4th Virtual global MAINTENANCE & OPTIMISATION cemproducer CONFERENCE & 'EXHIBITION'
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Accept the probability that the fire and explosion safety of your coal grinding system is nothing more than a mirage. Now what?

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introduction (1 1)

The following is an analysis after many years of work in the cement industry and with technology suppliers, in which the typical faults in the engineering of coal/petcoke/lignite grinding systems have been observed.

introduction (1$_2$)

This is to make sure that we are on the same page:
Fire & explosion protection of coal grinding systems.

introduction (1 3)

The following is not about maintenance issues or unprofessional alterations of systems. It is about wrong designs.

The following is also not about operating safely and about technology for the handling of emergency situations.

Evaluating the fire and explosion safety of systems with all kinds of ‘engineering culture’ backgrounds on all continents has led to the understanding described below.

introduction (1 4)

With the actual hot topic being decarbonisation, the so necessary awareness of people responsible for the fire and explosion safety of coal grinding systems is ever less present.

And with many unscrupulous or ignorant suppliers on the market, the already large number of incorrectly protected coal grinding systems is rapidly increasing.

Given the already low level of safety in place & the un-awareness of the responsible people, this is an alarming trend.

The number of accidents obviously has been too low as to stop this. That you may stay out of trouble is un-deserved in almost every plant and just good luck.

where it goes wrong (2_1)

The probability that the engineering of your coal grinding system is 100 % correct in terms of fire and explosion safety is minimal.

The probability that there are serious faults in the engineering is great.

where it goes wrong (2$_2$)

Depending on who was responsible for the engineering, your coal grinding system will have a degree of wrong engineering in it as the result of:

- unawareness/lacking knowledge on the side of the engineering party
- knowingly, willingly cutting corners by the engineering party
- re-using old designs with faults in them
- or a combination of the above

where it goes wrong (2$_3$)

When a coal grinding system is ordered, as part of a new line or as a separate entity, unawareness of both parties in the procurement process will cause the new system to have faults.

Some engineers of the supplier may have some knowledge about fire and explosion protection, but these normally are not the persons participating in the sales discussions.

It is normal that the contract on which the procurement of the system will be based makes the responsibility for correct engineering the sake of the supplier.

where it goes wrong (24)

The fire and explosion safety is dealt with in the contracts by ever-re-used text and a too long list of standards, most of which are not applicable and not known by both sides.

Knowledge of fire and explosion safety of coal grinding and pulverized fuel storage is very special knowledge.

The analysis of the faults found everywhere in the cement industry worldwide is that the necessary very special knowledge is not present in:

- operators of cement production systems
- engineers designing coal grinding systems
- certifiers of quality and safety management

where it goes wrong (25)

The following slides are showing examples of things going wrong, in design/engineering.

Many more wrongs than those shown here are found, in the industry.

where it goes wrong (2$_{6.1}$)

1) the raw coal yard, covered or not covered

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where it goes wrong ($2_{6.2}$)

1) the raw coal yard, covered or not covered

Workers not correctly equipped and trained for pile formation, monitoring, housekeeping and emergency handling.

That this is true shows only when it is already too late and intensified oxidation in the stockpile(s) has developed. Most stockpiling is not organised with the possible need of emergency actions in mind.

CO between the piles is dangerous and CH_4 can accumulate under the cover above the stockpiles.

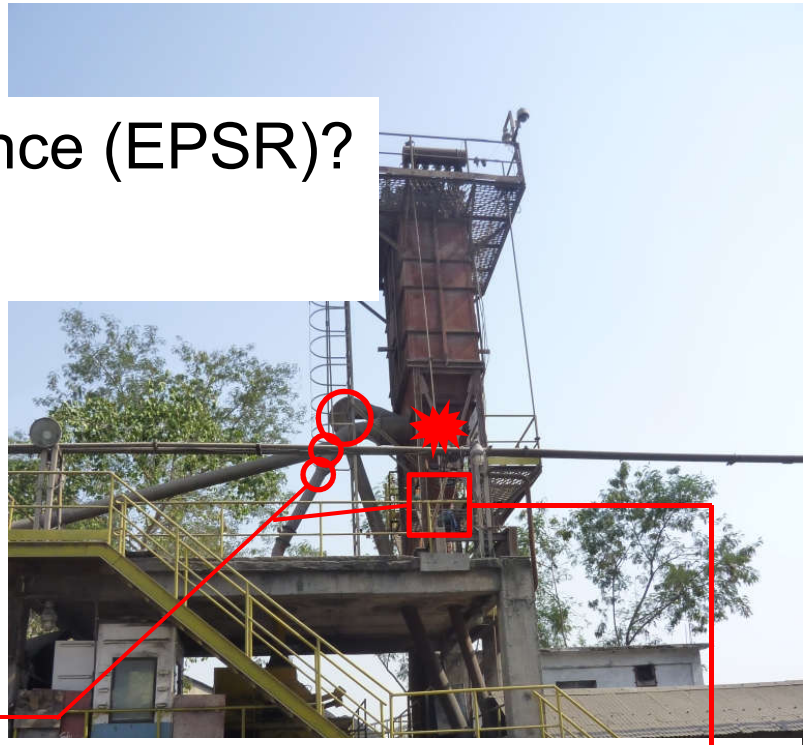
Wind can make it difficult to handle an emergency situation.

where it goes wrong (2$_{7.1}$)

2) transfer from the yard into the raw coal silo(s)

where it goes wrong (2$_{7.2}$)

2) transfer from the yard into the raw coal silo(s)



explosion pressure shock resistance (EPSR)?

questionable

adequate explosion vents?

no

adequate explosion isolation?

absolutely not

Flames and pressure may be felt at the open dust suction spots and on the belt, via the rotary valve.

And, under these conditions, the fan may be damaged.

where it goes wrong (27.3)

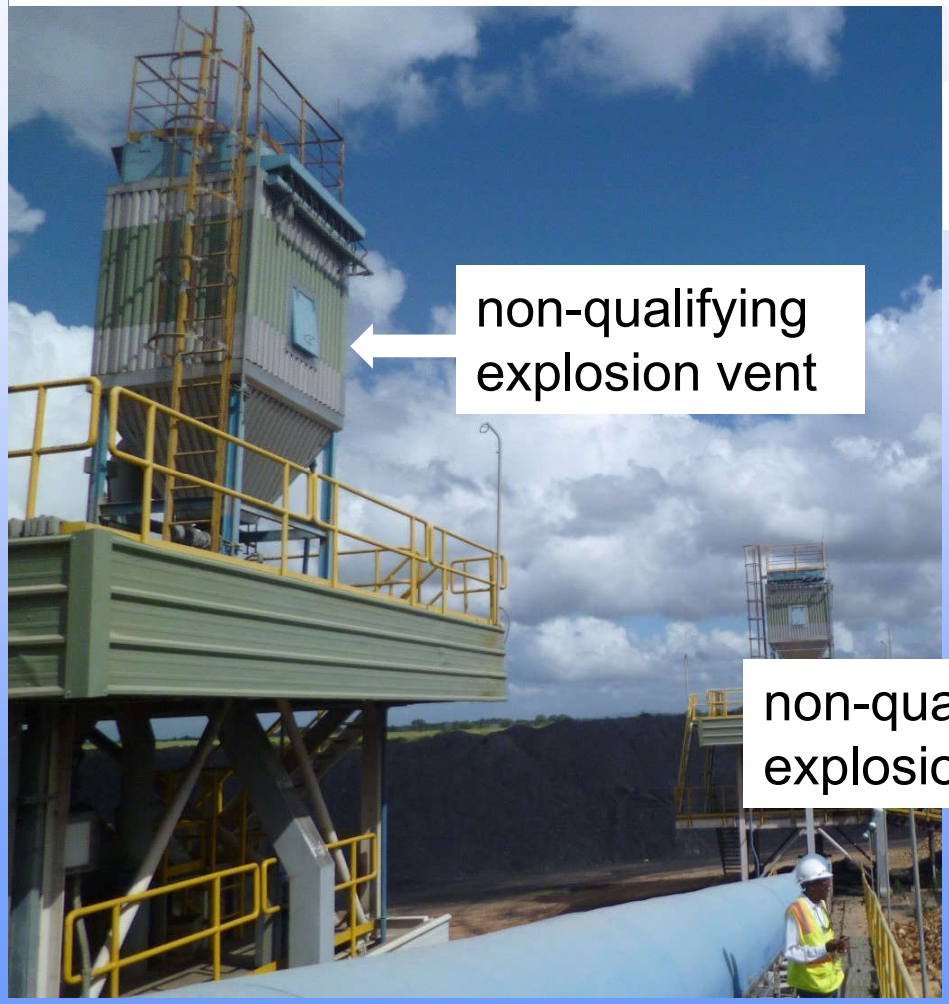
2) transfer from the yard into the raw coal silo(s)

In most cases, an overbelt magnet separation system is installed. This will effectively separate Fe tramp metal.
Often, non-Fe tramp metal is not separated, which is wrong.
And a pre-crusher for coal both needs protection and can be a source of tramp metal.

where it goes wrong (2$_{7.4}$)

2) transfer from the yard into the raw coal silo(s)

belt transition de-dusting filters



non-qualifying explosion vent

no explosion de-coupling in place

non-qualifying explosion isolation

where it goes wrong (2 7.5)

2) transfer from the yard into the raw coal silo(s)

belt transition de-dusting filters

When it is understood that explosion protection is necessary, which is the case here, as is proven by the fact that an explosion vent is installed, the explosion protection has also to include explosion isolation and de-coupling.

