



Lunch Box Safety Webinar

Safety Over Sandwiches

June 4

Grain Dust Explosion Prevention Strategies

Presented by Joe Mlynec, Progressive Safety Services LLC





Background

Late 1970's a series of devastating grain elevator explosions left 59 people dead and 49 injured

In 1987 OSHA published the Grain Handling Standard 29 CFR 1910.272 addressing several hazards associated with the handling of grain.

- 1910.272 Appendix A – Means of achieving performance goals outlined in the standard.

2018 Statistics

Purdue University's Department of Agricultural and Biological Engineering

12 Grain Dust Explosions reported in the U.S. compared to 7 in 2017

Ten year average – 8.4

Type of Facility

- Feed Mill - 2
- Ethanol Plants - 2
- Grain Elevators - 8

One Fatality

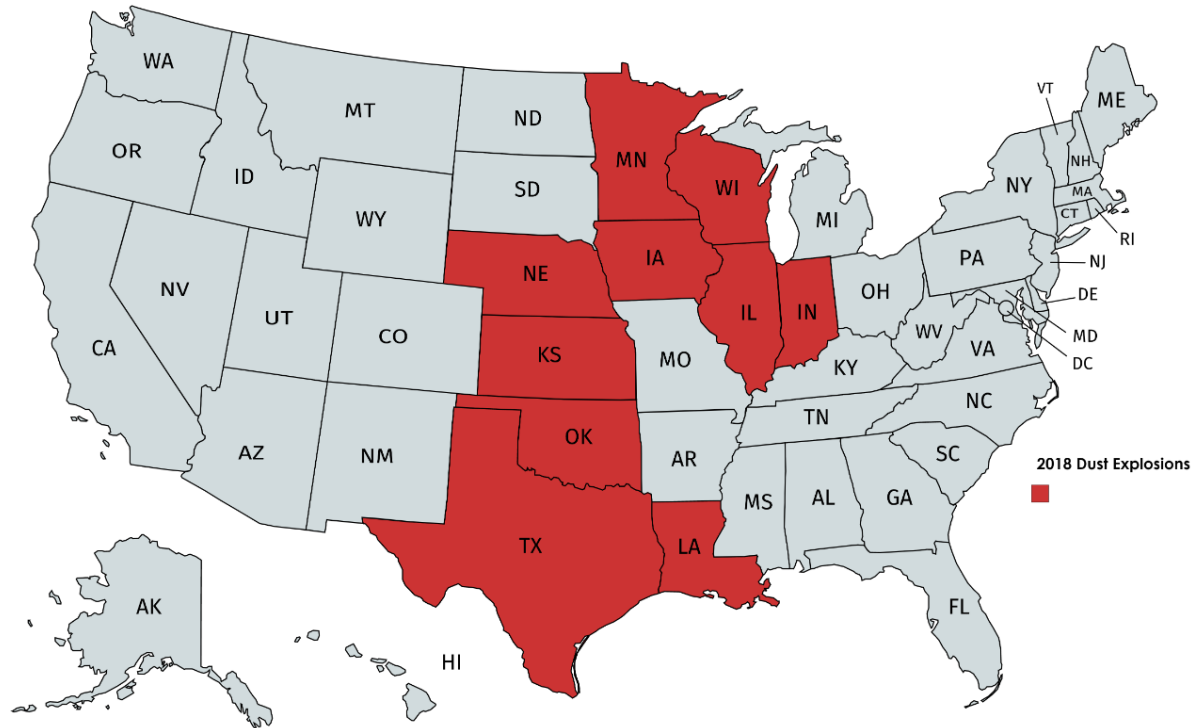
Four Injuries



2018 Statistics

Locations:

- Illinois – 2
- Iowa – 2
- Minnesota – 1
- Indiana – 1
- Nebraska – 1
- Texas – 1
- Oklahoma – 1
- Wisconsin – 1
- Kansas – 1
- Louisiana – 1



Probable Ignition Sources/Fuel Sources

Ignition Sources

Hot bearings and sparks – 3

Unknowns -9

Commodity

Grain dust – 3

Unknowns – 9



TABLE 1. U.S. AGRICULTURAL DUST EXPLOSION STATISTICS

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TEN YEAR TOTAL
Number	8	11	9	10	7	7	8	5	7	12	84
Fatalities	0	0	6	0	1	0	0	3	5	1	16
Injured	12	17	4	8	7	14	10	8	12	4	96
Type of Facility											
Grain Elevator	4	7	5	8	3	5	2	2	5	8	49
Feed Mill	2	2	2	1	2	1	4	1	0	2	17
Flour Mill	0	0	1	0	1	0	0	2	0	0	4
Other: Corn Milling, Dry	0	0	0	0	0	0	0	0	1	0	1
Corn Milling, Wet	0	1	0	0	0	0	0	0	0	0	1
Rice Mill	0	0	0	0	0	0	0	0	0	0	0
Other	2	1	1	1	1	1	2	0	1	2	12

