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## CO2 incapacitation, Douglas DC-8-51, 1998-04-29

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**Micro-summary:** The crew of this Douglas DC-8-51 reported side effects from CO2 inhalation, prompting a return to parking.

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**Event Date:** 1998-04-29 at 2100 CDT


**Investigative Body:** National Transportation Safety Board (NTSB), USA

**Investigative Body's Web Site:** <http://www.nts.gov/>

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1. Accident reports can be and sometimes are revised. Be sure to consult the investigative agency for the latest version before basing anything significant on content (e.g., thesis, research, etc).
  2. Readers are advised that each report is a glimpse of events at specific points in time. While broad themes permeate the causal events leading up to crashes, and we can learn from those, the specific regulatory and technological environments can and do change. ***Your company's flight operations manual is the final authority as to the safe operation of your aircraft!***
  3. Reports may or may not represent reality. Many many non-scientific factors go into an investigation, including the magnitude of the event, the experience of the investigator, the political climate, relationship with the regulatory authority, technological and recovery capabilities, etc. It is recommended that the reader review all reports analytically. Even a "bad" report can be a very useful launching point for learning.
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		NTSB ID: FTW98IA196		Aircraft Registration Number: N507DC	
		Occurrence Date: 04/29/1998		Most Critical Injury: Minor	
		Occurrence Type: Incident		Investigated By: NTSB	
Location/Time					
Nearest City/Place BROWNSVILLE		State TX	Zip Code 78521	Local Time 2100	Time Zone CDT
Airport Proximity: On Airport		Distance From Landing Facility:		Direction From Airport:	
Aircraft Information Summary					
Aircraft Manufacturer Douglas		Model/Series DC-8-51		Type of Aircraft Airplane	
Sightseeing Flight: No			Air Medical Transport Flight: No		
Narrative					
<p>Brief narrative statement of facts, conditions and circumstances pertinent to the accident/incident:</p> <p>On April 29, 1998, approximately 2100 central daylight time, a Douglas DC-8-51 cargo airplane, N507DC, was taxiing to takeoff at the Brownsville/South Padre Island International Airport in Brownsville, Texas, when all four occupants (three flight crewmembers and a jumpseat rider) became short of breath. All occupants donned oxygen masks, and the captain taxied the airplane back to the ramp. The crewmembers and the jumpseat rider were transported to a hospital where they were examined and released. There was no damage to the airplane, which was registered to Agro Air Associates of Miami, Florida, and operated by Fine Airlines per contract with Burlington Air Express. Visual meteorological conditions prevailed and an IFR flight plan was filed for the Title 14 CFR Part 121 non-scheduled cargo flight to Laredo, Texas.</p> <p>According to the Director of Training for Fine Air, the airplane was parked facing east on the Burlington Air Express ramp located near the northeast corner of the airport. Cargo was loaded into the airplane through the cargo door on the left forward side of the fuselage using a diesel powered hydraulic elevator or "K-loader." An electrical power cart, parked on the right side of the airplane's nose, was running to provide electrical power to the airplane during the cargo loading process.</p> <p>According to documents provided by Fine Air, two shipments containing dangerous goods/hazardous material were loaded on the airplane, and the captain was made aware of the nature, quantity, and location of these items. One shipment consisted of 5,482 pounds of frozen shrimp packed in 198 packages with each package containing 2.2 kilograms (4.85 pounds) of dry ice, or a total of 435.6 kilograms (960.3 pounds) of dry ice. The other shipment consisted of 180 pounds of paint. The packages containing the dry ice were located in the main cargo compartment with other items in shipping containers at positions 5 and 6, and the paint was located in the main cargo compartment with other items in the shipping container at position 1, directly aft of the cockpit and galley. Positions 2, 3, and 4 in the main cargo compartment were empty, and other cargo was loaded in positions 7 to 13 in the main compartment.</p> <p>Fine Air's Director of Training interviewed the flight crewmembers and reported that the first officer boarded the airplane first and was in his seat for approximately 30 minutes before engine start. The flight engineer arrived shortly after the first officer, and the captain arrived approximately 10 minutes before engine start. After the engines were started with an air start cart and the airplane was pushed back with a tug, there was an instrument failure on the first officer's side necessitating a return to the ramp. The engines were shut down, the electrical power cart was reconnected, and a mechanic boarded the airplane to assess the situation. After approximately 10 minutes, the problem was resolved and another engine start was initiated. During the engine start sequence, both sliding cockpit windows were open. The airplane was again pushed back for taxi, and the sliding cockpit windows were closed.</p> <p>In written statements, the three flight crewmembers described the symptoms they experienced</p>					
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following the second push back. The captain reported that during the initial portion of the taxi, he "felt a few hot flashes and some heart beat increases. As [the] taxi proceeded, [he] began to feel short of breath, increased hot flashes." The first officer stated that during the taxi, he "started to feel very hot, and started to breathe very heavy. After a few moments [his] vision blurred and [he] started to see stars in [his] field of vision." The flight engineer reported that he "felt short of breath, and [his] chest felt tight."

