

SAFE WOOD PELLET STORAGE

Preventing, Detecting and Managing Self-Heating Incidents

If a fire happens: effective approaches to fire suppression

Workshop Sponsors



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Presented by John Swaan – Operations Expert-FutureMetrics



Self heating: Probable Causes

1. External Ignition Sources:
 - Hot material accidentally falling into the storage facility
 - Foreign hot debris – hot work material etc.
 - Broken Conveyor belts or bearings etc.

2. Pellet Production Related Issues:
 - Feedstock preparation
 - Particle Size Distribution (PSD) – inconstancy
 - High Dryer Temperatures - case-harden (trap) moisture inside the fibre.
 - Pellet Cooler retention time inadequate – too short and also case hardening heat and moisture inside the pellets, only to release (oxidize) later.

3. Biological Activity – Chemical Composition:
 - Biomass Species
 - Higher lignin and fatty acid in some biomass species show a higher propensity for self-heating.
 - Oxidization of wood pellets post production process
 - Release of heat and moisture trapped due to improper production process

4. Long Storage Periods of Wood Pellets with the above characteristics are prone to self-heat.



Wood Pellet Silo or Warehouse Storage Firefighting Techniques & Procedures

“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”

“When dealing with wood pellet storage fire incidents, a long firefighting operation must be assumed in order to assure control of the fire and subsequently empty the silo in a safe manner”

1. Silo or Warehouse Fire Incident Response Plan
 - Communicate the response plan with all involved, employees, local fire brigade and neighbouring community
2. Setup for N₂ injection and calculate the volume and flow rate
 - Locate and contact a N₂ supplier to provide a supply of N₂ and mobilize a vaporizer.
 - Calculate the size of the silo to determine the flow rate and volume required (contact a gas expert).
3. Monitor the gas levels (CO, O₂) to determine when safe to abort the silo or warehouse.
4. Prepare and/or plan for a safe and secure location to spread out the aborted material



Silo Fires Report – Henry Persson

Fire extinguishing and preventive and preparatory measures



- The Silo Fires Report is a very comprehensive report of the research conducted at the SP Technical Research Institute of Sweden, Centre for Combustion Science and Technology, the Swedish Civil Contingencies Agency as well as several industry stakeholders.
- Knowledge gained from this research recommended the basic method for extinguishing silo fires is a combination of inerting the silo with **NITROGEN GAS** from the silo bottom and subsequent discharge of the silo while monitoring and extinguishing the hot material.
- This report is a **MUST READ** for every stakeholder dealing with storage and handling of wood pellets

Henry Persson

Silo Fires

Fire extinguishing and preventive and preparatory measures



Henry Persson works at the SP Technical Research Institute of Sweden on the Fire Safety Engineering Department. He has worked for more than 30 years with testing and research with his main focus on fire and fire safety problems in industry, and the fire service and then with fire extinguishing as his specialist field. In many cases his research projects have been of the problem-solving type, which have led to concrete results and applications, e.g. the building of the large-scale firefighting equipment for tank fires (SMC), which are now available in four locations in Sweden. For about 10 years now there has been considerable focus on biofuels, and on that he and his colleagues have worked on projects related to fire risks, emissions during fires and fire-extinguishing, both in solid biomass and waste. Several projects have focused specifically on the risks involved in the handling of wood pellets silos, the risk of spontaneous combustion and extinguishing problems.





SILO FIRE RESPONSE PLAN - Step 1

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 an N₂ distribution manifold.
- Calculate the feed rate and volume of N₂ required.
- Attempt 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 in the head space to gauge when safe to start aborting the silo (CO level below 5% or lower and O₂ below 5%).





SILO FIRE RESPONSE PLAN – Step 2 cont'd

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

- 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 of the silo - 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 silo's head space if safe to do so.
- Alternative to N₂ in the headspace would be medium or high-density foam but requires a foam station on top of silo.
- Connect hoses from the manifold and commence with N₂ injection.





SILO FIRE RESPONSE PLAN – Step 2

Setup for N₂ injection to a warehouse with no prior injection system:

Fabricate lances: 20mm - 24mm diameter lance (pipe) with 3 - 4mm openings spaced every 25mm perforated pipe lances in sections (6m). Pointed tip on the section to be driven into the stock pile and threaded ends on the sections required to place the lance near the centre of the warehouse from each side. Utilize thermal imaging camera to locate the hot spot (smoldering pyrolysis column or ball) to assist with placing the lance(s) where it will be most effective to stabilize the incident.

- Should the warehouse not have access hatches or openings in the walls, prepare the warehouse 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 warehouse as close to the bottom of the pile as possible by either mobile equipment or drilling drivers. Once inserted (no perforated holes exposed outside the warehouse), seal and ground the lance.
- Should the warehouse not be fitted with an overhead spray foam deluge system, when safe to do so spray a medium or high-density foam over the stock pile in the warehouse to minimize the loss of N₂.
- Connect hoses from the manifold and commence with N₂ injection.





SILO FIRE RESPONSE PLAN – Step 3

Nitrogen injection flow rate and volume calculations

Refer to the Silo Fire Report

- Calculate the m^3 volume of the silo.
- Flow rate of the nitrogen should be no less than $5\text{kg}/m^2$, preferably up to $10\text{kg}/m^2$ during the initial firefighting operation, depending on the porosity of the pellets.
- Consult with the gas supplier's technical support team (gas experts are normally on staff or consult with gas suppliers).
- Flow rate of N_2 into the silo headspace (should injection be possible) is lower than the bottom flow rate at $1 - 3\text{kg}/m^2$ 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 $5 - 15\text{kg}/m^3$ can be expected in relation to the gross volume of the silo.





