**To Blue Bird Corporation, Collins Industries, Inc., IC Bus, Starcraft Bus, Thomas Built Buses, Inc., Trans Tech, and Van-Con, Inc.:**

As standard equipment on all newly manufactured school buses, install fire suppression systems that at a minimum address engine fires. (H-19-11)

Ensure that, for any opening or penetration of the engine firewall, no hazardous quantity of gas or flame can pass through the firewall from the engine compartment to the passenger compartment in newly manufactured school buses. (H-19-12)

## 4.2 Previously Issued Recommendation Reiterated in This Report

The National Transportation Safety Board reiterates the following safety recommendation in section 2.4.4 of this report.

**To the National Highway Traffic Safety Administration:**

Revise Federal Motor Vehicle Safety Standard 302 to adopt the more rigorous performance standards for interior flammability and smoke emissions characteristics already in use throughout the US Department of Transportation for commercial aviation and rail passenger transportation. (H-15-12)

## 4.3 Previously Issued Recommendation Reclassified in This Report

**To the National Association of State Directors of Pupil Transportation Services, National Association for Pupil Transportation, National School Transportation Association, American School Bus Council, and Maryland School Bus Contractors Association:**

> Inform your members of the circumstances of the Baltimore school bus crash and lessons learned from the crash investigation to help raise awareness of the avenues available to report school bus drivers with medical conditions that may make it unsafe for them to operate a school bus. (H-18-16)

For the National Association of State Directors of Pupil Transportation Services, the National Association for Pupil Transportation, and the National School Transportation Association, Safety Recommendation H-18-16 is reclassified from “Open—Initial Response Received” to “Closed—Acceptable Action” in section 2.3.5 of this report.

## BY THE NATIONAL TRANSPORTATION SAFETY BOARD

**ROBERT L. SUMWALT, III**
Chairman

**EARL F. WEENER**
Member

**BRUCE LANDSBERG**
Vice Chairman

**JENNIFER HOMENDY**
Member

**Adopted: June 18, 2019**

# Board Member Statements

**Chairman Robert L. Sumwalt, III, filed the following concurring statement on June 21, 2019.**

In drafting a Probable Cause statement for this accident, the easiest thing in the world would have been to simply cite the 74-year-old driver as the sole cause. After all, he backed the bus into the ditch, which set off a series of tragic events, resulting in a loss of two precious lives—including his own. While the driver may have erred in his actions, he should have never been put in the position of driving with the physical impairment he was experiencing at the time of the accident.

The Riverside Community School District had the responsibility to ensure that its school bus drivers were medically fit to drive. For reasons that cannot be explained, however, the school district abandoned its practice of requiring physical performance tests for bus drivers, years before this tragedy. Furthermore, it failed to adhere to its own transportation policy by allowing a driver with a physical impairment to drive this school bus.

For these reasons, the Board amended the Probable Cause to cite the Riverside Community School District's failure "to provide adequate oversight by allowing a driver to operate a school bus with a known physical impairment that limited his ability to perform emergency duties."

The failure of school districts to provide proper oversight of their drivers is not an isolated problem. The Board noted similar oversight shortcomings in our Special Investigation Report, *Selective Issues in School Bus Transportation Safety: Crashes in Baltimore, Maryland, and Chattanooga, Tennessee*.

School districts and those who operate school buses should take notice—you have an obligation to provide oversight by keeping medically unfit drivers off the roads. To do anything less jeopardizes the safety of the students who entrust their lives to you. Lives depend on it.

**Vice Chairman Bruce Landsberg, Member Earl F. Weener, and Member Jennifer Homendy joined in this statement.**

**Member Earl F. Weener filed the following concurring statement on June 25, 2019.**

When asked to explain our mission, the Board often answers that while our investigations find cause and recommend changes to improve safety, we neither assign fault nor lay blame. In truth, the NTSB benefits from perspective afforded through a year-long investigation by the top experts in their fields and decades of multi-modal safety experience.

In this case, many people were involved and, prior to the tragic events that unfolded the day of the bus accident and fire, those people were likely working hard to serve their communities. Every day drivers show up for work, concerned that students make it to school to receive an education. Employers manage well-liked, trusted employees, some of whom may have health issues. Doctors treat patients, trying to make sure they have the best quality of life. None of these people had ill intent.

The point of this report, and many before it, is that we *all* should consider the broader, safety implications of our actions. Drivers, particularly professional drivers, are responsible for the impact their health may have on their ability to perform every aspect of their jobs. Doctors are responsible to the community in which their patients who operate vehicles work, particularly when that work involves commercial vehicles and school buses. And, schools are responsible not only for educating their students, but for their safety.

The NTSB is responsible for making sure that we learn from tragedy so that we can avoid such terrible loss ever happening again. In this spirit, I concur with this report and its findings. Not only can this school district and community benefit from our recommendations, but other communities can also read and consider this report. Safety is everyone's responsibility and simple, well-meaning choices can have devastating, unintended consequences. By explicitly considering potential, broader safety consequences, we can all make better decisions, improve outcomes, and help make sure that everyone makes it home.

**Chairman Robert L. Sumwalt, III, Vice Chairman Bruce Landsberg, and Member Jennifer Homendy joined in this statement.**

# Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified of the Oakland, Iowa, school bus run-off-road and fire on December 12, 2017, and dispatched an investigative team to the site. The NTSB established groups to investigate human performance; motor carrier operations; and highway, survival, and vehicle factors.

