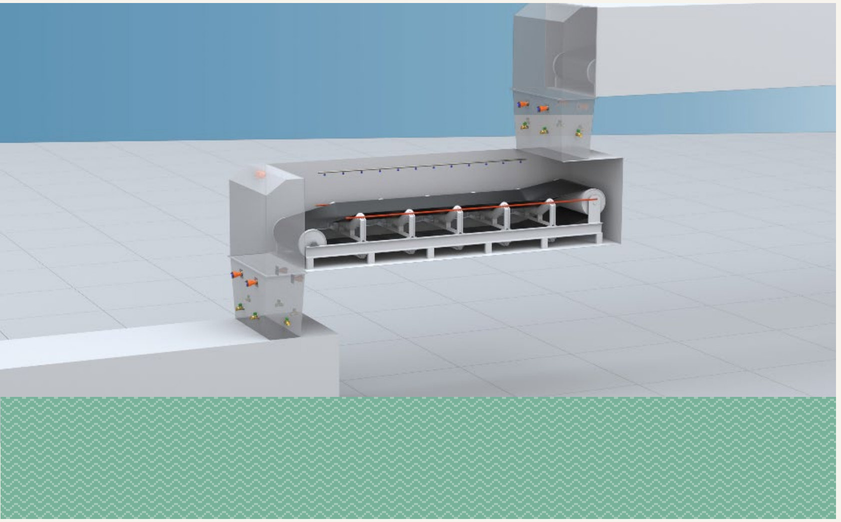
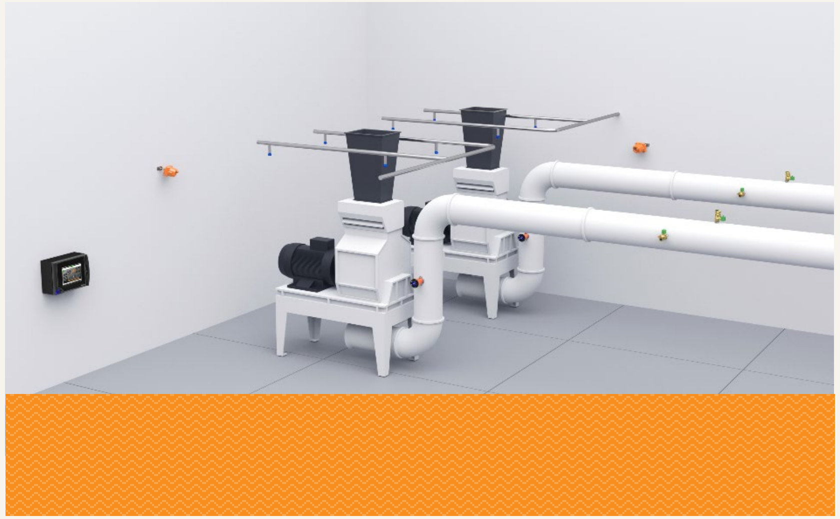
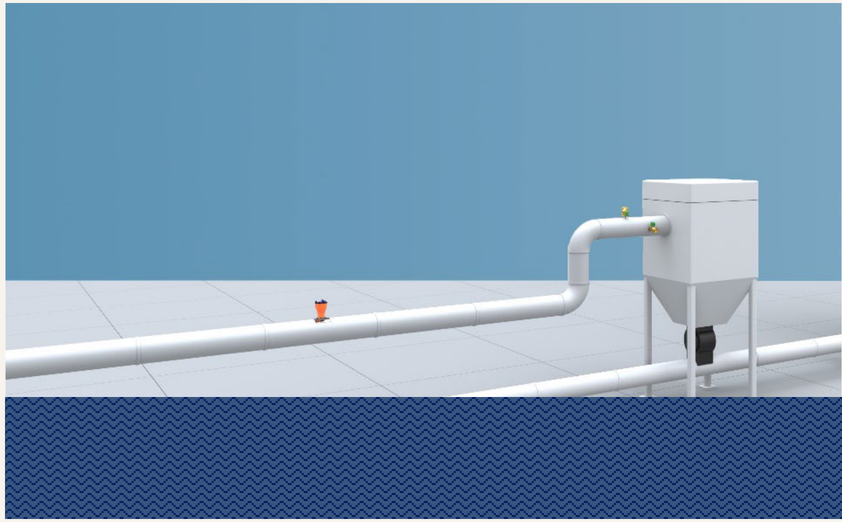
Prevention of Fires and Dust Explosions when handling Biomass

Jonas Persson, Firefly







RISKS WHEN HANDLING BIOMASS

Cofiring coal with biomass is a cost efficient way of reducing carbon dioxide emissions for coal fired power plants

However, there are some technical issues related to it…

The increased risk for **Fires** and **Dust Explosions** is one of them

RISKS WHEN HANDLING BIOMASS

Södra Cell Mönsterås Bruk, Sweden

”Probable cause of fire: friction and overheating of bearings resulting in hot particles falling down to the material stack”

20 days of loss in production, reached full capacity after 7 months.

