Volunteer Assistant Fire Chief Dies at a Silo Fire/Explosion - New York

Executive Summary

On April 11, 2010, a 26-year-old male volunteer Assistant Fire Chief (the victim) responded to a silo fire at a local farm. Upon arrival, he observed open doors (hatches) on top of the 60-foot metal oxygen-limiting silo. He climbed to the top of the silo via a ladder attached to the outside of the silo and closed and secured the hatches. He descended the silo and when approximately half-way down, the silo exploded. The explosion caused a section of the ladder to detach from the silo and the victim fell about 30-feet to the ground. The victim was given cardiopulmonary resuscitation by another fire fighter at the scene and then transported by ambulance to a regional hospital where he was pronounced dead.

Contributing Factors

- *unrecognized hazards associated with a silo fire*
- *closing and securing the hatches on top of the silo.*

Key Recommendations

- *review, revise, and enforce standard operating guidelines (SOGs) for structural fire fighting that include oxygen-limiting silos*
- *train officers and fire fighters on the hazards associated with different types of silos and the appropriate fire fighting tactics*
- *ensure that pre-emergency planning is completed for all types of silos located within fire department jurisdictions*
- *consider requiring that placards with hazard warnings and appropriate fire fighting guidelines be placed on silos*
- *consider silos as confined spaces and recognize the dangers associated with confined spaces when responding to silo fires*
- *ensure that an Incident Safety Officer is deployed at technical or complex operations.*

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Conventional silo (top) and oxygen-limiting silo (bottom)
(NIOSH Photos)

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH "Fire Fighter Fatality Investigation and Prevention Program" which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

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Introduction

On April 11, 2010, a 26-year-old male volunteer assistant Fire Chief 3 (the victim) suffered a fatal cervical fracture after falling from a ladder that detached from a silo when it exploded. On April 17 and September 20, 2010, telephone interviews were conducted with the Chief of the volunteer fire department who was incident commander during the fire. The NIOSH investigator met with the New York Occupational Safety and Health Administration Safety and Health inspector who investigated the incident. The investigator reviewed photographs, investigative findings, witness statements, and dispatch records of the incident. Subsequent contacts were made with the Director of County Fire and Emergency Services, the Deputy Fire Chief, and Installation Records Manager of the career fire department where the victim also worked as a fire fighter.

Fire Department

- The volunteer fire department involved in this incident is comprised of 65 volunteer fire fighters. The department has two stations and serves a population of 3,049 in a geographical area of 72 square miles.

- Personal Protective Equipment

- The victim was wearing bunker pants, bunker boots, turnout coat and gloves at the time of the incident. He was not wearing a helmet, fire hood, or a self contained breathing apparatus (SCBA).

Training and Experience

The victim had been with this volunteer department for more than 8-years and attended the New York State (NYS) Fire Academy. He completed the Recruit Fire Fighter Program which consisted of 360 hours of training that resulted in a national certification as Fire Fighter level I and II. He was also a member of a career fire department for 15-months before his death and had completed an additional 387 hours of training with the career fire department.

The Incident Commander (IC) had been with this department for more than 29-years and had completed the National Certification for Fire Instructor level I, NYS certification for Fire Officer level I, National Incident Management System 300, and NYS Emergency Medical Technician. The IC had also been a NYS Fire Instructor since February 2002.

Equipment and Personnel

Personal-owned vehicle (POV) – Fire Chief (Incident Commander [IC])

POV – Assistant Fire Chief 3 (Victim)

POV – Assistant Fire Chief 2

Engine #3 – Assistant Fire Chief 5 and fire fighter/driver

Tanker #1 – Fire fighter/driver

Tanker #2 – Fire fighter/driver

POV – Two Fire fighters

Timeline

0914 Hours
The victim received a telephone call on his cellular phone from the owner of a local farm requesting assistance for a silo fire.

0915 Hours
The volunteer fire department was dispatched to the silo fire.

0926 Hours
Two Tankers and Engine 3 arrived on scene.

0937 Hours
Approximate time of the silo explosion.

1059 Hours
Time of victim's death at the hospital.

Weather Conditions

The weather on the day of the incident was scattered clouds with an approximate temperature of 46°F. Winds were from the west at 10 miles per hour. Visibility was clear for 10 miles, and humidity was 71%.

