Explosion Protection

For the Cement Industry

White Paper
The Cement Industry Problem

An explosion is a deflagration or fire ball in a confined atmosphere, with parts of the confinement disintegrating and been blown apart. In most cases there is substantial damage to equipment, building, and operating facilities. These incidents can lead to severe personnel injuries and sometimes fatalities.

What kind of Fuel Grinding systems exist?

Raw Coal from a bunker or open space is fed in a coarse form, to the raw coal silo above a Mill. The coal is then fed to the mill for crushing. The mill crushes the coal to a fine dust and the fines are sucked via a large duct up to the filter which separates the air from the dust. The dust is normally conveyed to a silo from which it is fed to a kiln burner or pre-calciner burner.

In many fuel grinding systems, the connection between the mill inlet and the feeding system is not adequately protected against pressure and flames which could result from a deflagration in the mill.
Before the Mill

If there is not adequate explosion isolation, the raw fuel feeding system may be damaged. Many feeding systems have weak covers which may turn into missiles when exposed to this internal pressure.

The danger is not just in disintegrations of the raw fuel feeding systems but the distribution of the fines in the local building. This may cause a secondary, unconfined dust explosion in the building which is very dangerous, propagating from one section of a building to adjoining sections, e.g. via stairwells and corridors. Most industrial explosion-related losses of life happen as result of this chain of events.

The section between the raw fuel feeder and the mill inlet could theoretically be designed with inherent explosion isolation, such as product plug. In practice however, a safe concept would be difficult to accomplish without explosion isolation equipment. Correct explosion prevention/protection systems are not often found in the cement industry. This applies to both designs which attempt to work on the basis of inherent explosion isolation and designs which aim at safety by installing explosion isolation equipment.
Example of an indirect firing fuel grinding system layout typical for the cement plant industry
The Milling System

Most explosions in coal mill plants have their initial ignition location within the mill chamber. This is because the mill chamber is the section of the plant in which the conditions for the ignition of air & dispersed fuel are most favourable. Here the risk exists that tramp metal can get trapped in the grinding media. Grinding causes impact and friction.

Many fuel mills in the cement industry have a pressure shock resistance PSR that fulfils the 3.5 barg (50 psi g) NFPA 85 requirement. Some have a lower PSR, some a higher. Indeed there is pressure mitigating factors that in many cases justify a PSR below the Pmax value of the fuel: Volumes available for air expansion in form of ducts, air inlet and air-pulverized fuel outlet, a poorly distributed fuel cloud in the mill chamber and surfaces, with their capability to quench flames.

The problem with the indirect or storage fired process is that if a mill-induced explosion starts to propagate, it will encounter the next separator (or cyclone, or dust collector) on its course. This will result in ignition of
the dust clouds in these enclosures, under adverse conditions to which we will refer later. Usually, the grinding process in the cement industry (and in the steel and other industries) is combined with coal drying, which means that hot exhaust air, low in O₂ content from the kiln process and/or its preheating stage, along with air from other sources, enter the mill in order to contribute to the drying process with its thermal energy and to dilute the O₂ content of the mix of process air, flowing through the system.

In theory, by keeping the O₂ level low (normally below 12%), the possibility of an explosion can be excluded. Theoretically, it is not a problem to control the O₂ content of an air flow. In practical operation of a cement coal mill system, O₂ control is prone to difficulties varying from human error to mechanical failures of different kinds.

Since almost all coal mill systems are operated under negative pressure, to prevent dust emissions, among other reasons, the fan at the clean air outlet of the dust collector may suck atmospheric air into the system, perhaps unnoticed, via leakage in the duct joints, from the mill chamber up to the dust collector / bag house.

No matter how sophisticated and reliable O₂ concentration monitoring equipment can be, and often is when installed, it remains difficult to prevent O₂ concentration from building up.

The ground coal particles are suspended in the process air flowing through the mill and are conveyed upwards by the flow. At roughly 550 g/m³, air-suspended fuel particles typically are present in a middle-of-the explosive-concentration-range continuously.

Normally, the storage location is a silo, which needs to be at some height above the ground. The pulverized coal’s flow behaviour requires a 70° discharge funnel. This funnel substantially increases the height of the storage silo, which will additionally have a burner feeding system beneath it, with a height of several meters, adding to the silo system’s overall height by several meters.

