Self-heating hazards in silos containing combustible dust

Cargill

Cargill® Helping the world *thrive*

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Process Safety Lead

EMEA Region

Personal introduction

MSc. **Chemical Engineering**

12 years of experience on Process Safety:

- 5 years: Process Safety Engineer for Técnicas Reunidas, an EPC contractor for Oil&Gas turnkey projects
- 3 years: Process Safety Site Engineer at Cargill (Martorell, Spain)
- Aug 2020 – Jul 2022: PS Sr. Specialist for EMEA Region
- Currently Process Safety Lead in EMEA

Main areas of competency:

- Design / Engineering
- Process Hazard Assessments
- Functional Safety
- Combustible Dust and ATEX
- Chemical systems

Agenda

01 Know Cargill

02 Learning from self-heating incidents

03 Factors that increase the risk

04 Prevention measures and emergency response

05 Questions

About Cargill

Cargill is a family company committed to providing food, ingredients, agricultural solutions and industrial products to **nourish the world in a safe, responsible and sustainable way.**

160K+
Employees

70
Countries

125
Markets

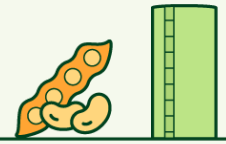
159
Years old

How we source, make and deliver goods that are vital for living

Source and trade

Partner with farmers and ranchers growing crops and raising animals.

Originate, source, store and trade commodities.



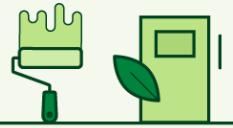
Provide global insights and risk management solutions.

Make and transport

Transport goods from where they're grown and produced to where they're needed.

Craft meat, egg and alternative protein products, and salt, oils, starches, cocoa and sweeteners.

Formulate feed to support animal health and productivity.



Create nature-derived, bio-based products and biofuels.

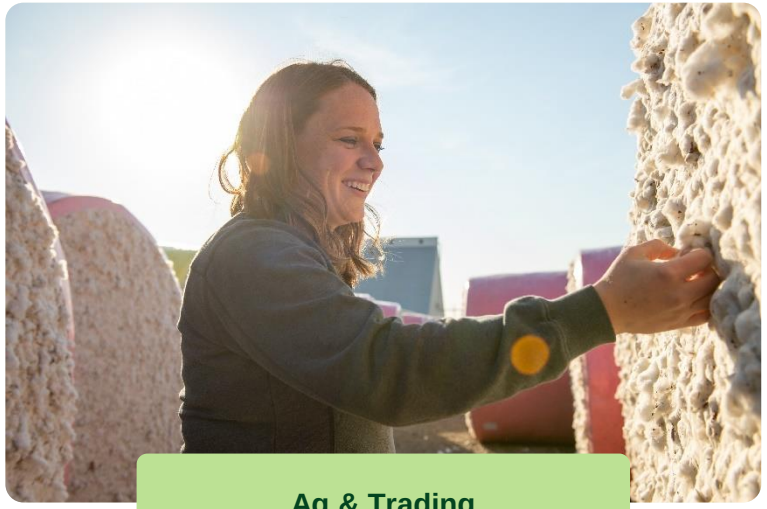
Deliver for customers

Sell food products and ingredients, agricultural solutions and bio-based industrial products to manufacturers, farmers and ranchers, foodservice customers, retailers and consumers—to nourish the world in a safe, responsible and sustainable way.

