NIOSH FIRE FIGHTER FATALITY INVESTIGATION AND PREVENTION PROGRAM

LINE-OF-DUTY DEATH REPORT

Lumber mill silo fire and subsequent explosion kills two firefighters and critically injures thirteen more – Maine

F2026-07 ME · August 2026

KEY POINTS

- Two volunteer firefighters died following an explosion of an oxygen-limiting silo that occurred on May 15, 2026.
- The explosion critically injured eleven volunteer firefighters and two EMS providers.
- Facility employees and firefighters were unaware that the silo was oxygen-limiting or that its contents were a combustible dust hazard.
- Over the past 40 years, NIOSH investigated several incidents where firefighters directing water into an oxygen-limiting silo unintentionally caused explosions.

Image 1. Aerial view of incident from Side Bravo of incident silo, post-explosion. (Source: State Fire Marshal's Office)

SUMMARY

The facility automatic notification system reported a fire in the silo with employees subsequently finding smoke conditions. When the fire department arrived, they deployed a hoseline and directed water into an opening at the silo's base. Facility owners and employees remained at the silo to answer questions to assist firefighters. After some time, firefighters believed the fire was largely under control. Without any warning, the silo launched into the air followed by a large plume of fire at the bottom as it rose. The explosion threw surrounding facility employees, firefighters, and EMS providers away in a blast of pressure and fire. Approximately two hours after the explosion, a personnel accountability check found that one firefighter was missing and later declared deceased. Another firefighter died four weeks later as a result of injuries sustained at the incident. *See Table 1 for contributing factors and prevention actions.*

Table 1. Contributing factors and prevention actions

Contributing factor	Prevention action summary
1. Combustible dust explosion	Train fire officers and firefighters on the hazards associated with different types of silos, including any unique hazards posed by silo contents.
2. Fire suppression tactics for silo fires	Ensure firefighters choose the appropriate firefighting tactics for silo fires and never direct water or foam into an oxygen-limiting silo.
3. Incident command	Establish and maintain unified command with high-hazard occupancy representatives throughout the incident.
4. Personnel accountability system	Use a personnel accountability system to identify the location and function of all operating personnel.
5. Fire department pre-incident planning	Develop a pre-incident plan for all high-hazard occupancies, such as lumber mills.
6. Lumber mill emergency planning	Ensure fire safety and evacuation plans include information on combustible dust explosion hazards and share this information with responding fire departments.
7. Combustible dust explosion mitigation and prevention	Properly operate and maintain silos and implement the applicable requirements of NFPA 660, Standard for Combustible Dusts and Particulate Solids.
8. Hazard identification	Update relevant codes and standards to require hazard labeling for bulk storage enclosures containing combustible dust.

BACKGROUND

Table 2. Fire department information

Category	Information
Department type	Volunteer
Jurisdiction	40 square miles
Population	1,400 residents
Average response	70 calls for service annually
Personnel	14
Leadership	Fire chief, assistant chief, safety officer, and three lieutenants

Apparatus, staffing, and communications

The county operates a public safety answering point (PSAP) that dispatches all emergency and non-emergency fire, EMS, and law enforcement response calls. At 10:08, 11 units and multiple privately owned vehicles (POVs) across six fire departments were dispatched for a fire in a silo (see Table 3):

Table 3: Units dispatched

Apparatus	Staffing	On-scene arrival
Engine 40-2	2	10:22
Engine 70-1	2	10:22
Engine 50-6	1	10:22
Engine 70-3	1	10:23
Engine 30-2	1	10:26-10:28
Engine 30-6	1	10:26-10:28
Engine 60-4	1	10:32
Engine 80-3	1	10:34
Tanker 60-3	1	10:36
Rescue 80-2	1	10:42
Engine 80-4	1	Broke down while enroute
Multiple POVs	14	10:22-10:59

At 10:18, the county PSAP dispatched EMS. Ambulance 40-1 arrived on scene at 10:29 with a crew of two. Ambulance 40-2 arrived on scene at 10:36.

Training, education, and professional development

The incident fire department (station 40) requires new firefighters to complete a 75-hour basic fire school at the county fire academy. The fire departments in this incident participated in periodic mutual aid trainings to enhance response by ensuring their personnel and resources were prepared to work together at incidents.

Chief 40 (incident commander) had 41 years of total fire service experience at the fire department, with 26 years as fire chief. Engine 30-2 firefighter (deceased firefighter) had 3.5 years of total fire service experience. Chief 40-1 (deceased firefighter) had 60 years of total fire service experience.

Cause of death and injuries

According to the state medical examiner report, the cause of death of Engine 30-2 firefighter was thermal injuries with smoke inhalation. Chief 40-1 died at the local hospital four weeks after this incident due to burn injuries. The silo explosion caused five firefighters to sustain serious injuries and six more to sustain minor injuries. The two Ambulance 40-1 EMS providers sustained serious injuries. Two of the lumber mill owners sustained serious injuries with one subsequently dying at the local hospital a month later. Multiple other facility employees sustained both serious and minor injuries.

Lumber mill

This incident occurred at a 40-acre lumber mill that produced white pine lumber products, such as boards and siding. As part of the production process, the facility operated multiple bandsaw mills, planer mills, and dry kilns. The facility generated power for production using an 8.5-megawatt biomass fired cogeneration power plant.

