



**U.S. Department  
of Transportation  
Federal Aviation  
Administration**

# SAFO

Safety Alert for Operators

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Flight Standards Service  
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*A SAFO contains important safety information and may include recommended action. Besides the specific action recommended in a SAFO, an alternative action may be as effective in addressing the safety issue named in the SAFO. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way. This document is intended only to provide clarity to the public regarding existing requirements under the law or agency policies.*

**Subject:** Transportation of COVID-19 Vaccines Requiring Large Quantities of Dry Ice.

**Purpose:** This SAFO provides information and recommendations to persons conducting operations under Title 14 of the Code of Federal Regulation (14 CFR) Parts 121, 125, 129, 135 on safety issues related to the transportation of COVID-19 vaccines by air, which may require larger than typical quantities of dry ice for preservation. Operators must comply with applicable federal regulations pertaining to the carriage of dangerous goods (49 CFR parts 171-180).

**Background:** Dry ice is the solid form of Carbon Dioxide (CO<sub>2</sub>), and is regularly and safely used to keep perishable goods cold, and therefore preserved, during transport. Certain COVID-19 vaccines require a temperature of -70°C (-94°F) for proper preservation. The primary means of maintaining this temperature involves packing the vaccine container with dry ice. In order to transport COVID-19 vaccines, operators may plan to carry dry ice quantities larger than quantities they may carry during typical operations. This volume of dry ice may present risks that existing mitigations do not adequately address.

**Discussion:** Dry ice continually sublimates (transitions directly from a solid to a gas) at temperatures higher than -78°C (-108.4°F) under normal atmospheric pressure. At reduced pressures, the sublimation rate of dry ice will increase, all other factors being equal. A potential risk associated with the sublimation of dry ice is that gaseous CO<sub>2</sub> will replace oxygen in aircraft compartments and interfere with the breathing abilities of the occupants. High levels of CO<sub>2</sub> gas in compartments can lead to unrecognized degradation of cognitive functioning and present an asphyxiation hazard to persons in that space (e.g., ground crew who handle the loading and unloading of cargo containers). The risk of hazardous conditions increases proportionately with the amount of the dry ice carried, the sublimation rate of that dry ice, and any ventilation degradation of the aircraft. The FAA has provided additional information regarding dry ice in Appendix A of this SAFO.

**Recommended Action:** When preparing to transport large amounts of dry ice associated with the COVID-19 vaccine, operators should consider the information in this SAFO. Additionally, operators with an approved Safety Management System must conduct safety risk assessments in accordance with their approved Safety Management System. Operators without an accepted SMS should conduct a safety analysis and apply appropriate risk mitigations.

The FAA recommends that operators consider the following information regarding the transportation of dry ice:

- Aircraft manufacturers provide information on maximum recommended dry ice quantities that the aircraft ventilation can accommodate, depending on the sublimation rate.
- An accurate determination of the dry ice sublimation rate is necessary to determine the correct quantity of dry ice that may be safely transported aboard an aircraft.
- As the dry ice sublimates, a loss of weight occurs, affecting the aircraft center of gravity.
- Dispatch with fully operational Environmental Control Systems, including all air conditioning packs and auxiliary power unit (APU), to enable effective ventilation for ground operations and inflight contingencies.
- CO<sub>2</sub> sensors installed or carried in the aircraft or worn by the pilots and other crewmembers will assist the operator and crew in recognizing hazardous concentrations of CO<sub>2</sub> and implementing effective risk controls.
- Pilot training on specific conditions and procedures can improve pilot decision-making in the event of a CO<sub>2</sub> detector alert or other system abnormalities.
- Maximum ventilation, including during the ground de-icing and anti-icing process, will mitigate CO<sub>2</sub> accumulation in the aircraft.

**Additional Information.** Additional information on dry ice and associated, hazards and risk mitigation may be found in the following documents:

- Advisory Circular (AC) 91-76A, Hazard Associated with Sublimation of Solid Carbon Dioxide (Dry Ice) Aboard Aircraft
- DOT/FAA/AM-06/19, Sublimation Rate of Dry Ice Packaged in Commonly Used Quantities by the Air Cargo Industry; August 2006; Office of Aerospace Medicine, Washington, DC 20591
- Hazardous Materials Cooperative Research Program (HMCRP Report 11), Technical Assessment of Dry Ice Limits on Aircraft; Sponsored by the Pipeline and Hazardous Materials Safety Administration (PHMSA); Project HM-09 ISSN 2150-4849 ISBN: 978-0-309-25883-8 Library of Congress Control Number 2013956247; 2013
- IATA - Guidance for Vaccine and Pharmaceutical Logistics and Distribution; Edition 1, 16 November 2020

**Contact:** Questions or comments regarding this SAFO should be directed to the Air Transportation Division, at 202-267-8166.

