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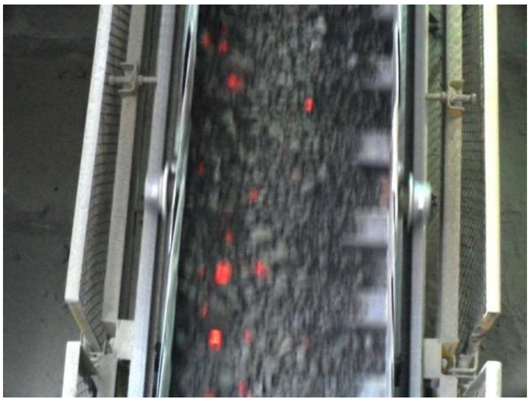
safe operation of coal grinding systems
raw coal silo protection against fire and explosions

Preventive explosion protection makes it difficult for fires and explosions to happen. For this, the safe operation of the system is necessary. For the handling of the raw coal this means:

- No coal undergoing intensified oxidation reaches the conveyor belt to the raw coal silo(s).
- No tramp metal, **Fe & Non-Fe**, reaches the raw coal silo(s).



Depending on the properties of the coal and the condition in which the coal arrives on the raw coal yard as well as on weather and stockpile conditions, the coal's natural continuous oxidation as result of its exposure to the O_2 of the ambient air may intensify.

typical end of belt drop off situation on top of a raw coal silo

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Especially coal with a high volatile matter content is prone to intensifying oxidation in the stockpiling.

Such intensified oxidation has to be discovered early and then be dealt with effectively and fast. See the write up by Coal Mill Safety Pte Ltd *safe operation of coal grinding systems - raw coal yard management*, issued 2021.12.13.

Safe operation of the coal grinding system includes the safe operation of the raw coal yard, which must ensure that coal undergoing intensified oxidation and tramp metal (Fe and non-Fe) will not reach the conveyor belt to the raw coal silo(s).

fig. 1
end of belt drop-off, here with a magnet that will separate Fe, possibly stemming from a damaged pre-crusher, from the belt load

fig. 2
technologically wrong: a bag filter for the de-dusting of the de-aeration of the raw coal silo installed as to also de-dust the air sucked from other equipment, for which explosion de-coupling between the bag filter and the suction spots has to be installed, but here and in most cases is not

Only during the last couple of years in some cases fire and explosion protection for raw coal silos and their de-aeration de-dusting bag filter has been installed in form of instrumentation for temperature and CO monitoring.

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In such cases the raw coal silo(s) is(are) equipped with a gas analyser for CO and O_2 and connected to the emergency inerting system, which then has to have the necessary gas distribution capacity.
The O_2 monitoring enables monitoring of the progress of the emergency inerting, which' aim it is to reduce the O_2 of the atmosphere in the silo.

Intensifying of the oxidation of the raw coal, in spite of all precautions and good raw coal yard management, also can start in the raw coal silo(s).

In most cases, the raw coal silo(s) will not have the explosion pressure shock resistance (EPSR) that would be required for protection by means of explosion venting. Explosion venting will never reduce the explosion pressure to zero.

typical raw coal silo situation without fire and explosion protection and without the explosion pressure shock resistance that would enable retro-installing explosion protection in form of explosion venting

In some cases, it has been understood that the bag filter for the de-dusting of the raw coal silo(s) needs explosion protection, since an ignitable dust-in-air concentration in the 21 % O_2 of the air inside the filter constitutes an explosive atmosphere, a condition that will be present more or less frequently.

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This is where *constructional explosion protection* comes in as an additional safety requirement. When this was understood, explosion vents may have been installed on the filter more or less correctly, but this, as can be seen in many cement plants, still almost always doesn't imply that the filter's constructional fire and explosion protection is complete and correct.

Often, it can be seen easily that the degree of explosion pressure shock resistance that would be required for a correct implementation of the protective technique explosion venting is lacking.

Also, in most cases the explosion isolation between the de-dusting bag filter and the raw coal silo into which it drops the dust it has caught is not adequate. The rotary valve used in most cases doesn't qualify as explosion isolation system, which it should. Its only function then is mitigation of air suction from the raw coal silo through the filter bags, by the filter's fan. Qualifying rotary valves are available on the market.

The necessary explosion de-coupling between the bag filter and the various suction spots from which the filter sucks mostly also is not in place.

typical top-of-raw coal silo situation in which the risk of a dust explosion is deemed not to exist

In practise, the frequency of fire in such bag filters is greater than the frequency of dust explosions in them, so that it makes sense to install fire (smoke) detection with remote signalising.
Fire can be caused by spontaneously intensified oxidation of coal dust particles trapped in the fabric of the filter bags.

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In must be expected that fire in the bag filter in practise will be discovered too late and that adequate means for firefighting will not be available quickly.

Although making the de-aeration de-dusting bag filter, with its risk of a developing fire in it, integral part of the raw coal silo may seem not a good idea, in reality this doesn’t increase the risks. This due to the fact that when the fire in a bag filter that is not integral part of the raw coal silo has developed, it anyway will be too late for the prevention of a transition of burning particles from the filter into the raw coal silo.

