

The Dangers of Carbon Dioxide in Fast Food-Type Occupancies

by Battalion Chief Frank Leeb

Three people injured—including two Firefighters—as a CO₂ leak sparked evacuation at a Phoenix McDonald's: That was the headline the author saw recently, and wondered, carbon dioxide? That must be a misprint; they must mean carbon monoxide (CO). A typical rookie mistake for a newspaper to confuse CO for CO₂, the author mused.

After reading the article and realizing that they were, in fact, talking about CO₂ and not CO, the author decided to do some research into the dangers of CO₂ cylinders stored and used in fast food-type occupancies. He was surprised to learn how seemingly unregulated the storage and use of CO₂ is and how little is written about CO₂ hazards to the fire service. This article helps to fill that void.

Carbon dioxide—also known as CO₂—is a very well-known gas, but not everyone knows how deadly it can be. CO₂ is the fourth most abundant gas in the earth's atmosphere. Most people know it as a gas that humans exhale or as an agent used in specific fire suppression systems. Commercially, CO₂ is manufactured and shipped as a liquefied compressed gas or is used as dry ice in its solid form.

One common use of CO₂ gas is in fountain soda systems to carbonate soft drinks by pressurizing CO₂ gas into liquid syrup. Nationwide, carbonated fountain soft drinks are served in bars, restaurants, fast food chains, sports arenas, movie theaters, cafeterias, nightclubs and similar occupancies.

Historically, these soda systems did not pose a hazard to Firefighters. This is due, in part, to the relatively small CO₂ cylinders that were used in establishments. The CO₂ hazards to Firefighters occur when there is an undetected leak from the larger-sized CO₂ cylinders or from a leak in the tubing used to supply CO₂ from the cylinder to the soda fountain system. While uncommon, leaks from the cylinders and supply tubing that supply CO₂ gas appear to be on the rise.

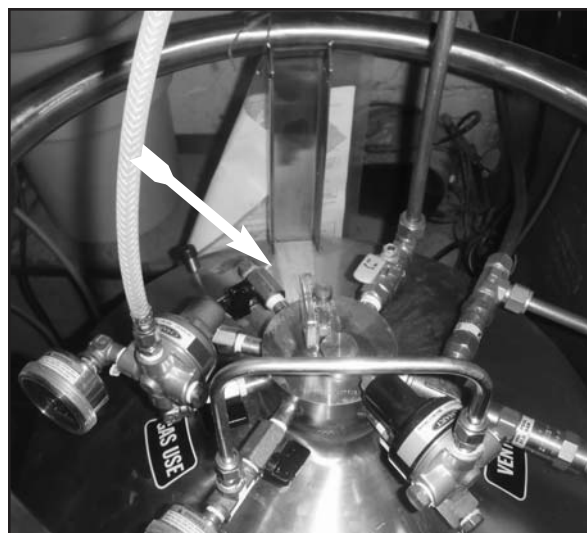
All businesses that serve fountain soda are using CO₂. There is an increased risk in occupancies that serve a high volume of

fountain soda. Occupancies such as Burger King, McDonald's, Wendy's, Applebee's and 7-11 are prime examples of high-volume occupancies. Be alert to a potentially toxic environment when responding to any occupancy that has a fountain soda system in place. This danger is increased if the storage of these cylinders is below grade (in the basement), as CO₂ is 1½ times heavier than air and will collect in these low-lying areas.

Supply hose-lines from the cylinders create an additional problem. Supply lines run through ceilings (common above a drop ceiling) and walls and can be found anywhere within the occupancy. These supply lines are plastic and run from the cylinder to the soda system that serves the final carbonated beverage. The danger from leaking supply lines is present even in occupancies that have outdoor storage for the CO₂ cylinders as the supply lines run inside the occupancy. Only the risk of leakage from the tank has been reduced in this case.