SILO FIRE RESPONSE PLAN – Step 4

When safe to abort and manage the extinguished material

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

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

- 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

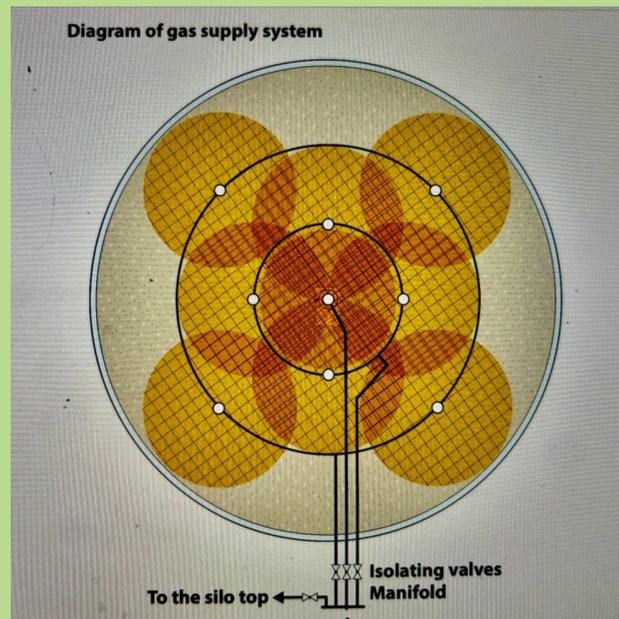


Silo and Warehouse Protection

Nitrogen Injection installation illustrations



Silo Lance installation



Nitrogen injection nozzles in silo bottom



Portal for warehouse or dome lance installation



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)



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 than rotating the product as self-heating may have already advanced to a fire smoldering state.



Fines Reduction - Gentle Handling

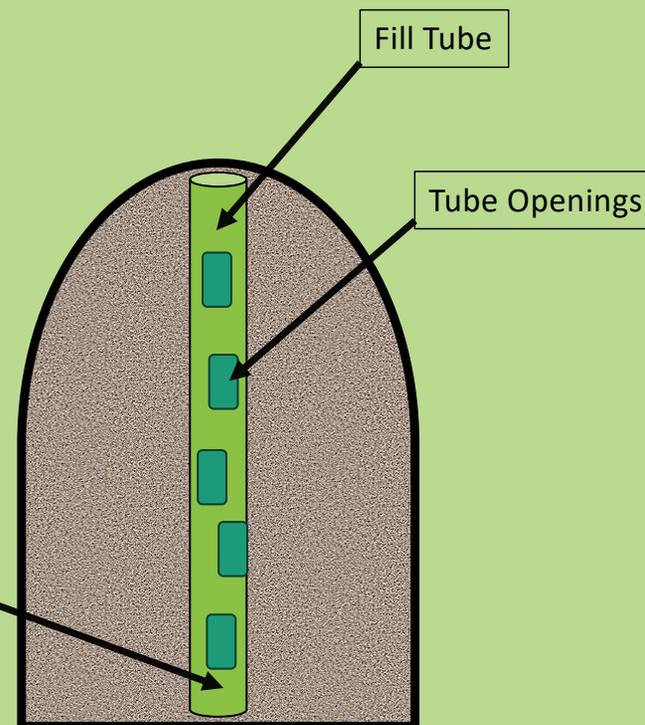
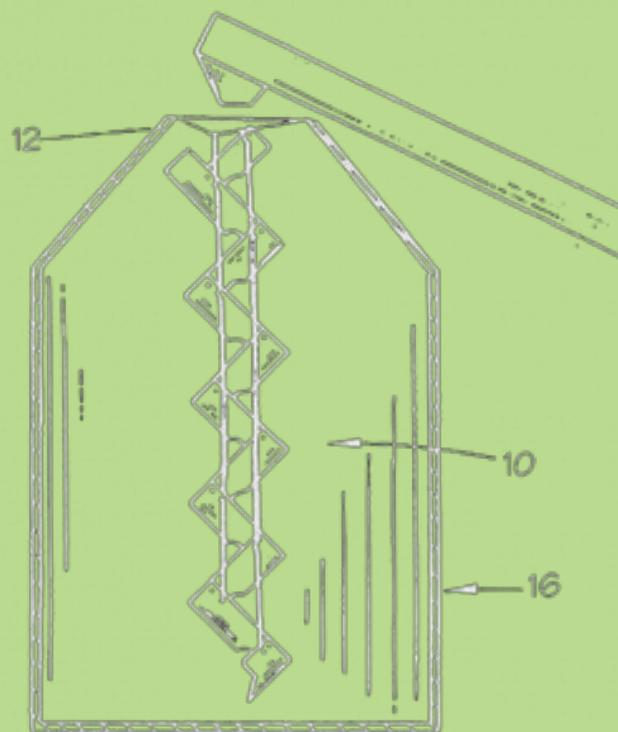
Self-heating Prevention by Reducing Fines Distribution in the silo and warehouse

- 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 Peoples 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
- Practice testing wood pellets for self-heating potential with ISO Isothermal Calorimetry, TAM or basket heating systems.
- 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 be scheduled



Communications

Reach out and encourage all 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 sprinkler system within the silo, compromise with a foam spray deluge and foam spray generator mounted on the side of the silo
- Insurance Agent(s)
 - Same as above – educate them
- Nitrogen supplier and gas expert

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



Thank – You

John Swaan

john.swaan@futuremetrics.com