Source: Dr. Kingsly Ambrose, Purdue University

TABLE 2. AGRICULTURAL DUST EXPLOSIONS BY COMMODITY HANDLED AT TIME OF EXPLOSION 2009-2018

<u>COMMODITY</u>	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TEN YEAR TOTAL
Corn	4	8	3	6	5	3	2	1	6	6	44
Soybeans	0	0	0	3	0	0	0	0	0		3
Wheat	0	0	0	0	1	0	0	0	0	0	1
Barley (malted)	0	0	0	0	0	0	1	0	0	0	1
Oats	0	0	0	0	0	0	0	0	0	0	0
Beet pulp	0	0	0	0	0	0	0	0	0	0	0
Corn starch	0	0	0	0	0	0	0	0	0	0	0
Sugar	0	0	0	0	0	0	0	0	0	0	0
Mixed feed	2	3	2	1	0	2	3	1	0	4	18
Rice (Bran)(Flour)(Hulls)	0	0	0	0	0	0	0	0	0	0	0
Wheat Flour	1	0	1	0	0	0	0	0	0	0	2
Wheat (Starch)(Gluten)	0	0	0	0	0	0	0	1	0	0	1
Other	1	0	3	0	1	2	2	2	1	2	14
TOTAL EXPLOSIONS	8	11	9	10	7	7	8	5	7	12	84

Source: Dr. Kingsly Ambrose, Purdue University

TABLE 3. U. S. AGRICULTURAL DUST EXPLOSIONS LEADING STATES - 1958 to Date

<u>STATE</u>	1958-2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	10-YEAR TOTAL	1958-2018
Iowa	85	3	1	1	0	0	0	0	1	1	2	9	94
Illinois	72	2	4	0	1	0	1	1	0	0	2	11	83
Nebraska	73	1	0	2	0	2	0	0	0	1	1	7	80
Minnesota	58	1	0	0	2	0	0	0	0	1	1	5	63
Kansas	52	0	0	1	1	1	0	0	1	0	1	5	57
Texas	46	0	0	0	0	0	0	0	0	0	1	1	47
Ohio	34	0	1	0	0	0	0	1	0	0	0	2	36
Missouri	31	0	0	0	1	0	3	1	0	0	0	5	36
Indiana	27	0	0	0	0	1	0	1	1	1	1	5	32
Louisiana	18	0	0	0	0	0	0	0	0	0	1	1	19
South Dakota	13	0	1	0	1	1	0	0	0	0	0	3	16
Wisconsin	7	0	0	0	0	1	0	0	1	2	1	5	12



Elements

GRAIN DUST EXPLOSIONS



Explosion Pentagon

1. Combustible Dust
2. Dispersion (Suspension)
3. Oxygen
4. Ignition Source
5. Containment/Confinement



Removal of any one of the elements may prevent an explosion or flash fire

Fuel

Grain Dust:

- Emitted from grain handling systems
- 425 microns or less
- As particle size decreases the risk explosion increases



Grain Dust

The dust concentration contributes to potential for an explosion.

Minimum Explosive Concentration (MEC):

- MEC = 50 g/m³ (range 25g/m³ – 55g/m³)

Concentrations generally reached in grain handling or processing equipment:

- Bucket elevators
- Conveyor housings
- Transfer/discharge points

Oxygen

Necessary for combustion

Difficult to eliminate



Ignition Sources

Welding and Cutting

Overheated Bearings

Faulty Electrical Equipment

Smoking

Sparks from Tramp Metal

Choked Legs

Misaligned or Slipping
Conveyors (Friction)

Phostoxin Pellets (moisture)



Ignition Temperatures

Dust Material	Ignition Source of Cloud (F)	Lower Explosive Limit g/m3	Relative Explosion Hazard
Corn	752	45	Strong
Corn Starch	716	40	Severe
Wheat	896	55	Strong
Wheat Flour	716	50	Strong
Grain Mixed	806	55	Strong

Heat from Ignition Sources

Welding

- Arc Welding – 10,000 F
- Gas Welding – 5,000 F

Mechanical Spark – 2,500 F

Grinding Steel – 1,200 F



Cigarettes

Temperature without drawing:

Side of the lit portion - 752 F

Middle of the lit portion - 1,112 F

Temperature during drawing:

Middle of the lit portion – 1292F



Confinement

Often beyond the control of the operator

Lessen the effects by using explosion venting



Suspended Dust

Inside grain handling equipment

Primary Explosion - caused by the ignition of dust under the right conditions

Pressure waves and fire waves are released

Secondary Explosions occurs when the blast wave from the primary explosion propagates and causes layers of dust to become suspended