Some examples of recent CO₂ leaks:

- A McDonald's restaurant in Phoenix, Arizona, in June 2011, had to evacuate everyone in the restaurant because of a leaking soda machine in the building's basement. A pregnant employee, who was exiting the basement, ended up collapsing due to the leaking CO₂. Other employees experienced lightheadedness and dizziness. Three people, including two Firefighters, were injured as a result. While this restaurant was equipped with on-site CO₂ monitors, they did not work at the time.
- In June 2011, a fast food restaurant in Yorkshire, United Kingdom, had to evacuate everyone due to a leaking CO₂ cylinder. Emergency service personnel, wearing self-contained breathing apparatus, were called in to disconnect the cylinder and ventilate the occupancy. No injuries were reported.
- A McDonald's restaurant in Savannah, Georgia, in September 2011, sickened 10 people, three of them Firefighters, and caused the death of a woman found unconscious in a rest room. This was due to a leaking plastic CO₂ gas line between the walls.



(Left) Photo #1—Typical size Dewar-type cylinder, capable of holding 387 lbs. of liquid CO₂. (Above) Photo #2—Top of cylinder. Note the numerous shut-off valves. The arrow is pointing to the gauge in the center, which shows how much CO₂ is in the cylinder. (Right) Photo #3—Interior installation. The arrow is pointing to CO₂ tubing going up to the ceiling.





(Far left) Photo #4--Interior installation. The arrow is pointing to CO2 supply line going to the exterior of the building. (Left) Photo #5--Typical exterior installation of Dewar-type CO2 cylinder. (Above) Photo #6--Top of cylinder. Note ID plate attached to the top of the cylinder. The arrow is pointing to the total contents in lbs. when full (387 for this size).

- Carbon dioxide was determined to cause the death of two people in a Sanford, Florida, McDonald's in 2005. An 18-year-old McDonald's employee was trying to help a driver for the company that refills the CO2 tanks when he died of asphyxiation. The 50-year-old driver died when he tried to help the teen.

Previously stored in smaller containers, business owners have turned to using larger storage containers, which carry a greater amount of CO2 (typically called Dewars) for their fountain soda systems. There are several advantages to this. Business owners benefit from the ability to buy CO2 in bulk due to the larger capacity tanks. Second, they benefit because employees do not have to change out these tanks as often and, in many cases, do not have to change them out at all as most have installed an exterior connection that allows the CO2 vendor to fill the tanks in place from an exterior connection. For responding Firefighters, this change to larger cylinders is a hazard. Changing from smaller to larger cylinders has greatly increased the danger associated with a CO2 leak to civilians and first responders.

Properties and effects of exposure to CO2

At room temperature, carbon dioxide is a colorless, odorless, slightly acidic-tasting, non-flammable gas that is 1 1/2 times heavier than air. While harmless at low concentrations, carbon dioxide becomes toxic at high concentrations. CO2 has an atmosphere immediately dangerous to life or health (IDLH) of 40,000 parts per million (ppm) which, on an O2 meter, will be less than a one percent drop.

According to the Centers for Disease Control (CDC) and the National Institute for Occupational Safety and Health (NIOSH), common symptoms of CO2 exposure include headache, dizziness, restlessness, difficulty breathing, sweating, malaise, increased heart rate, coma and convulsions.

Situational awareness

Units responding to EMS runs or unknown odors in this occupancy type should be cognizant that they may be responding to a CO2 leak. CO2 is heavier than air and, therefore, in the event of a leak in enclosed spaces--such as a walk-in cooler, manager's office, rest rooms, employee rest areas, and basement areas--are particularly vulnerable to increasing levels of CO2.

As CO2 is undetectable by human senses, the only way to safely monitor CO2 is by using fixed or portable alarm systems. Alarms are available that have been purposely designed for the restaurant industry. The alarm monitors the level of CO2 in the air. Since CO2 gas is heavier than air, it is recommended that the fixed

gas detectors should be installed at breathing zone level, which is four to six feet above the floor.

In order to minimize the chance of a deadly CO2 leak from happening in the future, employees in these establishments need to know the risks associated with CO2 gas, be able to identify early symptoms and be protected by a fixed gas monitoring system. Employees also must be trained in what to do in the event of CO2 monitor activation.

In New York City, this is clearly not the case. Most restaurants checked by the author did not have any metering capability. In the occupancies that had an alarm system in place, he was unable to find an employee or manager who knew what to do in the event of activation.

