Aviation Investigation Final Report

Location:	Bakersfield, California	**Incident Number:**	WPR19IA030
Date & Time:	November 23, 2018, 17:33 Local	**Registration:**	N781FE
Aircraft:	Cessna 208	**Aircraft Damage:**	None
Defining Event:	Medical event	**Injuries:**	1 Minor
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled		

Analysis

The pilot loaded the cargo onboard the airplane, closed the door, and started the engine with the cabin air vents closed, as it was cold outside. While taxiing the airplane to the run-up area, the pilot became sleepy, had difficulty breathing, and subsequently became unconscious and unresponsive to tower controllers. About 37 minutes after the pilot closed the door of the unvented cockpit, a firefighter responded to the airplane, which was still parked in the run-up area, opened the airplane door, and the pilot regained consciousness. The airplane was not damaged.

The shipper of the boxes had grossly underreported the amount of dry ice contained in the boxes due to an improperly trained employee who had deposited nearly twice the amount of dry ice in each box. Dry ice sublimates into carbon dioxide (CO2), which can lead to loss of consciousness and death at certain exposure levels. Within 5 minutes, the airplane's unvented configuration led to a CO2 concentration that was twice the Federal Aviation Administration and Occupational Safety and Health Administration standards and, within 30 minutes, the concentration reached a level consistent with loss of consciousness.

Based on the CO2 concentrations at the time of the incident, the cause of the pilot's loss of consciousness was CO2 poisoning from the sublimation of dry ice in an unventilated space.

The pilot may still have suffered symptoms from CO2 poisoning and possibly incapacitation had the unventilated cabin been loaded with the dry ice weight that was reported on the label; however, proper ventilation would have decreased the CO2 concentration in the cabin and may have prevented the pilot's loss of consciousness altogether. At the time of the incident, publicly available literature included an advisory circular to pilots flying cargo loads of dry ice to maintain an adequate circulation of fresh air. Despite the availability of this information, the pilot chose to fly the airplane in an unventilated configuration, and the operator did not have any guidance to encourage ventilation, as its policy permitted operation with both the overhead and side vents closed.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be:

The pilot's loss of consciousness while taxiing due to an accumulation of toxic levels of carbon dioxide gas inside the airplane as a result of dry ice sublimation. Also causal was the pilot's decision to fly the airplane in an unventilated configuration, the operator's policy that allowed this configuration, and the shipping company's inadvertent loading of excess dry ice, which exacerbated the concentration of carbon dioxide.

Findings

Personnel issues	Decision making/judgment - Pilot
Personnel issues	Other loss of consciousness - Pilot
Organizational issues	Adequacy of policy/proc - Operator
Organizational issues	Adequacy of policy/proc - Other institution/organization
Organizational issues	(general) - Other institution/organization

Factual Information

History of Flight

Taxi-from runway	Hazardous material leak/spill
Taxi-from runway	Medical event (Defining event)

On November 23, 2018, about 1733 Pacific standard time, the pilot of a Cessna 208B, N781FE, became incapacitated while taxiing near Bakersfield, California. The airline transport pilot received minor injuries and the airplane was not damaged. The airplane was owned by FedEx Corporation and operated by West Air, Inc as a Title *14 Code of Federal Regulations* Part 135 on-demand cargo flight.

According to the pilot, while loading the airplane, he counted a total of 68 boxes, 41 of which displayed labels indicating they contained 2 lbs of dry ice in each box. A FedEx dangerous goods representative approved the shipment but did not check the contents of the boxes nor was he required to. According to the operator's internal policy, a maximum of 168 lbs was permitted in the cabin. The reported dry ice weight furnished by the shipper was within the company’s operating limitations.

After the loading was completed, the pilot finished his paperwork and started the airplane at 1729. While taxing to the runway, he felt "strong sleepiness" accompanied by difficulty breathing. He stopped the airplane at the runway run-up area and closed his eyes.