Wood shavings and sawdust

The lumber mill operated two bagger systems to package wood shavings, a byproduct of lumber production. The wood shavings were kiln dried and heat treated, then transported from mill buildings using pipes to the bagger systems. Each bagger system had a silo where the wood shavings and residual sawdust were deposited at the top through an air-material separator. The wood shavings and sawdust were then fed into another piping system at the base of each silo using an auger. They were then transported through another pipe to a bagger machine where they were packaged for sale.

Image 2. Aerial view of lumber mill, pre-incident. (Source: Lumber mill)

Silo construction and characteristics

The incident silo was located at bagger #2. It was a 20 ft x 60 ft oxygen-limiting Harvestore® silo. The silo was bolted to the top of a concrete room that was 22 ft x 10.5 ft. The top of the room had an auger system that pulled wood shavings and sawdust into a 3 ft diameter hole. The hole led into a square chute that led to a pipe to a blower outside the room that transported the wood shavings to the bagger machine. The room contained electrical panels for the systems and had double wooden entry doors on Sides Alpha and Charlie. An air-material separator was installed on the roof of the silo.

The lumber mill purchased the incident silo used in 1993. In later years, the facility engineer modified it. A dry sprinkler system was installed in the room below and in the top of the silo headspace. The sprinkler system was connected to a local monitoring system. When either sprinkler was activated, a siren, water bell, and beacon were activated to alert facility employees. Per the lumber mill's emergency evacuation and fire prevention plan, the bagger machines were shut down in the event of a fire. Facility employees and firefighters interviewed by NIOSH were unaware that the silo at bagger #2 was oxygen-limiting or what unique hazards this type of silo had compared to conventional types. *More about types of silos and their characteristics can be found under more information.*

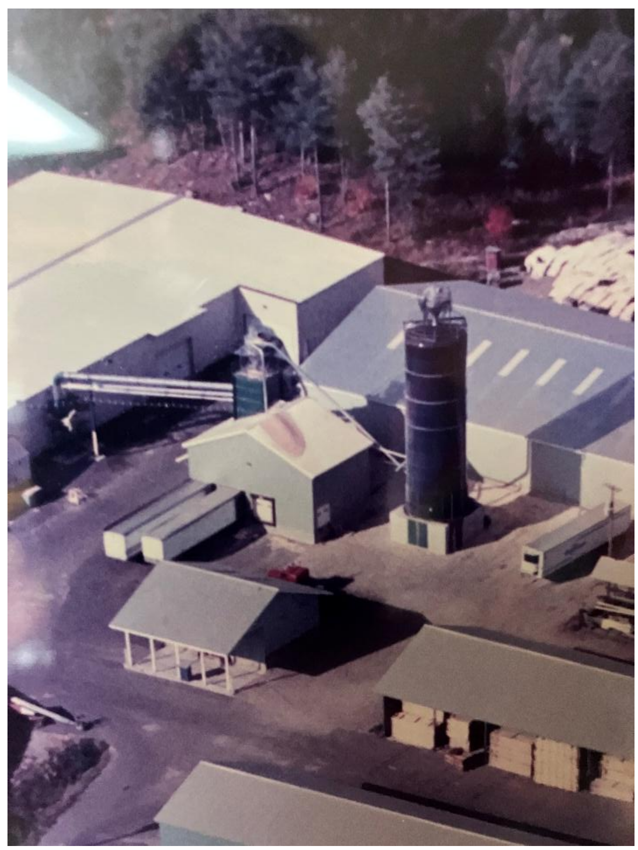

Image 3. View of incident silo at bagger #2, Side Alpha, pre-incident. (Source: Lumber mill)

Emergency planning, hazards, and previous fires

The lumber mill had an emergency evacuation and fire prevention plan. Employees were trained on the plan prior to their start and received annual refresher training. The facility had a fire alarm system, and each building was equipped with fire extinguishers. There were pre-designated marshalling areas for employee evacuation for accountability. In the event of a fire alarm, employees were trained to notify the main office and the safety officer via telephone or radio. When the fire department was requested, the safety officer and other employees would assemble at the facility's entrances to direct apparatus to the location of the emergency. The facility had 11 fire hydrants on site. Some buildings contained stations equipped with 1 ¾-inch hoseline with combination nozzles. On an annual basis, the facility would host a walk-through for the first alarm assignment fire departments to support familiarization of the facility, buildings, hydrant locations, etc.

Image 4. Station containing hoseline for facility fire suppression, post-incident. (Source: NIOSH)

Combustible dust hazard

The emergency evacuation and fire prevention plan listed several potential hazards at the facility. Wood dust was listed as a hazard only for buildup on or around electrical panels and equipment. Facility employees interviewed by NIOSH were unaware that the contents of the silos, wood shavings and sawdust, constituted a combustible dust hazard. Subsequently, facility employees and responding firefighters were not notified of any combustible dust hazards before or during the incident. *More about combustible dust can be found under more information.*

Previous fires

The six fire departments in this incident responded to several silo fires at the facility over the past 20 years. Those fires occurred in the silo at bagger #1, a conventional silo. Firefighters interviewed by NIOSH described these fires as "Roman candles," demonstrating the fires had vented at the top of the silo at each incident. In these previous incidents, firefighters connected to a deluge system the facility engineer had installed in the silo at bagger #1 to successfully bring the fires under control.

Image 5. Silo at bagger #1 where previous fires occurred. (Source: NIOSH).

Fire origin and explosion cause

The State Fire Marshal's Office and Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) cause-and-origin preliminary investigation classified the fire as accidental. It indicated that the area of origin was the unloader mechanism at the base of the incident silo. It also determined the facility's fire suppression system in the top of the silo headspace did not activate because temperatures at that elevation did not reach the activation threshold after the fire originated at the base of the silo. The preliminary investigation identified the subsequent explosion cause as combustible dust.