Structure

There are two types of upright silos: conventional silos and oxygen-limiting silos or "sealed" silos. Conventional silos are typically used to store corn, hay or other foodstuff for livestock feed. These silos provide for the preservation, storage and disbursement of the feedstock. Conventional silos usually have outside doors stacked up the silo wall. Conventional silos are normally unloaded from the top (see Photo 1).

Oxygen-limiting silos are sealed to prevent oxygen from entering the silo. These silos are constructed of steel or concrete and have tightly sealed openings and hatches. When the hatches are closed and the

silo is filled, the oxygen concentration should be insufficient to support a fire. The silo involved in this incident was the oxygen-limiting type. The silo was approximately 60-feet high and 20-feet in diameter, and was constructed of steel. The silo was filled to one third of its volume with the previous year's high moisture corn crop. The silo had been built over 20 years ago (see Photo 2 for an example of a similar silo).

Investigation

On April 11, 2010, at about 0914 hours, Assistant Chief 3 (the victim) received a telephone call on his cellular phone from the owner of a local farm requesting assistance for a silo that was on fire. The victim called fire dispatch and the local volunteer fire department was dispatched to the fire. The Chief of the department and the victim responded to the fire in their personally owned vehicles (POVs) while another assistant, Assistant Chief 2, drove to the station to help acquire the needed apparatus. The Chief, Assistant Chief 5, and the victim arrived on the scene along with Engine 3 and two tankers. The Chief assumed incident command (IC) and he and the assistant chiefs conducted a walk around of the silo. It was noted that smoke was coming from the top of the silo, and there was a glow at the bottom of the silo where the un-loader door was located. They also noticed, from ground level, that the top hatches for the silo fill tube and vent were open. The silo was not rumbling or shaking, and no smoke was coming from the un-loader door. It was also noted that the door for the un-loader at the bottom of the silo had been partiality melted away from a barn fire in which 100 cows were killed three days earlier on Thursday, April 8, 2010.

The IC and assistant chiefs agreed that the best course of action in combating the fire was to use no water on the silo, but instead to attempt to smother the fire by closing all the openings on the silo, and to introduce CO_2 at the un-loader door opening. Assistant Chief 5 began making preparations to obtain as many CO_2 extinguishers as were available. Simultaneously the IC called the farm owners to determine if they had any information from the silo manufacturer and request that the owners come to the scene. While the IC was on the phone, the victim decided to close the hatches on the silo. The victim and another fire fighter retrieved a 14-foot roof ladder from the side of Engine 3, and set it at the base of the silo to gain access to the ladder built into the side of the silo. The 14-foot roof ladder was too long so they retrieved the 10-foot folding attic ladder. The 10-foot ladder was placed against the silo and the victim gained access to the silo ladder. Wearing only his bunker pants, bunker boots, turnout coat, and gloves, he climbed to the top of the silo to shut the open hatches.

The victim reached the top of the silo and closed and secured the hatches. He then radioed Assistant Chief 2 stating that the hatches on top of the silo were now closed. The victim then started to climb down the ladder. When he was about half way down the silo, it exploded. The IC heard a loud sound and turned around in time to see the ladder break apart and the victim fall to the ground (see Photo 3 and Photo 4). The IC ran to the victim and found that he had a pulse and his breathing was shallow. The victim stopped breathing and cardiopulmonary resuscitation (CPR) was started. A full response from a mutual aid fire department and a medical helicopter were dispatched to the scene. While CPR was in progress, the victim's condition deteriorated, the helicopter was cancelled, and the victim was transported to a local hospital by ambulance where he was pronounced dead.

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Contributing Factors

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. NIOSH investigators identified the following items as key contributing factors in this incident that ultimately led to the fatality:

- unrecognized hazards associated with a silo fire
- closing and securing the hatches on top of the silo.

Cause of Death

According to the death certificate the victim died as a result of a cervical fracture.

Recommendations

Recommendation #1: Fire departments should review, revise and enforce standard operating guidelines (SOGs) for structural fire fighting that include oxygen-limiting silos.