Our enterprises: Sourcing, making and delivering vital products

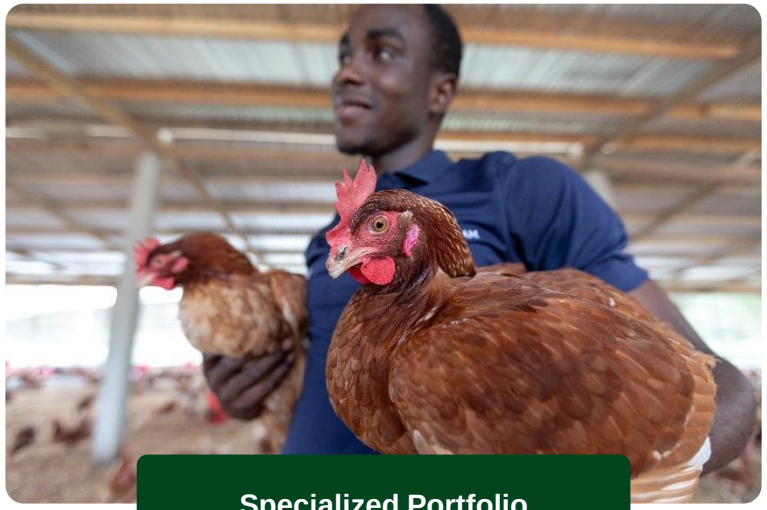
Food

Providing manufacturers, foodservice customers, retailers and consumers with protein products and a range of ingredients and solutions.



Ag & Trading

Connecting farmers and users of grains and oilseeds through sourcing, processing and distribution while providing trading and risk management solutions.



Specialized Portfolio

Serving diverse businesses serving unique customers or markets, including animal nutrition and health, bioindustrial, road safety salt, and Cargill joint ventures.

Learning from self-heating incidents

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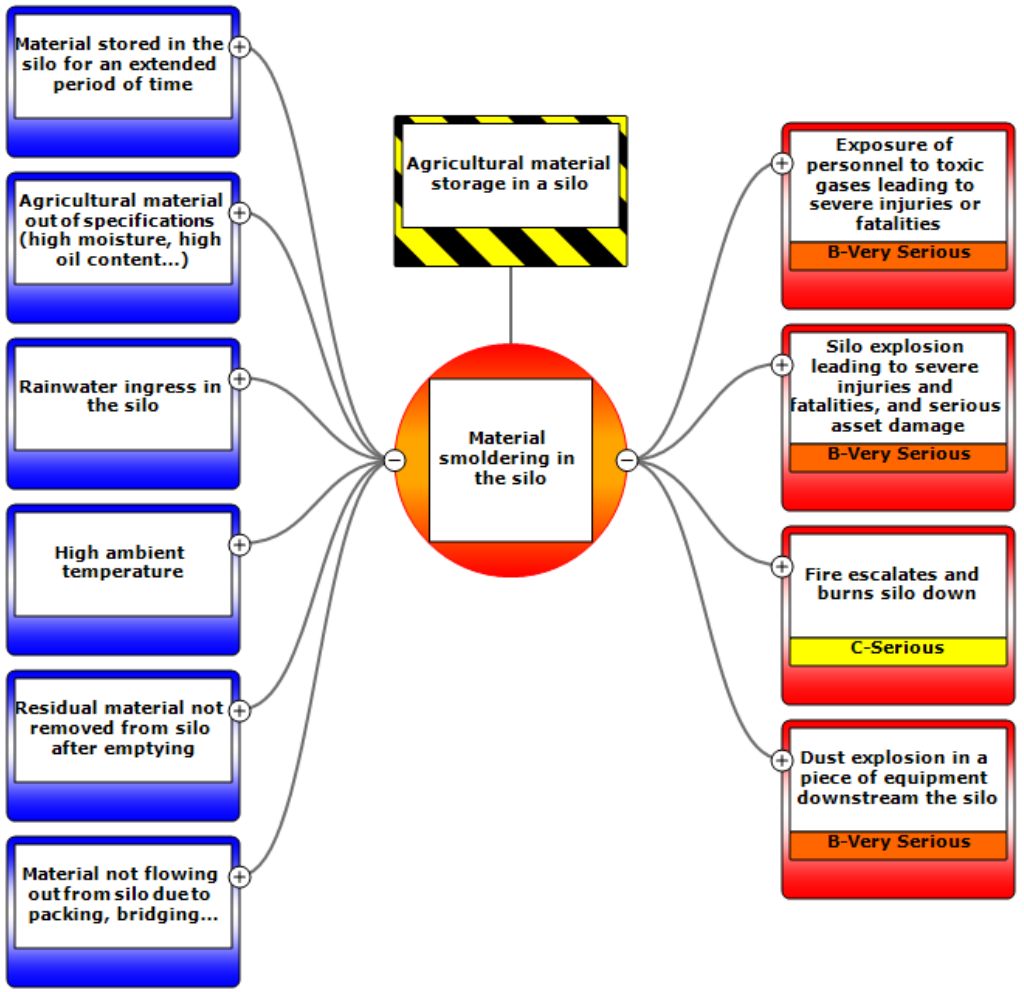
Learning from incidents

There are examples in the literature and the media of multiple silo fires and explosion caused by self-heating processes. If not controlled appropriately, the consequences can lead to people harm and asset damage, as well as significant losses.

