



## Silo response - The dangers of using carbon dioxide to quench silo fires

Hedlund, Frank Huess; Nichols, Jeffrey

*Published in:*  
Canadian Biomass

*Publication date:*  
2018

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Hedlund, F. H., & Nichols, J. (2018). Silo response - The dangers of using carbon dioxide to quench silo fires. *Canadian Biomass*, 18(2), 16-17.

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

# Silo response

*The dangers of using carbon dioxide to quench silo fires*

*By Frank H. Hedlund and Jeffrey C. Nichols*

**On** July 5, 2010 a wood pellet silo in Norway exploded when firefighters released inert carbon dioxide into the headspace to lower the oxygen content and suppress a smouldering fire. The lesson from this incident is that the use of carbon dioxide to suppress silo fires is unsafe.

Smouldering fires produce flammable pyrolysis gasses. The gasses can travel and accumulate, for example in the headspace of the silo. The release of carbon dioxide from high-pressure cylinders can generate static electricity with sufficient energy to ignite the pyrolysis gases.

## SMOULDERING FIRES

Smouldering fires in wood pellets storages can occur for a number of reasons. There are plenty of examples in industry where pellets self-heat deep inside an undisturbed pile. Another known cause is mechanical friction heat in, for example, a roller bearing, which can ignite dust particles. Embers can be difficult to detect and they can travel in conveyor systems and start fires in storage areas.

Water is often an unsuccessful method of fighting smouldering fires in bulk storage silos. Water from sprinkler or deluge systems will only cause damage to the silo and is ineffective in suppressing deep seated fires as the water will generally tunnel down through the outside of the material instead of wetting it through.

## SUPPRESS FIRES WITH INERT GASES

Alternative firefighting strategies have been devised which use the injection of inert gases to suppress combustion. Inert gases can deplete the oxygen available for combustion and quench the pyrolysis. The most commonly available inert gases in large quantities are nitrogen and carbon dioxide.

## PYROLYSIS GASES

Oxygen-deficient smouldering fires produce pyrolysis gases. A typical pyrolysis gas is carbon monoxide, which is poisonous and flammable. The presence of unburned pyrolysis gases is a known hazard to firefighters. If a compartment fire has little or no ventilation, leading to an oxygen-deficient environment, large amounts of unburned gases will accumulate. The gases may remain at a temperature hotter than the auto-ignition temperature. The sudden access to air by breaking a window or opening a door may result in large flames rapidly expanding towards the source of oxygen; this is known as a backdraft.



Top: Water is often an unsuccessful method of fighting smouldering fires in bulk storage silos.

Bottom: A pellet silo exploded in Norway when firefighters injected carbon dioxide to quench the smouldering fire. Image courtesy Dag Botnen, Hallingdal brann- og redningsteneste, Norway.

Mixtures of fuel and air will burn only if the concentration of fuel is within certain limits, the so-called flammability limits. The limits for methane, for example, are five – 15 per cent volume. Carbon monoxide has a much wider flammability interval, the lower and upper flammability limits are 12.5 - 74 volume per cent. Mixtures of pyrolysis gases and air, at temperatures below the auto-ignition temperature are therefore likely to be in the ignitable range and able to cause an explosion if they meet an ignition source. Carbon dioxide may provide that source of ignition.

## THE NORWEGIAN SILO FIRE

The silo in Norway was half full, with an inventory of about 3,500 cubic metres of wood pellets. The pellets had self-ignited and started a smouldering fire deep inside the pile. The first indications of trouble came about midnight when sensors in the pile registered elevated temperatures. Later came an alarm from the silo's fixed carbon-monoxide detector.

Firefighters were quick to order a shipment of nitrogen to be able to inject into the silo to quench the fire. For a number of reasons — it was late at night and the nitrogen gas production facility was located several hundred kilometres away — the tanker truck was estimated to arrive about noon. A revised estimate pushed the arrival of the tanker to late afternoon, at the earliest.

Firefighters are people of action and it is easy to imagine just how unattractive it must be for them to stand idle next to a burning silo, merely waiting for a truck to arrive. Unable to wait, firefighters began collecting CO<sub>2</sub> bottles from nearby power stations and industries. Only 22 bottles were available, about 220 cubic metres of CO<sub>2</sub> gas, just five per cent of the headspace volume. Although the effect of CO<sub>2</sub> injection was thought to be limited because of the limited quantities available, out of sheer frustration a CO<sub>2</sub> attack was decided, in the hope that it at least might attenuate the fire until nitrogen supplies arrived.