What has been installed here doesn't include this and the explosion vent is of an un-tested, non-self-reclosing and inadequate design.

Anyway, the effectiveness of de-dusting of belt transfer points by means of a dust filter that drops the fines on top of the belt load is questionable. But if such filters are installed, their fire and explosion protection has to be correct.

where it goes wrong (2$_{7.6}$)

2) transfer from the yard into the raw coal silo(s)

belt transition de-dusting filters

What is also missing is a smoke detector.
The risk of a fire in such filters is greater than the risk of a dust explosion.

where it goes wrong (2$_{7.7}$)

2) transfer from the yard into the raw coal silo(s)

where it goes wrong (2$_{7.8}$)

2) transfer from the yard into the raw coal silo(s)

Very often, raw coal silos are considered not in need of protection against fires and dust explosions.

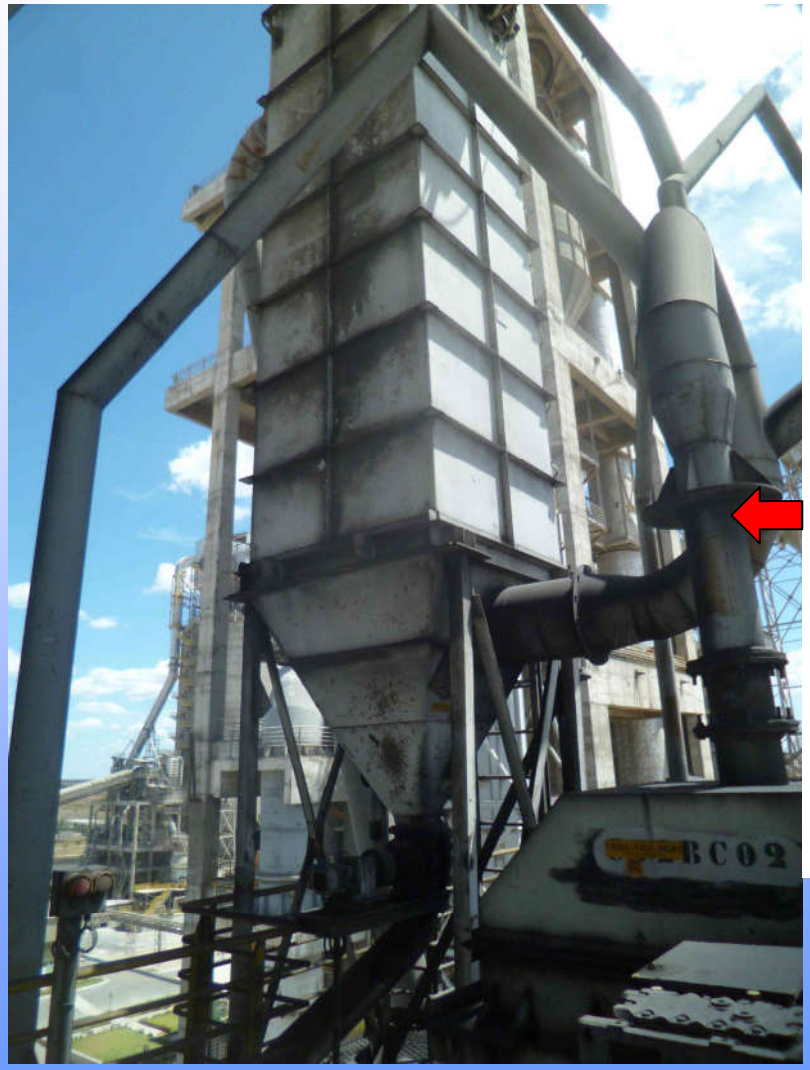
This is correct for types of coal of which one can be sure that no intensifying of the oxidation has to be expected.

As soon as this cannot be assumed, protection is necessary.

More and more raw coal silos are equipped with the relevant instrumentation and connected with the emergency inerting facility.

where it goes wrong ($2_{7.9}$)

2) transfer from the yard into the raw coal silo(s)



In many cases, the filter for de-dusting of the de-aeration of the raw coal silo(s) will be:
1) without explosion protection and smoke sensor, although it handles **coal dust**
2) serve more than one suction spot, so that, via the suction connections, a system of **interconnected pieces of equipment** is created.

where it goes wrong ($2_{7.10}$)

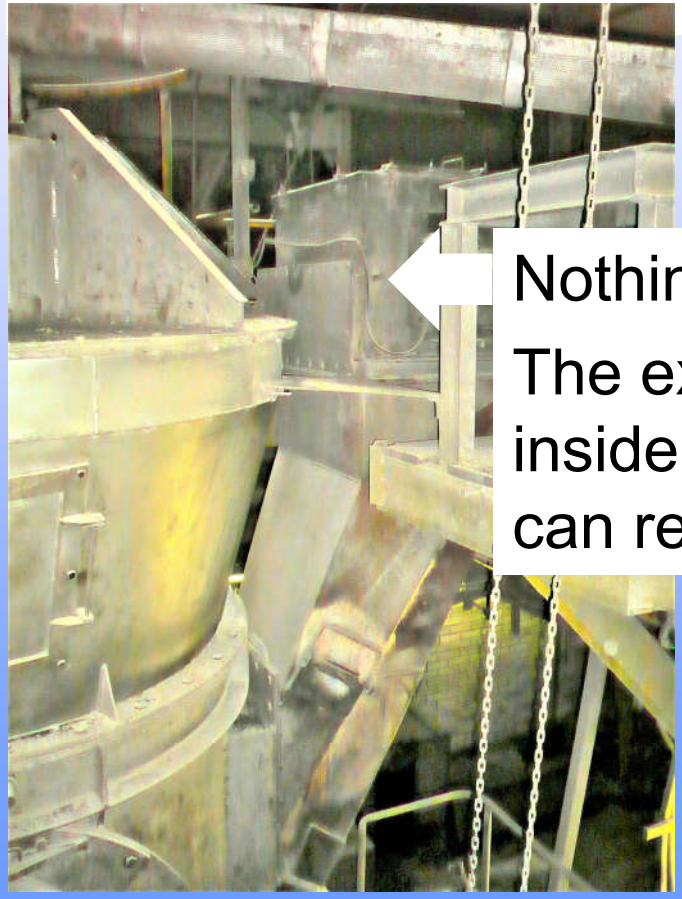
2) transfer from the yard into the raw coal silo(s)

Unprotected equipment interconnections enlarge the risk of damage and danger, in case of an explosion.
When there is more than one raw coal silo and the raw coal silos, with their substantial volume, are interconnected, this is incorrect and may become very dangerous.

where it goes wrong (2$_{8.1}$)

3) the final feeding and air lock device at the inlet of the mill

Qualifying explosion isolation is needed here.



Nothing is in place here!

The explosion pressure inside the VRM (or HBM) can reach up to 2 bar g.

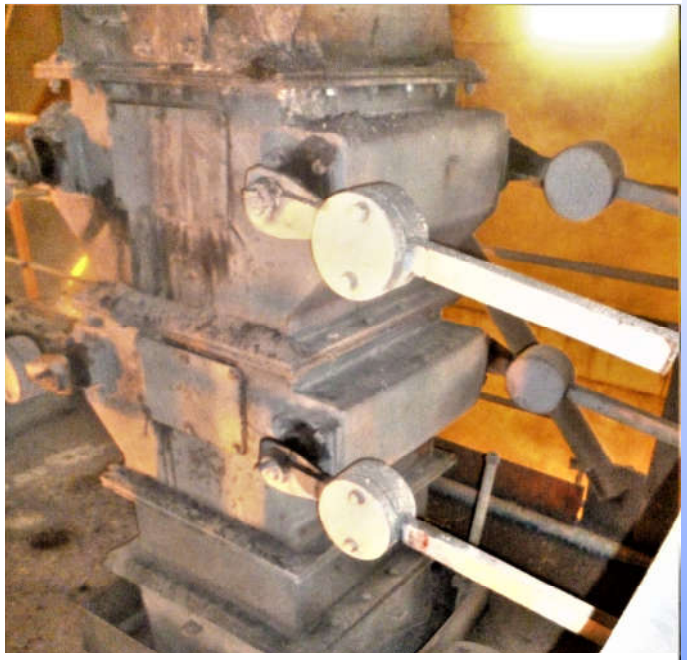
where it goes wrong ($2_{8.2}$)

3) the final feeding and air lock device at the inlet of the mill

Qualifying explosion isolation is needed here.

This airlock does not have the necessary explosion pressure shock resistance and doesn't qualify as explosion isolation, as it should.

The explosion pressure inside the HBM can reach up to 2 bar g.



