1973 ATEX Explosion Hazards Ltd 2014

A Simple step by step guide to making your Materials Handling Plant

ATEX Compliant II

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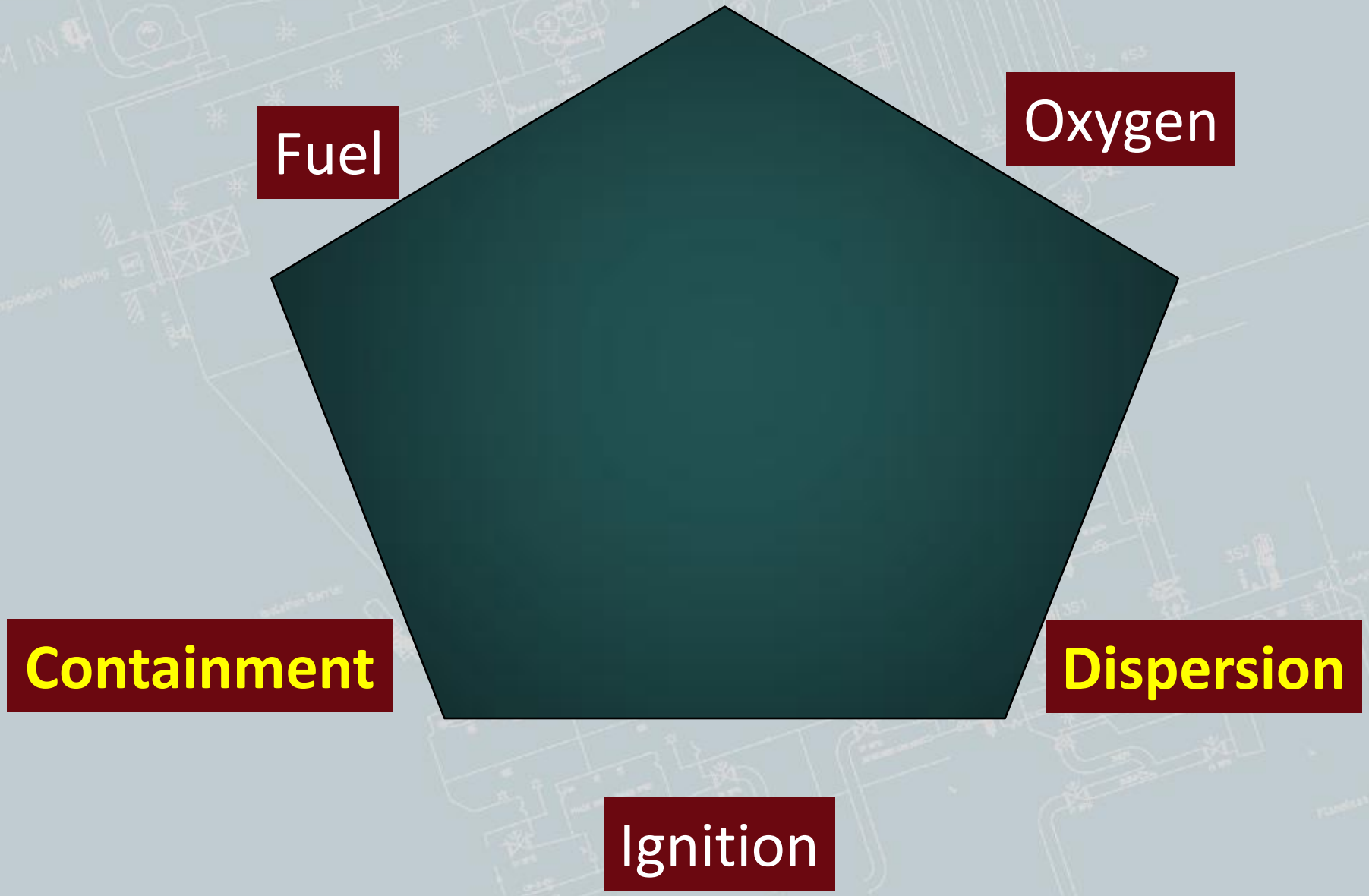
ATex Explosion Hazards Ltd

Dispersion but no Containment make it only a fire ball or unconfined deflagration

From fire to dust explosion



Now this is a wood dust explosion!