## Appendix A. Dry Ice and CO<sub>2</sub> Fact Sheet for Aviation Professionals

Dry ice is widely used in aviation to keep perishable goods cold as they traverse the supply chain. When properly vented and shipped in small quantities, dry ice poses little risk to aircraft occupants. However, when a large amount of dry ice is involved, sublimation can cause serious risks. The sublimation of dry ice occurs when it passes directly from a solid state to a gaseous state at temperatures higher than -78° C (-108.4°F), under normal atmospheric pressure.

### 1. What is dry ice and is it hazardous?

#### a. Dry ice is:

- Solid (frozen) carbon dioxide (CO<sub>2</sub>) pressed into dry blocks or pellets.
- Used as a refrigerant to package items that must remain cold or frozen during transport, such as biological samples, vaccines, or foodstuffs.

b. When dry ice melts, it does not pool on the ground or form a puddle; it sublimates or changes directly from a solid to a gas.

c. Dry ice can be hazardous in poorly ventilated, enclosed spaces due to CO<sub>2</sub> gas inhalation/overexposure; skin contact with dry ice can result in frostbite.

### 2. What is CO<sub>2</sub> gas and is it hazardous?

#### a. CO<sub>2</sub> gas is:

- A naturally occurring component (0.04%) of the atmosphere.
- A physiological respiratory gas.
- Colorless, odorless, and nonflammable.
- 1.5 times heavier than air and tends to accumulate near the ground.

b. Increased levels of CO<sub>2</sub> cause drowsiness; higher concentrations increase the rate and depth of breathing and increase heart rate.

c. CO<sub>2</sub> gas in higher concentrations is both an asphyxiant and a toxicant. It causes suffocation by displacing and diluting the amount of oxygen (O<sub>2</sub>) in the air, leading to hypoxia (lack of oxygen) and is toxic to brain functioning.<sup>1</sup>

**3. Is there a difference between CO<sub>2</sub> gas overexposure and hypoxia?** Symptoms of CO<sub>2</sub> overexposure are different from hypoxia symptoms. Pilots and flight crew should not rely on typical hypoxia symptoms (e.g. breathlessness, excessive yawning, euphoria, tiredness, and fatigue) to detect CO<sub>2</sub> overexposure. Standard hypoxia awareness training IS NOT training for overexposure to CO<sub>2</sub> gas.

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<sup>1</sup> Permentier K, Vercaemmen S, Soetaert S, Schellekens C., *Carbon dioxide poisoning: a literature review of an often forgotten cause of intoxication in the emergency department*, Int J Emerg Med., 10:14 (2017), available at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5380556/>.

#### 4. What are symptoms of CO<sub>2</sub> overexposure and health affects?

- 0.04% CO<sub>2</sub> (400 ppm): typical outside air CO<sub>2</sub> levels; no physiological symptoms.
- 0.5% CO<sub>2</sub> (5,000 ppm): FAA regulatory limit for transport category aircraft (14 CFR 25.831) and Occupational Safety and Health Administration (OSHA) occupational exposure limit; subtle to no physiological symptoms.
- 1% CO<sub>2</sub> (10,000 ppm): drowsiness.
- 2% CO<sub>2</sub> (20,000 ppm): headache and difficulty breathing during exertion.
- 3% CO<sub>2</sub> (30,000 ppm): mild sleepiness, reduced hearing, sweating, increased heart rate, difficulty breathing at rest.
- 5% CO<sub>2</sub> (50,000 ppm): lethargy, dizziness, confusion, rapid breathing/shortness of breath (noticeable inability to breathe fast and deep enough).
- 8% CO<sub>2</sub> (80,000 ppm): dimmed vision, muscle tremor/twitching, and unconsciousness.
- >10% CO<sub>2</sub> (100,000 ppm): immediate unconsciousness, seizures, and death.

#### 5. How does the sublimation of dry ice affect air transportation?

- Quoted sublimation rates outside those recommended in Advisory Circular (AC) 91-76A, Hazard Associated with Sublimation of Solid Carbon Dioxide (Dry Ice) Aboard Aircraft, are established under a specific set of conditions. If the operational conditions are not the same, the actual sublimation rate will be different.
- Decreased pressure, e.g., 8000-foot cabin altitude, will increase the sublimation rate.
- Reducing cabin pressure will draw CO<sub>2</sub> gas from a package(s), increasing the CO<sub>2</sub> concentration in the compartment. For this reason, existing smoke/fire/fume procedures should not be used unless they are modified to address this phenomenon.
- At the end of a flight, compartments containing dry ice will tend to have a high CO<sub>2</sub> concentration that can take several minutes to dissipate. When the cargo door is opened, the area immediately outside the door also experiences a high CO<sub>2</sub> concentration for several minutes.