This is a double flapper airlock at the inlet of a HMB.

where it goes wrong (2 8.3)

3) the final feeding and air lock device at the inlet of the mill

This U-through screw conveyor brings the coarse particles the separator has thrown out back to the HBM inlet.
The screw conveyor has no EPSR and a completely open connection with the HBM inlet. As a result, it may become the source of a coal dust cloud.
The sample taking facility is of a design that cannot be used here.

where it goes wrong ($2_{8.4}$)

3) the final feeding and air lock device at the inlet of the mill

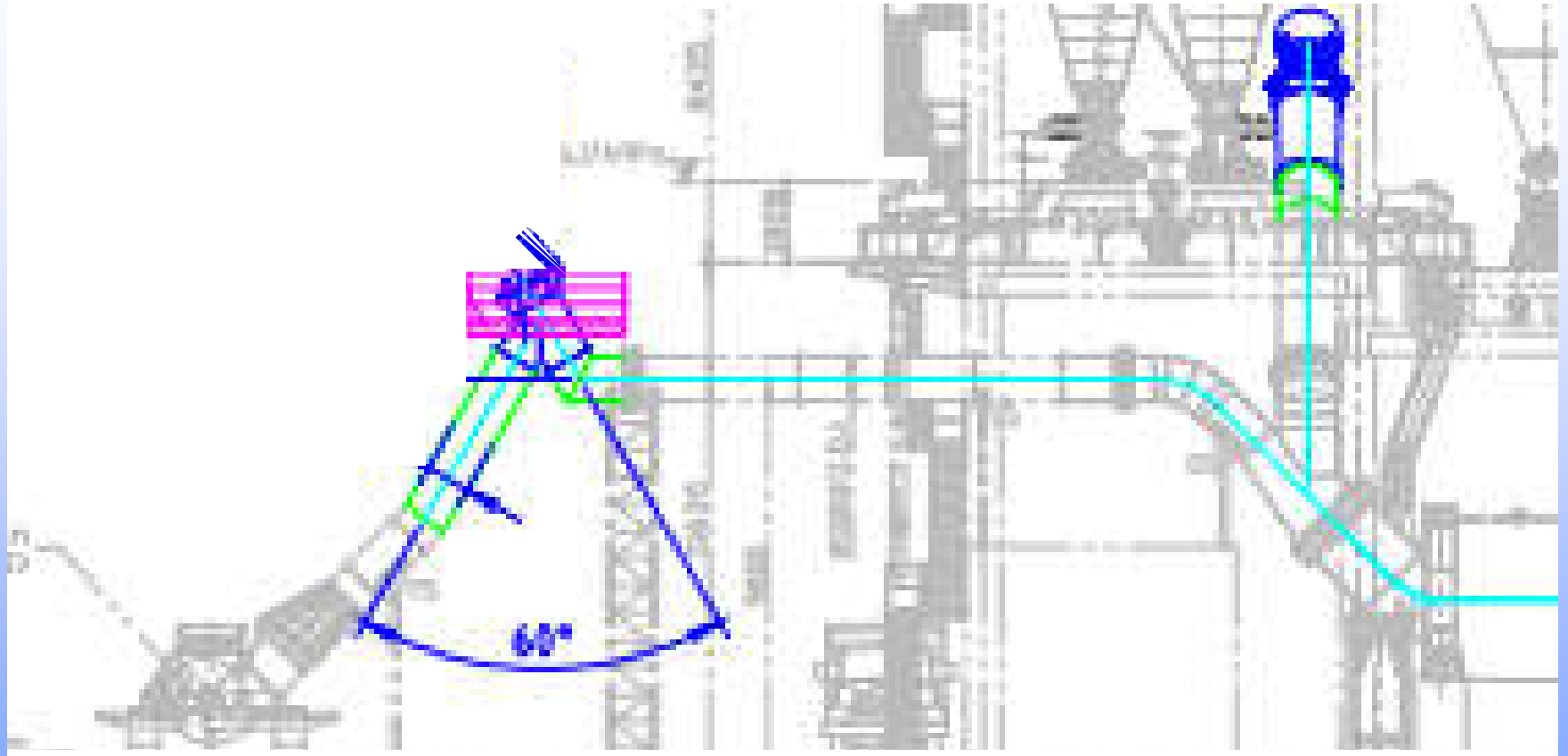
where it goes wrong ($2_{9.1}$)

4) the booster fan

When a booster fan is not designed to withstand some explosion pressure originating from its mill, it may be damaged, when an explosion in the mill occurs.

where it goes wrong ($2_{9.2}$)

4) the booster fan



Protection by means of pressure relief is possible.

where it goes wrong (2_{10})

5.1) the mill, vertical roller mill (VRM) or horizontal ball mill (HBM)

Coal mills have to have explosion pressure shock resistance (EPSR).

The USAmerican code NFPA 85 demands a strength ‘good for’ 50 psi g. That is roughly 3.44 bar g. The reason for demanding strength ‘good for’ 50 psi g was not found in NFPA’s archive, when it was searched for, some years ago.

Serious calculations considering the dissipation of the air expansion into the air-swept mill’s in and outlet have resulted in roughly 2 bar g being the maximum explosion pressure that may occur both in VRMs and HBMs.

where it goes wrong (2$_{11}$)

5.2) VRM rejects ejection

In order to provide for a safe working location for the personnel that takes the rejects away, it is necessary that a lock is in place.

Of 2 closing elements of the discharge channel always 1 has to be securely closed.

Where a conveyor for continuous removal is installed the situation often is unsafe.

where it goes wrong? ($2_{12.1}$)

6) in case of HBMs, the classifier/separator

If the separator is protected correctly, which in most cases it is not, it is protected against:

where it goes wrong? (2 12.2)

6) in case of HBMs, the classifier/separator

If the separator is protected correctly, which in most cases it is not, it is protected against:

- a propagating flame front with accompanying pressure shock resulting from am explosion in the HBM

where it goes wrong? ($2_{12.3}$)

6) in case of HBMs, the classifier/separator

If the separator is protected correctly, which in most cases it is not, it is protected against:

- effects resulting from an explosion ignited in it

where it goes wrong? ($2_{12.4}$)

6) in case of HBMs, the classifier/separator

If the separator is protected correctly, which in most cases it is not, it is protected against:

- a propagating flame front with accompanying pressure shock resulting from am explosion in the bag house

where it goes wrong? ($2_{12.5}$)

6) in case of HBMs, the classifier/separator

Also visible is that the U-through screw conveyor with its flat covers doesn't have EPSR.
An explosion in the separator would blow up the covers and a dust cloud could develop.
Should this equipment-external dust cloud be ignited to burn explosively, the effect could be disastrous.

where it goes wrong? (2$_{12.6}$)

6) in case of HBMs, the classifier/separator

In the photo at the left an airlock for the return (to the HBM inlet) connection is visible. This airlock does not qualify as explosion isolation (as it should) and has no EPSR.

Effective bi-directional explosion isolation between the separator and the inlet of the HBM also has to be in place.

Where goes it wrong? (8_1)

7) the riser duct between the mill, vertical roller mill (VRM) or horizontal ball mill (HBM) and the bag filter

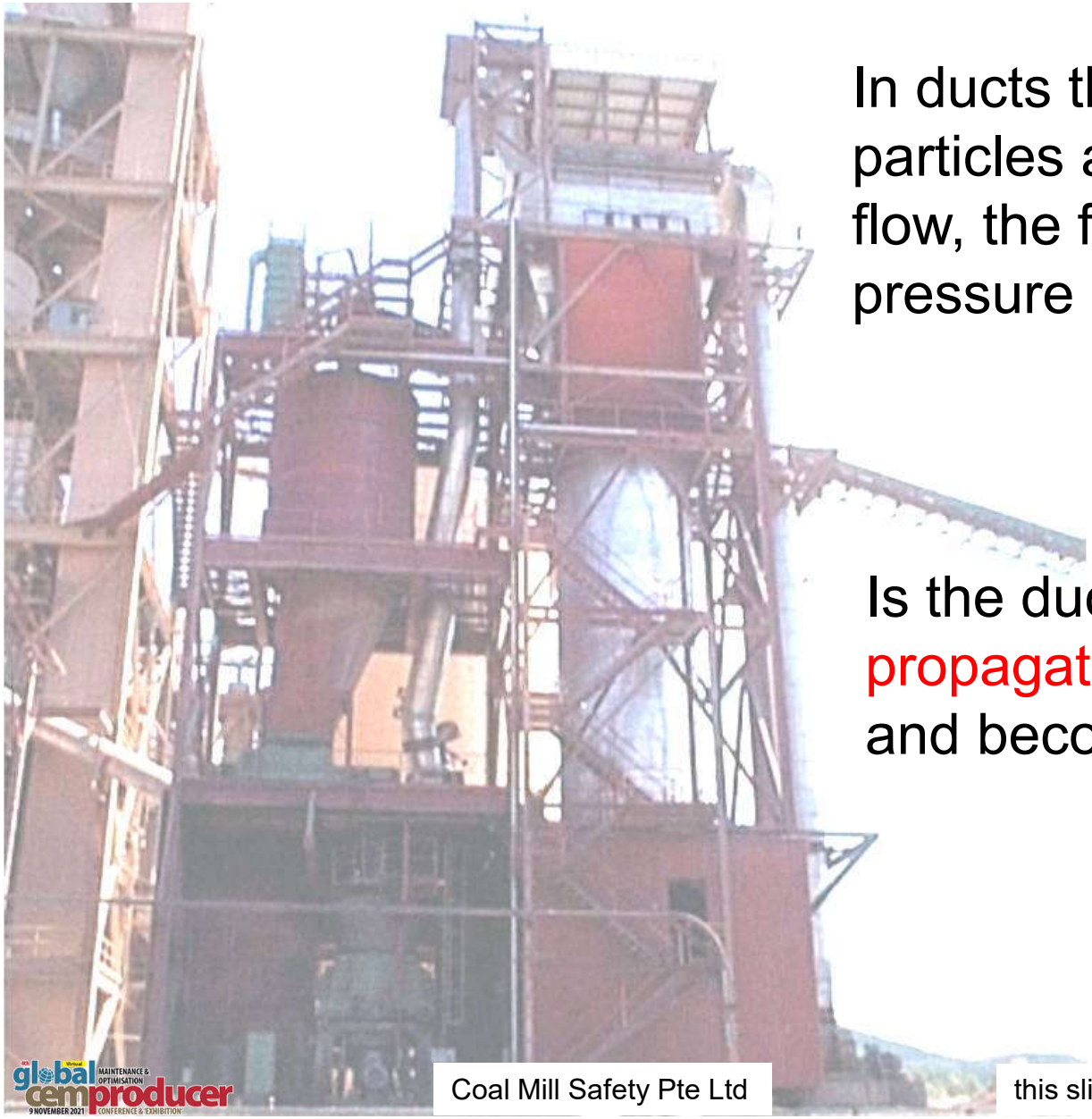
In the following slides the problem and its correct solution in case of a VRM system are shown.