Dust Explosions

The pressure wave travels away from the primary explosion at approximately 1,000 feet per second

Fire wave follows at 10-100 feet per second or more

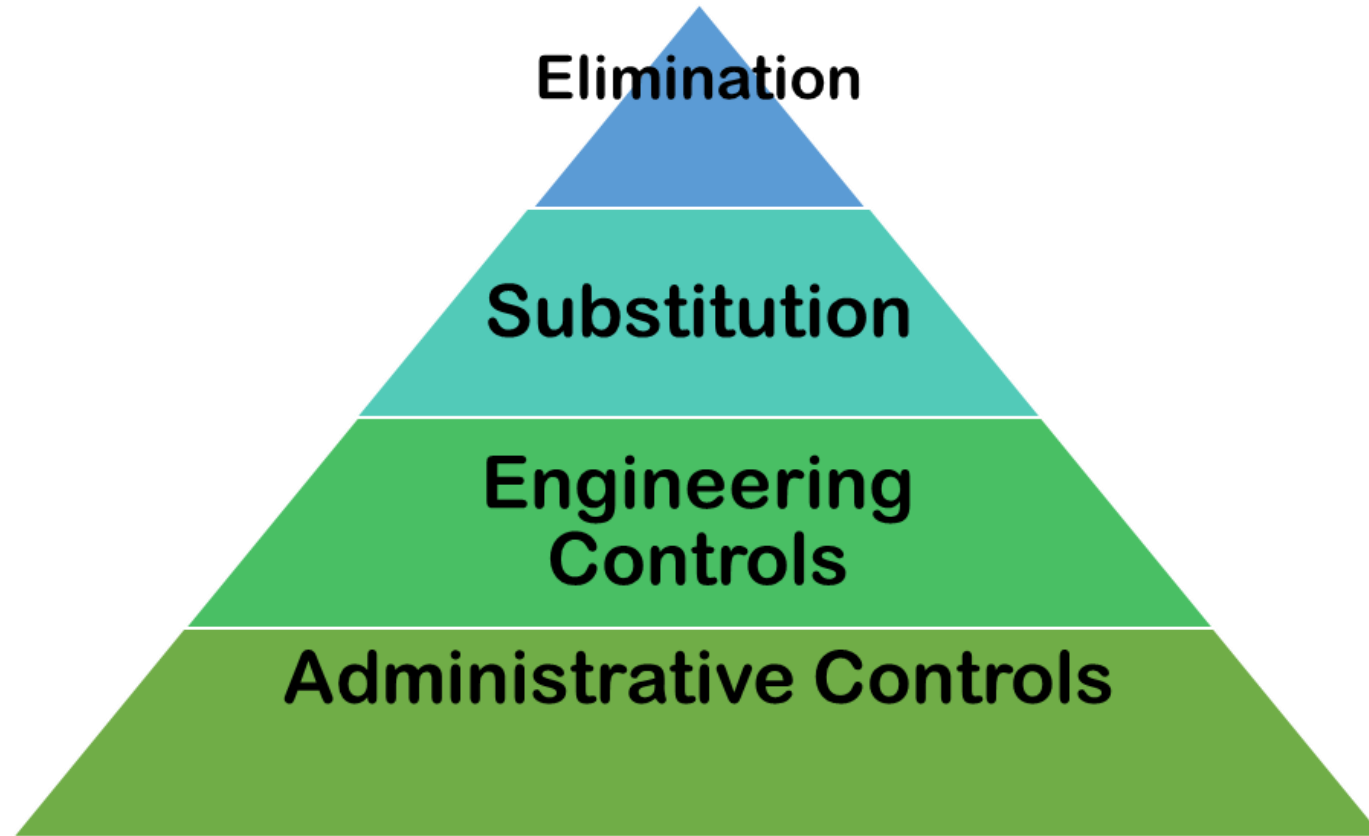
Pressures released by primary explosion generally near 2 psi

Pressures from secondary explosions can be in excess of 100 psi:

- Rupture strength:
 - Concrete 25 psi
 - Equipment >6 psi

Prevention Strategies

TECHNIQUES/EQUIPMENT



Eliminate

Eliminate

Avoid installation of horizontal surfaces where dust can accumulate.

Eliminate “hidden” areas where dust can accumulate.

Eliminate the use of compressed air for cleaning surfaces.

Eliminate point sources for fugitive dusts (i.e., leaks, patches, etc.)

Substitute

Install smooth ceiling and wall surfaces (instead of rough finish) to minimize dust accumulation and allow effective cleaning.

Install enclosed conveyance systems to replace “open” systems.



Engineering Controls

Install dust collection systems at transfer points, truck receiving/loadout areas, inside bucket elevators, conveyance, etc.

