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Request for Assistance in

Preventing Fatalities Due to Fires and Explosions in Oxygen – Limiting Silos

July 1986

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

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REQUEST FOR ASSISTANCE IN PREVENTING FATALITIES DUE TO FIRES AND EXPLOSIONS IN OXYGEN-LIMITING SILOS

WARNING!

FIRE DEPARTMENTS RESPONDING TO INCIDENTS INVOLVING OXYGEN-LIMITING SILOS ARE CAUTIONED THAT DIRECTING WATER OR FOAM ONTO THE FIRE THROUGH THE TOP OPENINGS OF AN OXYGEN-LIMITING SILO MAY RESULT IN THE SILO EXPLODING.

SUMMARY

This Alert requests the assistance of fire department personnel, farm owners and workers, and silo manufacturers in the prevention of fatalities due to fires and explosions occurring in oxygen-limiting silos.

Several recent incidents occurred while fighting oxygen-limiting silo fires which resulted in the death of fire fighters. Other fire fighters lost their lives as a result of similar explosions in the late 1960's. The problems associated with burning silos appeared to have abated during recent years, but these incidents demonstrate the need to renew efforts to minimize their recurrence. A concerted effort should be made to prevent silo fires from occurring and to provide training programs on controlling this type of fire.

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BACKGROUND

Oxygen-limiting silos by design have all their openings sealed to prevent oxygen from entering the silo. Generally, these silos are of steel or concrete construction of varying heights and diameters. The openings (bottom and top) are normally sealed with rubber-gasketed hatches. When these hatches are tightly closed and the silo is filled, the oxygen concentration should be insufficient to support a fire. If the hatches are left open or the oxygen-limiting features are not properly maintained, spontaneous heating can occur with subsequent ignition of the silage [1].

If improperly sealed or otherwise not operating as designed, the amount of oxygen entering the silo may be sufficient to allow a fire to smolder, causing an accumulation of combustible gases due to incomplete combustion. Any additional increase in oxygen content in such an environment can create an explosive atmosphere. Thus, merely opening the top hatches of such silos, or applying water or foam by hose stream from the top of the silo, could allow sufficient oxygen to enter the silo and create an explosive atmosphere [1-4]. Dust explosions may also occur if dust inside the silo becomes suspended as a result of the hose stream, and is ignited by the heat of the smoldering fire [3,5].

CASE REPORT OF A FATAL INCIDENT

The following case report resulted from a NIOSH investigation of the circumstances of the incident as part of the NIOSH Fatal Accident Circumstances and Epidemiology Program.

On August 27, 1985, three fire fighters were killed when a burning oxygen-limiting silo exploded. The fire fighters were spraying water onto the fire from the top of the silo at the time of the explosion. The explosion lifted the concrete roof of the silo approximately four feet in the air and the fire fighters were thrown from the silo.

This explosion was due either to a build up of combustible gases from incomplete combustion or a dust explosion, or a combination of the two. Regardless of the ultimate cause of the explosion, directing water into the top of the silo appears to have been an improper method for fighting this silo fire.

In this incident nothing should have been done to increase the level of oxygen inside the silo. Opening the top hatches to apply water to the fire could have increased the level of oxygen and created an explosive atmosphere. Air entrained in the water stream may have also contributed. Additionally, the water spray could have suspended the dust and increased the risk of explosion.

NIOSH is aware of three other explosions that occurred in oxygen-limiting silos at about the same time as the incident described in the case report. Two of the incidences occurred in the same geographical area as the incident described above. No fire fighters were applying water to these silos at the time, and there were no injuries. The third fire which occurred in another geographical area resulted in the fatal injury of one fire fighter [4].

REGULATORY STATUS

There are no specific OSHA regulations covering fire hazards of oxygen-limiting silos. Also, since most farms employ less than ten workers, other general OSHA regulations that might apply are not used. Therefore, OSHA estimates that over 90% of all farms in the U.S. are not covered by any OSHA regulations.