The correct solution shown is also possible in case of a HBM system, but is slightly more complicated then, since those systems' classifier/separator adds an inter-connected enclosure to the system.

Many cases of wrong engineering of these parts can be seen in the industry.

The features 'self-reclosing' and low activation pressure as well as the position and geometry of the explosion vents are very important for the functionality of the mitigation concept. Not many engineers seem to have understood that.

Violence especially can be seen in case of flame front propagation through ducts.



In ducts through which fuel particles are moving in an air flow, the flame and the pressure shock can propagate.

Is the duct very long, the propagation can accelerate and become very fast.

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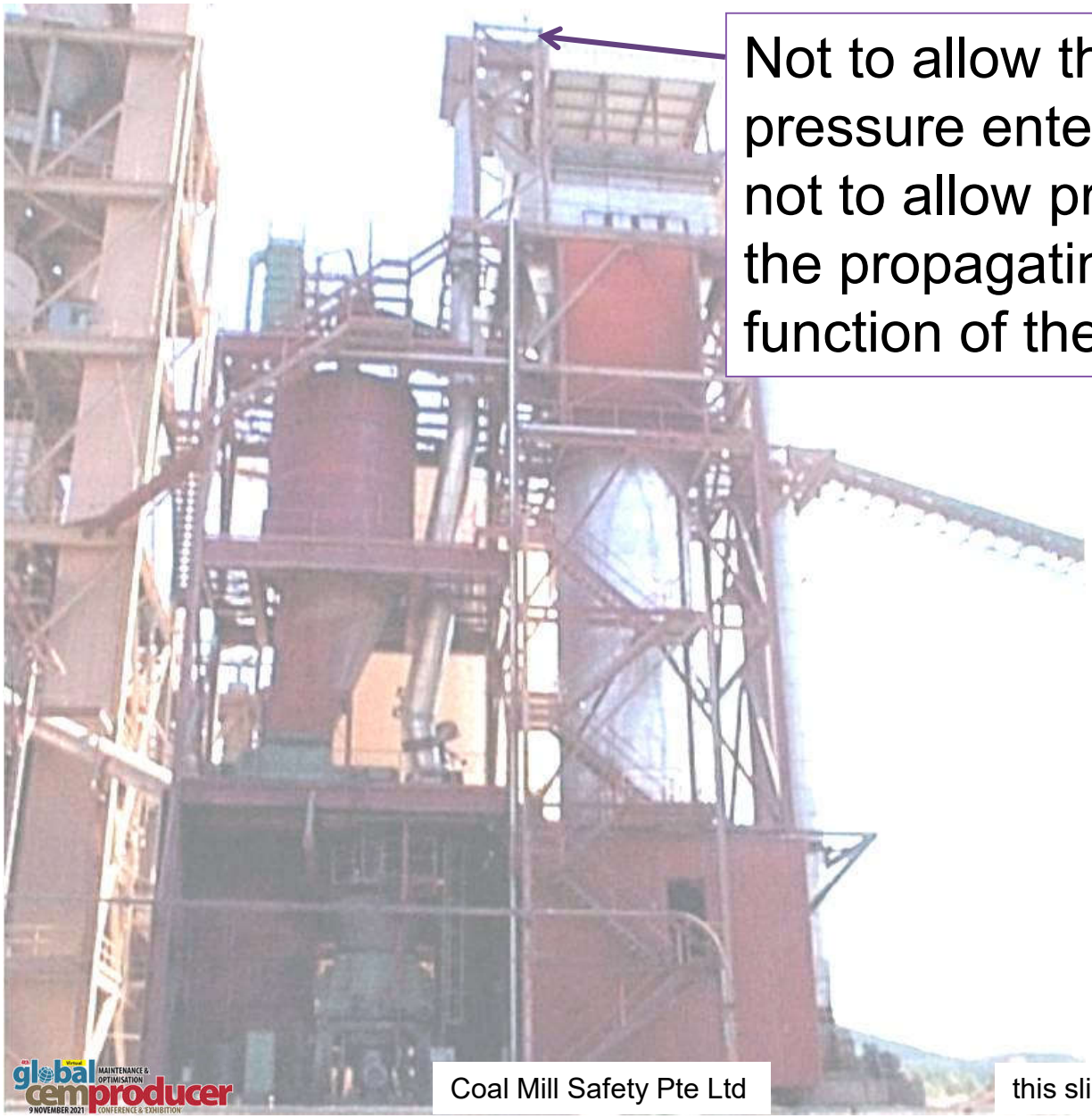
this slide courtesy Thorwesten Vent GmbH

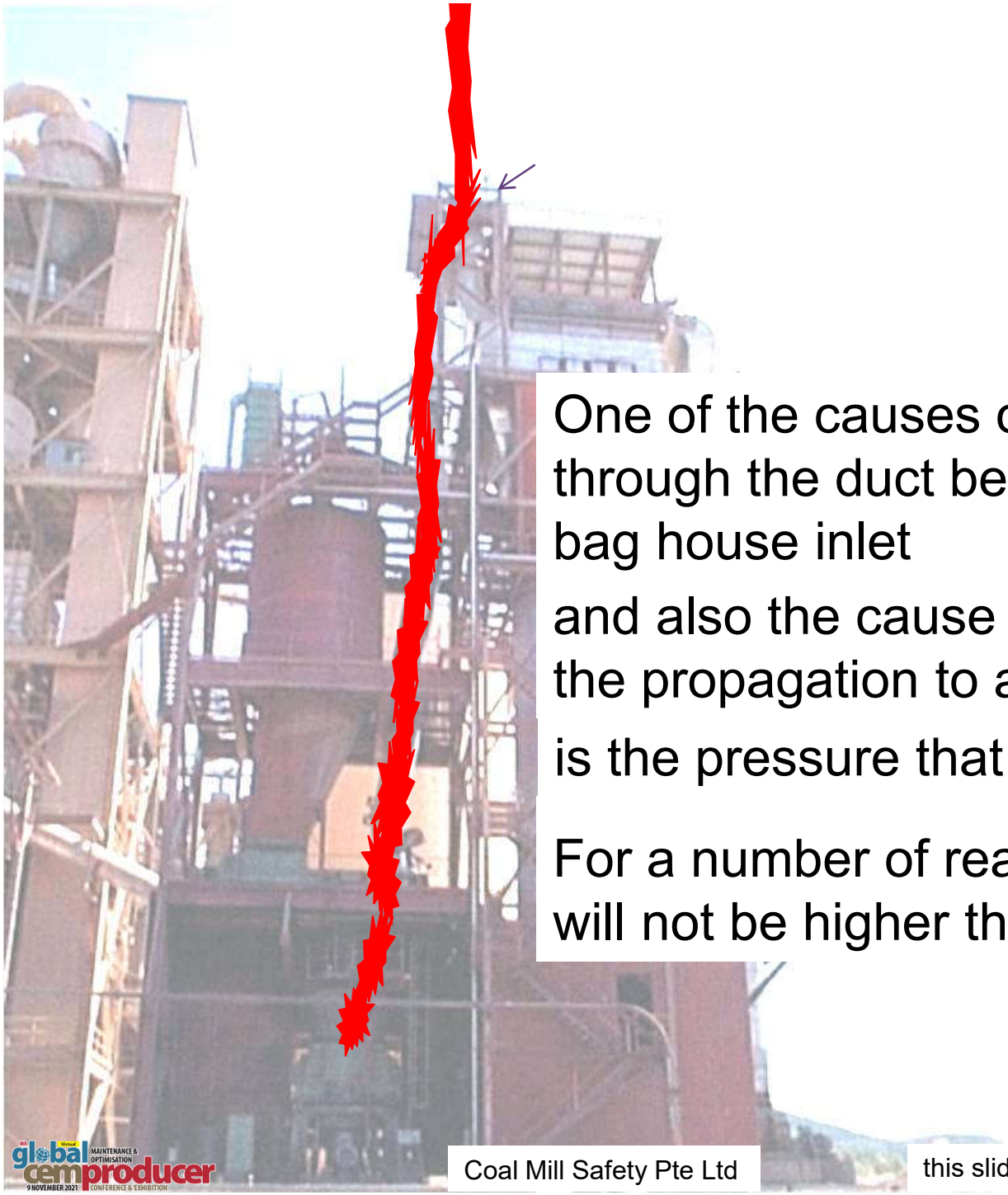
Violence especially can be seen in case of flame front propagation through ducts.



Not to allow the flames and pressure enter the bag house and not to allow pressure piling ahead of the propagating flame body is the function of the explosion diverter.

Coal Mill Safety Pte Ltd

this slide courtesy Thorwesten Vent GmbH



One of the causes of the propagation through the duct between mill outlet and bag house inlet

and also the cause for the tendency of the propagation to accelerate,

is the pressure that is created in the mill.

