Collaborative Bachelor's Degree Program of Fire Protection and Safety Engineering Technology between Southwest Jiaotong University and Oklahoma State University, U.S.A.

FPST 2023 Industrial and Occupational Safety

Grain Handling
and
Combustible Dusts

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Grain Handling Facilities

- Operations
  - Receive, Handle, Store, Process, Ship
- Raw Agriculture Commodities
  - Corn, Wheat, Oats, Barley, Sunflower seeds, Soybeans, Peanuts
- Industries
  - Grain mills, Feed mills, Grain warehousing…Craft Breweries

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Injury and Fatality Data

- BLS Data for Grain and Oilseed Milling (2018)
  - 2100 non-fatal recordable incidents TRIR
    - 2.65

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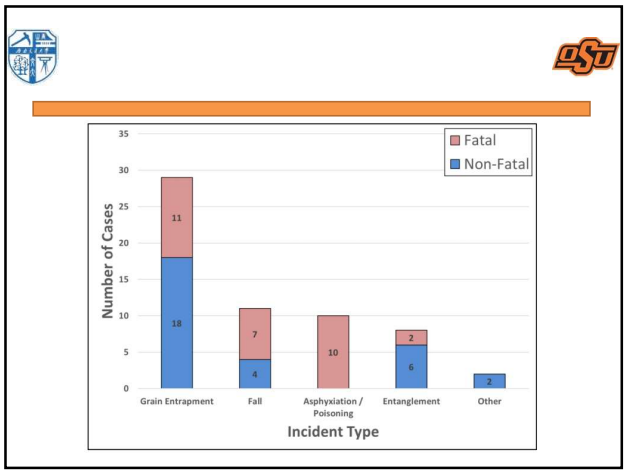

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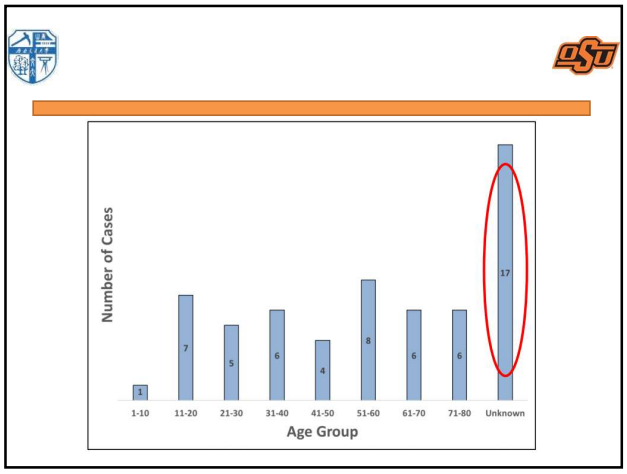

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Fatal Facts

- Case Studies
  - Farm Worker Asphyxiated in Grain Silo in Indiana
    - Before 1988 OSHA Standard was enacted
  - Farm Worker Suffocates in Flowing Grain while Clearing a Blocked Grain Auger
  - Iowa Farm Worker Suffocates / Trapped in Storage Bin Filled with Unstable Grain Product
  - Farmer Dies when Grain in Grain Bin Engulfs Him

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Hazards in Grain Handling

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Hazards in Grain Handling

- Fires and explosions from grain dust accumulation
  - Receiving Pits
  - Inside Bucket Elevator Legs
  - Dust Accumulations
- Suffocation from engulfment and entrapment in grain bins
- Falls from heights
- Crushing injuries and amputations from grain handling equipment

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Grain Dust Explosions

- Explosion 1 video
- Explosion 2 video
- Flammable or combustible?
- Explosion, detonation or deflagration?

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Grain Dust Explosions

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Grain Dust Explosions

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Grain Dust Explosions

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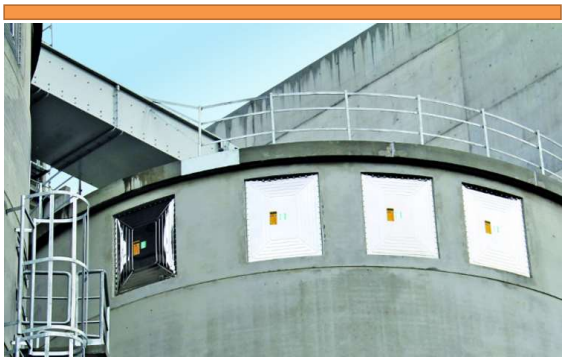

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Preventative Maintenance and Housekeeping are critical to prevention

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Grain Bin Entry Hazards

- Suffocation is the leading cause of death in grain bins
  - Enter a filled bin without fall protection
  - Engulfed/entrapped in flowing grain
  - Happens in a few seconds
  - Cannot self-rescue

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Grain Bin Entry Hazards

- Hazardous Atmospheres
  - Mold
  - Chemical Fumigants
    - Phosphine
      - Insect control
  - Decaying/Fermenting Product
    - H_2S
  - Oxygen deprivation
  - Dust
  - Flammable and/or Toxic Gas/Vapors