The transition of burning material into the silo can normally only be inhibited by stopping the rotary valve between the funnel hopper of the filter and the silo. To automatize this and in order to get it done on time, instrumentation needs to trigger stopping the rotary valve. Leaving this to the system’s operator is not safe.

raw coal silo de-aeration de-dusting cylindrical filter with its suction also being used for the de-dusting of the conveyor belt’s drop off point

The insert is a symbolically indicated pipe-in-pipe explosion diverter for the explosion de-coupling of the filter’s suction connections that is required in this configuration.

The use of cylindrical filters shows that the equipment supplier has understood that an enclosure with an explosive atmosphere (coal dust & air with 21 % O_2) in it has to have explosion pressure shock resistance (EPSR).
Cylindrical filters intrinsically are stronger in terms of EPSR than rectangular filters and the installed explosion venting capability therefore may correspond correctly easier. Still, the better EPSR doesn’t mean that the fire and explosion protection of such a filter is correct.

The photo at the left shows a situation in which the de-aeration (suction) connection of the filter with the raw coal silo is also used for the de-dusting of the conveyor belt’s drop off point.

The necessary explosion de-coupling is not in place. Should an explosion in the filter occur, even with its effects mitigated by explosion venting, flames and pressure could affect both the raw coal silo and the location where the filter sucks the dust from the conveyor belt.
With the explosion diverter as per the insert in the illustration at the left, correct explosion de-coupling would be in place.

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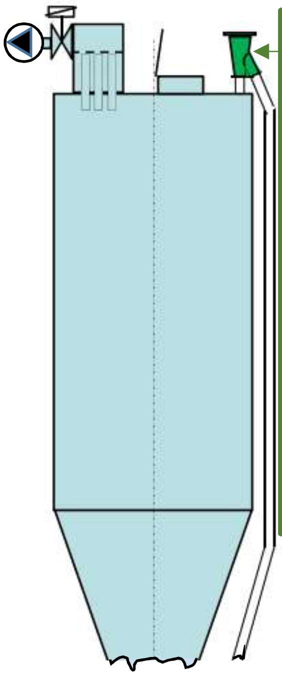
There is a rotary valve between the discharge of the filter and the raw coal silo. But, this rotary valve will in almost every case not qualify as explosion isolation system, which it has to.
In case of a fire in the filter, the rotary valve has to effectively inhibit the transition of explosion effects from the filter into the raw coal silo into which the filter's discharge is dropped and therefore has to stop automatically, for which fire detection is necessary.

It is normal for de-aeration de-dusting filters of raw coal silos not to be connected with CO detection. Smoke detectors that would trigger a remote alarm are also not installed.

It is also normal that the filter's fan is not protected against the effects an explosion in the filter may cause. The fan therefore may disintegrate.



Explosion de-coupling in form of an explosion diverter (pipe-in-pipe type)

The de-coupling by means of an explosion diverter makes it possible to connect de-dusting suction lines with a silo with an integrated filter, so that the silo's filter can also be used for the de-dusting of locations and vessels that are not part of the silo.

The integrated de-aeration de-dusting filter of a raw coal silo can be used to simultaneously de-dust (suck from) other equipment.
Then, however, in these suction connections explosion de-coupling has to be installed.

This de-coupling works in both possible flame propagation directions.

As mentioned before, the argument that silo-external filters are safer than silo top-integrated filters is not a good argument. A silo top-integrated filter can be monitored as part of the raw coal silo, for which of course the necessary instrumentation has to be installed. Should emergency-inerting of the raw coal silo be in place, the silo top-integrated filter would be included in the emergency inerting measure.

Explosion de-coupling, different from explosion isolation, doesn't completely inhibit the transition of explosion effects from one enclosure into another. However, it mitigates the effects of possible flame propagating through the suction pipe by releasing explosion pressure, diverting the propagating flame front into the atmosphere.

But, the transition of flames into the connected enclosure (the raw coal silo in this case) isn't inhibited completely.

The transition of flames into the raw coal silo that still has to be expected, compared to a situation without de-coupling, will be considerably less dangerous. This due to the concentration of dust-in-air in the relatively large empty top space of the silo the flames will enter. The pressure behind the flames that enter the top space also isn't supportive for the start of a dust explosion.