After the pilot failed to respond to air traffic control for 25 minutes, the tower controller alerted the fire department, and a firefighter illuminated the cockpit and observed the pilot with his head tipped back and his mouth open. The firefighter placed wheel chocks in front of the main landing gear tires and boarded the airplane. Following several unsuccessful attempts to get the pilot's attention, the firefighter administered a sternal rub, which caused the pilot to move. The firefighter engaged the fuel cutoff to shut down the engine and subsequently disengaged the electrical system. During this time, the pilot became more conscious, but his speech was unintelligible. Moments later, the pilot was able to demonstrate to the firefighter that he was coherent by answering a series of questions. The pilot exited the airplane on his own and was transported to the hospital by an ambulance.

The pilot reported that he carried dry ice only on occasion and usually a total of about 10 boxes (also 2 lbs each), located in the back of the airplane at zones 5 or 6. In this incident, the boxes were loaded into zones 1, 2, and 3, located directly behind the cockpit. The pilot did not report any medical conditions or use of medications at the time he was issued his most recent airman medical certificate on January 20, 2018. Several months later, he was diagnosed with and treated for Valley Fever, a fungal lung infection, with the drug fluconazole. The medication is not generally considered cognitively impairing. The pilot stated that he had not experienced any side effects while taking the medication apart from drowsiness experienced during the first night he took the medication, which took place several months prior to the incident.

Postincident medical treatment records showed that the pilot was given a CT scan of the head/brain that was unremarkable, a cardiac catheterization that showed no evidence of coronary artery disease, an echocardiogram that showed no abnormalities, and extensive laboratory testing that did not identify any abnormalities. A few weeks after the incident, the pilot received an outpatient review with his cardiologist who concluded that the signs and symptoms the pilot experienced as a result of the medical testing were consistent with carbon dioxide (CO_2) poisoning from the dry ice on the incident airplane. Excess inhaled CO2 is rapidly exhaled (within minutes) down to normal levels.

Review of the shipper's procedures revealed that the company used a standard of one scoop of dry ice that equaled 2 lbs per box, a standard practice they had used for years. The dry ice was not measured on a scale or by any other means nor was there a procedure to verify the weight of the dry ice used in packaging. According to a representative of the company, each package should contain only one scoop of dry ice. The company did not employ anyone to directly oversee the packaging process, but a supervisor on the floor was available during packaging.

The shipper stated that the incident shipment was an extremely high-volume shipment and irregular for their normal air freight operation. At the time the order was placed, they did not have their usual staff to fill the order, and they reassigned an employee who had not packaged hazardous materials in 17 months or completed hazardous materials training since September 2015 to complete the order.

The employee who distributed the dry ice for the incident flight stated that he normally used 2 scoops using the provided 64 oz scoop for larger boxes. On the day of the incident, he used between 1.5 to 2 scoops of dry ice for each box and then marked "0.9 kg" (2 lbs) on each box label because that is the standard they always used. Following the incident, the employee reported that the shipper measured the full scoops and determined that one scoop is equal to 2.3 lbs.

Based on the 2 lbs per scoop per box weight, the declared total shipment of dry ice would have been 81 lbs for the 41 boxes. Factoring in the weights supplied and adding 1.5 to 2 scoops per box, the computations showed that the net mass of the dry ice in the shipment would have been between 122 lbs and 162 lbs.

FAA Advisory Circular (AC) 91-76A describes the hazards associated with the sublimation of dry ice aboard aircraft. According to the AC, dry ice is generally carried aboard aircraft to keep food, medicine, or biological materials frozen or in a chilled condition and is considered a hazardous material. Dry ice sublimates into gaseous CO2 at aircraft environment temperatures and may lead to aircrew incapacitation at excessive levels of exposure. Tests performed by the FAA demonstrated that for small, insulated shipping packages containing 4.6 to 5.3 lbs of dry ice, such as those onboard the incident airplane, the sublimation rate averaged 2% per hour.

The AC states that exposures to CO2 should not exceed a concentration of 0.5% (5,000 parts per million [ppm]). The signs and symptoms of CO2 poisoning are similar to hypoxia and include headache, dizziness, muscular weakness, drowsiness and ringing in the ears. Removal from the exposure results in rapid recovery. Exposure can be mitigated by maintaining adequate circulation of fresh air. The pilot reported that at the time of the incident, he had closed off both the overhead and cockpit vents because it was cold outside, and he was in light clothing. The operator did not have any policies requiring pilots to keep the cabin ventilated with dry ice onboard at the time of the incident.