Operational considerations

Members suspecting a CO2 leak must use an SCBA while operating in a potential IDLH atmosphere and immediately call for a haz-mat-trained unit with greater metering capability. These units have the ability to check for O2-deficient atmospheres. Hazardous materials-trained and -equipped companies typically perform atmospheric monitoring for oxygen, methane, carbon monoxide and potentially explosive gases by metering for the lower explosive limit (LEL), but they don't monitor for carbon dioxide. When FDNY units detect low oxygen levels in occupancies with CO2 in use, they must consider the possibility that elevated CO2 levels exist.

Shutting down the Dewar cylinder

The typical CO2 Dewar cylinder used in this installation is the



Photos #7 and #8--Exterior fill connection shown in the open and closed positions. Often the cylinder will be located opposite this wall as long as there is access to this location for the supply truck. This would be a clear indication that CO2 cylinders are located inside.



Photo #9--Typical basement installation. Note the amount of plastic tubing present. Also note the system is installed onto the side of a walk-in refrigerator. A leak into this area could quickly displace O2.

DOT 4L292, known in the industry as the "292." This cylinder stores CO2 in its liquid form and is passed through a regulator as a gas to be used. On the top of the cylinder, numerous valves can be found, many with tubing running from them. Shutting down the valve with the regulator will isolate the cylinder supply to the soda system.

The "292" is a 160-liter cylinder that can be filled with up to 387 pounds of liquid CO2. Liquid CO2 has an expansion ratio of 553, which means even a small leak in the tubing from a full cylinder can cause dangerous O2 displacement anywhere within a structure.

The Dewar cylinder is shut down by turning the valve located on the top of the cylinder. Since many of these cylinders have more than one shut-off on them, members should shut off any and all valves that have plastic tubing attached to them, effectively isolating the cylinder. Due to the nature of CO2 as a (cryogenic) liquid stored at very cold temperatures, it is recommended that members attempting to shut off a cylinder be equipped with full PPE, including gloves.

Types of installation

A typical interior installation will have a large supply line hose connected to the cylinder. This hose will lead to an exterior fill connection used by the vendor to re-supply the CO2 tank, similar to the way a fuel oil truck makes a delivery. The exterior connection often can be found on the exterior wall closest to the cylinder, provided that it is accessible for a delivery truck to re-supply. If the closest wall is not accessible, this fill connection usually will

Members are urged to review Pass It On Program, Issue 8/2011, *Carbon Dioxide (CO2) Incident*.

be found at another exterior wall that is accessible for a delivery. This type of installation is common in areas of the City where real estate is at a premium or the occupancy does not have room on the exterior for tank storage.

A typical exterior installation will have a tank up against the building in an area that is away from the front of the occupancy, typically behind a chain-link fence for security. From the cylinder on the exterior, a plastic tubing supply line will be run to the interior of the occupancy to the location of the soda system.

Lessons reinforced

- Maintaining situational awareness on all responses helps keep FDNY members safe. This is true when responding to occupancies that use CO2. A CO2 leak initially may be reported as an unconscious patient in a restaurant.
- CO2, similar to propane, is heavier than air. High concentrations may be found in low-lying areas, such as the basement or in confined spaces or small rooms within occupancies, which will reach higher concentrations faster than a large area.
- Units operating at a fire in which the supply tubing or tank is involved or compromised in any way must ensure the CO2 tank is shut down to prevent a potentially lethal CO2 build-up.
- Use the Building Inspection Safety Program (BISP) to identify occupancies that use/store large amounts of CO2 and enter this information into the critical information dispatch system (CIDS).
- Frost or condensation on the exterior of a CO2 cylinder is a strong indicator that a leak exists, either in the supply tubing or the tank itself.



About the Author...

Battalion Chief Frank Leeb is a 19-year veteran of the FDNY. He is covering in Division 14. Prior assignments include Engine 323 and Squad 270 as a Firefighter; Engine 324 as a Lieutenant; and Captain of Engine 76. He holds a BS degree in Fire Service Administration from Empire State College. This is his first article for WNYF.



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