SAFE WOOD PELLET STORAGE WORKSHOP

Mitigation Strategy's and Best Practices Derived from these Experiences

September 3, 2025 Copenhagen, Denmark

Presented by John Swaan – Operations Expert-FutureMetrics

Workshop Sponsors

Ørsted

WOOD PELLET ASSOCIATION OF CANADA

FutureMetrics LLC

In Case of a Fire Incident; "the most difficult scenario for fire and rescue service (fire brigade) to handle is deep smoldering fires since such fires are extremely difficult to access"

Strongly recommend studying the "SILO FIRE" report of Henry Persson and the Enplus Safety Module 12

Effective Approach's to Fire Suppression

Plan for the long distance, take time to develop a plan of action

Inerting the silo with Nitrogen has been proven to be the best solution to gain control of a smoldering fire of wood pellets before aborting (discharging) the silo.

- Liquid nitrogen is easier to vaporize then carbon dioxide, more accessible and more economical
- No risks of static electricity during injection

WARNING: DO NOT USE water inside the silo as it could form explosive H2 through water gas shift. In the case of hoppered silos, water finding its way down along the outside walls of the silo into the hopper area will cause the pellets to swell and become very difficult to abort. Foam spray or N2 in silo head space only!

WARNING: DO NOT USE CO2 as it can lead to the formation of high volumes of CO and H2.

Silo Firefighting Technique's & Procedures

"Silo Fire Response Plan"

Setup for N2 Injection to a silo with no prior injection system

- Call out to N2 supplier
- Bring in a mobile N2 vaporizer unit
- Fabricate injection lances and install them into the (bottom) sides of the silo
- Setup and connect a N2 distribution manifold
- Calculate the feedrate and volume of N2 required
- Attempt was made to apply foam spray on the top of silo

- Seal off silo ventilation if possible to eliminate gas leakage
- Gas monitors (CO, O2) to monitor levels to gauge when safe to start aborting the silo (O2 level below 10% or lower)

In the case of a silo fire - preparing a silo for Nitrogen injection.

- Shut down all ventilation systems and close all ventilation hatches (seal where possible) top and bottom of the silo (take caution when on top of the silo). Pressure relieve only or rubber sheet
- Call for a nitrogen supplier and mobile vaporizer and gas distribution manifold system c/w hoses etc.

If not already equipped with N2 injection nozzles and/or lances within the bottom of the silo floor or hopper(s) and silo head space.

- Fabricate lances – 4 perforated pipe lances, place 1 within each quarter section of the silo, length – long enough to reach half of the silos radius - 20mm -24mm diameter lance (pipe) with 3 - 4mm openings spaced every 25mm for 1 – 2m depending on the silos radius and desired flow rate capacity
- Prepare the silo to receive injection lances, take caution not to create sparks when boring and/or cutting the lance holes and minimize O2 introduction.
- Drive the lances into the silo by either mobile equipment or drilling drivers. Once inserted (no perforated holes exposed outside the silo), seal and ground the lance.
- Install a lance or open pipe in the silos head space if safe to due so
- Alternative to N2 in the headspace would be medium or high density foam, but requires foam station top of silo
- Connect hoses from the manifold and commence with N2 injection

References of the above and additional info can found found in the Henry Persson "Silo Fire" handbook

Nitrogen Flow Rate & Volume - Calculations

- Calculate the m2 footprint of the silo
- Flow rate of the nitrogen should be no less the 5kg/m2 per hour, preferably up to 10kg/m2 per hour during the initial firefighting operation depending of the porosity of the pellets. Consult with the gas suppliers technical support team (gas experts are normally on staff or consult with gas suppliers).
- Flow rate of N2 into the head space (should injection be possible) is lower than the bottom flow rate at 1 – 3kg/m2 per hour to avoid leakage.
- Total volume of nitrogen required and consumed will depend on the leakage (ventilation systems and hatches), but a guideline based on experience of actual silo fires, a total of gas consumption of 5 – 15kg/m3 or more can be expected in relation to the gross volume of the silo.

Observations and measurement of gases before it's safe to discharge the silo

- Should there be no gas monitors or have been damaged a line (top of silo) and gas pump must be installed in a safe location to monitor gas levels, CO and Oxygen.
- Measure these gas levels before N2 injection begins for a reference to determine N2 concentration level
- Declining gas concentrations of mainly CO is a sign that the fire intensity has reduced
- Once gas concentrations stabilize to relatively low levels of CO below 1% and oxygen below about 5%, N2 flow could be reduced to 1 kg/m2.