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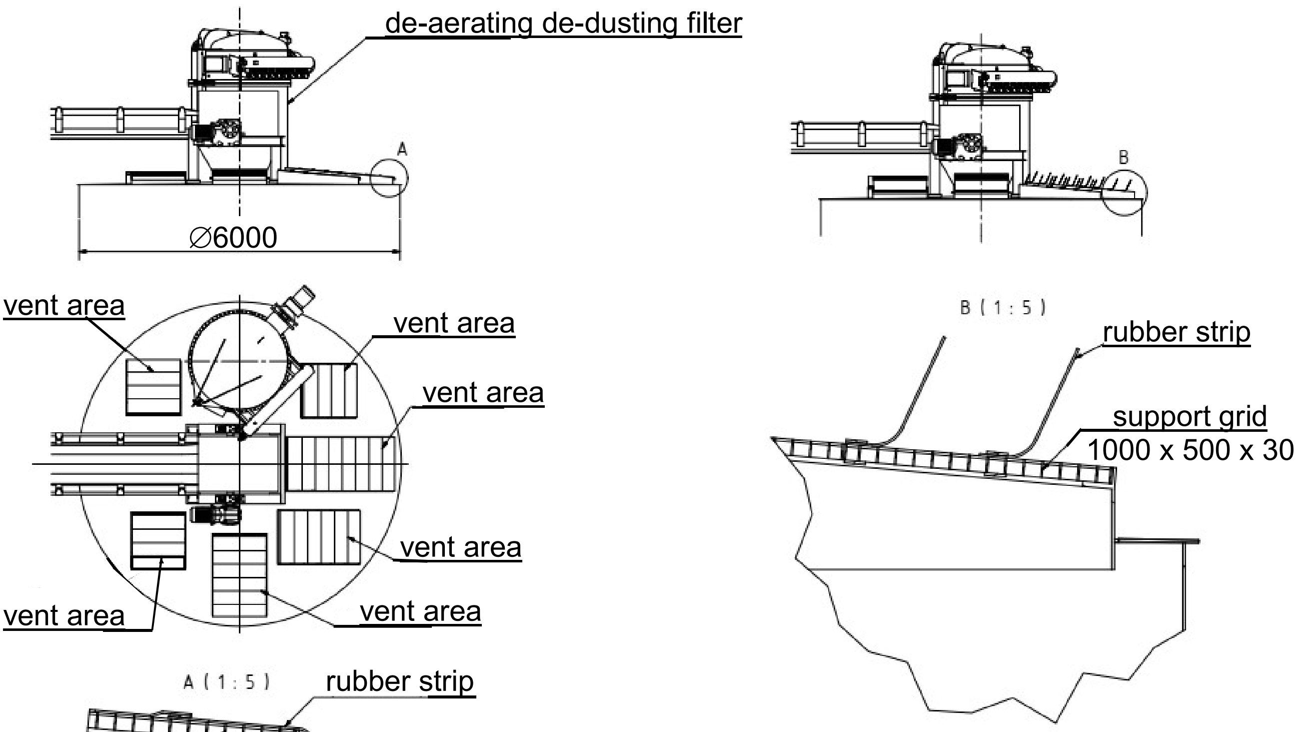
What is absolutely wrong is to use 1 de-dusting filter for more than 1 raw coal silo. Such configurations cause the need to install explosion isolation in all relevant connections.

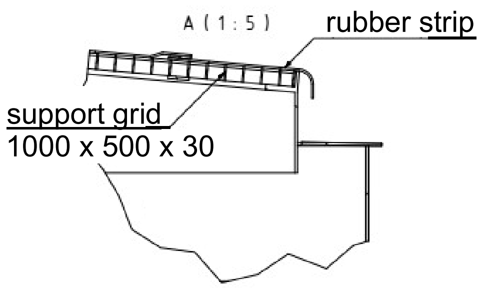
Such connections also would make it impossible to use gas analysers and emergency inerting effectively.

The reading and interpretation of CO measuring may have to be learned. Like with PF silos, meaningful alarm triggering values of the CO detection can be defined based on experience.

The same applies to monitoring of the air temperature above the column of raw coal in a silo.



rubber strips during explosion venting



normal rubber strip position

example of a low cost explosion venting concept for silos with a low explosion pressure shock resistance

The rubber strips could be cut from an old conveyor belt.

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The illustration on the previous page shows a low cost, retro-installation of explosion venting for a raw coal silo with little EPSR.
A raw coal silo with a low EPSR requires a high capacity explosion venting configuration, which can be provided at low costs as shown.

The belt conveyor drop off point will also contribute to the explosion venting.

conclusion

For many years it used to be normal to consider raw coal silos as not in need of explosion protection.

As result, the only protection possibly found is explosion venting for the de-aeration de-dusting filter of the silo.

The connection between the filter's funnel hopper and the raw coal silo is equipped with a rotary valve, which is necessary for the correct functioning of the filter. This rotary valve almost never qualifies as explosion isolation system, which it should.

The filters almost always are connected with multiple de-dusting spots and the connections don't include the necessary explosion de-coupling, which they should.

De-dusting filters for flammable dusts by definition need protection by *constructional explosion protection*. The usual correct *constructional explosion protection* for de-dusting filters comprises the elements:
- EPSR with corresponding explosion venting capacity
- explosion isolation between funnel hopper and raw coal silo
- explosion de-coupling between filter and suction spots

Only more recently, due to the properties of certain coals and petcokes, it has become more usual to include the raw coal silo(s) of the coal grinding systems of the cement industry in the preventive explosion protection of such systems.

This means that CO and temperature in raw coal silos are monitored and that the silo(s) is(are) connected with the emergency inerting system.

Certainly, situations in which the type(s) of coal used don't require this exist.

But, in a number of cases, it has been very necessary and as a result the number of raw coal silos which are equipped with CO monitoring and connected to emergency inerting systems is increasing.