Dong Energy, DK

“One hot conveyor roller drops down and ignites accumulated wood dust, underneath the conveyor belt” - Dong Energy

Fire fighting lasted for 12 days.

Gypsum Power Plant, US

The fire started in a conveyor carrying wood chips:

“there was fire in both of the plant's silos and on three different conveyor belts spreading across hundreds of feet…”

EVEN HIGHER RISKS WITH BIOMASS COMPARED TO COAL

- ✓ Biomass (wood or agriculture dust) has lower ignition temperature and is more “explosive” than coal
- ✓ The self-heating properties of biomass increases the risk for spontaneous combustion
- ✓ Increased dust emissions when handling biomass

TABLE 5-9A. Explosion Characteristics of Various Dusts

(Compiled from the following reports of the U.S. Department of Interior, Bureau of Mines: RI 5753, The Explosibility of Agricultural Dusts; RI 6516, Explosibility of Metal Powders; RI 5971, Explosibility of Dusts Used in the Plastics Industry; RI 6597, Explosibility of Carbonaceous Dusts; RI 7132, Dust Explosibility of Chemicals, Drugs, Dyes and Pesticides; and RI 7208, Explosibility of Miscellaneous Dusts.)

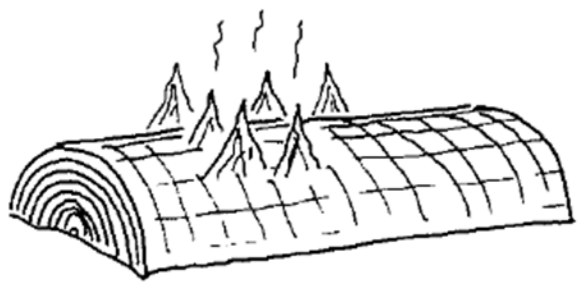
Type of Dust	Explosibility Index	Ignition Sensitivity	Explosion Severity	Maximum Explosion Pressure psig*	Max Rate of Pressure Rise psi/sec*	Ignition Temperature† Cloud °C	Ignition Temperature† Layer °C	Min Cloud Ignition Energy joules	Min Explosion Conc oz/cu ft‡	Limiting Oxygen Percentage§ (Spark Ignition)
Agricultural Dusts										
Cellulose	2.8	1.0	2.8	130	4,500	480	270	0.080	0.055	C13
Cellulose, alpha	>10	2.7	4.0	117	8,000	410	300	0.040	0.045	—
Cocoa, natural 19% fat	0.6	0.5	1.1	68	1,200	510	240	0.10	0.075	—
Coffee, fully roasted	<0.1	0.2	0.1	38	150	720	270	0.16	0.085	C17
Corn	6.9	2.3	3.0	113	6,000	400	250	0.04	0.055	—
Cornstarch commercial product	9.5	2.8	3.4	106	7,500	400	—	0.04	0.045	—
Cork dust	>10	3.6	3.3	96	7,500	460	210	0.035	0.035	—
Cotton linter, raw	<0.1	<0.1	<0.1	73	400	520	—	1.92	0.50	C21
Cube root, South American	6.5	2.7	2.4	69	2,100	470	230	0.04	0.04	—
Grain dust, winter wheat, corn, oats	9.2	2.8	3.3	131	7,000	430	230	0.03	0.055	—
Lycopodium	16.4	4.2	3.9	75	3,100	480	310	0.04	0.025	C13
Milk, skimmed	1.4	1.6	0.9	95	2,300	490	200	0.05	0.05	N15
Rice	0.3	0.5	0.5	47	700	510	450	0.10	0.085	—
Soy flour	0.7	0.6	1.1	94	800	550	340	0.10	0.06	C15
Sugar, powdered	9.6	4.0	2.4	109	5,000	370	400‡	0.03	0.045	—
Wheat flour	4.1	1.5	2.7	97	2,800	440	440	0.06	0.05	—
Wheat starch, edible	17.7	5.2	3.4	100	6,500	430	—	0.025	0.045	C12
Wood flour, white pine	9.9	3.1	3.2	113	5,500	470	260	0.040	0.035	—
Carbonaceous Dusts										
Charcoal, hardwood mixture	1.3	1.4	0.9	83	1,300	530	180	0.020	0.140	—
Charcoal, activated, from lignite	0.1‖	0.1‖	—	41	<100	670	370	#	2.000	—
Pitch, petroleum	4.0	2.8	1.4	82	3,800	630	—	0.025	0.045	—
Carbon black, acetylene	0.1‖	0.1‖	—	—	—	**	900	—	—	—
Coal, Kentucky (Bituminous)	4.1	2.2	1.8	101	4,000	610	180	0.030	0.050	—
Coal, Pennsylvania, Pittsburg (Experimental Mine Coal)	1.0	1.0	1.0	90	2,300	610	170	0.060	0.055	—