Personal protective equipment

At the time of the incident, the Engine 30-2 firefighter was wearing full structural firefighting turnout gear and a NIOSH Approved® self-contained breathing apparatus (SCBA). No evidence was identified to suggest that the structural firefighting turnout gear or SCBA contributed to the fatality.

Weather conditions

At 10:12, on May 15, 2026, the outdoor temperature was 59°F, dewpoint 51°F, the wind out of the east at 9 mph, no precipitation, and conditions were cloudy [Weather Underground 2026].

TIMELINE

This is a timeline of events. Sources include dispatch records, audio recordings, and witness statements, among others. This is not an official record of events.

Day 1: May 15, 2026

10:00-10:05

- Facility automatic notification system reported a fire. Bagger #2 zone fire system tripped with the system showing fire pumps were running.
- A facility employee radioed that there was smoke coming from the room under the silo at bagger #2.

10:06-10:07

- PSAP received a 911 call from a facility employee reporting a fire in the room under the silo and requesting fire department response. The employee stated smoke was visible but there were no flames.
- A facility employee shut down bagger #2 to terminate operations. Employees deployed a hoseline towards the silo.

10:08

- PSAP transmitted full alarm assignment for a fire in a silo. Fire departments 30, 40, 50, 60, 70, and 80 were dispatched.

10:09-10:21

- Facility owners and employees arrived at the silo and observed white-colored smoke coming from the room underneath. They noted the sprinkler system had activated, with water rushing to the ground.
- Facility employees used hoselines to spray water into the room under the silo while others used thermal imagers to try to identify any elevated temperatures on the silo.
- Additional facility employees terminated power to bagger #2 and nearby systems. System controls indicated that the silo was over 20% full of wood shavings and sawdust.
- Facility safety officer and other employees arrived at the site entrances to direct responding fire apparatus

to the silo location.

- PSAP dispatched Ambulance 40-1 and 40-2.

Image 6. View of room under the incident silo, Side Alpha, post-incident. (Source: State Fire Marshal's Office)

10:22-10:28

- Engine 40-2 arrived on scene, and Chief 40 gave a size-up of smoke showing. Chief 40-1, Chief 70, and Engines 70-1 and 50-6 arrived on scene.
- Engine 40-2 staged on the Side Alpha/Delta corner of the silo. Engines 50-6 and 70-1 staged close by.
- Engine 40-2 firefighter and Chief 70 deployed a 150 ft 1 ¾-inch hoseline to the Side Alpha doors of the silo room. They entered the silo room but could not see well due to the water spray from the activated sprinklers.
- Chief 40-1 (deceased firefighter) requested Engine 70-1 to connect to Engine 40-2 as a temporary water supply until a connection to a hydrant could be established.
- Engines 70-3, 30-2, 30-6, and Lieutenant 40 arrived on scene.
- Chief 70 exited the silo room and spoke with a facility owner and employees about access into the silo itself. They explained to Chief 70 that there was a plexiglass access panel on the chute in the room under the silo.

- Chief 70 returned and located the area described but noticed a portion of the panel had melted off. He placed the nozzle of the hoseline from Engine 40-2 in the opening and began to spray water through the 3 ft diameter hole into the base of the silo.

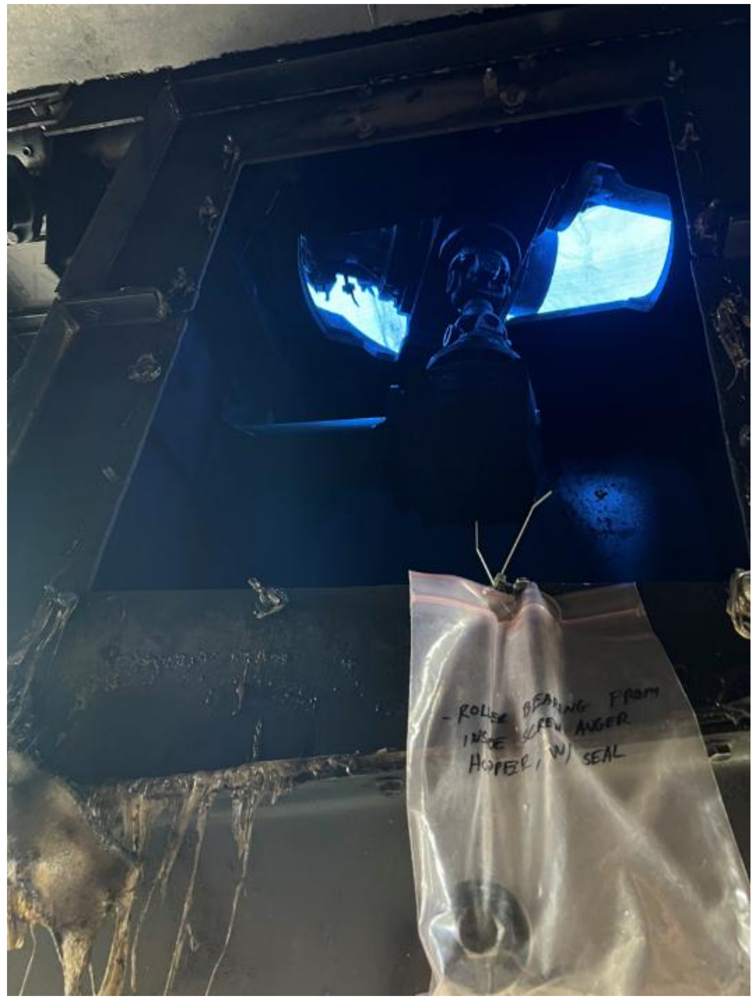

Image 7 and 8. View of nozzle in chute (left) and 3 ft diameter hole into base of silo (right), post-incident.
(Sources: State Fire Marshal's Office and NIOSH)

10:29

- Ambulance 40-1 arrived on scene. Its crew set up a treatment and rehab area near the Side Charlie/Delta corner of the silo.