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Hazardous Atmosphere

- "Hazardous atmosphere" means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness from one or more of the following causes:
  - Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL);
  - Airborne combustible dust at a concentration that meets or exceeds its LFL;
    - NOTE: This concentration may be approximated as a condition in which the dust obscures vision at a distance of 5 feet (1.52 m) or less
  - Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;
  - Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in Subpart G, Occupational Health and Environmental Control, or in Subpart Z, Toxic and Hazardous Substances, of this Part and which could result in employee exposure in excess of its dose or permissible exposure limit; [from OSHA, 1910.146(b)]
    - NOTE: An atmospheric concentration of any substance that is not capable of causing death, incapacitation, impairment of ability to self-rescue, injury, or acute illness due to its health effects is not covered by this provision

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Chemical Fumigants

- Fumigants commonly used for insect control on stored grain include methyl bromide, phosphine (also known as Phostoxin, "L-fume or aluminum phosphide) and mixtures of carbon tetrachloride and carbon disulfide
- None of these has adequate warning properties, yet their toxic effects can include permanent central nervous system damage, heart and vascular disease and lung edema as well as cancer
- SDS can be vital source of info for determining hazardous atmospheric properties

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Grain Bin Entry Hazards

- Machine Hazards
  - Augers

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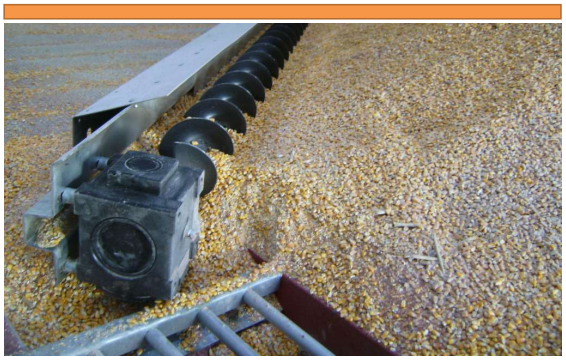
Grain Bin Entry Hazards



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Grain Bin Entry Hazards

Image: John Poole, NPR

- "Walking Down the Grain"
  - The practice of workers going into grain silos and bins with shovels and picks to break up clogs in the grain so that it can flow smoothly.

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Grain Bin Entry Hazards

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Grain Bin Entry Hazards

- Walking on Bridging or Buildup Conditions
  - Moisture or mold can cause grain spoilage, forming a crust…like 'thin ice' over a pond
  - "Bridge" can easily collapse under a worker's weigh
  - Loosening piles of grain or grain built up on sides of the bin

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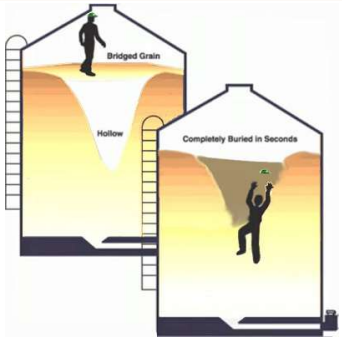
Bridged Grain



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Grain Bin Entry Hazards

- Why is flowing grain so dangerous?
  - Auger and valve centered under the bottom of the bin
  - Downward flow pattern immediately transmits to the top grain surface, starting a column of flowing grain
  - The grain across the bottom and away from the center of the bin does not move
- Bin unloading augers - 2,000 to 10,000 bushels/hour
  - 2,000 bushels/hour ~ 41 cubic feet of grain moved per minute
  - 6' tall person ~ 7.5 cubic feet
  - Entire body covered in 11 seconds
  - In rapidly moving grain, unable to free yourself in 5 seconds

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Hazards in Grain Handling

- Falls
  - Walls and floor openings
  - Unguarded catwalks
  - Platforms
  - Ladders

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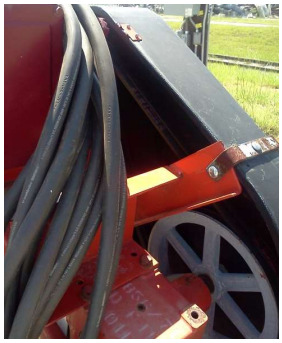
Hazards in Grain Handling



- Machine Hazards
  - Conveyors
  - Belts and pulleys

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Grain Handling Facilities Regulation 29 CFR 1910.272

- Administrative
  - Emergency Action Plan
  - Employee Training
  - Hot Work Issues
- Grain Bin Entry Procedures
- Dust Control Measures
  - Housekeeping
- Equipment Requirements
- Preventative Maintenance
- Effective since 1988
  - Main purpose was fire prevention
- Last amended 1996
  - Main focus is entry

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OSHA Inspection Activity for 1910.272

- Inspection Activity for FY 2018
  - 26 Inspections
    - 88 citations
    - $619,203 penalties
  - In 2010
    - 300 inspections
    - 340 citations
    - to $4.1 million penalties
  - Commonly Cited Industries by NAICS:
    - 4245 Farm Product Warehousing and Storage
    - 3111 Animal Food Manufacturing
    - 2382 Building Equipment Contractors
    - 3112 Grain Oilseed Milling
    - 1151 Support for Crop Production