A ladder on the silo led to a fixed platform, which provided access to an inspection hatch in the roof. The firefighters decided to manually discharge the CO<sub>2</sub> bottles through this hatch opening. When discharging the fifth CO<sub>2</sub> cylinder, the silo exploded.

The firefighters were briefly enveloped in flames, but fortunately their personal protective equipment offered excellent protection and they suffered minor burn injuries only. Static discharges from the CO<sub>2</sub> bottles may have ignited the pyrolysis gasses. It is conceivable that the firefighters themselves inadvertently introduced the source of ignition that led to the explosion, which easily could have killed them had the blast been strong enough.

## HAZARD UNDER-APPRECIATED

A recent paper in *Biomass and Bioenergy* (Carbon dioxide not suitable for extinguishment of smouldering silo fires: Static electricity may cause silo explosion - Volume 108, January 2018, pages 113-119) examines international standards, guidelines, recent editions of frequently cited pellet handbooks and other literature. The paper argues that the electrostatic hazard of CO<sub>2</sub> is widely under-appreciated, across countries. The situation appears particularly grave for NFPA 12 on carbon dioxide extinguishing systems, which gives ill-conceived advice on the application of CO<sub>2</sub> to deep-seated fires involving solids subject to smouldering. NFPA 69 and NFPA 850 should also be revised to highlight the hazard.

## PAST ACCIDENTS FORGOTTEN

In the past, major explosions have been attributed to electrostatic ignition of flammable vapours during the release of CO<sub>2</sub> for fire-prevention purposes. The most dramatic explosion may have been an explosion of a U.S. Air Force underground tank with JP-4 in 1954, which killed 37 people. The victims were officials, technicians and contractors who were standing on the roof of the tank while carrying out acceptance tests of the tank's novel carbon

dioxide fire extinguishing system. Unfortunately, there is evidence to suggest that those early lessons learned have at least partly passed out of sight.

We wish to alert the pellet community that suppression of a smouldering silo fire with carbon dioxide is potentially unsafe. Firefighters have no means to determine if the atmosphere in the silo headspace is ignitable. The release of liquid carbon dioxide is associated with electrostatic discharges with sufficient energy to ignite flammable pyrolysis gases. The result may be an internal explosion with loss of life. •

*Frank Huess Hedlund is a risk expert at COWI and associate external professor at the Technical University of Denmark (DTU) teaching risk management. He has 25 years of experience, working for clients in industry and government carrying out risk and safety studies and industrial accident prevention work. fhhe@cowi.com, fhuhe@dtu.dk*

*Jeffrey C. Nichols is managing partner at Industrial Fire Prevention, LLC and has been applying systems for the protection of equipment and personnel in processing industries since 1979. Mr. Nichols is a member of the NFPA 664 technical committee. Through his company, Jeff has been instrumental in bringing protection to many types of processes including drying, milling, grinding, and dust collection systems in industries handling combustible dust. JNichols@IndustrialFirePrevention.com*

# MORBARK<sup>®</sup> STRONG!



**Morbark Strong.** It's more than a slogan; it's a way of life for us. It's our commitment to you that our heavy duty equipment is built to withstand the rigors of even your toughest jobs.

All Morbark equipment is aggressive, productive and engineered to give you the power and features you need to maximize output, minimize downtime and enhance your profitability.

Contact Cardinal for all your Morbark equipment, parts and service needs!  
[www.cardinalsaw.com](http://www.cardinalsaw.com)



**ANGLIERS**  
Administration, manufacturing, Engineering and service  
7, rue du Cheminot  
J0Z 1A0  
819.949.2281

**QUÉBEC**  
Equipment & Parts Sales  
2700, rue Jean-Perrin  
Office 114  
G2C 1S9  
1.800.463.4862

**NORTH BAY**  
Parts Sales  
161, Ferris Drive Unit 7  
Ontario  
P1A 4K2  
1.800.598.3044

**PORT PERRY**  
Parts Sales  
171, North Port Road Unit 5  
Ontario  
L9L 1B2  
416.659.936

**NOUVEAU-BRUNSWICK**  
Parts Sales & Service  
553, Ferdinand Blvd Unit 4  
Dieppe  
E1A 7G1  
1.800.931.9611