History of Recent Events I

Curtis Furniture Leeds

Edinburgh Napier Campus

Egger Biomass Incinerator

RWE Power station Tilbury

Avedore Conveyor roller ignites dust to silo

Koda Energy lost 2 Silos

History of Recent Events II

Port of Tyne silo

Egger Brilon Germany

James Jones Timber Moray

Sonae Chipboard Knowsley

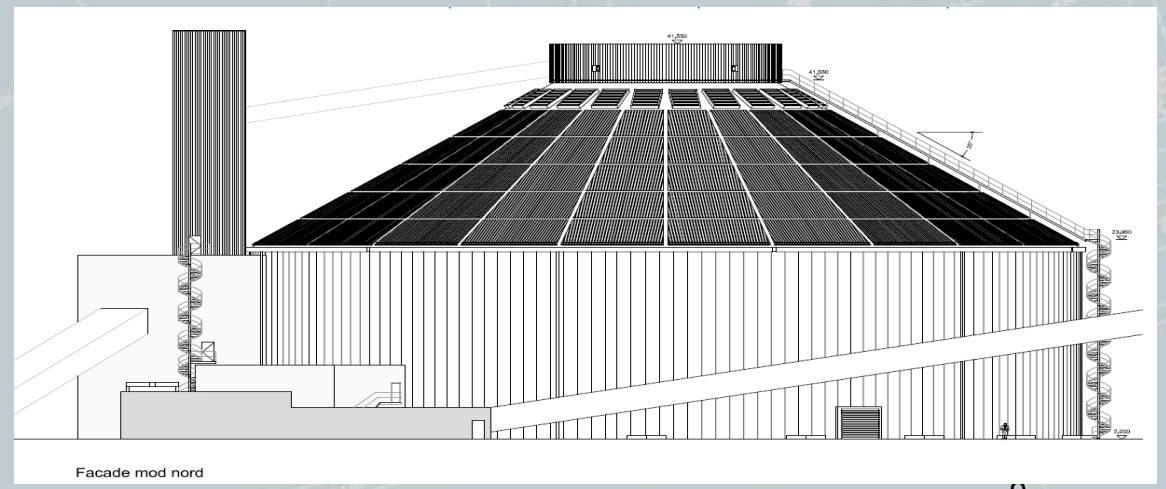
Texas plywood Filter blast injures eight

Explosions by Industry

			
Foodstuff (Inc Animal feed)	25%	42%	51%
Wood/Paper	34%	12%	19%
Metal	13%	14%	7%
Plastic	13%	5%	6%
Coal/Peat	9%	5%	6%
Other	6%	22%	11%

Statistics

- Up to 2013, 22 fires and explosions have been recorded in biomass plant, with 45 wood pellet plants and 20 wood products mills, with fires of various degree of damage or destruction.
- Fires at biomass facilities typically start from spontaneous combustion of woodchip or sawdust piles or wood dust explosions according to the Institute of fire Engineers.



Sources of Ignition

2 EXPLOSIONS PER DAY IN EUROPE	Germany	UK	NL
Mechanical Friction	35	38	18
Fire / Smouldering Pockets	19	10	14
Hot Surface / Auto Ignition	10	14	15
Welding	5	7	17
Electrostatic Discharge	9	4	10
Electrical Equipment	3	3	2
Other / Unknown	19	24	17

Self Heating Ignition

Dong Power Energy Copenhagen.

On Sunday the 12th August 2012, Avedore plant Copenhagen, 50.000 tons wood pellets, huge plant investments and the production from a 800 MW CHP at risk.