RECOMMENDATIONS FOR ACCIDENT PREVENTION

A. Basis for Needed Actions

The information collected in this case study suggests that the following factors may have contributed to the fatal accident as reported:

1. Improper fire fighting methods; and

2. Lack of proper operating and maintenance procedures on the silo.

B. Recommended Measures

Acknowledging concern for the above factors, NIOSH recommends the following steps for both the prevention of fires and explosions in oxygen-limiting silos, and for fire control procedures once a fire has developed:

1. Prevention

a. When not being filled or emptied, oxygen-limiting silo hatches should be **kept closed**. If an oxygen-limiting silo is properly sealed, there is very little likelihood of a fire occurring by spontaneous heating, since the amount of oxygen trapped in the silo is usually insufficient to support a fire.

b. Proper maintenance of the silo should be performed to ensure the integrity of the oxygen-limiting features. The manufacturer of the silo should be contacted for proper operating and maintenance procedures for the silo.

c. The moisture content of stored silage should be controlled, as should the type of cut of the silage. Filling rates recommended by the manufacturer should also be followed to reduce the possibility of spontaneous heating of stored silage. "Elements of good silage" can be obtained from the bulletin, "Extinguishing Silo Fires," NRAES-18, published by the Northeast Regional Agricultural Engineering Service, Cornell University, Riley Robb Hall, Ithaca, New York 14853.

2. Fire Control

a. During fire fighting operations on oxygen-limiting silos, water or foam should not be directed onto the fire through the top hatches, since this may allow oxygen to enter the silo and cause the suspension of explosive dust.

b. Placards should be placed on the oxygen-limiting silos warning fire fighters that the silo is in fact an oxygen-limiting silo, and should include information concerning the proper extinguishing techniques.

c. If the roof hatches of oxygen-limiting silos are open, no attempt should be made to close them if there is smoke or steam coming from the open hatches or if the silo is vibrating.

d. The roof hatches should be safe to close if the silo is quiet and there has been no smoke or steam coming from the hatches for several hours. Do not secure the hatch. This will permit the relief of any subsequent pressure that may build up.

e. Large quantities* of carbon dioxide or liquid nitrogen should be injected into the silo to extinguish the fire. Some silos have valves specifically designed for this. If it is necessary to drill a small hole in the side of the silo for insertion of the gas tube, care should be taken not to allow additional oxygen to be pulled into the silo. All precautions normally associated with either nitrogen or carbon dioxide should be taken when handling these gases.

*Note: As an example, for a 20-foot diameter by 60-foot-high silo, the estimated amount of carbon dioxide or liquid nitrogen would be: 20 standard cylinders of carbon dioxide or 40 standard cylinders of liquid nitrogen. Reference #1 provides estimated amounts of CO_2 or liquid nitrogen for other silo sizes.

f. Manufacturers, in conjunction with local fire departments, should establish a program to provide valves designed for injection of gases for fire control on all new and existing oxygen-limiting silos.

g. Certain manufacturers have step-by-step instructions on how to extinguish fires in their silos. Therefore, farm owners are encouraged to contact the silo manufacturer to obtain these instructions.

NIOSH has published the following documents which contain further information:

NIOSH Alert: Request for Assistance in Preventing Hazards in the Use of Water Spray (Fog) Streams to Prevent or Control Ignition of Flammable Atmospheres, DHHS (NIOSH) Publication No. 85-112.

Occupational Safety in Grain Elevators and Feed Mills, DHHS (NIOSH) Publication No. 83-126.

NIOSH requests that the technical information and warning contained in this Alert be disseminated to personnel of fire departments, fire training academies, other emergency response organizations, farm extension associations, farm workers and owners, and manufacturers of silos.

Requests for additional information or questions related to this announcement should be directed to Mr. John Moran, Director, Division of Safety Research, National Institute for Occupational Safety and Health, 944 Chestnut Ridge Road, Morgantown, West Virginia 26505, Telephone (304) 291-4595.

We greatly appreciate your assistance.

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REFERENCES

1. Murphy DJ, Arble WC: Extinguishing Silo Fires. NRAES-18. Ithaca, NY: Northeast Regional Agricultural Engineering Service (1982).

2. NIOSH Alert: Request for Assistance in Preventing Hazards in the Use of Water Spray (Fog) Streams to Prevent or Control Ignition of Flammable Atmospheres, DHHS (NIOSH) Publication No. 85-112. National Institute for Occupational Safety and Health, 4 pages (1985).

3. Bahme CW: Fire Officer's Guide to Emergency Action. NFPA No. FSP-38. Boston, MA: National Fire Protection Association, 185 pp. (1974).

4. Upgrade Training Programs Aimed at Controlling Silo Explosions, Say National Volunteers. Fire Control Digest, 12(2):6 (1986).

5. Occupational Safety in Grain Elevators and Feed Mills, DHHS (NIOSH) Publication No. 83-126. National Institute for Occupational Safety and Health, 85 pp. (1983).