10:30-10:39

- Engines 60-4 and 80-3, and Tanker 60-3 arrived on scene.
- Chief 70 and Engine 40-2 firefighter periodically stopped flowing water to reassess conditions. During one pause, they noticed flames and an orange glow in the silo's base.
- Lieutenant 40 climbed a step ladder and began to flow water into the blower on Side Charlie of the silo using the facility's hoseline. He believed there may be burning wood shavings in the pipe and blower.

Image 9. View of operations at incident silo, Side Delta. (Source: Fire department)

10:40-10:42

- At this time, firefighters on scene believed the fire was largely knocked down and overhaul was needed for hotspots. There was no sense of urgency, and firefighters described the response as relaxed.
- Chief 40 and other firefighters discussed a plan of requesting a ladder truck to introduce water into the top of the silo. Chief 40 requested the PSAP to dispatch station 90 for their tower.
- Chief 40 then requested on-scene firefighters to establish a water supply for the enroute Tower 90-3. Engine 30-6 began a reverse hose lay to a hydrant from the Side Bravo/Charlie corner of the silo.
- Multiple firefighters assisted Engine 30-6 but found that the located hydrant would not operate. The firefighters waited for facility employees to assist as the power to the water pumps may have been shut down.
- Rescue 80-2 arrived on scene.
- Chief 70 and Engine 40-2 firefighter exited the room under the silo. They were replaced with firefighters from station 60 who continued directing water into the base of the silo.

Image 10. View of apparatus placement near incident silo with Engine 70-1 supplying Engine 40-2. (Source: Fire department)

10:43-10:59

- Facility employees shut down the sprinklers in the room under the silo. Station 60 firefighters placed wedges in the system to prevent future sprinkler activation.
- Noticing no change in conditions, Lieutenant 40 stopped flowing water into the blower on Side Charlie.
- A facility employee and Chief 70 went up the ladder onto the room under the silo to look for other access points. While they looked, firefighters using thermal imagers noted readings between 40°F and 120°F on the silo exterior metal.
- Facility employees and firefighters considered removing panels to better access the base of the silo.
- Suppression efforts continued with firefighters flowing water from the room under the silo. On-scene firefighters, including Engine 30-2 firefighter (deceased firefighter) and Chief 40-1, stood around the silo as operations continued.

Image 11. Lieutenant 40 flowing water into the blower on Side Charlie. (Source: Fire department)

11:00

- Firefighters around the silo heard a “whoosh” noise as smoke began to quickly emanate from the air-material separator on the top of the silo.
- The silo launched into the air followed by a large plume of fire at the bottom as it rose.
- The explosion threw surrounding facility employees, firefighters, and EMS providers away in a blast of pressure and fire. The burning contents of the silo covered the area and those thrown by the blast.
- Tower 90-3 arrived on scene.

Image 12. Surveillance footage capturing moment the incident silo exploded. (Source: Lumber mill)

11:01-15:00

- Engine 80-3 firefighter reported to the PSAP that the silo had exploded. He requested help as firefighters were down and there were multiple burn victims.
- Following the explosion, firefighters searched for survivors and pulled them away from the area of the explosion. Many of the firefighters assisting others were critically injured themselves but attempted to provide assistance amidst the chaos.
- Multiple stations began on-scene accountability checks. Firefighters and victims were transported to multiple hospitals using both ground and air transportation.
- The subsequent fire began to involve multiple structures around the silo. Defensive operations began to protect exposures and limit further fire spread to the rest of the facility.
- The fire destroyed Engines 40-2, 50-6, and 70-1.
- Approximately two hours after the explosion, the State Fire Marshal's Office completed a full on-scene accountability check with the new incident commander. Engine 30-2 firefighter was the only firefighter unaccounted for.
- Engine 30-2 firefighter's remains were located near the silo under burning wood shavings. An honorable transfer of his remains from the scene was conducted.
- Chief 40-1 was transported to a local hospital where he died four weeks later as a result of injuries

sustained at the incident.

- In total, 299 firefighters from 46 fire departments across four counties responded to the incident until the fire was brought under control. The local fire chiefs organized peer support and mental health services for all first responders involved in the incident.

Image 13. View of defensive operations after explosion. (Source: State Fire Marshal's Office)

CONTRIBUTING FACTORS AND PREVENTION ACTIONS

1

Contributing factor · Combustible dust explosion
Prevention action · Fire departments should train fire officers and firefighters on the hazards associated with different types of silos, including any unique hazards posed by silo contents.

Facility employees and firefighters interviewed by NIOSH were unaware that the silo at bagger #2 was oxygen-limiting or what unique hazards this type of silo has compared to conventional types. Additionally, facility employees were unaware that the silo's contents, wood shavings and sawdust, constituted a combustible dust hazard. Subsequently, responding firefighters were not notified of any combustible dust hazards before or during the incident.

