



# **Lunch Box Safety Webinar**

***Safety Over Sandwiches***

**March 14 • Grain Dust Explosions -  
Preventing Catastrophe**

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# Outline

Elements of a Grain  
Dust Explosion



Characteristics / Ignition  
Sources



Prevention Strategies

# 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.



# Grain Dust Explosions Drop Nationwide in 2016

*Falling to a 10-year low with only five explosions*



# 2016 Statistics

Purdue University's Department of Agricultural and Biological Engineering

- ▶ Number of grain dust explosions fell to a 10 year low
- ▶ Three people killed, eight injured nationwide
- ▶ Two of the incidents resulted in the first reported fatalities since 2013
- ▶ Total of five grain dust explosions in 2016, compared to eight in 2015.
  - Feed Mill –1
  - Grain Milling –2
  - Grain Elevators – 2



# 2016 Statistics

- ▶ 10 year average of 9.2 per year
- ▶ Causes
  - Sparks from friction between machine parts
  - Overheated bearings such as those from conveyor belts and bucket elevators
- ▶ Confirmed that grain dust was the source of fuel in three of the five incidents, could not confirm source of fuel in the other two

# Statistics May Be Misleading





# Elements

»» Grain Dust Explosions

# Explosion Pentagon

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

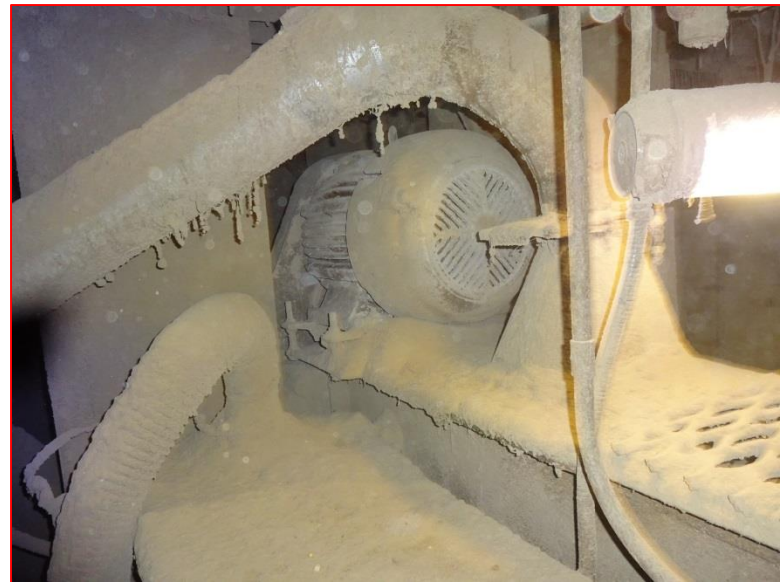
Removal of any one of the elements may prevent an explosion or flash fire





# Fuel

- ▶ Grain Dust:
  - Emitted from stock handling systems
  - 425 microns or less
  - As particle size decreases the risk explosion increases



# Fuel – Grain Dust

- ▶ The dust concentration contributes to potential for an explosion.
- ▶ Minimum Explosive Concentration (MEC):
  - $MEC = 50 \text{ g/m}^3$  (range  $25\text{g/m}^3 - 55\text{g/m}^3$ )
- ▶ Concentrations generally reached in grain handling or processing equipment:
  - Bucket elevators
  - Conveyor housings
  - Transfer/discharge points



# Oxygen

- ▶ Necessary for combustion
- ▶ Difficult to eliminate



# Ignition Source

- ▶ 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

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

# 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



# What About Lit 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

# 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 Compress 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

- ▶ Need to have a 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
- ▶ 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



# Smoking



NO SMOKING

- ▶ Designate smoking areas away from the handling facility:
  - Distance requirements
  - Designated areas
  - No smoking anywhere at facility
- ▶ Post “No Smoking” signage 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 1 psi
- Vary from aluminum to PVC
- Should be secured by chain or cable
- Make sure not positioned near work areas