Cause of the fire, one hot conveyer roller drops down and ignites accumulated wood dust, underneath the conveyer belt.

Fire-fighting operations & handling of biomass lasted 12 days using up to 60 man-day & more than 10.000 external man-hours.

Inerting gases were used consuming nearly 170 tons CO2/day
The operation cost was equivalent to 2 month use of wood pellets (14.000 tons) and a 15,000 tons silo and conveyer systems had to be rebuilt.

Self Heating Ignition

- "Fermenting wood piles…are a fire risk and there are generally huge piles of woodchips and pellets on site" at biomass facilities.... "Most processed, dried biomass/wood particles put into storage with a moisture content of 15% or more, can start to heat."
- The surrounding drier biomass insulates the heating area, supporting a rise in its temperature up to auto-ignition and combustion with oxygen levels in the biomass/wood.

What causes self-heating?

- Fermentation: Bacteria feed on starches and sugars Produces heat
- Biomass is good insulator, so temperature rises
- Direct oxidation of material is initiated which further increases heat production & more temperature rise
- Thermal runaway

  Oxidation takes over

  Bacteria killed off

  Rate of temperature rise accelerates
- Result = smouldering fire

RWE Npower statement:

Tilbury, February 2012:

"A number of relatively minor events that, taken in isolation would not have escalated, combined to cause the fire, which developed from a localised smouldering incident.

When wood pellets in neighbouring hoppers were moved, significant air drafts were created and, despite fire suppressant foam having been used to cap the affected areas, it is likely that the increased levels of oxygen caused the ignition of the smouldering dust.

Although it has not been possible to definitively identify the mechanism for the escalation, this is considered to be the most likely cause."

Dong Report

Main risk related to wood pellet storage are:

- external burning nests conveyed into the storage facility,

- burning belts spreads fire into the silo,
- dust/flue – gas explosion in the silo head
- self ignition of the bulk biomass.

Immediate Lessons Learnt by Dong

- Clean Plant, design to minimise horizontal surfaces

- Make easy access to all equipment for good maintenance

- Cable route to storage monitoring systems, not to follow conveyor bridges, to be supplied from separate electrical system to the one that feeds the conveyor and mechanical systems.

- Design Fire fighting equipment, so first actions can be done by plant staff.

Consequences of Chipboard Explosion

Explosion Protection Document

Technical
&
Management

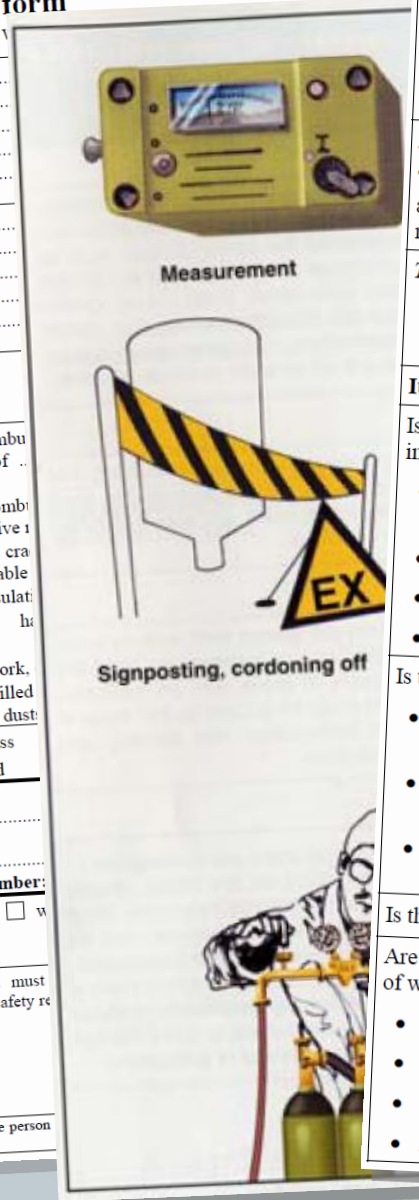
"People Cause Explosions not Equipment"