Since 1985, NIOSH has investigated six incidents of firefighter fatalities and injuries resulting from silo fires and explosions. For each incident, NIOSH recommended that firefighters be trained on the hazards associated with and the appropriate firefighting tactics for silos [NIOSH 2025; NIOSH 2012; NIOSH 2011; NIOSH 2006; NIOSH 2004; NIOSH 1985]. The existing literature on silo fires and explosions has remained unchanged for more than 40 years based upon the science of the conditions created by the design and contents. Typical firefighting tactics can unintentionally create the conditions for an explosion in a silo by creating dust clouds, introducing air, applying incompatible extinguishing methods, and using equipment that can become an ignition source [OSHA 2013]. Additionally, the building characteristics of silos can present vulnerabilities that require special consideration and planning for firefighting activities [NFPA 1700 2026]. In terms of content hazards, the fermentation process naturally forms various gases in the silo, such as carbon dioxide. When organic material burns, the organic compounds also release hazardous gases such as carbon monoxide, nitric oxide, nitrogen dioxide, and nitrogen tetroxide. Many of these gases are flammable, maintain an explosive range, and can accelerate the burning of combustible materials. Additionally, chemical additives may be added to silo contents such as corn. These include urea, anhydrous ammonia, and organic acid preservatives [Murphy and Arble 2000; Arble and Murphy 1988]. According to USFA [1998], firefighters should consider the presence of these gases and chemicals, especially in an oxygen-limiting silo. One of the most dangerous hazards that silos present is a combustible dust explosion. Since 1980, there have been over 200 combustible dust incidents at industrial facilities that have led to the deaths and injuries of workers [OSHA 2024].

Fire departments can develop training from available resources or requisition existing training. Silo fire and emergency trainings are available through fire academies and private fire training organizations. Fire departments can develop standard operating procedures/guidelines using the information and response techniques learned from these trainings [NIOSH 2025].

2

Contributing factor · Fire suppression tactics for silo fires
Prevention action · Fire departments should ensure firefighters choose the appropriate firefighting tactics for silo fires and never direct water or foam into an oxygen-limiting silo.

The fire departments in this incident responded to several silo fires at the lumber mill over the past 20 years. All of these fires occurred in the silo at bagger #1, a conventional silo. At the incident, firefighters employed similar tactics of flowing water into the oxygen-limiting silo as these efforts worked previously at the conventional silo. NIOSH investigators obtained the manufacturer's published silo emergency procedures. Under fire department instructions, the document states "DANGER: Do not fight fire by adding water or foam to the structure." The document warns against spraying water or foam into the oxygen-limiting silo as it will force air in and may create a potentially explosive mixture [Harvestore 1993]. The application of water into the silo in this incident likely entrained oxygen into the silo headspace, stirred up dust within the contents, and caused it to become suspended in an explosive concentration.

One of the most important factors for firefighters to consider with silo fires is time. Time is especially important when dealing with an oxygen-limiting silo whose design reduces the ingress of oxygen to support combustion. Unlike when other dry materials and flammable structures burn, silo fires burn slowly (days, weeks, months). There is often ample time at the scene to analyze the situation and develop a plan for extinguishing the fire. This includes time to meet with facility employees and collect all pertinent information regarding the silo [NIOSH 2025; Murphy and Arble 2000; Arble and Murphy 1988]. There are several firefighting tactical considerations for fires in oxygen-limiting silos that fire departments can implement around size-up and hazard recognition, extinguishment actions, and safety considerations [NFPA 350 2022; Hill and Rickenbach 2015; OSHA 2013; OSHA 2011a; OSHA 2011b; Murphy and Arble 2000; Arble and Murphy 1988]:

Size-up and hazard recognition

- Verify the type of silo, location of the silo unloading/opening, utility shutdowns (lockout/tagout), all additional openings, and location of exposures
- Determine the content type and amount in the silo

- Determine the length of time the silo fire has lasted
    - Fire burning for an extended period can create void spaces in the contents
- Observe smoke conditions and location (if present)
    - Smoke emitting from the top hatches of an oxygen-limiting silo dictates that the top hatches should not be closed or secured
- Establish a collapse zone around the silo

Extinguishment actions

- **Avoid** all firefighting activities that introduce air into the silo
    - No attempt should be made to enter, breach, or directly extinguish fire in the silo
    - Water or foam **should not** be directed into the silo
    - Attempting to drown the fire with a deluge of water is not effective as the water will not penetrate deeply into the contents, but run off towards and down the inside walls (water follows the path of least resistance), by passing the hot areas of contents
- Allow an oxygen-limiting silo to smother itself out by not opening the top or bottom hatches for several weeks
    - Assign the facility to conduct a fire watch during this time
    - Facility may have to partially or completely empty the silo with extinguishment of the burning contents after removal from the silo
- Consult with the silo manufacturer for step-by-step instructions or recommendations on how to extinguish fires in their silos

Safety considerations

- Any attempt to extinguish a fire inside an oxygen-limiting silo may introduce oxygen into the silo (via natural oxygen ingress through openings or through water), increasing the risk of causing the suspension of combustible dust resulting in an explosion or backdraft type of situation
- Firefighters should stay off an oxygen-limiting silo that is shaking, noisy, hot, smoking heavily, or that has been opened (allowing oxygen ingress) within the past few days
- Silos are considered permit-required confined spaces due to being large enough to bodily enter, having limited access, having a potential for a hazardous atmosphere, and containing a potential for engulfment
    - Silos may contain immediately dangerous to life and health (IDLH) atmosphere due to the presence of combustible gases, dust, vapors, and toxic agents in accordance with 29 CFR 1910.272
    - Silos are a confined space and any planned entry should utilize considerations provided in NFPA 350, Guide for Safe Confined Space Entry and Work

3

Contributing factor · Incident command
Prevention action · Fire departments should establish and maintain unified command with high-hazard occupancy representatives throughout the incident.