Ensure proper electrical classifications are used when installing/retrofitting equipment (i.e. Class II).

Install hazard monitoring (motion detection, belt alignment, bearing temperature monitoring) on bucket elevator legs and conveyance.

Install deflagration suppression systems on bucket elevator legs.

Install oil -addition systems (food grade) to reduce dust levels.

Pressurize interior areas to reduce fugitive dust.

Prevent tramp metal from entering the product stream by using magnets and properly sized grating at receiving areas.

Install magnets to remove metal from the process flow.

Administrative Controls

Develop and implement a written housekeeping program that defines the responsibility, frequency, and acceptable methods for cleaning.

Develop, implement, and enforce a hot work permit program.

Develop, implement and enforce the “No Smoking” policy.

Educate employees, contractors, visitors, and drivers on the hazards of combustible dusts including common ignition sources such as smoking.

Implement cleaning techniques that minimize placing dust in suspension.

If the using compressed air for cleaning, implement a permit system that requires the elimination of ignition sources during cleaning activities.

Develop and implement a documented preventive maintenance program that defines the types of equipment inspected (bucket elevator legs, drying equipment, conveyance, dust collection, etc.) frequency of inspection, inspection elements, etc.

Develop and implement a routine inspection program to identify point sources of fugitive dust to include bucket elevators, distributors, conveyance enclosures, dust collection equipment, spouting, etc.

Develop and implement a program for inspecting and cleaning magnets.

Housekeeping

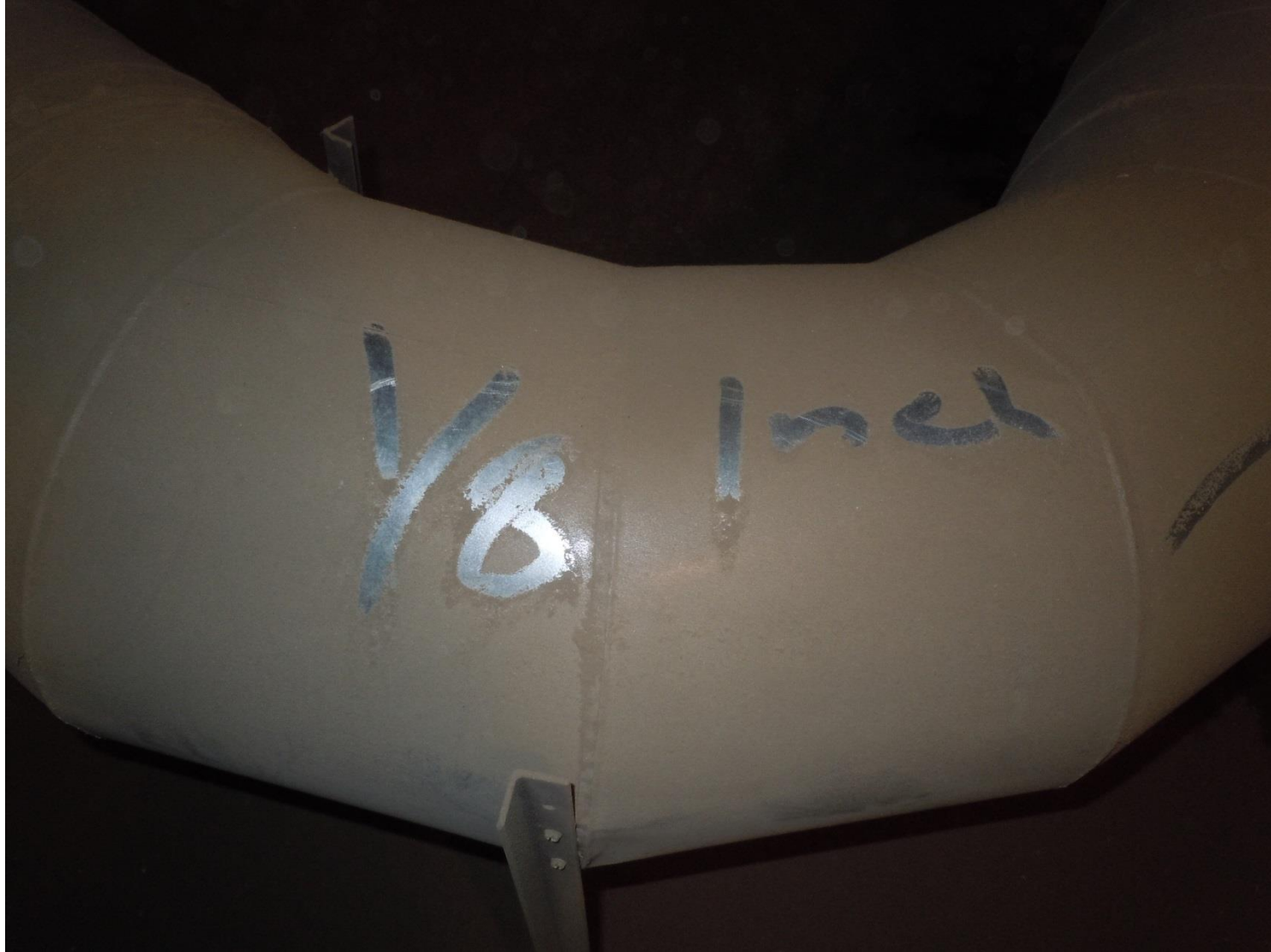
OSHA 1910.272:

- Immediately remove fugitive grain dust accumulations that exceed 1/8 inch (0.32 cm) at priority housekeeping areas.
- Develop a written housekeeping plan that establishes frequency and methods for removing fugitive grain dust on:
 - Ledges
 - Floors
 - Equipment
 - Exposed Surfaces

Housekeeping

Housekeeping program must address **priority areas**:

- Areas within 35 feet of **inside** bucket elevators.
 - “a bucket elevator that has the boot and more than 20 percent of the total leg height (above grade or ground level) inside the grain elevator structure.”
 - “Bucket elevators with leg casings that are inside (and pass through the roofs) of rail or truck dump sheds with the remainder of the leg outside of the grain elevator structure, are not considered inside bucket elevators.”
- Floors of enclosed areas containing grinding equipment
- Floors of enclosed areas having grain dryers inside the facility







Housekeeping

Use of Compressed Air Used for Cleaning

- All machinery presenting an ignition source is shut down
- All other known potential ignition sources are removed or controlled
- Recommend using a compressed air cleaning permit



Pneumatic Dust Control Systems

Captures dust suspended in air at grain transfer points

Goal: decrease dust concentration to below the minimum explosive concentration (MEC)



Pneumatic Dust Control System

OSHA Grain Handling Standard Requirements for Fabric Dust Filters:

- Equipped with a monitoring device that will indicate the pressure drop across the filter (magnehelic gauge).
- Located outside the facility (After 1988) or;
- Located in an area inside the facility protected by explosion suppression system or;
- Located in an area separated from other areas by a one hour fire resistance rating, which is adjacent to an exterior wall and vented to the outside.

Pressurization

Enclosing conveyance

Pressurizing the work area and providing a lower pressure inside the enclosed conveying system

Pressurize motor control centers



Proper Electrical Classifications

Class II, Division 1, Group G

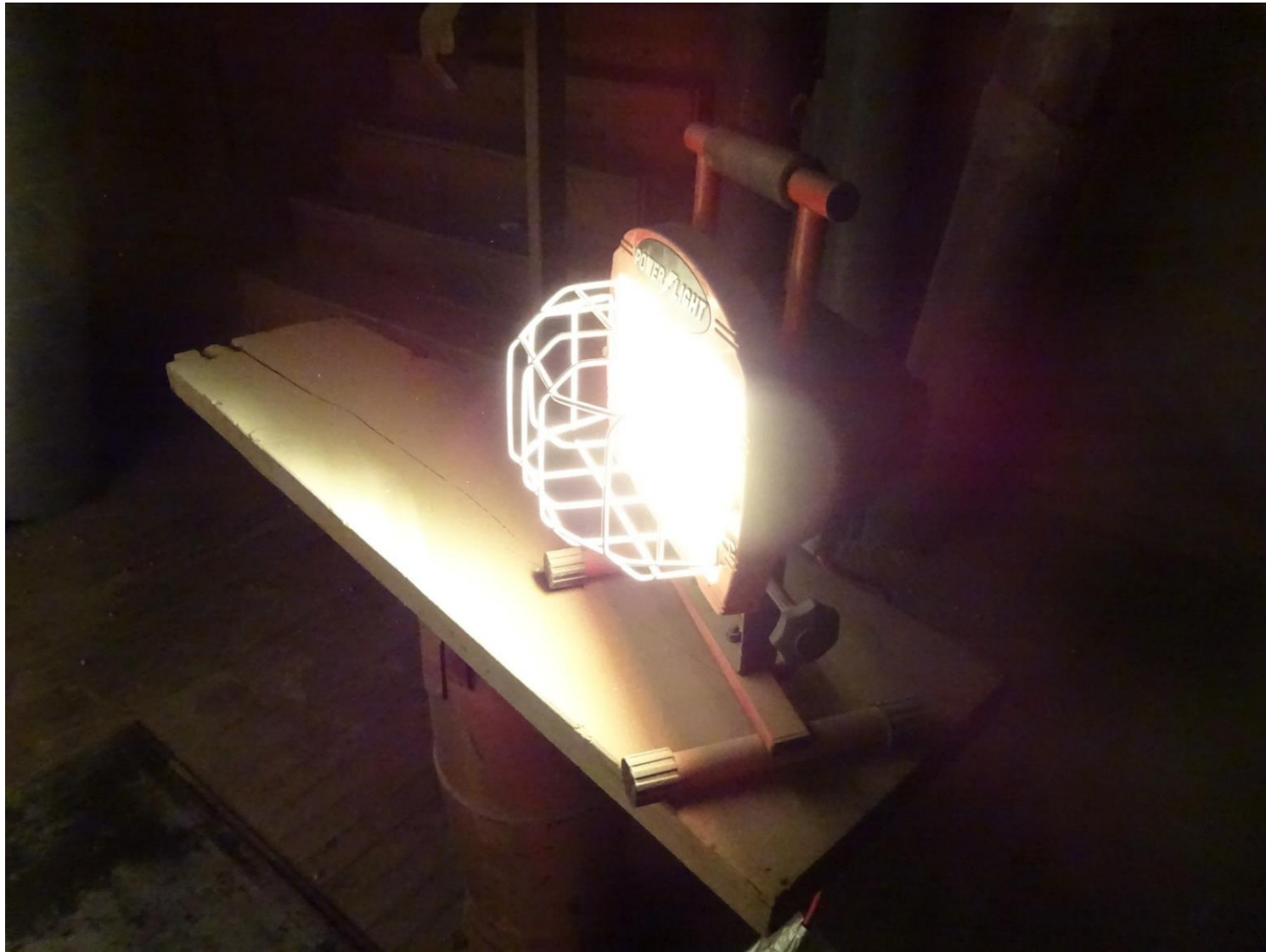
- “Open System”