# Explosion Vent Panels



# 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

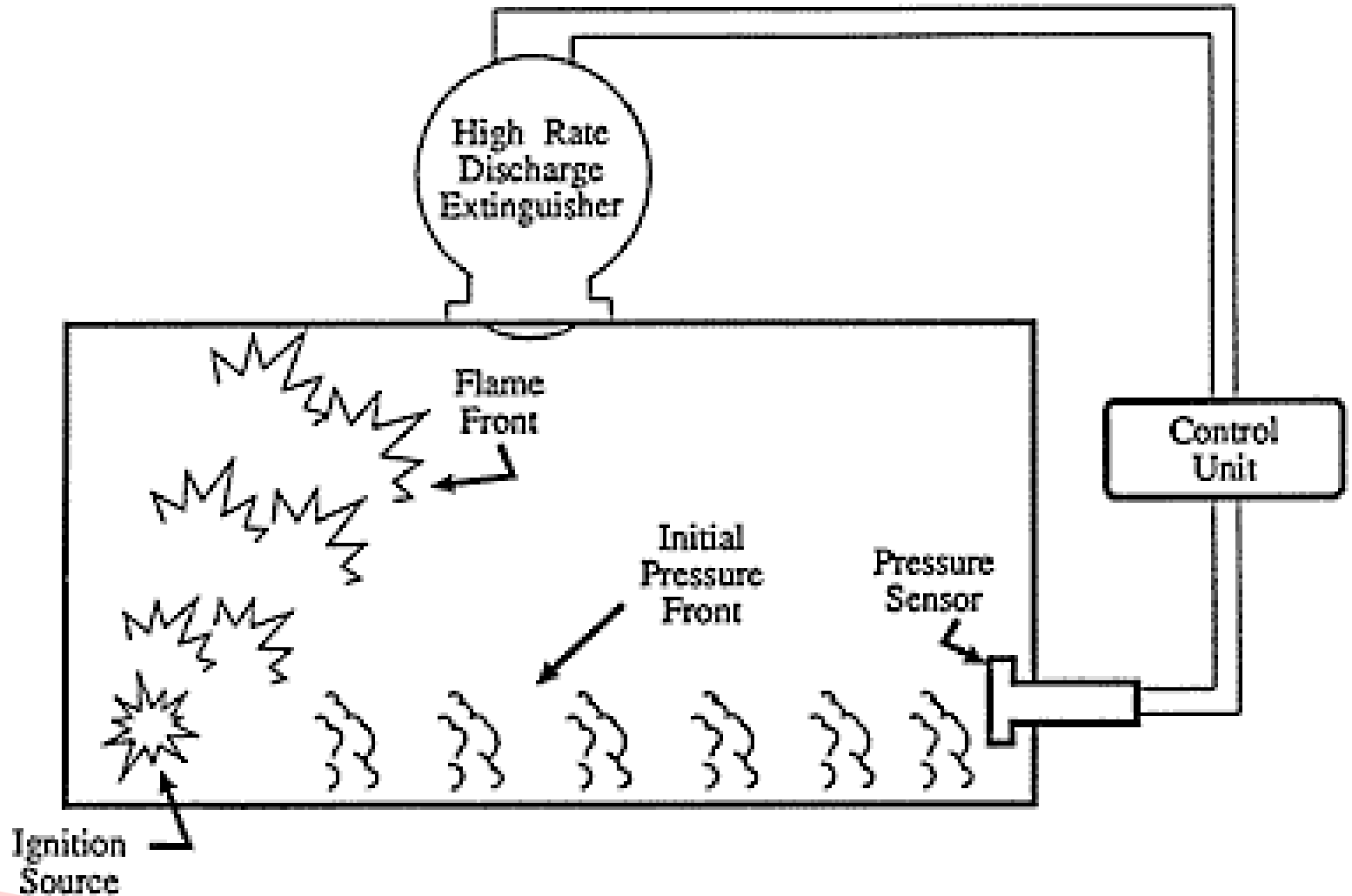
- ▶ Grain dust explosion can be detected by sensors:
  - Optical
  - Thermal
  - Pressure – Most Common
- ▶ Diaphragm type device responds to initial pressure by quickly closing electrical contacts

# 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



# Operation of Explosion Suppression







# 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.













# Additional Materials / References

- ▶ Supervisor Talking Points
- ▶ Employee Quiz
- ▶ OSHA 1910.272 Grain Handling Facilities
  - Appendix B Consensus Standards
- ▶ NFPA 61 – Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities

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# Questions?

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