At this incident, the fire department worked independently during operations. Facility owners and employees were around the silo to answer questions from individual firefighters but were not part of a unified command structure. While the firefighters routinely responded to the lumber mill for emergencies, the facility owners and employees knew the facility and its operations, which may have benefited overall incident operations and decision making.

Unified command is an application of the incident command system where designated members of different agencies, jurisdictions, or disciplines collectively participate in managing an incident as an integrated team. The members establish a common set of objectives and strategies which address multiagency or multijurisdictional priorities. This type of command structure allows agencies with different functional authorities and responsibilities to perform integrated incident operations without losing individual agency responsibility, authority, or accountability [NFPA 1550 2024]. Unified command is often utilized for complex incidents that involve multiple jurisdictions, agencies, or functional responsibilities. The use of this system [NRT 2007]:

- Allows for information sharing
- Ensures logistical support and coordination of resources
- Reduces duplicative efforts and chances for conflict
- Establishes awareness of individual plans, actions, capabilities, and limitations
- Encourages a cooperative response environment

A unified command structure should be implemented as early into the incident as possible when fire departments respond to high-hazard occupancies. Representatives of these occupancies may have knowledge about hazards and logistics that the fire department does not. Establishing this structure begins with an initial meeting of the incident commanders to discuss priorities, incident objectives, an overall strategy, and the selection of a unified command spokesperson. This meeting will also provide an opportunity to discuss capabilities and constraints related to authorities, skills, experience, and equipment which may affect achieving response objectives. Planning and periodic exercises before an incident provides opportunities to formalize how a unified command will be implemented at high-risk occupancies [NRT 2007].

4

Contributing factor · Personnel accountability system
Prevention action · Fire departments should use a personnel accountability system to identify the location and function of all operating personnel.

The fire departments in this incident utilize a tag system for accountability. Firefighters are trained to place their accountability tags on rings affixed to the pump panel of the first arriving apparatus. This personnel accountability system was not utilized at this incident. Multiple fire departments conducted station-specific personnel accountability checks following the explosion. Engine 30-2 firefighter was discovered to be missing two hours after the explosion when a full personnel accountability check was conducted by the State Fire Marshal's Office.

Image 14. Accountability rings on pump panel. (Source: Fire department)

A personnel accountability system is a system that identifies the location and function of all members operating at an incident scene [NFPA 1550 2024]. This system is activated during an incident to collect and maintain the status and location of personnel that may be working in an IDLH environment. All personnel operating at an incident are responsible for understanding and participating in this system. The incident commander is responsible for all personnel but may delegate certain responsibilities to another person, such as the accountability officer. An integral part of the accountability system is to make sure that the firefighters who are assigned and operating in the hazard zone are accounted for throughout the entire incident. A properly initiated and enforced personnel accountability system can improve firefighter safety and survival [NIOSH 2024]. A functional personnel accountability system can identify [NIOSH 2026a; NIOSH 2016]:

- Members operating in the hazard zone
- Where members are in the hazard zone
- Conditions in the hazard zone
- Actions used in the hazard zone
- Paths of access and egress in and out (i.e., exits) of the hazard zone

- Rapid intervention teams/crews and their assignments

Different methods and tools are available for resource accountability, including [NIOSH 2026a]:

- Tactical worksheets
- Command boards
- Company responding boards
- Electronic bar-coding systems
- Accountability passports or keys

5

Contributing factor · Fire department pre-incident planning
Prevention action · Fire departments should develop a pre-incident plan for all high-hazard occupancies in their jurisdictions, such as lumber mills.

On an annual basis, the facility would host a walk-through for the fire departments dispatched for this incident for familiarization of the facility, buildings, hydrant locations, etc. Firefighters interviewed by NIOSH had noted the benefits of these walk-throughs and were able to identify key hazards and layout of the site. However, the incident fire department (station 40) did not have a formal pre-incident plan for the facility. Site-specific strategy and tactics were dictated by individual knowledge and memory of responding firefighters who had been to the facility.

A pre-incident plan is a document developed by gathering general and detailed data that is used by responding personnel to effectively manage emergencies for the protection of occupants, participants, responding personnel, property, and the environment. A pre-incident plan identifies deviations from normal operations and can be complex and formal, or simply a notation about a particular problem. Examples may include the presence of flammable liquids, explosive hazards, modifications to structural building components, or structural damage from a previous fire [NFPA 1660 2024]. For an oxygen-limiting silo, examples may include a pre-incident plan noting the presence of combustible dust.

NFPA 1660 [2024] outlines steps involved in developing, maintaining, and using a pre-incident plan by breaking the incident down into planning, implementation, and execution phases. The planning phase, for example, covers factors such as physical elements and site considerations, occupant considerations, protection systems and water supplies, hydrant locations, and special hazard considerations. Building characteristics that are important to record include type of construction, materials used, occupancy, fuel load, and unusual or distinguishing characteristics [NFPA 1660 2024]. Because many fire departments are unable to pre-plan for every structure within their jurisdiction, departments may opt to prioritize plans for structures that have elevated or unusual fire hazards and life safety considerations. Strategies and tactics employed at an emergency incident need to match the structure. The pre-plan information can help ensure that residential fire tactics are not applied at commercial structures [NIOSH 2026b].