Discussion: Standard operating guidelines (SOGs) are organizational directives or plans that establish how the organization will react in various situations to increase the effectiveness and ensure the safety of the fire fighting team. Standard fireground guidelines include, but are not limited to: basic command functions; delegation of command responsibility; communications and dispatching; fire ground safety; tactics; initial resource deployment; and designation of roles and responsibilities of companies and units. SOGs should be comprehensive and encompass training, fire protection agreement plans, and procedures for those incidents involving mutual and automatic aid. SOGs should be written, periodically reviewed, and enforced.[1] Important elements that should be incorporated into SOGs for conducting operations on an oxygen-limiting silo fire include:

- Confirm pre-plan information on arrival
- Do not direct water or foam onto the fire through the top hatches. This will allow oxygen to enter the silo and can cause a “backdraft-like” explosion of fire gases
- Do not enter, breach, or open any external silo hatches in an attempt to extinguish the fire
- If the top hatches are open, fire fighters should not close them if there is smoke coming out from the top, especially if the silo is vibrating or making unusual sounds
- Lockout and tagout the electrical service to the silo
- Roof hatches should be safe to close if the silo has been quiet for several days and there has been no smoke coming from the hatches. The hatch should be closed, but not securely, to permit the relief of any pressure that may build up
- Leave the silo closed for up to three weeks or until the fire consumes all the oxygen in the silo and self-extinguishes
- Establish a collapse zone around the silo at least 1 and ½ times the height of the silo, keep unauthorized personnel away from the area, inspect for extension and protect adjacent exposures

- Ensure that all responders wear the appropriate personal protective clothing and equipment
- Some silos have external valves to inject carbon dioxide or liquid nitrogen from compressed gas cylinders to extinguish the fire
- If the silo still continues to burn, seek assistance from the silo manufacturer.[2-3]

In this case, the fire department had SOGs regarding Silo Emergencies (Fires). However, the SOGs were not comprehensive in nature and did not contain information regarding the closing of top hatches and danger signs to look for (e.g., smoke coming out from the top of the silo).

Recommendation #2: Fire departments should train officers and fire fighters on the hazards associated with different types of silos and the appropriate fire fighting tactics.

Discussion: There are two types of upright silos: conventional silos and oxygen-limiting silos or "sealed" silos. Conventional silos are typically used to store corn, hay or other foodstuff for livestock feed. These silos provide for the preservation, storage and disbursement of the feedstock. Conventional silos usually have outside doors stacked up the silo wall. Conventional silos are normally unloaded from the top. Oxygen-limiting silos are sealed to prevent oxygen from entering the silo. Both types of silos can be found on farms. It is critical for fire fighters to recognize the type of silo involved prior to beginning any fire fighting operations.

Fires in conventional silos are slow burning and typically do not represent an explosion hazard since conventional silos are not designed to be sealed. In conventional silo fires, time is on the side of the fire fighter. If it can be done safely, taking all due precautions for confined space entry, a fire fighter wearing full protective clothing, an SCBA, and full-body harness with lifeline, should survey the fire from above the silage. This may be performed from an aerial ladder truck or by climbing the access ladder to the top of the silo. *Note: It may be difficult for a fire fighter wearing full turnout gear and a self-contained breathing apparatus to climb a typical silo access ladder, due to the design of the ladder.* Once above the fire, the fire fighter can examine the contents of the silo for hot spots. The use of a thermal imaging camera may be helpful. A fire burning for an extended period of time can create void spaces in the silo contents so fire fighters should use extreme caution and avoid stepping onto the silo contents if at all possible. If a fire fighter must move onto the silo contents, a ground ladder or sheets of plywood should be laid down on top of the silage to prevent the fire fighter from dropping into a void space under the surface. Additionally, it is essential that any fire fighter entering a confined space don an SCBA and utilize a full body harness retrieval system with a lifeline attached to an appropriate anchoring point outside the confined space. Using carbon dioxide or nitrogen to extinguish a fire in a conventional silo may not be effective, since the structure is open to atmosphere and oxygen may still reach the fire. Using adjustable penetrating nozzles from the silo's access chute is a better practice. It may be impossible to completely extinguish a fire in a conventional silo. Attempting to drown the fire with a deluge of water is not effective as the water will not penetrate deeply into the silo contents. The farmer may have to partially or completely empty the silo, with the fire department present to immediately extinguish any hot spots that flare up when oxygen reaches the smoldering fire.