As the airplane neared the runway, the first officer told the captain that he did not feel well, and the captain acknowledged that he also felt ill. The flight engineer then said that he "felt the same way." The captain instructed the crewmembers to put on their oxygen masks, set them to 100 % oxygen and open both sliding cockpit windows for fresh air. After donning his oxygen mask, the flight engineer assisted the jumpseat rider in putting on his mask. The flight engineer reported that after he put his mask on he "began to feel more alert." After taxiing back to the ramp, the flightcrew shut down the engines and exited the airplane. The captain stated that he needed help to exit the airplane and "felt dizzy." The flight engineer stated that "upon standing and walking, [he] felt dizzy."

According to a report prepared by Fine Air's operations coordinator, at 2044, the airplane "block[ed] out" of Brownsville for Laredo, and at 2115, he was notified that the airplane was returning to the ramp by Burlington Air Express (BAX) Operations Control Center. At 2125, he requested that BAX personnel in Brownsville "check on listed HAZMAT [hazardous material] to have info on what may have spilled/released." He was told that there were two HAZMAT items on the manifest, a "total of 396 kilos" of "dry ice cooling shrimp" and four "1-gallon containers of paint." BAX personnel further reported to the Fine Air operations coordinator that "the paint on Pallet 1 had been inspected and no evidence of leak had been detected, no visual signs, damage to containers or smell."

At the request of an agent with the FAA Civil Aviation Security Office in Houston, Texas, all the airplane's doors were closed approximately 2145. The doors remained closed until approximately 0100, on April 30, 1998, when a hazardous materials response team entered the airplane via the crew entry door and took readings with air monitoring equipment. The measured oxygen levels in the cockpit, galley, and at positions 1 and 5 in the main cargo compartment were 20.2, 19.3, 18.6, and 18.5 %, respectively. (The normal oxygen level is 21.0 %.) Anomalous levels of carbon monoxide were not detected by the hazardous materials team.

The Brownsville Fire Department's report on the incident stated that the hazardous materials team "found low oxygen levels of 18.5 [%]. The plane was carrying frozen shrimp packed in dry ice. [The team] concluded that maybe the dry ice displaced the oxygen in the cabin."

The section in Fine Air's Flight Operations Manual entitled "Dry Ice Shipments" explains that sublimation of dry ice (solid carbon dioxide) to the gaseous state occurs constantly and that carbon dioxide (CO2) gas is heavier than air, "displaces air, and in high enough concentrations, can cause hypoxia and asphyxia." The section describes the symptoms of high concentrations of CO2 gas as "headache, dizziness, muscular weakness, shortness of breath and ringing in the ears" and states that "removal from exposure results in rapid recovery. Such removal can be accomplished by donning an oxygen mask and selecting delivery of 100 percent oxygen."

With regard to the atmospheric levels of CO2 typically associated with symptoms, the Fine Air Manual states, in part:

No symptoms occur from inhalation of the gas if the air contains only slightly more than normal amounts of CO2 (0.035 %). When the concentration reaches 2 %, depth of respiration increases so that the amount of air brought into the lungs with each breath increases up to 30 percent. Above 4 %, breathing becomes rapid and very deep, to the point of becoming extremely labored and almost unbearable in some individuals. The most that can be

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tolerated is 7 % to 9 %. More than 10 % can cause ataxia and unconsciousness.