6

Contributing factor · Lumber mill emergency planning
Prevention action · Lumber mills should ensure their fire safety and evacuation plans include information on combustible dust explosion hazards and share this information with responding fire departments.

The facility's emergency evacuation and fire prevention plan listed several potential hazards present at the facility. Wood dust was listed as a hazard only for build up on or around electrical panels and equipment. NIOSH interviewed facility employees who were unaware that the contents of the silos, wood shavings and sawdust constituted a combustible dust hazard. Subsequently, facility employees and responding firefighters were not notified of any combustible dust hazards before or during the incident. Facilities such as the one in this incident that produce and store combustible dust are classified as Group H-2 high-hazard occupancies

[IBC 2024].

The 2024 International Fire Code (IFC) provides fire and life safety requirements based on occupancy and use. The IFC dictates that all Group H occupancies shall have and maintain an approved fire safety and evacuation plan. Fire safety plan requirements include a list of all major fire hazards associated with the normal use and occupancy of the premises. The IFC also dictates that occupancy employees should be made aware of fire hazards associated with the processes and materials they are working with, through training and availability of Safety Data Sheets. This also includes requirements for each employee to be instructed in the proper procedures for preventing fires and responsibilities in the event of a fire [IFC 2024].

The 2024 IFC provides the requirements for operations that manufacture, process, and generate potentially combustible dust. These include completing a dust hazard analysis for new and existing facilities to identify combustible dust hazards for the fire safety and evacuation plan. The fire safety plan requirements allow for facility employees to communicate hazards to the responding fire department in the event of an emergency [IFC 2024]. This includes specific hazards and precautions that firefighters should be aware of when selecting fire suppression tactics. This would include precautions for combustible dust and explosions in silos.

7

Contributing factor · Combustible dust explosion mitigation and prevention
Prevention action · Lumber mills should properly operate and maintain their silos and implement the applicable requirements of NFPA 660, Standard for Combustible Dusts and Particulate Solids.

Facility employees interviewed by NIOSH were unaware that the silo at bagger #2 was oxygen-limiting. While a fire detection system was installed and working, prevention methods to mitigate fires, flash fires, and explosion hazards posed by the combustible dust and particulate solids were not present.

Facilities should routinely inspect and maintain all equipment to ensure safe operation and condition. This includes using the silo manufacturer's recommended proper maintenance procedures to ensure the integrity of their oxygen-limiting features [NIOSH 2004]. NFPA 660 [2025] prescribes the minimum requirements necessary to prevent or mitigate the fire, flash fire, and explosion hazards posed by combustible dust and particulate solids. The standard explains that owners and operators of these facilities should identify fire and explosion hazards associated with their facility and their potential consequences. This can be conducted through hazard identification and dust hazard analysis. They should manage and communicate these hazards to their employees [NFPA 660 2025].

NFPA 660 [2025] recommends managing these hazards by utilizing risk assessments, building design, equipment design, dust control, ignition source control, explosion prevention and protection, and fire protection. This may include the use of dust collection (vacuum) equipment as well as explosion prevention, relief, and venting devices and systems. The standard also includes requirements for emergency response plans that designate a facility employee to meet emergency responders to coordinate response to the incident [NFPA 660 2025].

8

Contributing factor · Hazard identification
Prevention action · Voluntary consensus standard-setting organizations, such as the NFPA and International Code Council, should update relevant codes and standards to require hazard labeling for bulk storage enclosures containing combustible dust.

The facility installed confined space warning labels on each silo to warn employees and firefighters about the hazards associated with these spaces. Firefighters interviewed by NIOSH were knowledgeable about confined space considerations associated with the silos. However, no warning labels were installed to notify employees and firefighters of the combustible dust hazards of the silos.

Previous NIOSH reports involving silo fires and explosions recommended that facilities install warning labels or placards on the exterior of silos that include information on the type of silo, emergency contact for the facility, and proper fire suppression tactics. Specifically, these reports recommended placards that clearly state "DANGER - Sealed Silo – Water Contributes to Explosion of Sealed Silos" or some variation [NIOSH 2025; NIOSH 2012; NIOSH 2011; NIOSH 2004]. NFPA 660 [2025] provides hazard management strategies for mitigation and prevention where a dust or particulate solid fire, flash fire, or explosion hazard exists. Section 9.4.9 discusses these for bulk storage enclosures such as silos, bins, tanks, and hoppers. While this section provides engineering strategies, it does not require warning labels for bulk storage enclosures. Other relevant codes and standards currently do not require installation of warning labels for bulk storage enclosures, such as silos, that contain combustible dust.

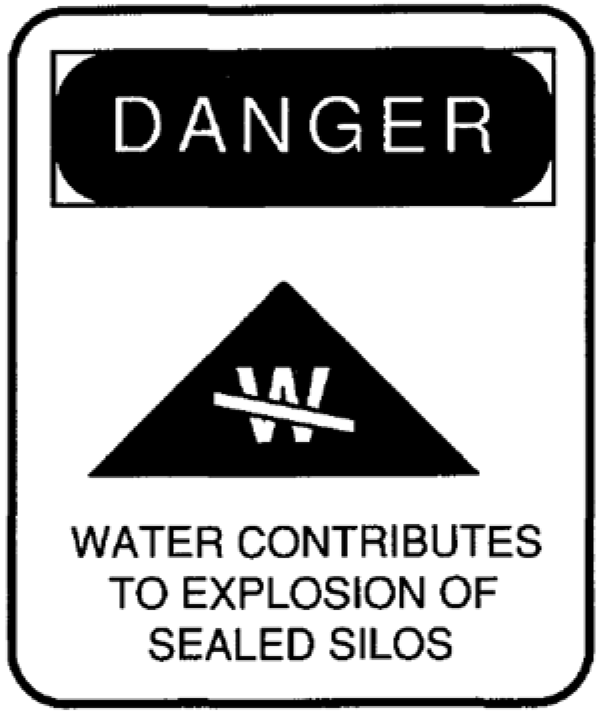

Figure 1. Example oxygen-limiting silo warning label. (Source: NIOSH)