This bow-tie diagram summarizes the risk of storing agricultural goods in silos.

This presentation points out the threats that increase the risk of self-heating and possible measures to prevent it.



Factors that increase the risk

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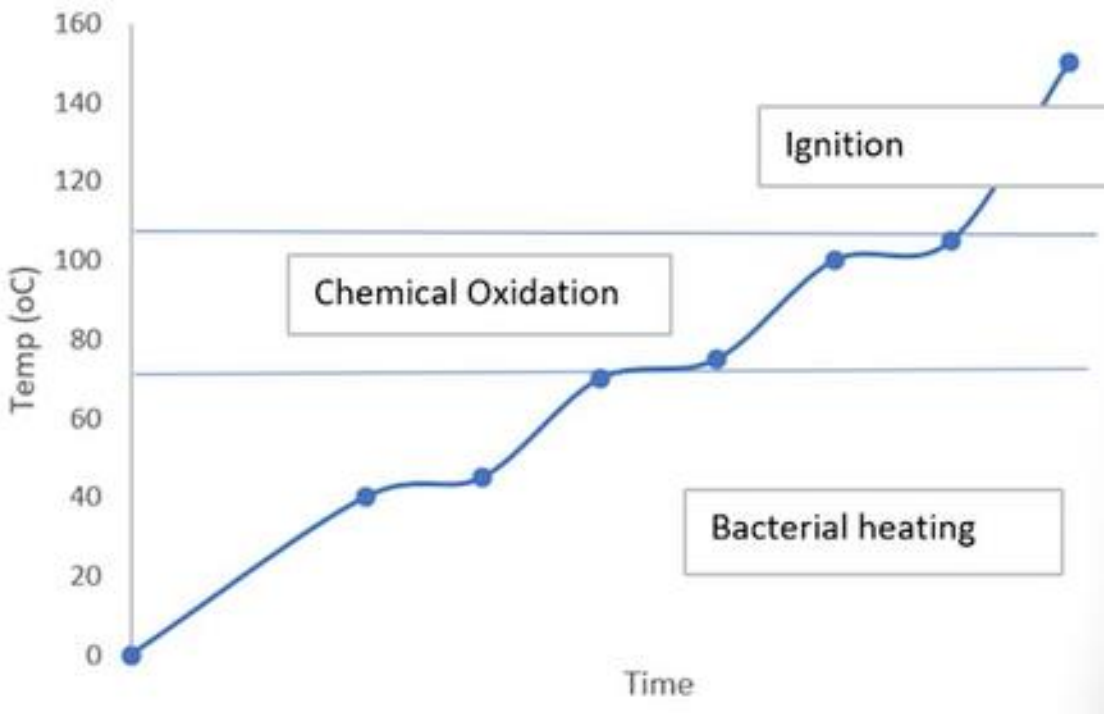
Self-heating process, explained

The process of self-heating of combustible organic material follows a series of steps

- Biological and oxidation reactions generate heat in the bulk
- Powders and grains are excellent insulators
- Once the heat production rate exceeds the heat loss rate the path to ignition is set
- Bacteria need water to live so if the material gets wet self-heating is more likely
- Dry materials stored at room temperature are therefore lower risk