WHY IS DUST DANGEROUS?

- ✓ Dust from a leaking process will be spread and accumulated on all horizontal surfaces
- ✓ For example a mechanical failure in the process will create friction heat that can easily ignite these dust layers
- ✓ Dust deposits in the facility will lead to a quicker spreading of a fire
- ✓ Airborne dust creates a large risk for rapid fires (flame fronts) or even dust explosions

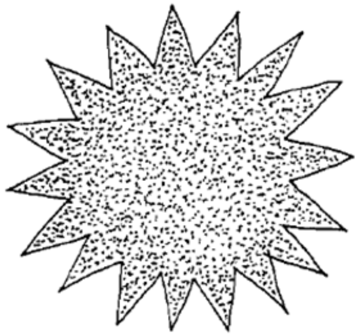
UNDERSTANDING DUST EXPLOSIONS

The more finely divided the material is – the easier it is to ignite and the more “explosive” it will become.



(a) SLOW COMBUSTION

(b) FAST COMBUSTION



(c) EXPLOSION

From *Dust explosions in the process Industries* by Rolf K Eckoff

CONFINEMENT

A quick combustion will lead to
a quick increase in temperature

A quick temperature increase will lead to **a quick expansion of the air**

If this quick expansion of the air occurs inside an enclosed volume
= dust explosion

WHY IS DUST DANGEROUS?

- ✓ Primary explosions
  - Often initiated by ”ignition sources” inside the process
- ✓ Secondary explosions
  - Initiated by a primary explosion
  - Can be disastrous!