Safe discharge of the silo and/or warehouse

WARNING: DO NOT attempt discharging the silo till the exothermal fire is STABILIZED

Reaching a stabilized fire incident before discharge may take several days or more depending on the size of the silo and N2 leakage

- Develop a plan for the discharge of the silo or warehouse, select an safe area where the potential for open fire and oxidizing gases can be managed and out of danger to personnel and other infrastructures.
- Monitor the gas concentrations during discharge as the falling bridged material may disrupt the inert stability level within the silo.
- Monitor discharge material handling equipment for temperature and/or fire as the oxidizing material may burst into fire.
- Prepare to have water suppression available for the material handling systems and dosing of discharged material in the safe area.
- Monitor the atmospheric gases at the discharging areas, all personnel and/or fire brigade working within the discharge area(s) will require SCBA/SABA (breathing apparatus equipment).
- Clumps formed by the pyrolysis (smoldering) of the fire incident may bridge and/or disrupt the flow of material discharge, which will necessitate manual clearing.

Silo Fire Prevention - Methods & Practices

- Pellet Quality Awareness– Process temperatures (drying & cooling), moisture levels and fines
  - Wood Pellet process manufacturing temperatures – that effect self-heating
    - High drying temperatures will case harden (trap) moisture inside fibre particles
    - Pellet cooling – short residence time at high air volume extraction will case harden moisture within the pellets which generate excess CO when pellets begin to oxidize
    - Higher moisture levels and/or a mixture of MC will accelerate self-heating
    - Access fines will create layers while cascading (free falling) into silos and/or warehouses, these layers of fines reduce the porosity of the wood pellets reducing the ability of gases to ventilate escalating the potential of self-heating

Awareness of the suppliers wood pellet manufacturing process is important criteria when choosing a supplier

Silo and Warehouse Protection

Nitrogen Injection - Spray Foam

<u>For New Silo construction or retro-fit – Nitrogen injection and/or Purging system is the most effective silo fire prevention method</u>

- Silo
  - Install N2 injection system – nozzles in the bottom of the silo hopper or flat bottom
  - Install the injection nozzles so as not to interfere or be damaged under normal operating conditions
  - Consult with a local fire suppression systems company and/or engineer (insure the engineer is knowledgeable about dealing with wood pellet fire incidents)
  - Should the local authority's and/or fire brigade insist on water sprinklers, install a foam spray station on the top of the silo(s). However, try to educate them on the advantage of N2.
- Warehouse
  - Portals along the outside of the warehouse should be installed for lances to be inserted in case of a fire incident (thermal cameras may be utilized to seek out the smoldering hot spot to better penetrate the lances.
  - Foam spray deluge system is a good solution to provide somewhat of a seal to minimize the loss of N2

Silo/Warehouse Temperature and Gas Monitoring

- Multiple temperature cables with multi-level readings do not always provide adequate readings to pinpoint a self-heating incident occurring , but will usually give an indication when self-heating activity is occurring.
- Installation of quality gas and humidity monitors is critical as rising levels of CO and humidity is usually the first signs of self-heating.
- Protection from external hot matter (failed bearings, rubber belting etc) requires hot spot detectors mounted at the material handling receiving transitions in order to abort any suspect material (Firefly – GreCon)

Product Rotation

Should wood pellets be stored for periods exceeding a month or more?

- Wood pellets have been safely stored in silo and/or warehouses for periods of up to 2 years or more, but these wood pellets were manufactured correctly, low resin (fatty acids) wood species, very minimal fines and well ventilated storage facility's'. (more research required)
- Recommend (if possible) rotating co-mingled wood pellets once a month or less.
- Should the gas concentrations begin to become suspect, than N2 injection is required rather rotating the product as self-heating may have already advanced to a fire smoldering state.