For a number of reasons this pressure will not be higher than roughly 2 bar g.

this slide courtesy Thorwesten Vent GmbH

In order not to damage the explosion diverter, the propagation speed, which easily could reach 200 m/s (720 km/h), has to be mitigated.

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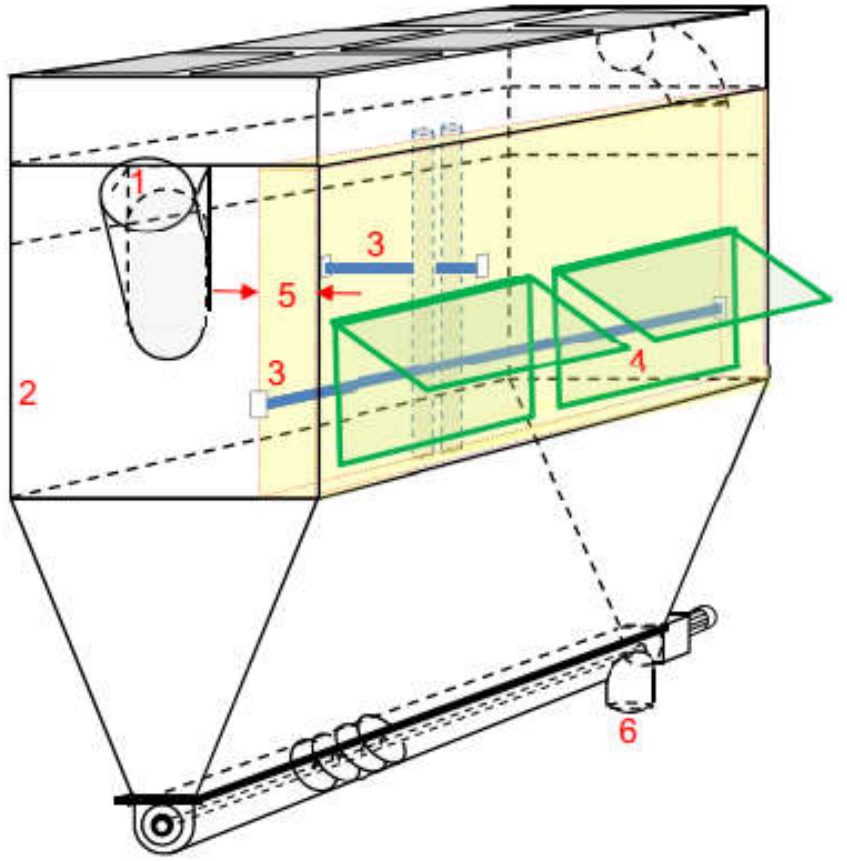
this slide courtesy Thorwesten Vent GmbH

Where goes it wrong? ($2_{13.1}$)

8) the baghouse

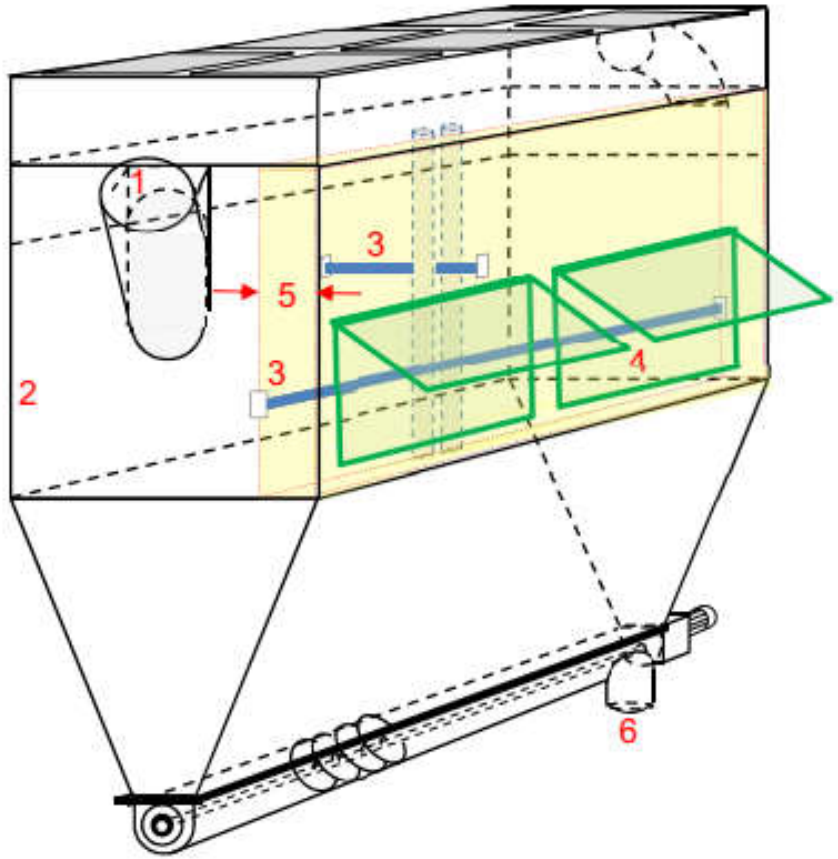
1) position of explosion de-coupling ensuring that the to-be-expected explosion effects from upstream, which could affect the baghouse in ways that make its explosion protection impossible, are inhibited and that explosion effects initiated inside the bag house don't harmfully propagate towards upstream equipment – Normally this is done by installing an explosion diverter. The explosion diverter needs to feature a self-reclosing venting mechanism and to be installed close to the baghouse inlet.



Where goes it wrong? ($2_{13.2}$)

8) the baghouse

2) EPSR for the baghouse corresponding with the installed explosion venting capability – The EPSR needs to include the flange connection with the screw conveyor underneath, the screw conveyor proper, the tube sheet and its fixtures, the penthouse and the penthouse covers with their fixtures and all ductwork that can be affected by explosion pressure initiated inside the baghouse.

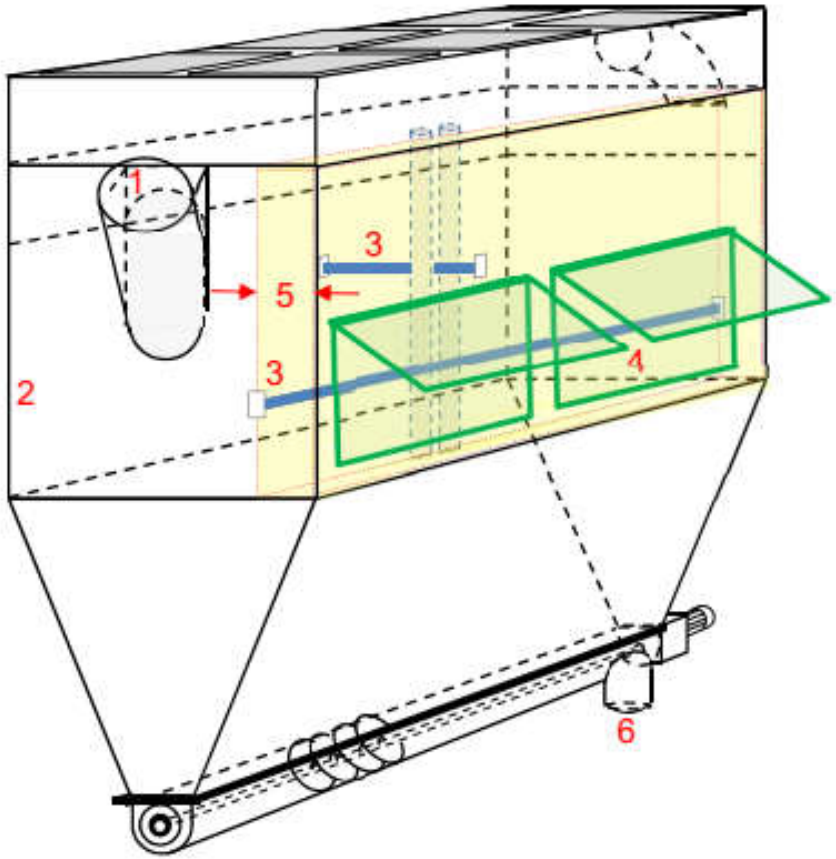


Where goes it wrong? ($2_{13.3}$)

8) the baghouse

3) The baghouse internally shall not have surfaces on which a dust deposit could be formed.