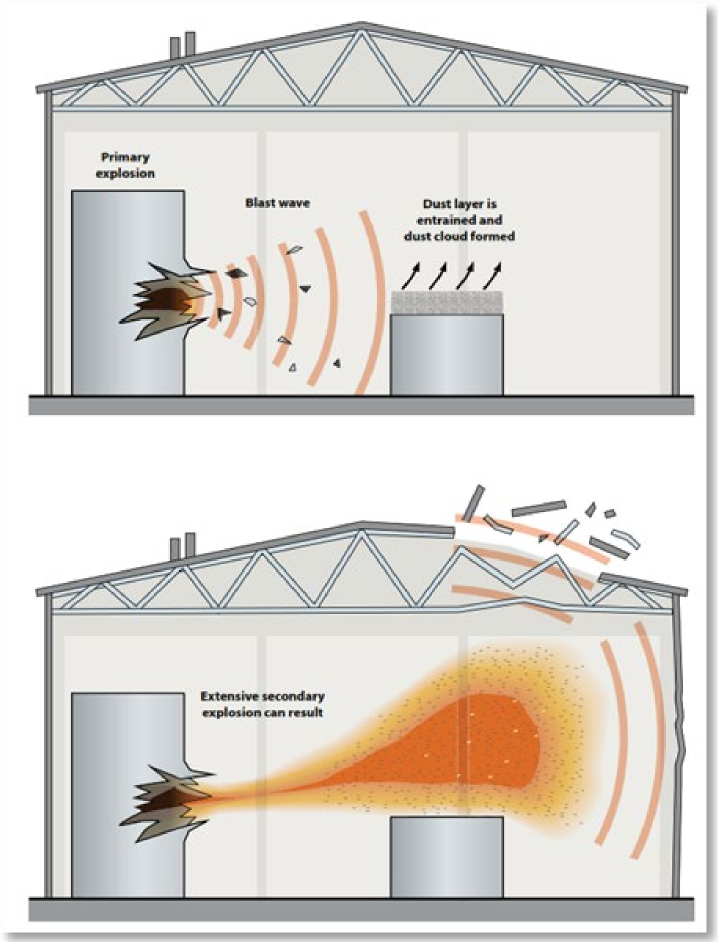


Illustration from ’Silo Fires’ by Henry Persson, SP

ROOT-CAUSES OF FIRES IN THE FUEL HANDLING PROCESS

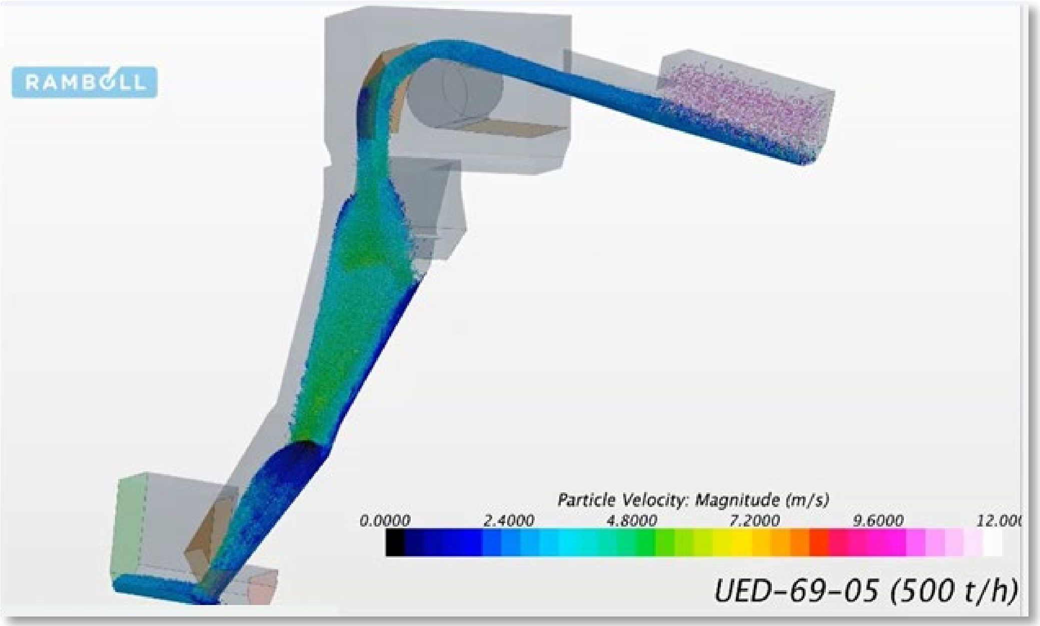
- Common causes of fires are:
- Smoldering biomass from the transport
- Mechanical failure in conveyors
- Self heating of the biomass in the storage silos
- Ignition sources generated by Mills / Crushers or other equipment
- Hot works

HOW TO PREVENT FIRES OR DUST EXPLOSIONS

- Minimize dust leakages and dust accumulations
- Solid routines for housekeeping and maintenance of equipment
- Follow the code of practice for hot works
- Spark detection systems
- Protection of conveyors
- Protection of Silos
- Quick Suppression systems for high-risk areas

MINIMIZE DUST LEAKAGES AND DUST ACCUMULATIONS

- Follow best practices for dust emission & control
- Optimized transfer chute design
- Dust containment systems / enclosures
- Dust extraction systems
- Design floor, walls and platforms to prevent dust accumulations
- Proper cleaning and house keeping procedures
  - Document your housekeeping schedule

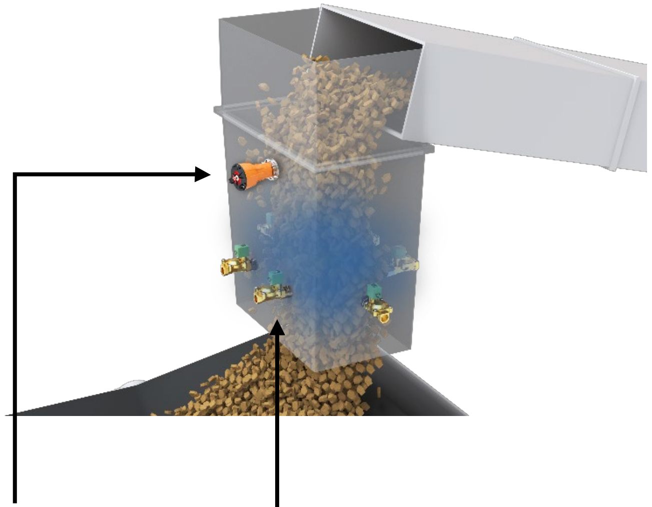


SPARK DETECTION SYSTEM

Detection and extinguishing of **ignition sources** inside the process **before** fire or explosion occurs