Organisational & Training

Permit-to-work form

for work involving ignition sources in places w

1	Working place	.....
2	Task (e.g. weld pipe)	.....
3	Nature of work	☐ Welding ☐ Abrasive cutting ☐ Thawing
4	Precautions taken before starting work	☐ Remove all movable combu deposits, within a radius of .. rooms ☐ Cover the immovable combu plastic parts, with protective r ☐ Seal openings, joints and cra gratings with non-flammable ☐ Remove cladding and insulati ☐ Eliminate explosion ha possibly by inerting ☐ Close openings in pipework, ☐ Post a fire sentry with filled fire hose (spray only for dust
5	Fire sentry	☐ While work is in progress ☐ After work is completed
6	Alarm	**Location of the nearest** Fire alarm ..... Telephone ..... **Fire service telephone number:**
7	Firefighting equipment/extinguishing agent	☐ Fire extinguisher with ☐ w ☐ Filled water buckets ☐ Connected fire hose
8	Authorisation	The safety measures listed must prevention and the insurers' safety re
	Date	Signature of the manager or the person appointed by him



Checklist: Coordination measures

- Focus: On-site explosion protection -

Processed by

Date

Purpose

This checklist may serve as an aid to checking whether the protective measures are being carried out as agreed to allow principal and contractor to work together safely, whether the persons concerned have received adequate instruction and whether they are complying with the agreed protective measures.

Task

Item	Yes	No
Is a check made on compliance with statutory and company regulations implementing Directive 1999/92/EC?	☐	☐
• Has a person (the coordinator) been appointed to coordinate work carried out jointly [see 5.1]?	☐	☐
• Does the appointed person meet the necessary requirements [see 5.1]?	☐	☐
• Is the coordinator known on site?	☐	☐
• Are subcontractors notified to the employer?	☐	☐
Is the work procedure checked for hazardous interaction [see 5.2]?	☐	☐
• Is it impossible for hazardous explosive atmospheres to form in places where there may be ignition sources?	☐	☐
• Is the use or creation of ignition sources prevented in places with hazardous explosive atmospheres?	☐	☐
• Are malfunctions avoided in nearby operations involving hazardous places?	☐	☐
Is the work procedure laid down [see checklist in Annex A.3.5]?	☐	☐
Are the agreed protective measures adapted to take account of the progress of work or of any shortcomings detected?	☐	☐
• Is training provided throughout?	☐	☐
• Is there consultation throughout?	☐	☐
• Are instructions issued throughout?	☐	☐
• Are checks made throughout?	☐	☐

Basis of Safety

Material properties
Equipment
Procedures

Acceptable residual risk
Human Factors
Deviations

Avedore: Post incident actions taken

1. Analysis was carried out by a national knowledge centre
   Share the risk assessment results with all levels of staff
   Results used to define the cause, consequence and barriers related to both processes and plant design.
2. How did the fire spread and how do we prevent the spread of fire?
   (in-house workshops supplied by external consultants)
3. Different monitoring systems to be used on conveyor belts.
4. Non flammable conveyor belts
5. Water sprinklers on conveyor belts
6. Use liquid and gaseous nitrogen as inerting agent together with gaseous CO2
7. Permanent foam installation, in case of failure of above
8. Silo specific: IR Temperature, gas analysers, temperature measuring with-in the pellets
9. Use of spark detection and explosion suppression.
10. Improved cleaning processes
11. Improved plant maintenance and surveillance
12. Training and education of all staff.

What are we doing in the UK?

Biomass and Waste Materials: Fire Prevention, Detection and Fighting in Silos

Open discussion in January 2013 and 2014 in University of Greenwich

Primary conclusions:
There is a need to validate the work in small vessels to larger vessels!

