



International Association of Fire Chiefs

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IAFC Hazardous Materials Committee White Paper on Dry Ice (Carbon Dioxide) Response

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Some of the first generation COVID-19 vaccines require ultra-low temperature storage until a time just prior to use. The unprecedented creation, movement, and storage of these materials at ultra-low temperatures (approximately -80°C) will present hazards for first responders at a variety of locations if the materials are not transported or handled correctly or are involved in an accident. Therefore, the fire service must be prepared to manage these incidents at any step in the process. The use of dry ice in this process creates the potential for container overpressure (explosion), chemical exposures, leaks, and contact with ultra-cold materials. First responders must be cognizant of these hazards along with safe operating practices when responding to unknown vapor clouds and dry ice incidents.

Solid carbon dioxide, or dry ice, is an extremely cold material and will be used in the vaccine storage and transport system. Carbon dioxide (CO_2) is a colorless and odorless gas found naturally in the earth's atmosphere. When gaseous carbon dioxide is placed under extreme pressure and compression, it changes into the solid phase known as dry ice. When dry ice sublimates it converts from a solid state directly to carbon dioxide gas at -78°C (-109°F). The carbon dioxide gas then expands and cools the surrounding area.

The fire service has been called upon for years to respond to dry ice incidents related to its use as a coolant and refrigerant, for low temperature transport and storage of food and medical products, for carbonating beverages, and as a rodenticide. An expanded risk of dry ice will now come from its use in the transportation of COVID-19 vaccines. Dry ice as a refrigerant may be encountered in aircrafts, over-the-road transport vehicles, and in storage areas. If gas is released while in transport or in storage, hazards may include inert atmospheres in enclosed spaces or an increased potential for an explosion due to pressure buildup within tightly sealed containers with no pressure relief device.

The primary health hazard occurs when dry ice returns to its gaseous carbon dioxide state. The gas quickly expands and displaces oxygen inside enclosed spaces such as in transport compartments, small buildings, walk-in coolers, etc. The 'off-gassing' from dry ice can occur quickly and result in oxygen displacement. Although CO_2 is not considered a knockdown gas, oxygen displacement can take someone down very quickly. A 0.5% drop in the oxygen level due to the presences of carbon dioxide gas can result in unconsciousness.

Scene Management, Dry Ice Incidents

First responders may be requested when there are leaks in known dry ice containers, when there are reports of container over-pressurization, for unknown gas clouds, vapor leaks, or when ill or unconscious individuals are encountered. First responders should isolate the area and deny entry except for immediate rescues in appropriate personal protective equipment. For small leaks without other hazards or for breaches in dry ice containers, fire crews usually can manage these types of incidents by ventilating the space and securing the area until the leak is depleted. A four-gas meter should be used to monitor oxygen-depleted atmospheres until there is containment and ventilation of the gas. When conducting air monitoring with a four-gas meter, responders need to understand the potential for sudden extreme changes in temperature that can affect oxygen sensor performance. Even if the environment shows oxygen (O₂) levels are within acceptable limits initially, a rapid change can drop the O₂ levels to an unsafe percentage. The use of self-contained breathing apparatus and “a buddy system” are required to operate safely in and around these atmospheres. Cold containers should not be handled or moved without special cold temperature gloves.

Hazardous materials response teams may be needed to manage and mitigate larger or uncontrolled incidents involving dry ice. Visible indicators could include high pressure leaks, bulging drums or sealed containers, or “persons down”. Hazardous materials response teams carry specialized equipment to manage extremely cold materials.

If possible, every attempt should be made to preserve the ultra-cold environment for the protection of the vaccines.

Scene Management, Personnel Safety

Larger, more complicated, incidents will require a buddy system with a backup team to operate safely in and around these CO₂ atmospheres. Self-contained breathing apparatus is required for respiratory protection. An N95 mask or air purifying respirator may not be worn for respiratory protection during CO₂ incidents or in oxygen-deficient atmospheres. Structural turnout gear, fire gloves, and extrication style gloves offer limited protection to extreme cold temperatures; they can be utilized to make immediate rescues only. They should not be relied upon to handle dry ice products or containers. Specialized cryogenic gloves, approved for cold contact and conductive cold, are required when handling dry ice or damaged and leaking containers. Cryogenic gloves need to be loose-fitting so they can be readily removed if liquid material or dry ice splashes or drops into them.

Storage Information

Dry ice must be stored in well-ventilated locations and placed in insulated and ventilated storage containers, insulated coolers, or special containers designed for the storage of dry ice. Due to its thermal expansion, dry ice should never be stored in a tightly sealed container such as an ultra-low freezer or glass container. Note that dry ice will sublime about 5 to 10 pounds every 24 hours in a typical storage container. Where possible, continuous monitoring of CO₂ should be implemented to ensure that levels remain below 5,000 ppm.

Health Hazards and Patient Management

Vaccine Concerns - Current information suggests that the new class of mRNA (messenger RNA) type vaccines for COVID-19 will be those first released for use and will require ultra-cold storage during transportation and while on site. The Pfizer and Moderna vaccine candidates are both mRNA type vaccines. ***The vaccines themselves are not harmful if accidentally released, spilled, or released from broken containers. They contain no "live" or toxic material.***

Oxygen Deficiency - A 0.5% drop in the oxygen level on a four-gas meter indicates up to 25,000 ppm of carbon dioxide gas is present. Exposure to those oxygen deficient atmospheres can quickly lead to poor judgment, impaired ability to escape, and unconsciousness. Deaths have occurred from these situations.

Thermal Burns - Contact with unprotected skin will cause severe thermal injury equivalent to full-thickness burns. Dry ice and the interior of transport containers are extremely cold with temperatures around -79°C (-109°F) making them an extreme contact hazard. Unprotected skin may become stuck to the material or container. The contact area will need to be warmed or it will not be able to separate without tearing the skin off. Where skin is injured due to exposure to dry ice, remove any clothing that is not frozen to the skin. Warm to separate the skin from other materials. Place the affected part of the body in a warm water bath (not above 104°F). Do NOT rub frozen body parts because tissue damage may result. Significant-sized cold injuries should be transported to a burn center, if feasible.