A sublimation study performed by the NTSB Vehicle Performance division showed that the cabin CO2 concentration in an unvented configuration would have reached 1% in 5 minutes, twice the FAA and Occupational Safety and Health Administration standard. By 30 minutes, the concentration would have reached 6.37%; this concentration is consistent with loss of consciousness, coma, and eventually, death. For additional information, see the dry ice sublimation study in the public docket for this accident.

At the correct weight of 81 lbs (37 kg) of dry ice, the cabin would have a reached CO2 concentration level of 1% in about 10 minutes and would have likely been above 4% when the firefighter opened the door.

The NTSB medical review stated that as CO_2 levels rise above 1,000 ppm the person will begin to experience drowsiness, poor concentration, along with other symptoms consistent with low oxygen. As inhaled levels rise above 5,000 ppm, "coma and eventually death will ensue. At higher inhaled levels, negative effects occur more rapidly."

At the time of the incident, the operator's policy for carrying dry ice included a chart that stated a maximum of 168 lbs of dry ice could be carried with both the overhead and side vents closed. The operator distributed CO2 detectors to many of its pilots following the incident. The pilot did not have a CO2 detector with him at the time of the incident.

On March 5, 2018, the pilot experienced similar symptoms as he did on the day of his loss of consciousness. He picked up a shipment of dry ice and after he closed the door, started the engine, and began taxiing, the pilot had difficulty breathing and keeping his eyes open. The pilot reported that he did not have any of the cockpit vents open at that time. The CO2 detector issued to him by the operator indicated 4,000 ppm after he had only taxied about 200 ft. An irregularity report filed by the pilot stated that he opened 3 air vents after the detector indicated levels above 5,000 ppm. The pilot turned the airplane around to return to the ramp and, as he approached, his symptoms grew worse, and the detector showed 7,800 ppm. According to the irregularity report, he then opened the door and the detector immediately decreased to 6,450 ppm.

Pilot Information

Certificate:	Airline transport; Commercial; Flight instructor	**Age:**	59,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine; Instrument airplane	**Toxicology Performed:**	No
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	February 12, 2018
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	November 8, 2018
Flight Time:	13410 hours (Total, all aircraft), 3420 hours (Total, this make and model), 13257 hours (Pilot In Command, all aircraft), 200 hours (Last 90 days, all aircraft), 53 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N781FE
Model/Series:	208 B	**Aircraft Category:**	Airplane
Year of Manufacture:	1991	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	208B0278
Landing Gear Type:	Tricycle	**Seats:**	2
Date/Type of Last Inspection:	100 hour	**Certified Max Gross Wt.:**	8763 lbs
Time Since Last Inspection:		**Engines:**	1 Turbo prop
Airframe Total Time:	12600.4 Hrs at time of accident	**Engine Manufacturer:**	Pratt & Whitney
ELT:	Installed, not activated	**Engine Model/Series:**	PT6A-114A
Registered Owner:	Federal Express Corporation	**Rated Power:**	1865 Lbs thrust
Operator:	West Air, Inc.	**Operating Certificate(s) Held:**	On-demand air taxi (135)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:	17:37 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Few / 2200 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	Overcast / 3900 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	5 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	130°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	14°C / 12°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Bakersfield, CA (BFL)	**Type of Flight Plan Filed:**	IFR
Destination:	Ontario, CA (ONT)	**Type of Clearance:**	IFR
Departure Time:	17:29 Local	**Type of Airspace:**	Class D

Airport Information

Airport:	Meadows Field BFL	**Runway Surface Type:**	Asphalt
Airport Elevation:	509 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:	30R	**IFR Approach:**	None
Runway Length/Width:	10849 ft / 150 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	1 Minor	**Aircraft Damage:**	None
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Minor	**Latitude, Longitude:**	35.433612,-119.054443(est)

Administrative Information

Investigator In Charge (IIC):	Stein, Stephen
Additional Participating Persons:	Ryan Smith; Federal Aviation Administration; Fresno, CA Nathaniel Eisenman; Federal Express; Memphis, TN Thomas Jordan; West Air, Inc.; Fresno, CA
Original Publish Date:	April 1, 2022
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this incident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=98675