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OSHA Enforcement

- OSHA Cites Kansas Grain Bin Operator $507,374
- OSHA Proposes Over $1.8 Million in Fines Against a Wisconsin Corn Milling Facility After Fatal Grain Dust Explosion
- OSHA Cites Farmers Cooperative $373,911 After Worker Entrapped in Grain Bin
- FFY2018 Inspection Results for NAICS 3112 Grain & Oilseed Milling

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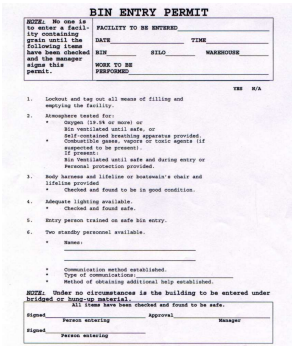
Bin Entry Requirements

- Written Entry Permit
  - Kept on file until completion of entry operation
  - Certified by employer or employer's representative
  - Ensures that precautions required by the standard are implemented
  - Exception:
    - If employer, or representative, is present during entire operation, then the permit need not be written. BUT, all precautions are still required to be implemented



BIN ENTRY PERMIT

NOTE: No one is to enter a facility containing grain until the following items have been checked and the manager signs this permit.

FACILITY TO BE ENTERED_____

DATE_____ TIME_____

BIN_____ SILO_____ WAREHOUSE_____

WORK TO BE PERFORMED_____

YES N/A

1. Lockout and tag out all means of filling and emptying the facility.
2. Atmosphere tested for:
   - Oxygen (19.5% or more) or Bin ventilated until safe, or
   - Self-contained breathing apparatus provided.
   - Combustible gases, vapors or toxic agents (if suspected to be present). If present: Bin Ventilated until safe and during entry or Personal protection provided.
3. Body harness and lifeline or boatswain's chair and lifeline provided
   - Checked and found to be in good condition.
4. Adequate lighting available.
   - Checked and found safe.
5. Entry person trained on safe bin entry.
6. Two standby personnel available.
   - Names:
   - Communication method established.
   - Type of communications_____
   - Method of obtaining additional help established.

NOTE: Under no circumstances is the building to be entered under bridged or hung-up material.

All items have been checked and found to be safe.

Signed_____ Approval_____

Person entering Manager

Signed_____

Person entering

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Bin Entry Requirements

- De-energize all equipment inside grain storage structures
  - Mechanical
  - Electrical
  - Pneumatic
  - Hydraulic

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Bin Entry Requirements

- Atmospheric Testing
  - 1st – Oxygen deficiency
    - > 19.5%, < 23.5%
  - 2nd – Combustible gases and vapors
    - < 10% of LFL
  - 3rd – Flammable gases and vapors
    - < 10% of LFL
  - 4th – Toxic gases and vapors
    - < Permissible exposure limit
- Continuous forced-air ventilation
- Periodic monitoring should be performed

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Bin Entry Requirements

- Fall / Engulfment Protection
  - Body Harness with Lifeline
  - Boatswain's Chair
- Lifeline must be positioned to prevent employee from sinking further than waist-deep in grain
- Exceptions:
  - Alternate, equivalent protection
  - Demonstration of no engulfment hazards
  - Creates a greater hazard

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Bin Entry Requirements

- Observer
  - Acts as "attendant"
  - Stationed outside bin
  - Maintains communication with employee entering bin
  - Trained in non-entry rescue procedures

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Bin Entry Requirements

- Rescue
  - Bin-specific plan and procedures
  - Rescue equipment
  - Communication for additional assistance
  - Training
- Rescue Methods
  - Cofferdam / Rescue Tube
  - Mechanical Retrieval Devices
  - Opening sides of bins to release grain
  - Watch videos:
    - Grain bin rescue
    - OSU Rescue trailer

Photo courtesy of Liberty Rescue Systems

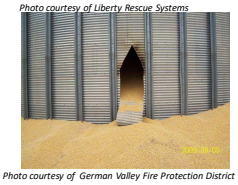

Photo courtesy of German Valley Fire Protection District

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Bin Entry Requirements

- Bridging / Build-Up Check
  - From below: No entry allowed when engulfment hazards present
  - From above: Must utilize boatswain's chair
  - Vibrating devices attached to exterior of bin can assist in removing build-up for small bins
  - Watch video:
    - Bridging - Air Blaster Solution

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Bin Entry Requirements

- Flat Storage Structures
  - Ground Level Entry without a Lifeline
    - Atmospheric Testing
    - LOTO
    - No recent history of draw-off problems that could create a cavity
    - No engulfment hazards present

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General Resources

- OSHA Grain Handling Safety Page
  - http://www.osha.gov/SLTC/grainhandling/index.html
- NIOSH Grain Handling Health Topics
  - https://www.cdc.gov/niosh/agforfish/
- OSU Bin Entry Trailer
  - http://www.dasnr.okstate.edu/Members/sean-hubbard-40okstate.edu/osu-rolls-out-mobile-grain-bin-safety-trailer
- OSU SPREC
  - Stored Products Research and Education Center
  - http://sprec.okstate.edu/safety/

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