Military specifications for the transportation of dangerous goods by air, such as U.S. Army Technical Manual 38-250, provide the following information regarding CO2 concentrations:

If the carbon dioxide concentration in the aircraft is over 0.5 percent, crew personnel may suffer shortness of breath. Carbon dioxide concentrations of 3.0 percent are endurable from 1/2 to 1 hour. Concentrations of 5.0 percent are dangerous from 1/2 to 1 hour and concentrations of 9.0 percent are fatal from 5 to 10 minutes.

FAA Advisory Circular (AC) 103-4, dated May 1, 1974, entitled "Hazard Associated with Sublimation of Solid Carbon Dioxide (Dry Ice) Aboard Aircraft" states that "the rate of carbon dioxide release varies with the degree of insulation used in packaging, crushed or solid form, temperature, and atmospheric pressure. Experience during flight shows that as a rule, a sublimation rate of one pound per hundred pounds of dry ice per hour can be expected." The AC recommends use of this 1 % per hour sublimation rate "for calculation of CO2 concentration in aircraft spaces." Additionally, the AC states that "CO2 concentration in the aircraft generally should not be allowed to exceed 0.5 %" and provides a formula for calculating the maximum dry ice load that can be carried in a particular aircraft without exceeding the allowable CO2 concentration.

Douglas Aircraft Company's report number DAC 66729, issued December 15, 1967, and revised April 22, 1980, entitled "Transportation of Dry Ice by Air" states that "flight tests, conducted by Pan American World Airways and others, indicate that approximately one pound of gas is released every hour for each 100 lbs. of dry ice carried." The report further states that this sublimation rate "is associated with a quantity [of dry ice] being transported as a bulk shipment and not for use as a refrigerant. If the dry ice is being used to refrigerate cargo, there is a possibility that the sublimation rate will increase over that determined for bulk shipment." Contained within the report is a table giving the maximum dry ice load in the main cabin for various Douglas airplanes based on the recommendations in FAA AC 130-4 (allowable CO2 concentration of 0.5 % and sublimation rate of 1 % per hour). For the DC-8-50, the table lists the maximum dry ice load in the main cabin (main cargo compartment) as 11,148 pounds under normal airflow conditions and 5,574 pounds under minimum airflow conditions.

An article in the March 1977 edition of "Aviation, Space, and Environmental Medicine", written by H. L. Gibbons and entitled "Carbon Dioxide Hazards in General Aviation," describes the results of a test in which "dry ice was permitted to sublimate within paper bags at room temperature of 72 to 73 degrees F." Over a 4 hour period, a single 2,248 gram (5 pound) block of dry ice decreased in weight from 2,248 grams to 1,000 grams for a sublimation rate of 14 % per hour. Using the formula in AC 130-4 and substituting a sublimation rate of 14 % per hour for the 1 % per hour recommended by the FAA, the NTSB investigator-in-charge calculated the maximum dry ice load that can be carried in the main cargo compartment of a DC-8-50 without exceeding a CO2 concentration of 0.5 % as 794 pounds under normal airflow conditions and 397 pounds under minimum airflow conditions.

The Douglas report referenced above points out that the formula for computing the allowable dry ice load in AC 130-4 "is based upon uniform mixing of air and carbon dioxide. Whether this represents the actual situation or not is questionable because the carbon dioxide is cold and heavier than air." The Douglas report suggests that the CO2 gas "may quickly drop to the floor and flow horizontally."

Fine Air's Director of Training reported that when the DC-8's doors are closed and the airplane is ready for taxiing, air flows forward from the main cargo compartment through a louvered vent near the bottom of the cockpit entry door. The air moves forward to the instrument panel, back along the sides of the cockpit, up into the top of the radio rack, and is then drawn down through an opening in the floor of the radio rack and exhausted into the forward belly compartment. Additionally, the incident airplane was equipped with an air conditioning unit mounted in the

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cockpit ceiling just inside the cockpit entry door. The unit recirculates cockpit air which is drawn in from the rear of the unit and blown forward and down.

According to the aircraft manufacturer, the volume of the DC-8 cockpit is approximately 700 cubic feet. Therefore, 3.5 cubic feet of CO<sub>2</sub> gas produces a CO<sub>2</sub> concentration of 0.5 % in the DC-8 cockpit, 14 cubic feet produces a concentration of 2 %, and 28 cubic feet produces a concentration of 4 %. At sea level and 70 degrees F, 3.5 cubic feet of CO<sub>2</sub> gas weighs 0.4 pounds, 14 cubic feet weighs 1.65 pounds, and 28 cubic feet weighs 3.3 pounds.