PRINCIPAL OF SPARK DETECTION

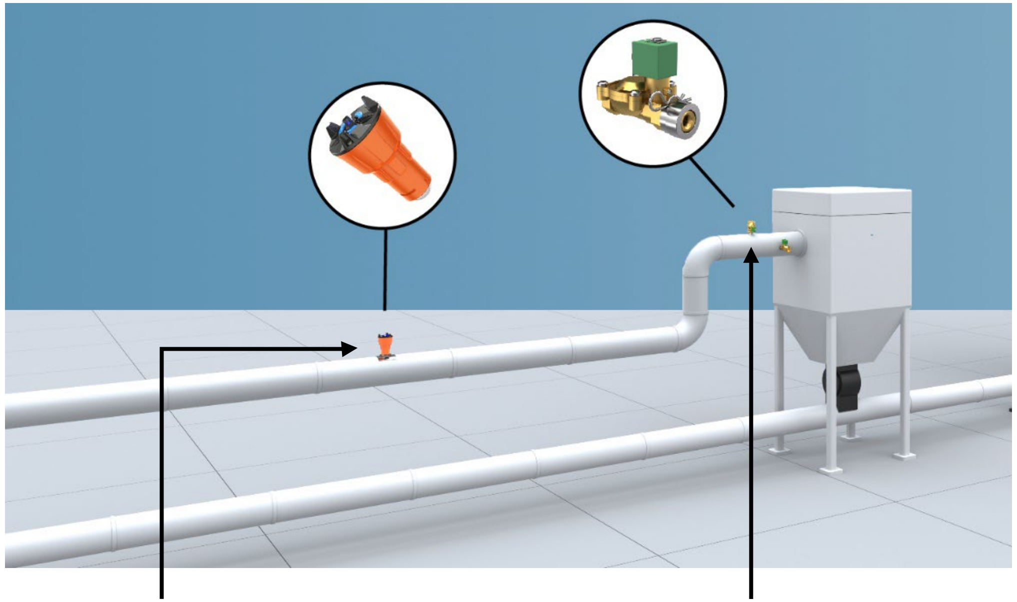
System in Chute



Detection zone

Water Extinguishing zone

System in Extraction Duct to Filter



Detection zone

Water Extinguishing zone

IMPORTANT PARAMETERS FOR SPARK DETECTION SYSTEMS

What is the Minimum Ignition Temperature – **MIT** of the fuel?

- MIT - Dust Cloud
- MIT - Dust Layer

What is the Minimum Ignition Energy – **MIE** of the fuel?

Make sure that the detection system can detect down to the right **temperature** and **energy**

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Example MIT Wood Dust (Dust Cloud) = 470°C

Example MIT Wood Dust (Dust Layer) = 260°C

Example MIE Wood Dust = 40mJ

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[illegible]	[illegible]	0.2	0.1	38	150	720	[illegible]	0.16	0.085	C17
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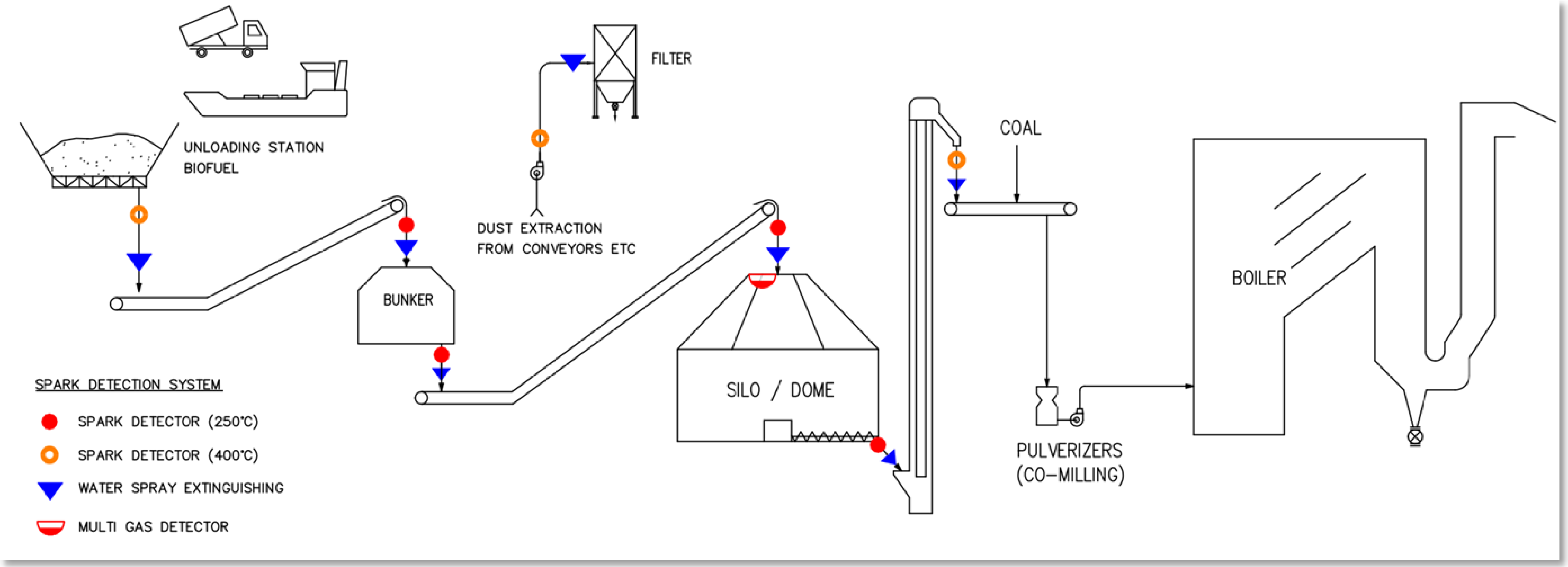
Hot particles can be dangerous even if they do “glow” or emit any light