The greatest hazard of a fire in an oxygen limiting silo is the risk of an explosion. These silos are constructed of steel or concrete and have tightly sealed openings and hatches. When the hatches are closed and the silo is filled, the oxygen concentration should be insufficient to support a fire. Any attempt to extinguish a fire in an oxygen limiting silo may introduce oxygen into the silo, increasing the risk for a back-draft or explosion.

Smoke emitting from the top hatches of an oxygen-limiting silo dictates that the top hatches should not be closed and secured. Fire fighters should stay off an oxygen-limiting silo that is shaking, hot, noisy, smoking heavily, or that has been opened within the past few days. If the structure is quiet, motionless and cool, has not been opened recently and is smoking minimally, fire fighters should close the bottom unloader door and top hatches. Do not lock down these roof hatches, as they allow the silo to vent itself.[4] Always seek assistance from the silo manufacturer or field representative.

The silo involved in this incident was an oxygen-limiting silo. The hatches on the top were open and the bottom unloading door had been partially melted away from a barn fire three days before. Critical information, that this silo was emitting smoke, was noted during the initial size-up, but the hazard was not included in the pre-plan. It is believed that the silo fire was started three days earlier when the adjacent barn caught fire and partially melted the access door for the silo unloader at the silo's bottom. The Incident Commander and other fire fighters on scene observed smoke coming from the top of the silo and a red glow was observed at the partially melted unloader door. The decision to avoid using water on the silo fire was correct but the fire fighters did not recognize that the oxygen-limiting silo had been breached when the barn burned; thus, the oxygen limiting silo had been open for the past three days.

In all cases, fire fighters and incident commanders should practice proper risk management including a full risk management analysis following the guidelines listed in *NFPA 1500 Standard on Fire Department Occupational Safety and Health Program*, Chapter 4.2, Risk Management Plan.[5] Fire departments should identify the different types of silos within their jurisdictions and develop risk management plans that address the specific potential hazards present and including the components of a risk management plan listed in Chapter 4.2.3:

- Risk identification – actual and potential hazards
- Risk evaluation – the likelihood of occurrence of a given hazard and the severity of its consequences
- Establishment of priorities for action – the degree of a hazard based upon the frequency and risk of occurrence
- Risk control techniques – solutions for elimination or mitigation of potential hazards
- Risk management monitoring – evaluation of the effectiveness of risk control techniques

Recommendation #3: Fire departments should ensure that pre-emergency planning is completed for all types of silos located within fire department jurisdictions.

Discussion: Pre-emergency planning, pre-planning, and pre-incident planning are all terms that mean essentially the same thing. By first identifying target hazards (e.g., oxygen-limiting silos present high risk to life safety and property) within a department's jurisdiction, the fire department can prioritize and begin to establish pre-emergency plans for those target hazards before an incident occurs. Pre-emergency planning enhances effective and safe operations and helps save lives and protect property. The pre-incident plan should not be confused with fire inspections which monitor code compliance. Pre-incident planning assumes an incident will occur and is one of the most valuable tools available for aiding responding fire fighters in effectively controlling an emergency.

In conducting pre-emergency planning for silos, fire departments must recognize the basic silo types as well as the construction features, materials used, presence of loading devices, other distinguishing characteristics, and the hazards associated with each type. Pre-emergency planning should identify the type of silo, the age of the silo, structural integrity of the silo, type of material normally stored in the silo, the hazards of the material stored in the silo, roof structural integrity, and the silo interior layout. Whenever possible, silos should be inspected during the construction phase to aid in assessing the different types of construction, materials, etc. The silo manufacturer should be consulted to insure that accurate information is obtained. Some silo manufacturers have step-by-step instructions on how to extinguish fires within their silos.[4]

NFPA 1620, Standard for Pre-Incident Planning can be used to establish a pre-incident plan for silos within their jurisdiction so as to minimize the risk to emergency responders.[6]

Recommendation #4: Municipalities should consider requiring that placards with hazard warnings and appropriate fire fighting guidelines be placed on silos.