In 10 minutes, at a sublimation rate of 1 % per hour, the 960 pounds of dry ice carried in the main cargo compartment of the incident airplane would produce 1.6 pounds of CO<sub>2</sub> gas, and at a rate of 14 % per hour, 22.4 pounds would be produced. At sea level and 70 degrees F (incident conditions were 23 feet msl and 66 degrees F), 1.6 pounds of CO<sub>2</sub> gas occupies 13.6 cubic feet and 22.4 pounds occupies 190.4 cubic feet.

According to information provided by Fine Air, the hospital diagnosed the occupants as suffering from carbon monoxide (CO) poisoning. With the consent of the flight crewmembers and the jumpseat rider, their medical records were obtained from the hospital. The measured levels of carboxyhemoglobin (COHb) in blood samples taken 2 to 3 hours after the incident ranged from 1.2 to 1.6 %.


The second edition of the reference book, "Ellenhorn's Medical Toxicology," provides formulae for back calculation of the COHb concentration at the time a person is removed from a CO source. The jumpseat rider had the highest COHb concentration measured by the hospital at 1.6 %, and his blood was drawn approximately 3 hours after the incident. Using the formulae, his COHb concentration at the time of the incident was estimated at approximately 2.4 % if breathing air and 12.8 % if breathing 100 % oxygen since exposure.


With regard to the levels of COHb typically associated with symptoms of CO poisoning, the thirteenth edition of the reference book, "Harrison's Principles of Internal Medicine," states that "traditionally, levels of 20 to 30 percent are associated with mild symptoms, 30 to 50 percent with moderate symptoms, 50 to 60 percent with severe symptoms, and levels above 60 percent are often fatal."

FAA Advisory Circular 20-32B, dated November 24, 1972, entitled "Carbon Monoxide (CO) Contamination in Aircraft - Detection and Prevention" describes the symptoms of carbon monoxide poisoning as follows:

Early symptoms of CO poisoning are feelings of sluggishness, being too warm, and tightness across the forehead. The early symptoms may be followed by more intense feelings such as headache, general weakness, dizziness, and gradual dimming of vision. Large accumulations of CO in the body result in loss of muscular power, vomiting, convulsions, and coma. Finally, there is a gradual weakening of the pulse, a slowing of the respiratory rate, and death.

On May 15, 1998, an FAA inspector with the Flight Standards District Office in Miami, Florida, assisted by a Miami Fire Department hazardous materials response team, measured CO levels in the cockpits and main cargo compartments of four different DC-8 airplanes parked on the ramp at Miami International Airport. Three of the airplanes had operating electrical power carts located beside them, and the fourth airplane had an operating K-loader and an operating electrical power cart located beside it. No anomalous levels of CO were detected.

		NTSB ID: FTW98IA196				
		Occurrence Date: 04/29/1998				
		Occurrence Type: Incident				
Landing Facility/Approach Information						
Airport Name BROWNSVILLE/SOUTH PADRE		Airport ID: BRO	Airport Elevation 23 Ft. MSL	Runway Used 0	Runway Length	Runway Width
Runway Surface Type:						
Runway Surface Condition:						
Type Instrument Approach:						
VFR Approach/Landing:						
Aircraft Information						
Aircraft Manufacturer Douglas		Model/Series DC-8-51		Serial Number 45855		
Airworthiness Certificate(s): Transport						
Landing Gear Type: Retractable - Tricycle						
Homebuilt Aircraft? No		Number of Seats: 4	Certified Max Gross Wt. 315000 LBS		Number of Engines: 4	
Engine Type: Turbo Fan		Engine Manufacturer: P&W		Model/Series: JT3D-3B	Rated Power: 18000 LBS	
- Aircraft Inspection Information						
Type of Last Inspection Continuous Airworthiness		Date of Last Inspection 04/1998	Time Since Last Inspection 7 Hours		Airframe Total Time 3636 Hours	
- Emergency Locator Transmitter (ELT) Information						
ELT Installed? Yes		ELT Operated? No		ELT Aided in Locating Accident Site?		
Owner/Operator Information						
Registered Aircraft Owner AGRO AIR ASSOCIATES		Street Address PO BOX 524236				
		City MIAMI		State FL	Zip Code 33152	
Operator of Aircraft FINE AIRLINES, INC.		Street Address 4600 NW 36TH ST, BLDG 22				
		City MIAMI		State FL	Zip Code 33122	
Operator Does Business As: FINE AIR				Operator Designator Code: FXLA		
- Type of U.S. Certificate(s) Held:						
Air Carrier Operating Certificate(s): Cargo						
Operating Certificate:			Operator Certificate:			
Regulation Flight Conducted Under: Part 121: Air Carrier						
Type of Flight Operation Conducted: Non-scheduled; Domestic; Cargo						
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**First Pilot Information**