Some interesting Prevention topics

• Pros and cons of ventilation of the silo bulk for cooling and improved gas monitoring versus accelerating the fire

•Aspiration of the conveyor and the storage facility to minimise dust and gas accumulations

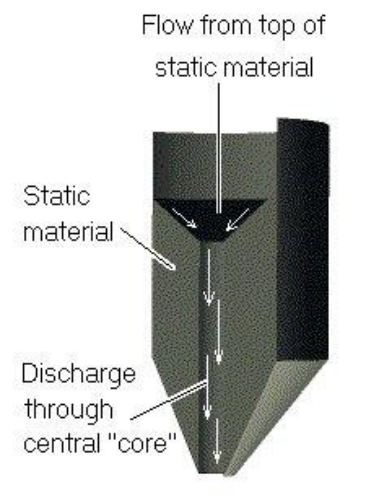
•Temperature detection at surface is unlikely to give a clue to what is happening inside the bulk, due to deep seated fires and combustion condensation cooling the surface.

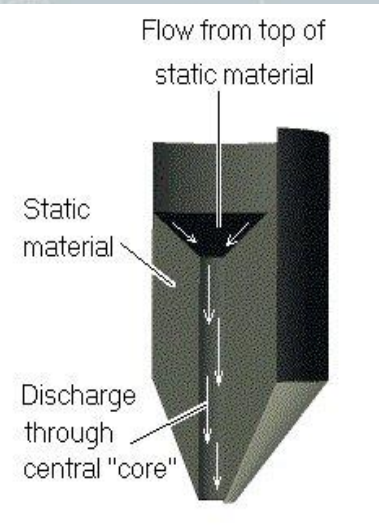
•Condensation from environmental conditions and condensation as a by product of combustion needs to be examined

•General bulk temperature trends and off gassing may be useful. The onset of direct oxidation of 65 to 70 C seems to be a maximum if unventilated but varies with product.

•Heat migration travels up and towards the centre due to segregation of fines, discharge characteristics FIFO versus LIFO

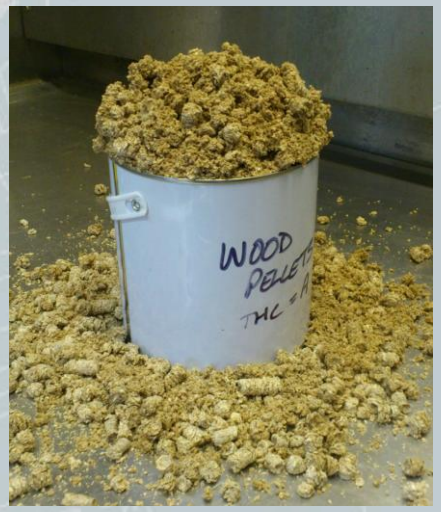
•Quality Control from supplier, traceability and monitoring;
• Age of pellet,10 to 20% of fines in the road or train unloading.





more interesting Protection topics

• Avoid using water but as a last resort, a small amount of water for cooling gas space can be effective – a few tens of seconds at a time, especially for surface fire.



•Beware of water gas reaction and H2 explosion
also CO2 dissociation above say 600C

•Foam on surface may help reduce smouldering fire in bulk
but the quality of the foam is critical to avoid drainage,
beware application does not add oxygen or disturb the dust.
What about the addition of fly ash?

•Inerting with Nitrogen versus CO2
there are many pro's and con's but the general consensus is people are more afraid of CO2 and there is not enough of it available in the UK for such large events.

•Discharge rates of the inert gases needs careful consideration and has consequences for personnel

Explosion Venting

Silo & Filters Vented with reclosing Doors

Silo Venting without Reclosing Doors

Do your fire measures require reclosing vents after explosion?

Ex-Go-Vent Open

Q-Box Vent Quenched

Basic Fire Conclusions

•Ensure the connection points for your fire safety measures are in place and suitable for different suppliers, at safe distance from the designated hazard area.

• Personnel protection – are there enough PPE & air bottles the scale of the response and for the probable long duration of the event days or even weeks.