WHERE TO LOCATE SPARK DETECTION SYSTEMS IN THE PROCESS?

- In transfer chutes
- Infeed to bunkers / silos
- Outfeed of bunkers / silos

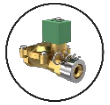
Filter units
Elevators

After mills / shredders etc.
(Unless the fuel is sent right into the boiler after the mill)



FIREFLY ConveyorGuard™ SOLUTION

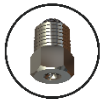
Spark detection system in the Chutes



- ✓ To avoid sparks, hot particles or flames to enter/exit the conveyors via the material flow
- ✓ Efficiently prevents fires caused by ignition sources that comes via the material flow
- ✓ Prevents spreading of fire or ignition sources into other areas

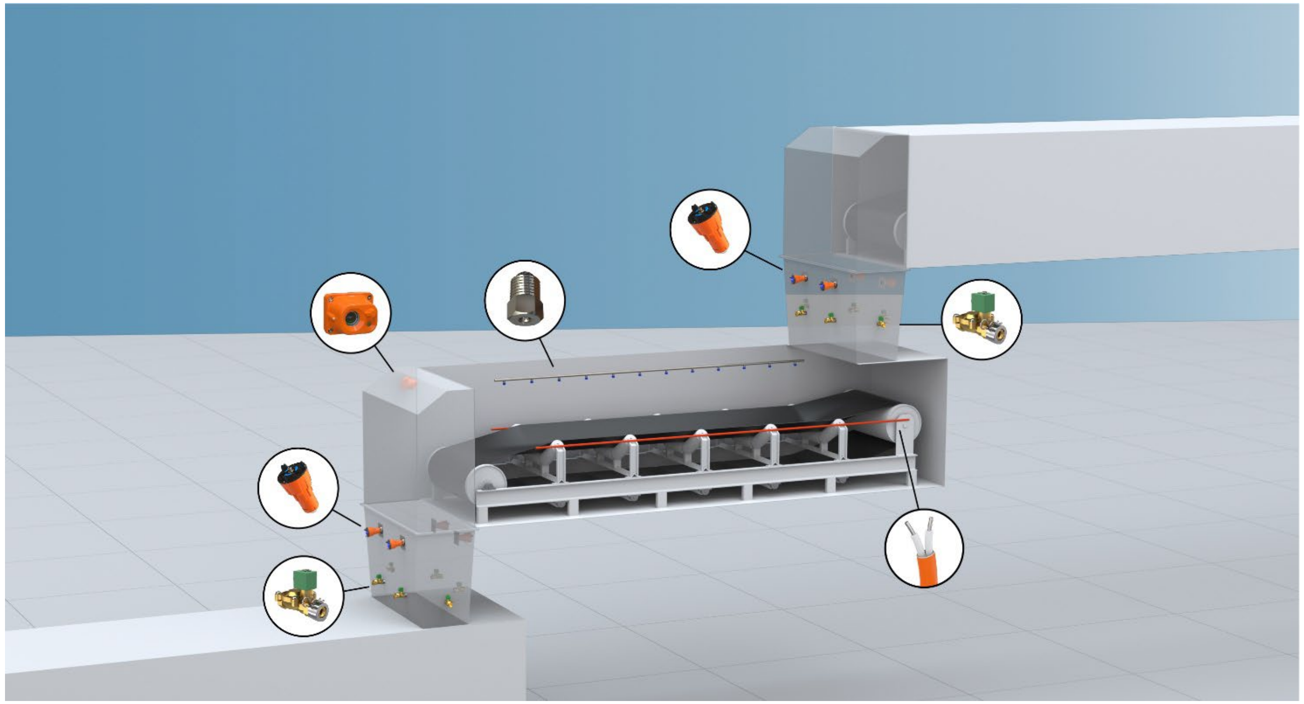
Flame detection

- ✓ Detection of flames at the conveyor for immediate action



Water Mist Suppression

- ✓ Quickly activated water mist to cover the conveyor. Efficient suppression capabilities utilizing small amounts of water