Class II, Division 2, Group G

- “Closed System”
- Dust Tight













Oil Addition Systems

Application of food grade quality oil to the grain surface

Fine particles stick to the surface of the grain kernel rather than becoming airborne at transfer points

Usually positioned in receiving systems prior to transfer/discharge points

Hot Work Permits

Documented program to include use of the permit system

All efforts should be taken to remove equipment and perform hot work in areas outside of the grain handling structure

Engineering – eliminate hot work with the use of bolts with new installations

Hot Work

Plan hot work activities to ensure adequate fire watch during and after

Best Practice: Shut down/isolate equipment/machinery in close proximity to hot work activities to prevent transfer of hot/smoldering materials, sparks, etc.

Best Practice: Isolate ventilation equipment, spouting, ductwork, conveyance, bins, silos, tanks to prevent airflow, sparks, or flame.

- Use of dampers
- Blanking and Blinding
- Fire resistant tarps/blankets

Hot Work

Contractors must understand the company's hot work policy

Contractors must be made aware of fire and explosion hazards associated with their work and work area

Best Practice: Pre-Project Meeting/Training

Smoking

Designate smoking areas away from the handling facility:

- Designated areas
- No smoking anywhere at facility

Post “No Smoking” signs so that employees, customers and contractors are aware



Communicate and enforce the policy with employees, contractors and customers



Ferrous (Tramp) Metal

Metal tools, bolts, scrap, etc. are transported to grain facilities from the farm.

Tramp metal can cause:

- Equipment overheating
- Sparks
- Damage to equipment

Ferrous Metal

Ferrous (tramp) metal can be addressed in two ways:

- Receiving pit openings covered with grates with maximum openings of 2.5 inches (OSHA requirement).
- Use of magnets that remove metal not stopped by use of the grate.
- Dual approach is most effective.
- OSHA requires grain stream handling equipment (hammermills, grinders, pulverizers) to have an effective means of removing ferrous metal from incoming grain stream.

Receiving Pit Grating



Use of Magnet at Receiving







Equipment Issues

Equipment Issues may include:

- Overheated Bearings
- Misaligned Belts – Frictional Rubbing
- Choked Legs
- Overloaded Belts



Equipment Issues

Two methods to address equipment issues:

- Documented Preventive Maintenance Programs
- Installation of Safety Control Equipment

Dual Approach Most Effective!