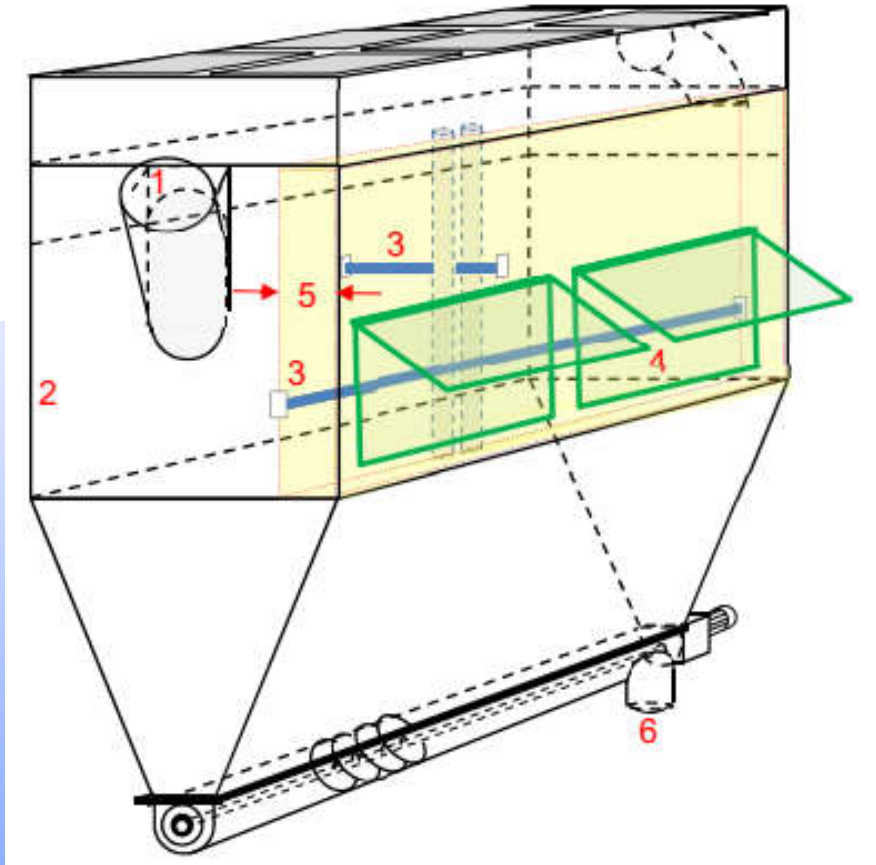
Bracing struts reinforce the bag-house's EPSR and inhibit undesired lateral movement of the bags during operation and when exposed to explosion pressure.



Where goes it wrong? ($2_{13.4}$)

8) the baghouse

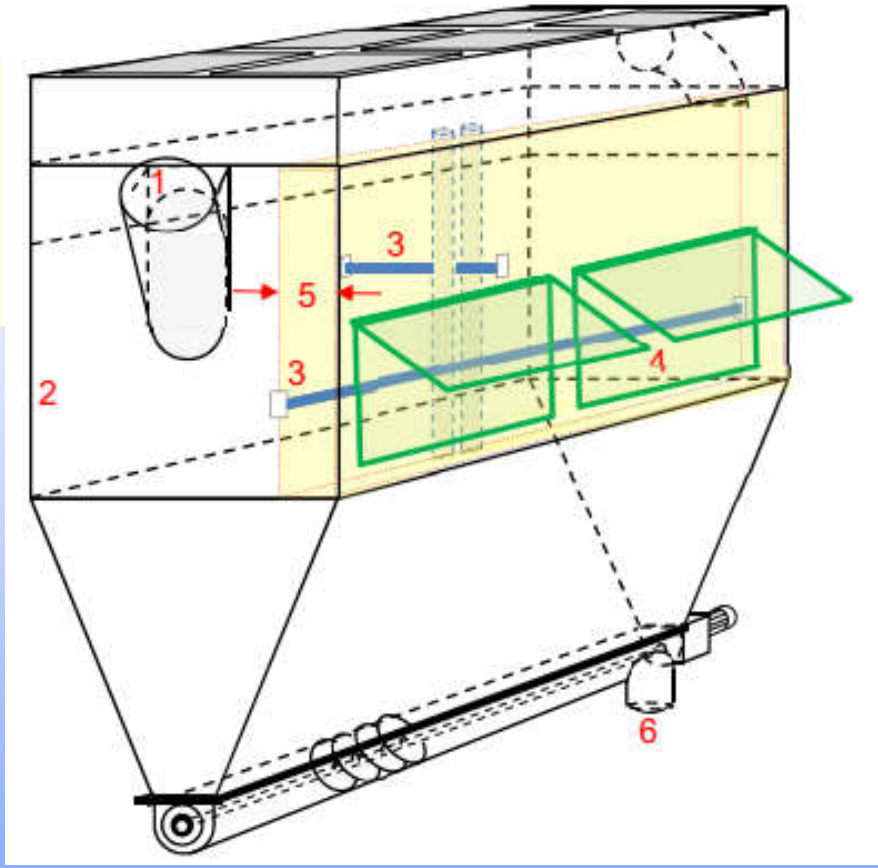
4) self-reclosing explosion vents with a venting capability that corresponds with the baghouse's EPSR



Where goes it wrong? ($2_{13.5}$)

8) the baghouse

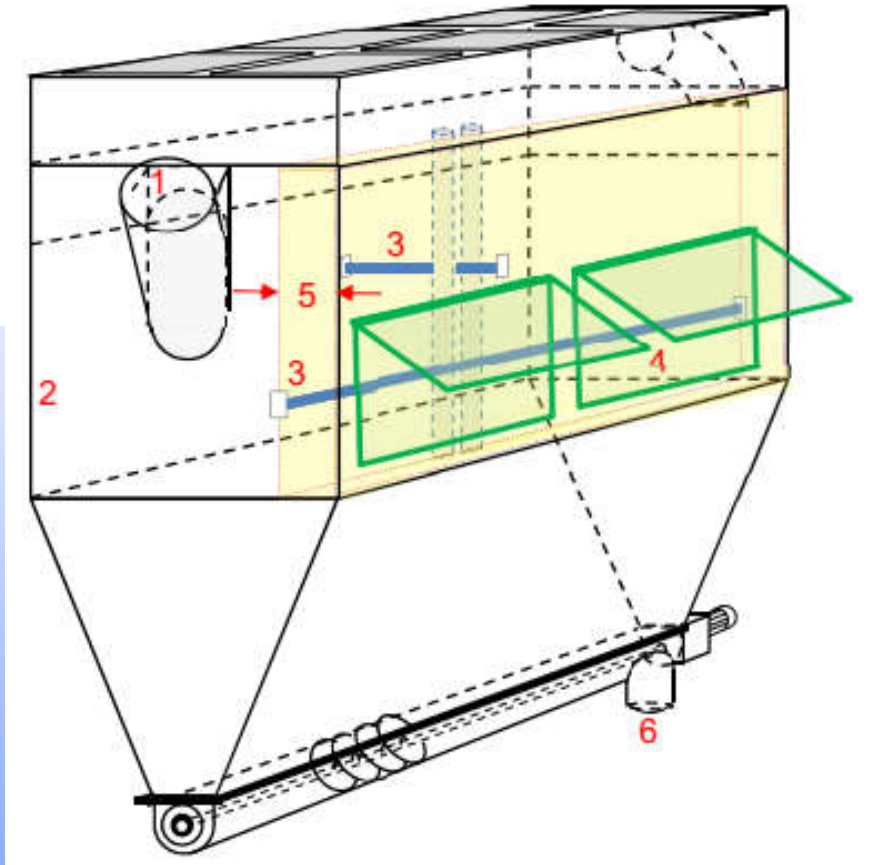
5) clearance between the outermost row of bags and the surface into which the explosion vents have been placed



Where goes it wrong? ($2_{13.6}$)

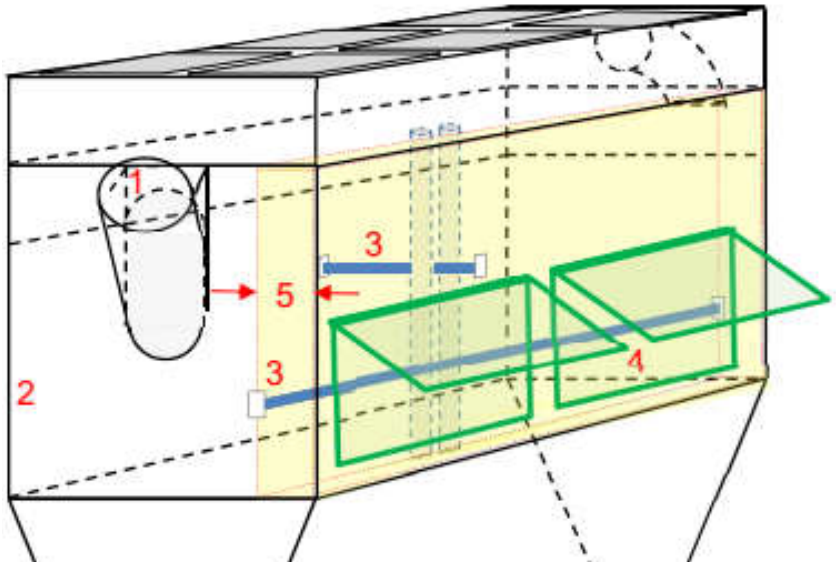
8) the baghouse

6) explosion isolation keeping the baghouse isolated from the downstream process equipment bi-directionally



Where goes it wrong? (2$_{13.7}$)

8) the baghouse



Certain suppliers just build their standard baghouse, which has not been designed as to have the dust explosion protection necessary for fuel grinding applications.
They simply install explosion vents, or things that are supposed to be explosion vents, and cannot answer when asked which EPSR the design has.

Where goes it wrong? (2$_{13.8}$)

8) the baghouse

All kinds of things go wrong, with the design of coal mill system baghouses.
To find a coal mill system baghouse with completely correct protection in the cement industry is rare.
Almost all suppliers do at least something wrong.

Where goes it wrong? ($2_{13.9}$)

8) the baghouse

1 continuous funnel hopper

in 1 row: 3 funnel hoppers

2 continuous funnel hoppers

in 2 rows: 2 x 4 funnel hoppers

Where goes it wrong? (2 13.10)

8) the baghouse

The applicable standards don't offer equations for the calculation of the necessary capability of an explosion venting concept for the more complex geometries of multi-funnel hopper baghouses.