Temperature sensing cables - Option

- ✓ Temperature monitoring along rollers and pulley

SILOS

Fire in a silo could be a worst case scenario if not handled correctly

Once a fire has started, extinguishing is very complicated and imply great risks for the fire fighters

There are ways to minimize the risk for a fire to happen, but the risk cannot be eliminated completely

Research and experimental studies of fire extinguishment in silos have been performed by
SP Swedish National Testing and Research Institute
SP Report 2006:47 with detailed firefighting methods for silo fires

Ref: 'Silo Fires' by Henry Persson ISBN 978-91-7383-364-6.

SILO PROTECTION

Detection and extinguishing of
hot particles before entering the silo

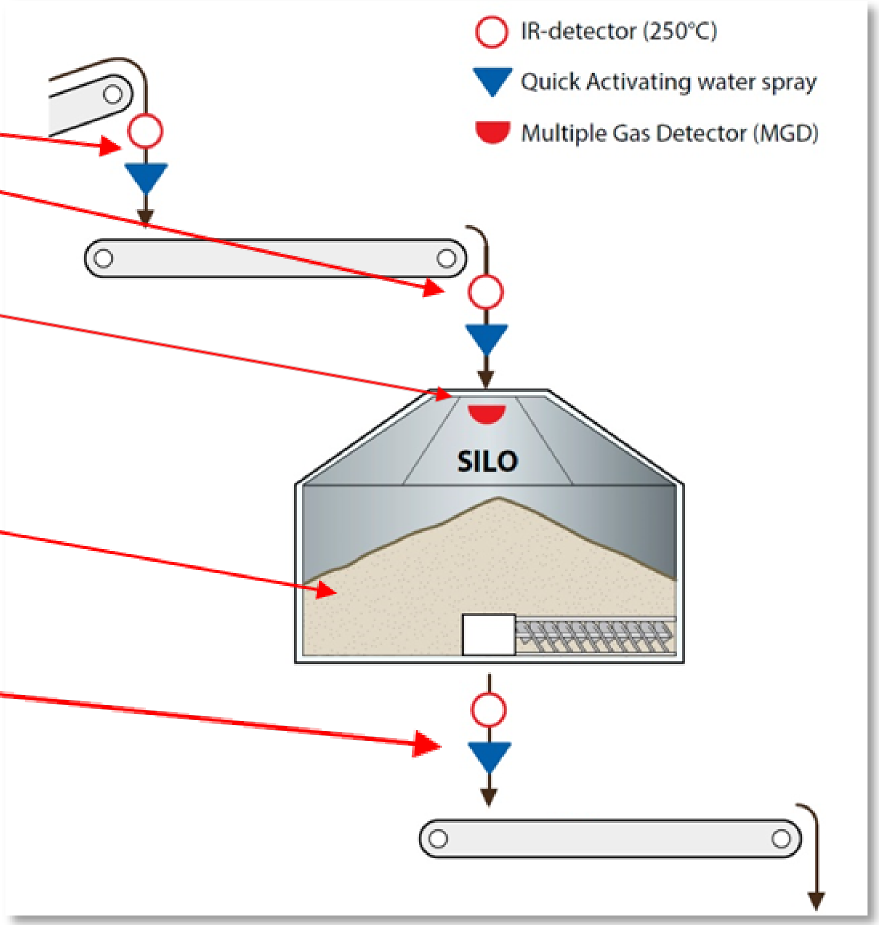
MGD – Multiple Gas Detector in the top of the silo
- Detection of combustion gases inside the silo

Temperature sensors / Monitoring cables inside the silo
- Detection of overheated material