Preventive Maintenance

Outlined in the OSHA Grain Handling Standard

- Employer shall implement preventive maintenance procedures
- Regularly scheduled inspections of at least the mechanical and **safety control equipment** associated with:
 - Grain Stream Processing Equipment
 - Filter Collectors
 - Bucket Elevators
 - Grain Drying Systems

Preventive Maintenance

Lubrication schedules and maintenance in accordance with manufacturer recommendations, or as determined by prior operating records

Promptly correct dust collection systems which are malfunctioning or operating below design efficiency

Employer shall promptly correct , or remove from service, overheated bearings, and slipping or misaligned belts associated with inside bucket elevators

Certification record needs to be maintained for each inspection to include:

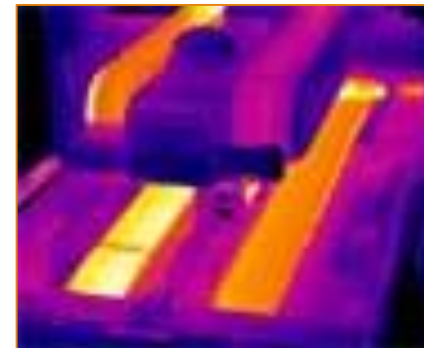
- Date of inspection
- Name of person inspecting, repairing, etc.
- Serial number or other identifier of equipment

Preventive Maintenance

Infrared Thermography - the use of an infrared imaging and measurement camera to "see" and "measure" thermal energy emitted from an object.

Can be used on:

- Electrical Systems
- Bearings
- Motors



Control Equipment

Bearing Monitoring Systems

Conveyor Zero Speeds

Belt Alignment Systems



Preventive Maintenance – Hazard Monitoring

Approved for the area (Class II, Group G)

Prescribed preventive maintenance at regular intervals – Contact installer or manufacturer



Control Equipment - Bearings

Bearings (OSHA requirement for Inside Bucket Elevators):

- Bearings should be mounted externally to the leg casing (Pillow Block) or;
- Vibration monitoring, temperature monitoring or other means to monitor the condition of the bearings mounted inside or partially inside the leg casing.

Does not apply to bucket elevators with:

- Explosion suppression on head and boot sections
- Bucket elevators equipped with pneumatic dust control systems that keep the dust concentration in inside bucket elevators at least 25% below the MEC during operation.

Pillow Block Bearings



Control Equipment - Motion

Motion Detection (OSHA Requirement for Inside Bucket Elevators)

- Bucket elevators must be equipped with a motion detection device.
- Must shut down the bucket elevator when the belt speed is reduced to no more than 20% of normal operating speed.

Does not apply to bucket elevators with:

- Explosion suppression on head and boot sections, or
- bucket elevators equipped with pneumatic dust control systems that keep the dust concentration in inside bucket elevators at least 25% below the MEC during operation, or
- Grain elevators having a permanent storage capacity of less than 1 million bushels, provided that daily inspection of bucket movement and tracking of the belt.

Control Equipment - Alignment

Belt Alignment (OSHA Requirement for Inside Bucket Elevators):

- Equip bucket elevators with belt alignment devices which initiate an alarm to employees when the belt is not tracking properly or;
- Provide a means to keep belt tracking properly.

Does not apply to bucket elevators with:

- Explosion suppression on head and boot sections.
- bucket elevators equipped with pneumatic dust control systems that keep the dust concentration in inside bucket elevators at least 25% below the MEC during operation, or
- Grain elevators having a permanent storage capacity of less than 1 million bushels, provided that daily inspection of bucket movement and tracking of the belt.

Control Equipment

Systems should at a minimum be connected to an audible/visual alarm to alert employees

Helpful to tie systems into office computers or areas that are always staffed

Interlock to shut down equipment (PLC)

Add testing to PM Schedule

Should have person(s) knowledgeable of the system, testing, maintenance



Explosion/Deflagration Venting

Design concept used with elevator legs to vent the pressure and fire front of the primary explosion outside of the elevator reducing the probability of the more devastating secondary explosions

- NFPA 68 – Guide to Explosion Venting

Explosion Vents replace a portion of a leg casing

Designed to rupture or release at low pressures

Maintain the structural integrity of the leg casing

Can also vent bins, silos, dust collection equipment, etc.

Explosion Venting

Vent Panels

- Rupture strength of no more than 1psi
- Vary from aluminum to PVC
- Should be secured by chain or cable
- Make sure not positioned near work areas

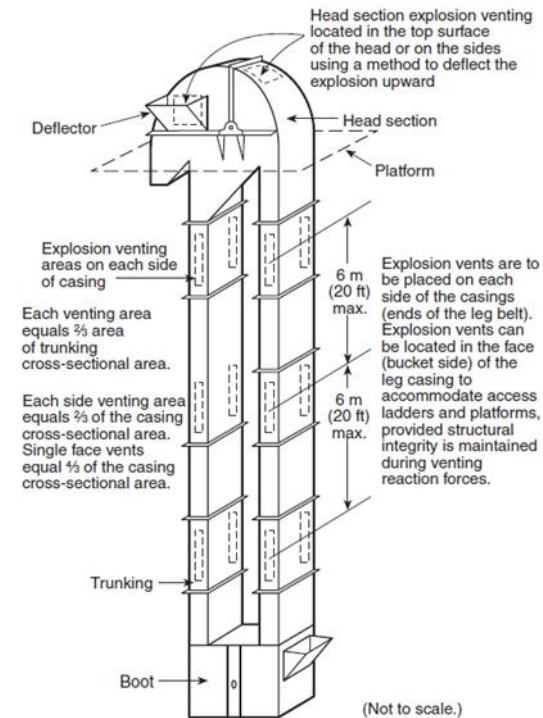


FIGURE 8.3.7.2.2(b) Typical Elevator Explosion Venting for a Double Casing Leg.