The suppliers of baghouses with multi-funnel hoppers simply ignore this fact.

To configure a correct explosion venting concept would require highly complex computer modelling.
Nobody does that!

Where goes it wrong? (2$_{15.1}$)

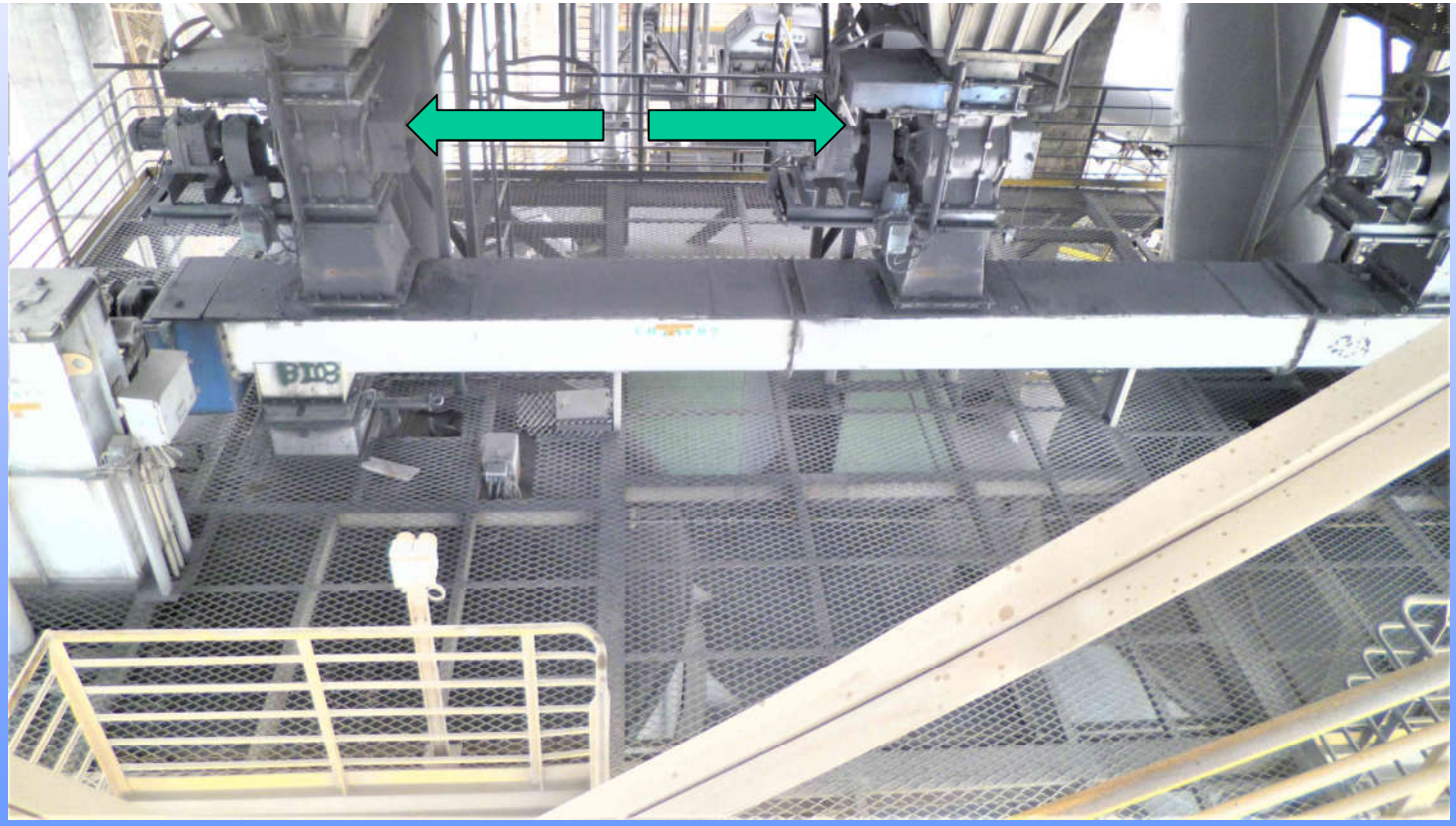
9) PF silo(s)

Where goes it wrong? (2$_{15.2}$)

9) PF silo(s)

Situations like these can be found in many plants:

inadequate explosion isolation between the baghouse funnel hoppers and the screw conveyor(s) to the PF silos



Where goes it wrong? (2 15.3)

9) PF silo(s)

Situations like these can be found in many plants:

open connections between the screw conveyor(s) and the PF silos

Apart from the fact that this could lead to blowing up the screw conveyor, this makes the PF silos interconnected vessels, which is very dangerous.

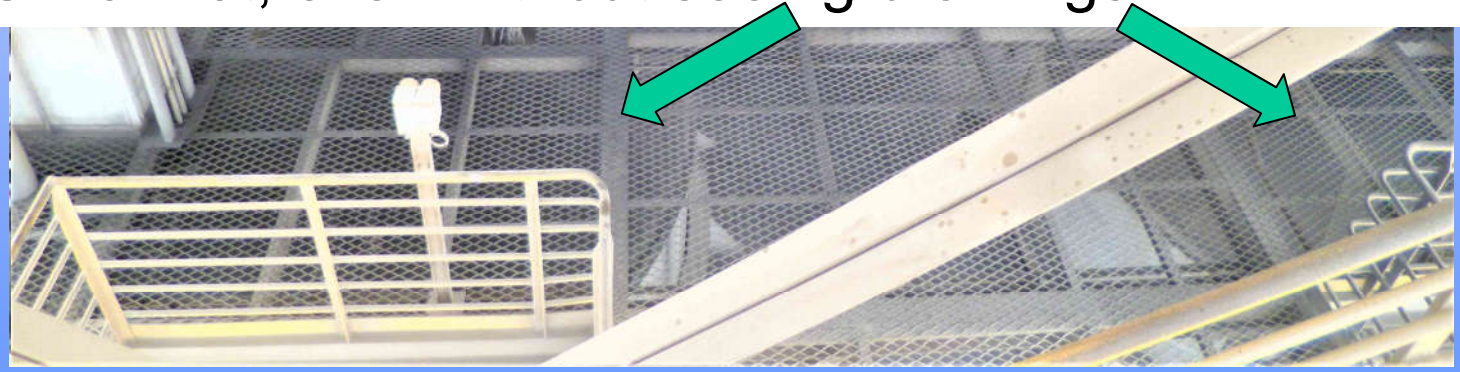
The rules for constructional explosion protection require explosion isolation in the connection.

Where goes it wrong? ($2_{15.4}$)

9) PF silo(s)

Situations like these can be found in many plants:

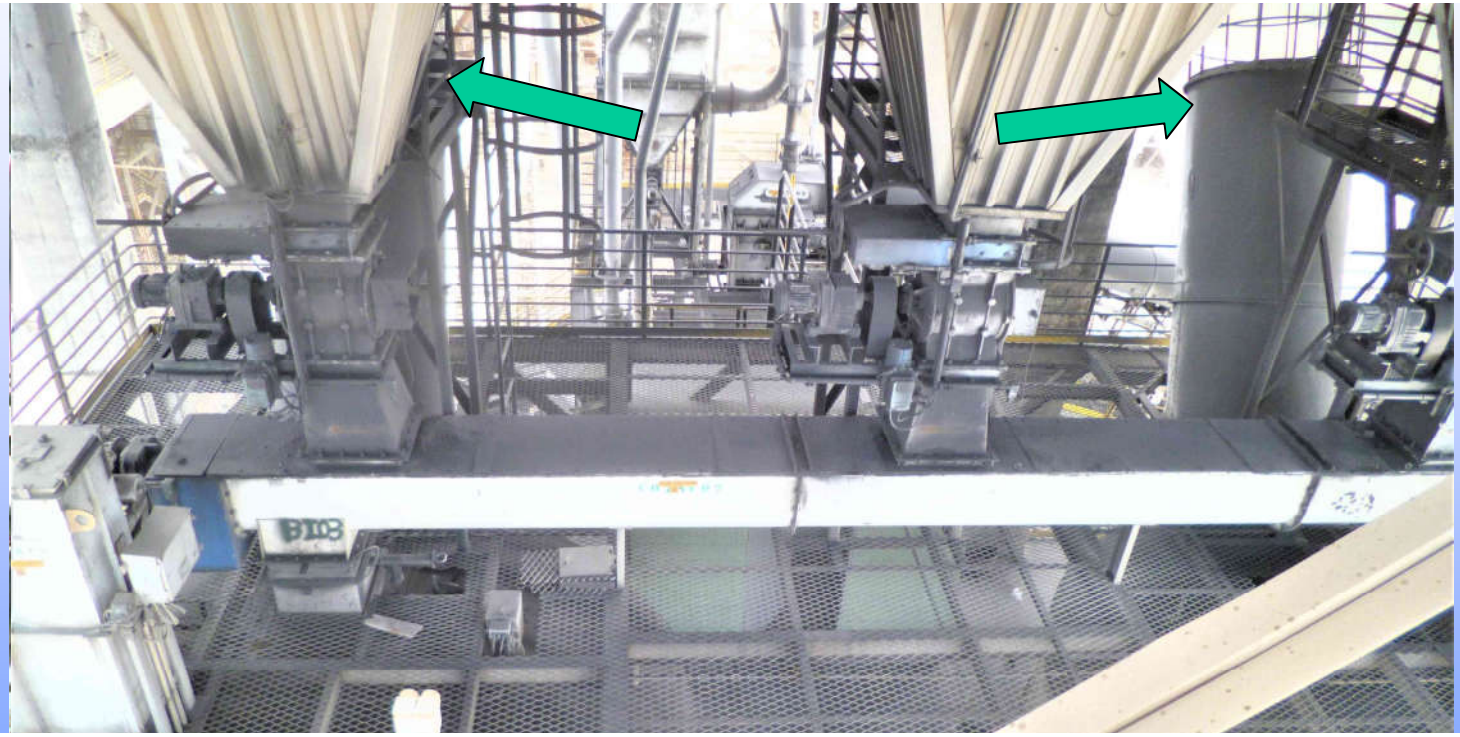
incorrect EPSR of the PF silos
A specialist may become suspicious regarding the EPSR and in some cases distinguish between reinforced for EPSR or not, even without seeing drawings.