Detection and extinguishing of hot particles at the outlet of the silo

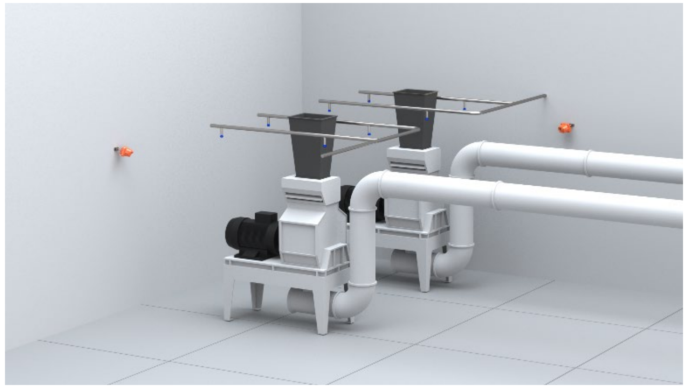
Explosion Venting and/or Explosion Suppression
- To mitigate the effects of an explosion

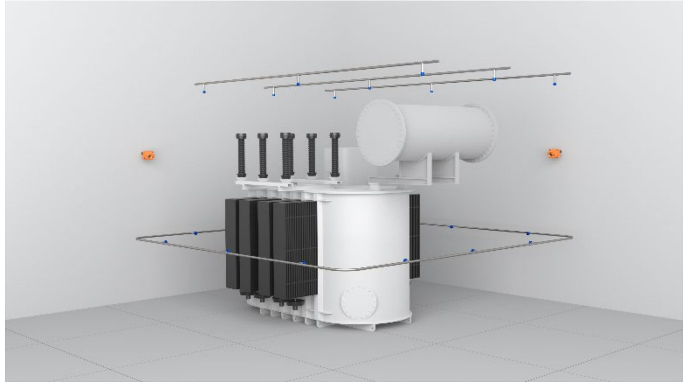
Prepare the silo with injection points in the bottom for Nitrogen extinguishing



QUICK SUPPRESSION SYSTEMS - FOR HIGH RISK AREAS

- ✓ High Risk Areas in the plant can be protected with Quick Suppression Systems
- ✓ Quick Detection and Suppression of flames
  - System is based on Flame detectors and Water Mist Suppression
- ✓ The aim is to detect and extinguish quick enough to avoid damages and downtime in the plant
- ✓ Can be used for spot-protection of most types of machines or high risk areas
- ✓ A new test protocol - DFL TM170307-1261 for certification of Quick Suppression Systems is available since 2017

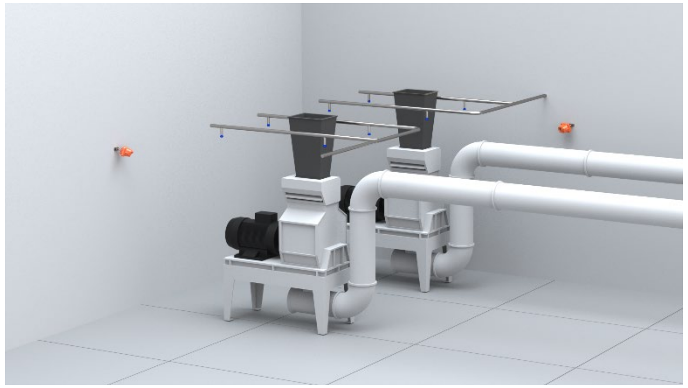


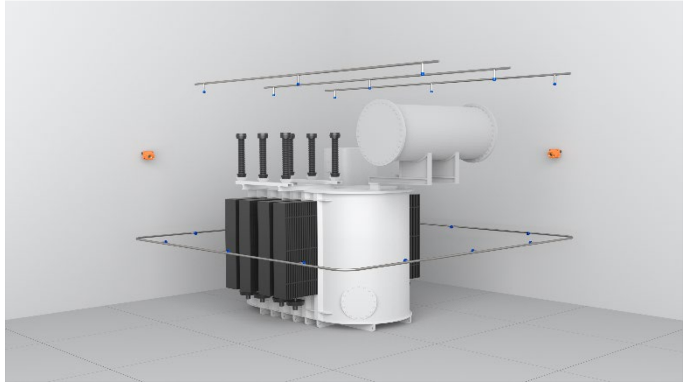


PRINCIPLE OF QUICK SUPPRESSION SYSTEMS

Example of applications for Quick Suppression Systems in Power Stations

- Unloading Stations / Receiving stations
- Mill rooms
- Conveyors / Elevators
- Turbines
- Transformer Stations
- Etc





CONCLUSION

- ✓ Do not neglect the fire risk when handling Biomass
- ✓ Good process design is the first step to minimize dust emissions and reduce the risk for fires and dust explosions
- ✓ Use applicable methods to prevent fires and dust explosions in combination with methods to fight fires
- ✓ Solid routines for housekeeping and maintenance of equipment

If you think Safety is Expensive – Try an Accident!

PROTECTION SYSTEMS FROM

firefly®

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