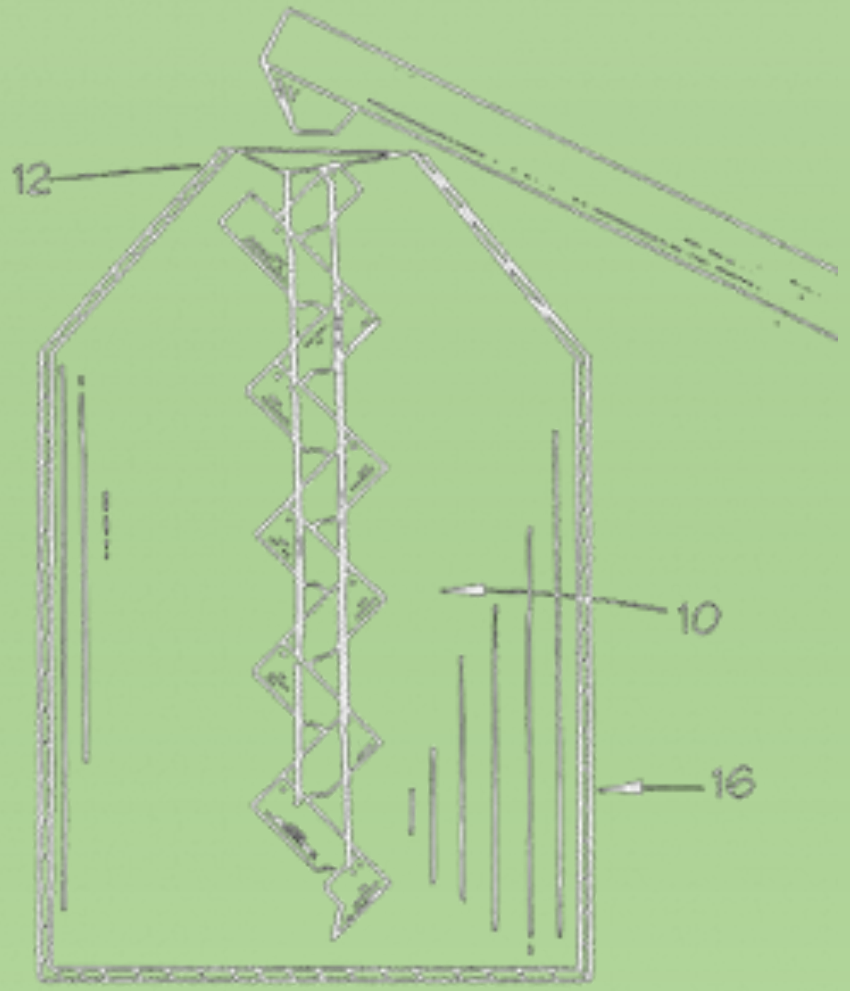
Fines Reduction - Gentle Handling

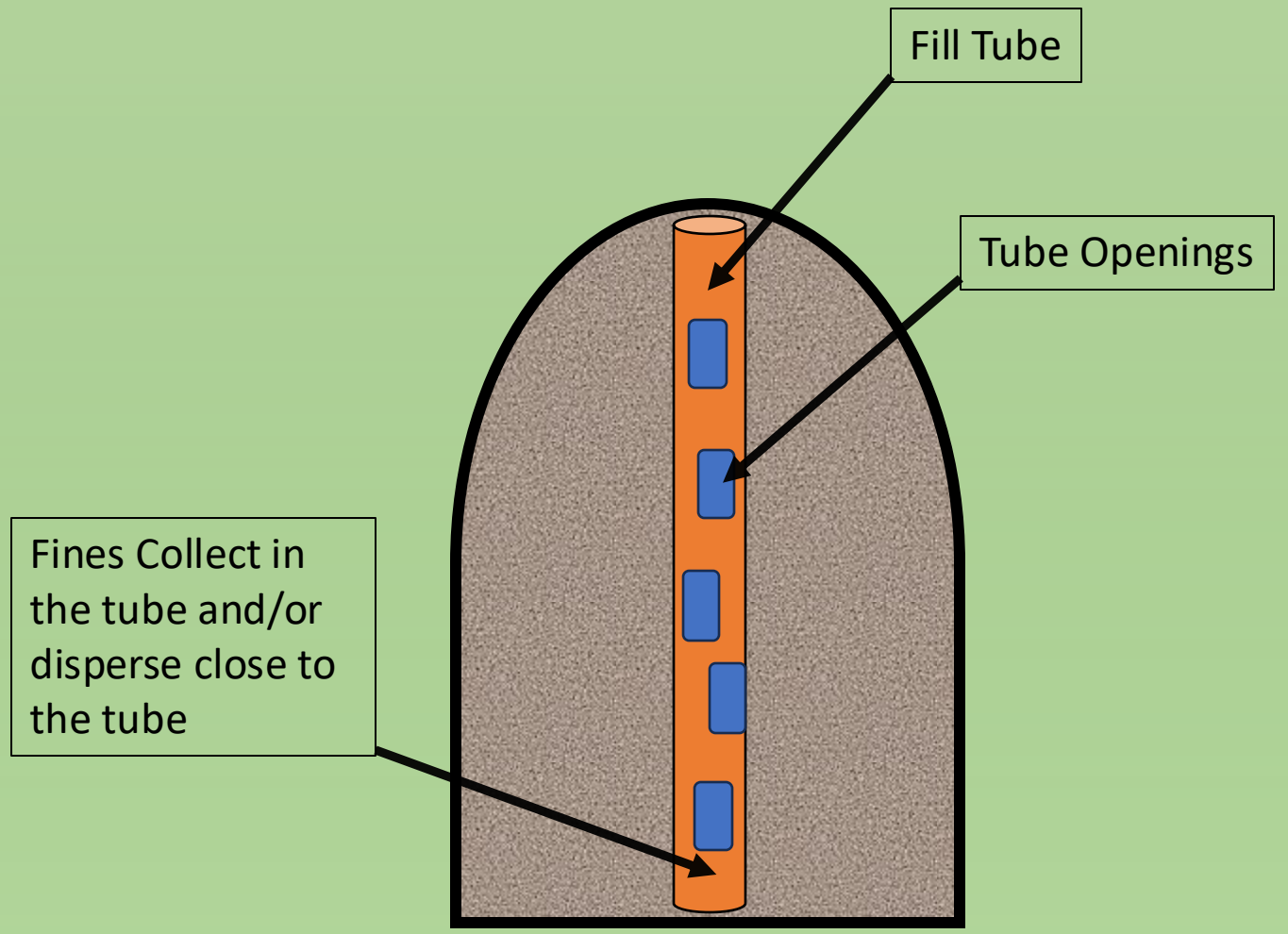
Self-heating Prevention by Reducing Fines Distribution in the silo and warehouse

- Fines distributed by cascading in layers over the pellets as the silo or warehouse is being filled, will reduce the porosity of the pellets and accelerate self-heating due to reduced ventilation capacity to release oxidizing heat and moisture.
- Gentle Handling equipment have had positive results in reducing self-heating by reducing the free-fall of pellets and confining the fines to the center of the pile in the silo.
- Warehouses can utilize a slide system allowing pellets to roll down the pile instead of free falling. Another method for warehouses is to index the drop close to the pile.

Examples of Gentle handling equipment

Also known as bean ladders





Reference Peeples Industries – Dome Technology Silo Installation

Preventative and Preparatory Measures

"Silo Protection Systems & Protocols"

Silo Firefighting Protocol – Incident Response Template

- Develop an Onsite Silo Fire Handbook

Silo Protection Systems - Review

- Gas Monitors, Temperature sensors, Humidity sensor
- Hot Spot detectors – Wood pellet material handling equipment
- Nitrogen injection system – Onsite vaporizer
- Nitrogen Purge system – Small nitrogen generator (PSA)
- Foaming Station – top of silo and/or warehouse

Personnel Safety

- Silo Fire Awareness – Training
  - Recommend all personnel study the following reports:
    - Silo Fire Report by Henry Persson
    - WPAC Safety Report
    - Enplus Safety Report
- Firefighting Procedure Training
  - Recommend all personnel study the Silo Fire Handbook developed for onsite silo(s) and/or warehouse
  - Regular practice drills should scheduled

Communications

Reach out and encourage are parties that may be involved in a silo fire incident to become informed

- Local Fire Brigade Awareness and Training
  - **No Water** to be sprayed on top and/or within the silo but rather nitrogen injection to inert the fire incident before aborting the silo and/or warehouse.
  - Share the Silo Fire Handbook with the local fire brigade.
- Local Authority's – Regulators
  - Should there be pressure to install sprinkle system within the silo, compromise with a foam spray deluge and foam spray generator mounted on the of the silo
- Insurance Agent(s)
  - Same as above – educate them
- Nitrogen supplier and gas expert

Thank - You