Discussion: Information regarding the type of silo would be invaluable to fire fighters should an incident occur. Placards should be placed on silos warning fire fighters that the silo is an oxygen-limiting silo, and the placard should include information regarding the proper extinguishing techniques. The placard should also warn fire fighters not to use water to extinguish an oxygen-limiting silo fire, and have emergency contact information available. The placard should state "DANGER - Sealed Silo – Water Contributes to Explosion of Sealed Silos."[1]

Recommendation #5: Fire departments should consider silos as confined spaces and recognize the dangers associated with confined spaces when responding to silo fires.

Discussion: The National Fire Protection Association, *NFPA 1670 Standard on Operations and Training for Technical Search and Rescue Incidents* includes silos under the definition of a confined space. Chapter 3.3.25 defines a "confined space" as "a space that is large enough and so configured that a person can enter and perform assigned work, that has limited or restricted means for entry or exit

(e.g., tanks, vessels, silos, storage bins, hoppers, vaults, and pits), and that is not designed for continuous human occupancy." When responding to silo fires, fire departments should consider silos to be confined spaces and recognize the dangers associated with confined spaces throughout the incident response. Pre-incident planning and risk management analysis for silo operations should consider the dangers and hazards associated with confined spaces. Any operations that could lead to entering a silo should be done in accordance with NFPA 1670.[7]

Recommendation #6: Fire departments should ensure that an Incident Safety Officer is deployed at technical or complex operations.

Discussion: The National Fire Protection Association *NFPA 1500 Standard on Fire Department Occupational Safety and Health Program*, Chapter 8.3.5 requires the use of an Incident Safety Officer (ISO) at technical or complex incidents.[5] Chapter 8.3.5 states "At significant incidents and special operations incidents, the incident commander shall assign an incident safety officer who has the expertise to evaluate hazards and provide direction with respect to the overall safety of personnel." Silo fires represent significant incidents that present operational challenges requiring special tactics and oversight.

Chapter 6 of NFPA 1521, *Standard for Fire Department Safety Officer*, defines the role of the ISO at an incident scene and identifies duties such as: recon of the fireground and reporting pertinent information back to the Incident Commander; ensuring the department's accountability system is in place and operational; monitoring radio transmissions and identifying barriers to effective communications; and ensuring established safety zones, collapse zones, hot zones, and other designated hazard areas are communicated to all members on scene.[8] Larger fire departments may assign one or more full-time staff officers as safety officers who respond to working fires. In smaller departments, every officer should be prepared to function as the ISO when assigned by the IC. The presence of a safety officer does not diminish the responsibility of individual fire fighters and fire officers for safety. The ISO adds a higher level of attention and expertise to help the fire fighters and fire officers. The ISO must have particular expertise in analyzing safety hazards and must know the particular uses and limitations of protective equipment.[9]

In this incident, an ISO could have aided the Incident Commander in evaluating the risks associated with the silo fire and in formulating the risk management analysis and the incident action plan.

Recommendation #7: Fire departments should ensure that fire fighters understand risks and hazards associated with climbing vertical ladders.

Discussion: Although there is no evidence that this recommendation would have prevented this fatality, it is being provided as a reminder of a good safety practice. This is the second incident investigated by NIOSH in the past year, in which a fire fighter died while climbing a vertical ladder (see NIOSH report F2010-25 IL).[10] Vertical ladders, such as the one that the victim used to access the top of the silo in this incident, represent a high level of risk to emergency responders. The presence of

vertical ladders should signal the potential for a high risk operation requiring a detailed risk analysis that considers how fire fighters will access the vertical ladder. Fire fighters, wearing turnout clothing, heavy and thick-soled boots, helmet and self-contained breathing apparatus should pay careful attention when climbing these types of ladders. The use of heavy, thick-soled fire fighter boots may make it difficult to get a secure foot-hold on the narrow ladder rungs. Enclosed ladders may present clearance issues to fire fighters wearing self-contained breathing apparatus. Emergency responders need to carefully size-up the scene and climb slowly, ensuring a three-point contact with the ladder at all times. The emergency responder should continually size-up the scene, ideally with the aid of an ISO or other designated observer. Risk analysis should be used to carefully plot the responder's actions, evaluating and considering the risk to life, including the life of the responder. Consideration should be given to the use of alternative means of access such as the use of fire apparatus aerial ladders, aerial platforms, or, where practical, properly positioned ground ladders.