Flameless Venting



Explosion Suppression

Detects grain dust explosion early

Floods area with an extinguishing agent

Can effectively suppress grain dust explosions in bucket elevator legs and dust collection equipment



Explosion Suppression

Grain dust explosion can be detected by sensors:

- Optical
- Thermal
- Pressure – Most Common

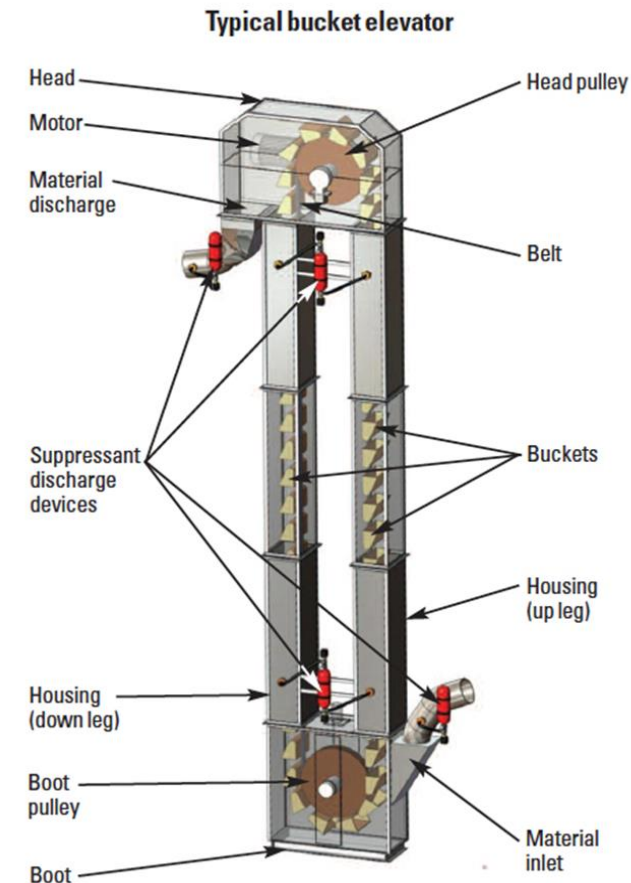
Diaphragm type device responds to initial pressure by quickly closing electrical contacts

Explosion Suppression

Sensor detects the pressure front and sends a signal through a control unit to a high rate discharge extinguisher:

- Dispenses in 3-5 milliseconds
- Uses dry powders
 - Sodium Bicarbonate
 - Mono-ammonium phosphate

Battery powered, interlocked to equipment





Additional Prevention

Training

- Employer shall provide training annually on:
 - Recognition of hazards related to dust accumulations
 - Common Ignition sources such as smoking
 - Cleaning procedures
 - Housekeeping procedures
 - Preventive Maintenance
 - Properly rated tools and equipment
 - Emergency Procedures
 - PPE/Clothing

Miscellaneous OSHA Requirements

Inside Bucket Elevators

- Shall not be jogged to free a choked leg.
- All belts and lagging purchased after 1988 shall be conductive.
- All bucket elevators shall have a means of access to the head pulley to allow inspection of the head pulley, lagging, belt and discharge.
- Boot section of bucket elevator shall also be provided with a means to access for clean-out of the boot and for inspection of the boot, pulley and belt.

Emergency Action Plans

Required

Define emergency procedures

Involve local fire departments

Practice



Additional Materials/References

Supervisor Talking Points

Employee Quiz

OSHA 1910.272 Grain Handling Facilities

- Appendix B Consensus Standards

NFPA 61- 2017 – Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities

This presentation was developed to give general safety information. Progressive Safety Services LLC (Progressive Safety) does not make any representation or warranty as to the accuracy or completeness of the information in this presentation. Refrain from doing any act or omission that are reasonably foreseeable that a particular other person (or class of persons) is likely to suffer damage or loss as a result of the act or omission. Progressive Safety is excluded from liability for negligence for both personal injury and damage to property. The information within this presentation is general. It does not constitute and should not be relied on as legal advice. Progressive Safety Services LLC tries to ensure that the content of this presentation is accurate, adequate or complete, it does not represent or warrant or its accuracy, adequacy of completeness.



Questions?

JOE MLYNEK CSP, OHST

JOE.MLYNEK@PROGRESSIVESAFETY.US

JOE@SAFETYMADESIMPLE.COM