• Keep air out when extracting the burnt product and maintain your inerting at all times.

• It may not be feasible to dump whole contents of very large silo, so you need a contingency plan in place.

• Every control measure should be remote there should be no need for personnel to go in close.

•Fire services Plan agreed in advance.

•To improve safety of the plant area and safety of personnel Storage should be away from power station and in multiple units – for business continuation

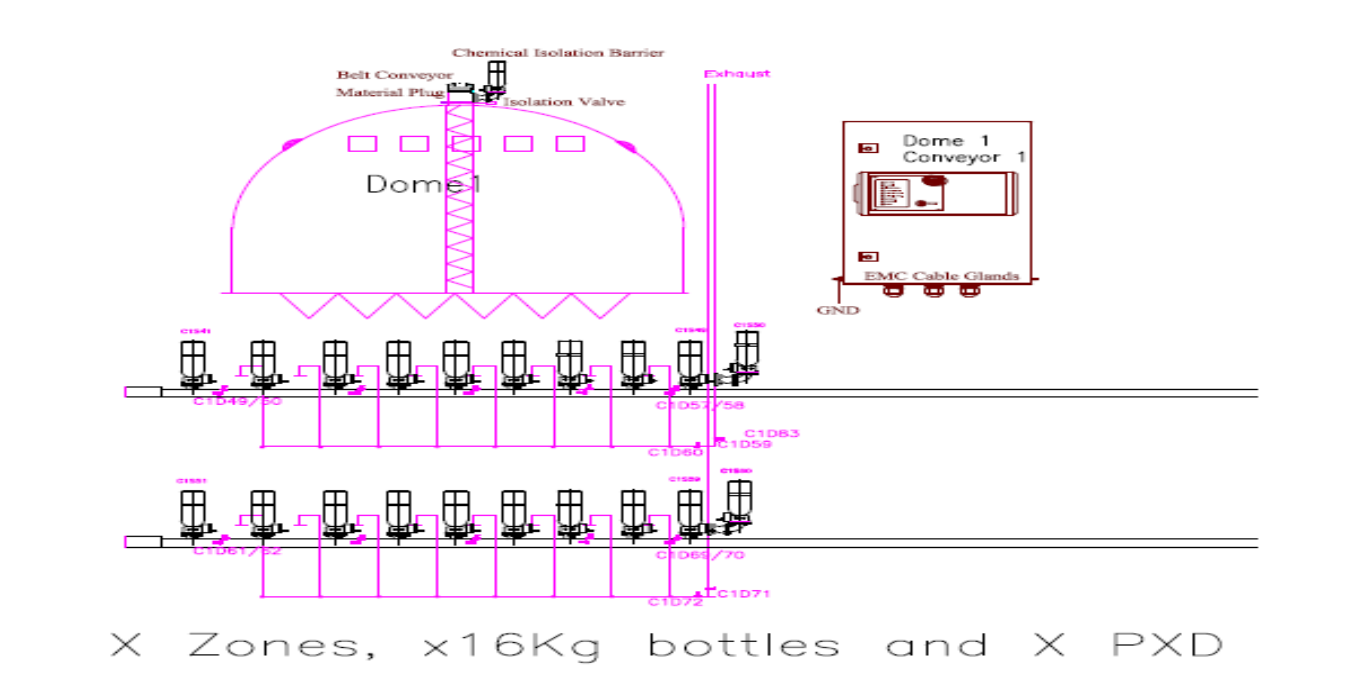
Basic Explosion Conclusions

•Explosion Venting; If the silo is nearly empty the proportion of flame to empty volume is too low to create a significant pressure.

•Only in exceptional circumstances can you get a real dust cloud or when the silo is nearly full.

•Explosion propagation needs to be taken more seriously. The dust coming off the belt and the dust being exhausted ahead of the flame path.

Isolation of flame propagation into and out of the silo



THANK YOU

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