References

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4. Halpin [2010]. A different animal. Agricultural silo fires present unique challenges and dangers to firefighters. Fire Chief. October 1, 2010. http://firechief.com/suppression/tactics/silo-firefighting-lessons-tactics-201010/index1.html. Date accessed: March 1, 2011.

5. NFPA [2007]. *NFPA 1500 Standard on Fire Department Occupational Safety and Health Program*, 2007 Edition. Quincy, Massachusetts: National Fire Protection Association

6. NFPA [2010]. *NFPA 1620 Standard for Pre Incident Planning*, 2010 Edition. Quincy, Massachusetts: National Fire Protection Association.

7. NFPA [2009]. *NFPA 1670 Standard on Operations and Training for Technical Search and Rescue Incidents*, 2009 Edition. Quincy, Massachusetts: National Fire Protection Association.

8. NFPA [2008]. *NFPA 1521 Standard for Fire Department Safety Officer*. 2008 Edition. Quincy, Massachusetts: National Fire Protection Association.

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10. NIOSH [Pending]. *Career Fire Fighter Dies from Falling off Fire Escape Ladder - Illinois.* Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Morgantown, WV. FACE Report F2010-25.

Investigator Information

This incident was investigated and the report written by Richard Braddee, safety consultant to the National Institute for Occupational Safety and Health, Division of Safety Research, Surveillance and Field Investigation Branch, Fire Fighter Fatality Investigation and Prevention Program. An expert technical review was provided by Dan Neenan, Manager, National Education Center for Agricultural Safety. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

Additional Sources for Information Regarding Silo Fires

Several sources of information concerning the unique hazards associated with agricultural silos are available. The U.S. Fire Administration (USFA) has prepared a report to help inform fire fighters of the particular dangers of fires in agricultural silos and the hazards that may be encountered in fire operations in and around these structures. Many universities distribute similar information through their agriculture programs and farm extension services. Some examples include:

USFA Technical Report Series. *Special Report: TR-096 - The Hazards Associated with Agricultural Silo Fires*. April 1998. http://www.usfa.dhs.gov/downloads/pdf/publications/tr-096.pdf. Date accessed 03/01/2011.

Silo Fires: Prevention and Control – Conventional and Sealed Silos. National Ag Safety Database: University of Tennessee Agricultural Extension Service, Knoxville, Tennessee 37901. Publication # PB1307, date: October 1988.
http://nasdonline.org/document/918/d000759/silo-fires-prevention-and-control-conventional-and-sealed.html. Date accessed 3/01/2011.

Extinguishing Fires in Silos and Hay Mows. Dennis J. Murphy and William C. Arble. Natural Resource, Agriculture and Engineering Service. Publication Number NRAES-18.

This book explains the causes of silo and hay mow fires and teaches firefighters how to safely and effectively extinguish them. Because the approach to fighting a silo fire depends on whether the silo is conventional, oxygen-limiting, or modified oxygen-limiting, the book first describes and illustrates the differences among these three silo types. Most of the book focuses on the different techniques for locating and extinguishing fires in different types of silos.

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Preventing hazards in the use of water spray (fog) streams to prevent or control ignition of flammable atmospheres. Morgantown, WV: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 85-112.

A Different Animal. Halpin. Fire Chief Magazine, October 2010. http://firechief.com/suppression/tactics/silo-firefighting-lessons-tactics-201010/# Date accessed 2/1/2011.

Photo 1. Conventional silo. This type of silo is distinguished by the round-domed top and the enclosed unloading chute seen on the right side of the silo, adjacent to the barn.
(NIOSH Photo)

Photo 2. Oxygen limiting silo. This type of silo is distinguished by the flat or the slight-pitch to the roof, the lack of unloading doors along the length of the silo and the lack of a chute. ***(NIOSH Photo)***

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