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Fighting Pellet Silo Fires

BY FRANK HEDLUND AND JEFFREY NICHOLS

Smoldering 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, e.g., in a roller bearing, which can ignite dust particles. Embers can be difficult to detect, and they can travel in conveyor systems, starting fires in storage areas.

Oftentimes, smoldering fires in bulk storage silos can't be fought with water. Realize that putting 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.

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

Oxygen-deficient, smoldering fires produce pyrolysis gases, such as carbon monoxide, which is poisonous and flammable. The presence of unburnt 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 unburnt gases will accumulate. These gases may remain at a temperature hotter than the auto-ignition temperature, and sudden access to air—for example, breaking a window or opening a door—may result in large flames rapidly expanding toward the source of oxygen, known as a backdraft.

Carbon monoxide has an unusually wide flammability interval, the lower and upper flammability limits are 12.5 to 74 percent by volume. Mixtures of pyrolysis gases and air at temperatures below the auto-ignition temperature may therefore 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.

A real example is an explosion that occurred in a wood pellet silo in Norway. It was half full, with an inventory of about 3,500 m³ of wood pellets. The pellets had self-ignited, and started a smoldering fire deep inside the pile. The first indications of trouble came about midnight, when sensors in the pile registered elevated temperatures. Later, an alarm sounded from the silo's fixed carbon monoxide detector.

Firefighters were quick to order a shipment of nitrogen to inject into the silo to quench the fire. For a number of reasons,

the tanker truck was estimated to arrive about noon. A revised estimate pushed the arrival time to late afternoon, at the earliest.

Firefighters are men of action, and it is easy to imagine the difficulty of standing idle next to a burning silo, merely waiting for a truck to arrive. Unable to wait, firefighters began collecting CO₂ bottles from nearby power stations and industries. Only 22 bottles were available, about 220 m³ of CO₂, just 5 percent of the headspace volume. Although the effect of CO₂ injection was thought to be limited because of the limited quantities available, out of sheer frustration, a CO₂ 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 that provided access to an inspection hatch in the roof. The firefighters decided to manually discharge the CO₂ bottles through this hatch opening, and when discharging the fifth CO₂ 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 CO₂ bottles may have ignited the pyrolysis gases. 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.

The electrostatic hazard of CO₂ is widely underappreciated, across countries. The situation appears particularly grave for NFPA 12 on carbon dioxide extinguishing systems, which gives ill-conceived advice on the application of CO₂ to deep-seated fires involving solids subject to smoldering. NFPA 69 and NFPA 850 should also be revised to highlight the hazard.

In the past, major explosions have been attributed to electrostatic ignition of flammable vapors during the release of CO₂ 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.

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