Warning labels have long been used to increase the safety of workplaces. These are used as a method of supplementing design solutions focused on removing or reducing hazards [Lehto and Clark 1991]. For example, OSHA regulations require employers to install signs or labels for confined spaces that can be perceived and understood by all employees [OSHA 1994]. These do not eliminate the hazard but make employees aware that the hazard exists to inform their decision making. Voluntary consensus standard-setting organizations should update relevant codes and standards to require warning labels about combustible dust hazards to support dust hazard analysis practices. As in previous NIOSH recommendations, these can list appropriate fire suppression tactics.

FIRE DEPARTMENT ACTIONS TO ECHO

Actions to echo are measures the fire department took before and during the incident that may have prevented further serious injuries or fatalities or may help prevent similar incidents. NIOSH investigators identified the following actions to echo:

Conduct periodic mutual aid training.

The fire departments in this incident participated in periodic mutual aid trainings to enhance response by ensuring their personnel and resources were prepared to work together at incidents. Mutual aid departments should train together before an incident occurs to ensure they can integrate as a functional team. Periodic joint-training can benefit fire departments in understanding each other's equipment, procedures, and capabilities.

Participate in regular walk-throughs at high-hazard occupancies.

On an annual basis, the facility would host a walk-through for the first alarm assignment fire departments for familiarization of the facility, buildings, hydrant locations, etc. Firefighters interviewed by NIOSH had noted the benefits of these walk-throughs and were able to identify key hazards and layout of the site. Participation in walk-throughs can assist with pre-incident planning and incident response.

MORE INFORMATION

Silo types and characteristics

Review information previously shared on this subject above.

Silos are used for preservation, storage, and disbursement of organic materials such as foodstuff. Silos can also be used for storage of materials such as coal, powdered mixes, and sawdust. There are three types of vertical or upright silos [NIOSH 2025; Murphy and Arble 2000; Arble and Murphy 1988]:

1. **Conventional silos** are typically constructed of concrete staves with pretensioned steel hoops. They can also be constructed of brick, glazed tiles, and wood. They either feature a fabricated domed roof for weather protection or are open at the top. They often feature an external unloading chute with their contents unloaded from the top.
2. **Oxygen-limiting silos or "sealed" silos** have design features to limit the exposure of the contents to outside air which creates an oxygen deficient environment inside. They are often constructed of poured reinforced concrete, concrete staves, or enamel-coated steel. They do not have outside chutes and typically have bottom unloaders that remove the contents from the bottom using augers and conveyor systems. Fill and unloading hatches are sealed with clamps and gaskets to limit airflow.
3. **Modified oxygen-limiting silos** are those that were used as an oxygen-limiting silo but have been converted to a conventional silo. In any emergency situation involving this type of silo, they should be treated as an oxygen-limiting silo until a very detailed assessment of the structure, contents, and specific situation is completed.

Combustible dust

Review information previously shared on this subject above.

Combustible dust is a solid material composed of distinct particles which present a fire or explosion hazard when suspended in air or some other oxidizing medium over a range of concentration. Dust explosions often occur in a series where the first explosion stirs the dust settled in other areas of the confined space and results in additional explosions that are larger and stronger. These dusts are often byproducts of organic materials that are finely ground. For a dust explosion to occur, five conditions must be present [IFSTA 2016; NIOSH 1986]:

- Combustible dust is suspended in air
- Particle concentration is within explosive range
- Ignition source is present
- Dust is in a confined space
- Oxygen content is sufficient to support combustion

Investigator information

Incident investigators and report authors were Dr. Wesley R. Attwood, Senior Investigator, and Louis (Rick) Lago, Investigator, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH. The Occupational Safety and Health Administration and the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) performed a federal partner review of the investigation report. A subject matter expert review was provided by Eric J. Rickenbach and Travis Martin of RescueTechs, LLC. Dan Madrzykowski from the Fire Safety Research Institute, part of the UL Research Institutes, provided an expert review. The NFPA Emergency Response & Responder Safety Division provided a technical review.

RESOURCES

Request for assistance in preventing fatalities due to fires and explosions in oxygen-limiting silos

This NIOSH Alert discusses how firefighters are at significant risk for injury or death due to fires and explosions of oxygen-limiting silos. It provides additional information about prevention actions for both firefighters and workers related to these silos.

NFPA 660, Standard for Combustible Dusts and Particulate Solids (2025 edition)

NFPA 660, *Standard for Combustible Dusts and Particulate Solids*, 2025 edition, was written by consolidating the requirements of several previous standards so that this standard provides safety requirements for all combustible dust and particulate solids.

Silo initial assessment worksheet

This worksheet developed by RescueTechs, LLC can be used by fire officers and firefighters to collect all relevant information, including silo type and contents, to develop a plan before committing resources to a silo fire. The worksheet also provides critical initial management considerations for silo fires.

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