Self-heating temperature increase example



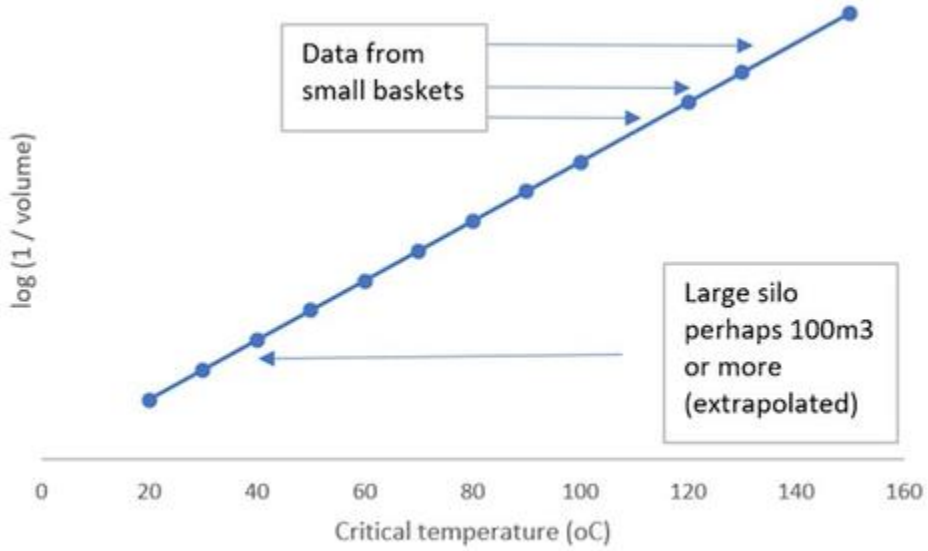
Materials with a high oil content produce more heat

This makes them prone to self-heating. Some examples include sunflower seeds.

Silo size makes a big difference

Critical ignition temperature

- The graph presents the critical temperature at which the runaway reaction would occur. This is determined experimentally with a basket test.
- The heat generated in the reaction is lost through the air and the silo walls.
- In food and agricultural industry, some silos are tenths of meters in diameter. For large silos, critical temperatures aren’t far from ambient conditions during the summer.
- The bigger the silo, the lower the critical temperature is. Shape is also important.
- Therefore, the closer this temperature is to your storage, the higher the risk of smouldering.



“Frank-Kamenetskii” Plot

Prevention measures and emergency response

Self-heating hazards in silos containing combustible dust

Prevention measures against self-heating

- Control storage time
- Prevent water ingress
- Aeration systems
- React immediately when the material in the silo doesn’t flow.
- Using smaller silos is more expensive but helps reduce the risk of self-heating.
- Ignition can also happen in other pieces of equipment, such as dryers or other type of facilities, like flat storage buildings.

How do we know self-heating is occurring?

It’s usually challenging

Temperature monitoring

A temperature cable is a steel cable with thermal couples attached to it covered in a protective sheath. Grains are insulating so it may not immediately see the increase in temperature if the hot spot is far from it.

CO monitoring

An increase in the CO level may indicate a slow combustion process in the silo. A gas analyzer system is also helpful if further action must be taken as part of emergency response.

Burnt smell and lumps

Operators may detect the presence of lumps or burnt smells in the grain, which may also indicate a combustion is going on in the silo.

We confirmed there is a smouldering fire, now what?

Responding to a fire in a silo requires depth knowledge. If the decisions taken aren't correct, the situation will get much worse. It is highly recommended to get expert support.

These are some ideas to consider:

- Using water is generally not recommended - fire fighters must be informed.
- Don't stand on the silo roof if the atmosphere is not being monitored – a gas explosion can occur.
- Generally, inerting is the best way of putting out the fire in the silo.

We confirmed there is a smouldering fire, now what?

Make certain it’s safe to empty the silo upfront. Smoulders are slow burning and there is time to plan the response if detected in advance.

- Smouldering fires burn slowly due to lack of oxygen in the bulk. Combustion can drastically accelerate when in contact with open air.
- Don’t take any action that can put combustible dust in suspension in the silo.
- The flow of bulk material is erratic and can’t be accurately controlled. Combustible dust explosions can occur if dust with embers is dispersed in the air.
- The burnt material must be disposed in a safe area.
- Control the gases in the area around the silo, especially in galleries, tunnels, and other confined areas.
- Monitor the structural elements to detect early symptoms of damage.

Key takeaways

Manage and risk assess the combustible dust stored in bulk

Monitor the key parameters that are associated with self-heating

Maintain an emergency plan that deals with fires in silos and bins

Questions

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Thank you!


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