Where goes it wrong? ($2_{15.5}$)

9) PF silo(s)

Situations like these can be found in many plants:

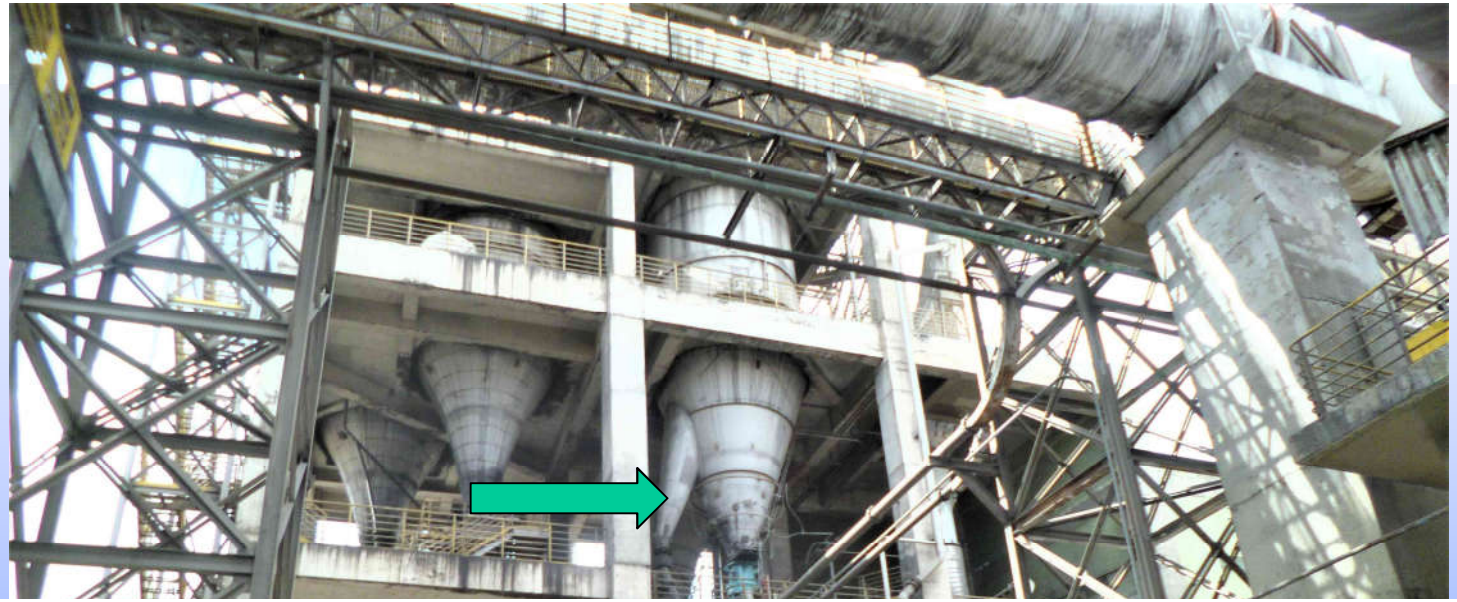


completely wrong explosion vents, positioned completely wrong

more about this in slides $2_{15.8}$ and $2_{15.9}$

Where goes it wrong? (2$_{15.6}$)

9) PF silo(s)



It may be very desirable to have this extraction facility, but the ‘dead’ pocket that is created for this purpose can become a location in which coal starts to smoulder. Its removal then can become dangerous and difficult.
Such designs must not be used, for PF silos.
This is asking for trouble.

Where goes it wrong? ($2_{15.7}$)

9) PF silo(s)

With these explosion vents the following is wrong:

A venting duct has been installed, obviously with the idea to guide the venting blast away from where it could cause harm.

Venting ducts are covered by some standards and rules for their design apply. For a number of reasons they have a very negative impact on the effectiveness of explosion venting.

Another issue here is that the explosion vents are not self-reclosing explosion doors.

After the vent has responded to pressure by opening a fire may develop as the result of ingress of O_2 and emergency inerting becomes ineffective, since the gaseous medium will dissipate into the atmosphere.

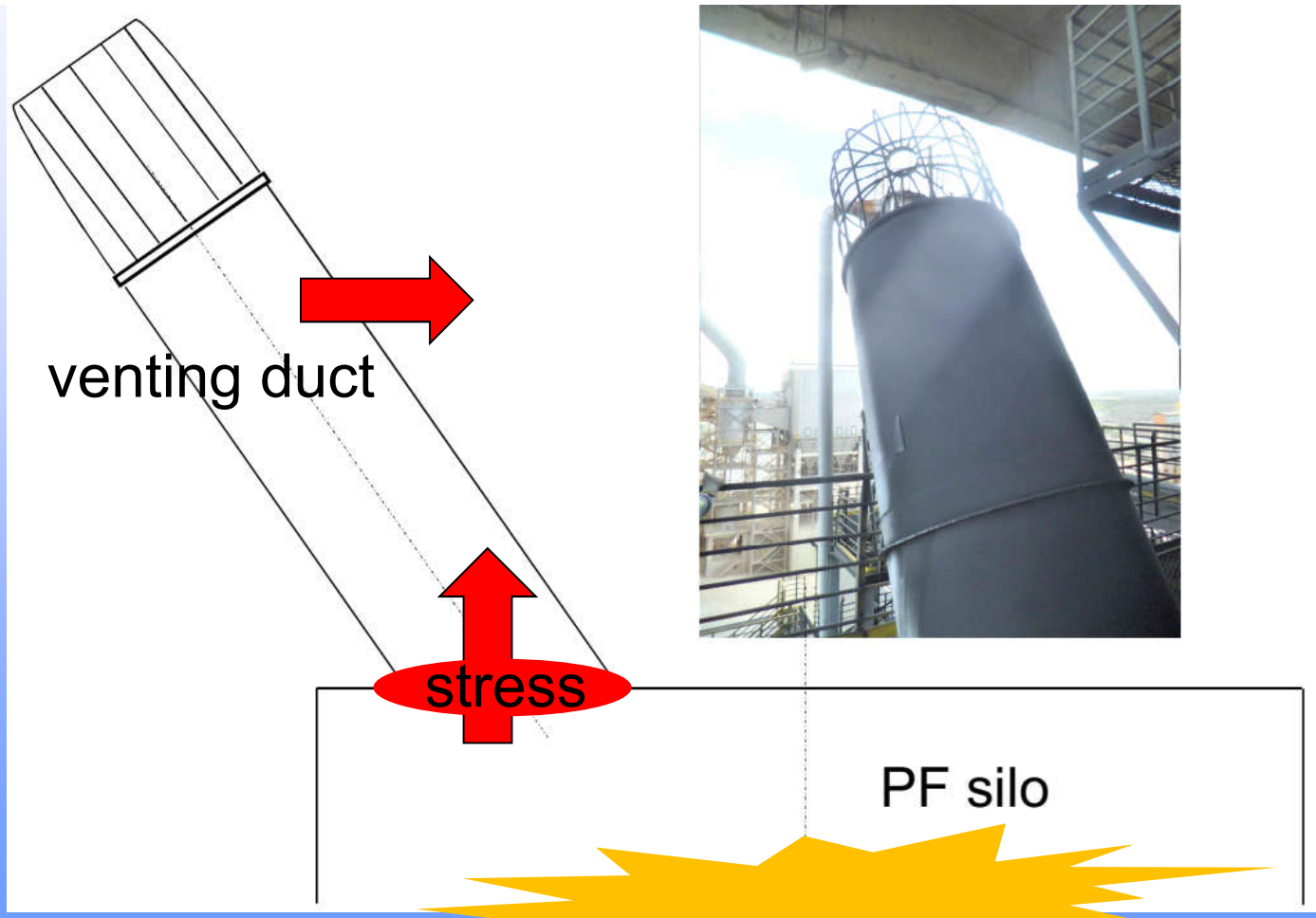
Where goes it wrong? (2 15.8)

9) PF silo(s)

Where goes it wrong? (2 15.9)

9) PF silo(s)

This must be expected to damage the top of the silo.



Where goes it wrong? ($2_{15.10}$)

9) PF silo(s)

There are no good reasons for location of PF silos (and also raw coal silos) inside buildings or semi-enclosed structures.
Such silos in many plants and under all weather conditions are positioned in stand alone positions without problems.

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Hopefully, this message that things are not as they should be is taken seriously.

Only serious evaluations of as-is situations & conditions can help understand how far you are away from being correctly protected.

Once you know that, corrections can be started. You will need assistance.

Hopefully, this message that things are not as they should be is taken seriously.

Thank you for following up on this!

This Powerpoint presentation is available free of charge.

Send an email to info@coalmillsafety.com to ask for it.