Parties to the investigation were the Pottawattamie County Sheriff's Office, the Pottawattamie County Secondary Roads Department, the Iowa Department of Education, the Riverside Community School District, and Navistar, Inc.

# Appendix B: Driver Medical Examination History

Investigators could not locate medical documentation for the driver from 2007. In 2015, the driver was certified for only 1 year because of hypertension and diabetes. In 2016, the driver was certified for 1 year because of hypertension. Previous to his medical examination in 2017, shown in table B, the driver reported a history of hypertension in 2009, 2015, and 2016, but did not report the condition in 2011, 2013, or 2017. He reported a history of diabetes in 2015 and 2016 but not in 2017.

**Table B.** Driver medical certification and self-reporting history, 2005 to 2017.

| Item | 2005 | 2009 | 2011 | 2013 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **Condition** | | | | | | | |
| Hypertension | | X | | | X | X | |
| Diabetes | | | | | X | X | |
| Hypercholesterolemia | | | | | | X | X |
| Cataracts | | | | | | | X |
| **Medication** | | | | | | | |
| Simvastatin | | | | X | X | X | X |
| Gabapentin | | | | X | X | | |
| Lisinopril | | | | X | X | X | |
| Wellbutrin | | | | X | X | | |
| Lortab | | | | | X | | |
| Metformin | | | | | X | X | |
| **Years certified** | 2 | 2 | 2 | 2 | 1 | 1 | 2 |

# Appendix C: Fire Block Test

## Iowa Administrative Code

In July 2014, changes to Iowa's school bus specifications in the state's "Minimum Specifications for Construction of School Transportation Equipment" (Iowa Administrative Code chapter 44, updated November 2006) included a requirement for fire block upholstery in all seating positions), as follows:

> *44.3 g*. Seats and seat back cushions shall be covered with a material having 42-ounce finished weight, 54-inch width, and finished vinyl coating of 1.06 broken twill or other material with equal tensile strength, tear strength, seam strength, adhesion strength, and resistance to abrasion, cold and flex separation.
>
> *44.3 i*. Passenger seats shall be constructed with materials that enable them to meet the criteria contained in the School Bus Seat Upholstery Fire Block Test specified in the National School Transportation Specifications and Procedures Manual 2010, Central Missouri State University, Humphreys Suite 201, Warrensburg, Missouri 64093. Fire block material, when used, shall include the covering of seat bottoms.

## NSTSP School Bus Seat Upholstery Fire Block Test

The provisions of the NSTSP fire block test are reproduced below, omitting illustrations.

### Test Chamber

**Cross Section**

The suggested test chamber is the same cross section as the bus body in which seats are used with the rear section on each end. If a bus section is not used, the cross section is to be 91+/-1 inch in width x 75 inches +/-3 inches in height. There shall be a door, which does not provide ventilation, in the center of each end of the test chamber. The doors shall be 38+/3 inches in width and 53+3 inches in height and include a latch to keep the doors closed during the test.

**Length**

The length of the test chamber shall allow three rows of seats at the minimum spacing recommended by the installer.

In order that different types of seats may be tested in the same chamber, a length tolerance of plus 45 inches is allowed.

**Ventilation**

One ventilation opening shall be in each end of the test chamber and shall be 325 square inches ±25 square inches. The bottom of the opening shall be 30 inches

±3 inches above the chamber floor. Ventilation openings shall be on the same side of the test chamber.

There shall be no ventilation openings along the length of the test chamber.

A forced-air ventilation system may not be used.

Baffles shall be used to prevent wind from blowing directly into the ventilation openings.

**Camera View Area**

An opening covered with glass shall be provided at the midpoint of the test chamber length for camera viewing. The opening shall allow the camera to view the seat parallel to the seat width.

## Test Sample

The sample shall be a fully-assembled seat.

Record the weight of all padding and upholstery prior to assembly. Record the weight of the fully-assembled seat.

## Ignition Source

A paper grocery bag with dimensions of approximately 7x11x18 inches is used to contain double sheets of newsprint (black print only, approximately 22x28 inches). The total combined weight of bag and newspaper shall be seven ounces ±0.5 ounces.

## Test Procedure

1. Install three seats in the test chamber at minimum spacing, per installer recommendation. Seats shall be perpendicular to the dimension indicated as “length” in Figure 1. Install so that seat frames will not fall during the test. Seat width shall be determined so that maximum passenger capacity per row (two seats) for the seat style shall be tested.
2. For each test, position the ignition source in the following positions.
   - Position A. Position ignition source with 18-inch dimension in contact with the seat cushion and touching the seat back. Center the bag on top of the cushion.
   - Position B. Position the ignition source on the floor behind the seat with 18-inch side resting on the floor and parallel to seat width, centered on width so that the rear of bag does not extend beyond the rear seat back.
   - Position C. Position the ignition source on the floor on the aisle side of the seat with 18-inch dimension on the floor and perpendicular to the seat width touching the seat leg, with centerline of the bag at the center of the seat back.

3. A wooden match shall be used to light the ignition source. Time the test, beginning when the ignition source is on fire and ending when all flames are out.
4. After each ignition source position test, weigh seat assembly, including loose material which has fallen off the seat onto the floor.

## Performance Criteria

For each ignition source position test, the seat tested must meet all of the following criteria. A new seat specimen may be used for each ignition source position test.

1. Maximum time from ignition to flameout shall be 8 minutes.
2. Flame shall not spread to any other seat with the ignition source in Position A and Position C.
3. Weight loss may not exceed 10% of the pretest weight of padding and upholstery. Padding and upholstery may be combined in the form of integrally bonded seat foam.

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