Name On File	City On File	State On File	Date of Birth On File	Age 54
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Sex: M	Seat Occupied: Left	Principal Profession: Civilian Pilot	Certificate Number: On File
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Certificate(s): Airline Transport; Commercial

Airplane Rating(s): Multi-engine Land; Single-engine Land

Rotorcraft/Glider/LTA: None

Instrument Rating(s): Airplane

Instructor Rating(s): None

Type Rating/Endorsement for Accident/Incident Aircraft? Yes	Current Biennial Flight Review?
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Medical Cert.: Class 1	Medical Cert. Status: Valid Medical--w/ waivers/lim.	Date of Last Medical Exam: 01/1998
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- Flight Time Matrix	All A/C	This Make and Model	Airplane Single Engine	Airplane Multi-Engine	Night	Instrument		Rotorcraft	Glider	Lighter Than Air
						Actual	Simulated			
Total Time	19037									
Pilot In Command(PIC)	10000									
Instructor										
Last 90 Days	37	37								
Last 30 Days	37	37								
Last 24 Hours	8	8								

Seatbelt Used? Yes	Shoulder Harness Used? Yes	Toxicology Performed? Yes	Second Pilot? Yes
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**Flight Plan/Itinerary**

Type of Flight Plan Filed: IFR

Departure Point Same as Accident/Incident Location	State	Airport Identifier BRO	Departure Time 0000	Time Zone
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Destination LAREDO	State TX	Airport Identifier LRD	
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Type of Clearance: VFR


Type of Airspace: Class D

**Weather Information**

Source of Briefing:

Method of Briefing:



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**Weather Information**

WOF ID	Observation Time	Time Zone	WOF Elevation	WOF Distance From Accident Site	Direction From Accident Site
BRO	2056	CDT	23 Ft. MSL	0 NM	0 Deg. Mag.
Sky/Lowest Cloud Condition: Clear			0 Ft. AGL	Condition of Light: Night/Bright	
Lowest Ceiling: None		0 Ft. AGL	Visibility: 10	SM	Altimeter: 30.00 "Hg
Temperature: 19 °C	Dew Point: 15 °C	Wind Direction: 50		Density Altitude: Ft.	
Wind Speed: 5	Gusts:	Weather Conditions at Accident Site: Visual Conditions			
Visibility (RVR): 0 Ft.	Visibility (RVV) 0	SM	Intensity of Precipitation: Unknown		
Restrictions to Visibility: None					
Type of Precipitation: None					

**Accident Information**

Aircraft Damage: None	Aircraft Fire: None	Aircraft Explosion: None
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Classification: U.S. Registered/U.S. Soil

- Injury Summary Matrix	Fatal	Serious	Minor	None	TOTAL
First Pilot			1		1
Second Pilot			1		1
Student Pilot					
Flight Instructor					
Check Pilot					
Flight Engineer			1		1
Cabin Attendants					
Other Crew					
Passengers			1		1
- TOTAL ABOARD -			4		4
Other Ground	0	0	0		0
- GRAND TOTAL -	0	0	4		4



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**AVIATION**



NTSB ID: FTW98IA196

Occurrence Date: 04/29/1998

Occurrence Type: Incident

Administrative Information

Investigator-In-Charge (IIC)

GEORGIA R. SNYDER

Additional Persons Participating in This Accident/Incident Investigation:

WILLIAM J EVERETT

FAA FSDO

MIAMI, FL 33159