The combined height of the pulverised coal feeder, storage silo (with cone) and air/coal separation system; all of which form part of the grinding system in a modern, large cement plant, can be well in excess of 50 m.

The ignition side of the triangle cannot be fully controlled. Smouldering nests in the mill can be reliably detected by means of CO monitoring. To a great extent, tramp metal can be separated before it enters the mill. The hot air intake can be sufficiently hot to serve as an ignition source and the grinding process works on the basis of impact and friction. The difficulty of avoiding too high a concentration of O₂ as well as the permanent ignition sources in the mill chamber, demand the implementation of at least one additional protection technique as a last resort.

Since, in practice, the prevention technique Oxidant Concentration Reduction can only be realized with extreme difficulty on a 24 h/day failsafe basis, a suitable solution has had to be found. For years, the engineering industry has been using explosion venting as the ideal, additional, last resort means of protection. Explosion vents, which respond to the system’s excess of internal pressure, are passive devices i.e. they need no external source of energy and no triggering by monitoring and control systems. However, although their basic technology is simple, their application and design is not.
In cement industry coal mills and their heavy duty environment, explosion vents have to be of rigid construction and be tightly sealed in order to prevent ingress of atmospheric air into the vacuum system. Their seals must be capable of functioning permanently under elastomeric-unfriendly temperature conditions. Explosion vents must be resistant against a fluctuating vacuum, as well as against corrosion and wear. Despite this, their venting element must have little mass.

Their original activation pressure value plays an important role in the venting process and must be kept constant over long periods, despite temperature fluctuations and dust deposits. Last, but not least, explosion vents must work dependably in the case of an explosion, without any disintegrating parts which might become dangerous missiles.

The guidelines concerning explosion venting deal with these matters, although unfortunately, as far as coal mill plants are concerned, they do not go beyond general statements. Certainly, it is extremely difficult and costly to carry out explosion tests in large plants. It is very difficult to run explosion tests under controlled, reproducible conditions in a small test facility, and in a large plant, under simulated production conditions, it is even more difficult. Although suppliers of venting equipment still carry out relevant field test work and computer modelling, the cost can be enormous.

In guidance’s such as the NFPA and EN 14491 it points out quite clearly that: When considering the propagation of a flame front and the rise in pressure during a dust explosion, one has to differentiate between a standard cubic explosion at relatively slow speeds and flame propagation in elongated enclosures or pipes. The maximum explosion overpressure may reach up to ten times the initial starting pressure of the process. Obstructions may increase the intensity of the explosion.
In coal mill systems, as used in the cement industry, the riser duct length can be considerable. It is not so much the question of whether high speed propagation will occur. Any accelerated flame propagation would constitute a real hazard and an engineering challenge. Coal mill systems always comprise interconnected “vessels”; the mill, separator and dust collector.

Vent areas determined by standard Equations may not be adequate, if the dust explosion propagates from one vessel into another through a pipeline. Increased turbulence, pressure piling and broad flame jet ignition may result in increased explosion violence. This results in an elevated maximum reduced explosion overpressure. Measures for explosion decoupling in the connecting pipelines are therefore needed.

Since the mill is probably protected depending on whose point of view you accept, you should still place a vent near the vessel. This ensures adequate venting near the mill while taking the kick out of the initial explosion.
Since the venting of such a large duct is diverted close to the mill there is no guarantee that you have totally isolated the explosion. The flame front propagation may restart after the vent and has to be prevented from reaching and running into the next duct-connected enclosure, e.g. the Filter. Further flame diversion may be required, depending on the L/De of the duct, but definitely an Explosion Diverter should be located before the filter to prevent Pressure piling and Flame jet ignition.

**Pressure piling;** condition during deflagration in which pressure increases in the un-reacted medium ahead of the flame front as a result of the deflagration

**Flame jet ignition;** ignition of un-reacted pre-compressed and turbulent medium in an enclosure by a flame with a larger than normal surface area and high energy
**How not to do it:**

### Consequences of no explosion isolation or decoupling

#### older ball mill system with inadequately and dangerously positioned non-re-closing explosion diverter

Understandably, the designers have positioned the explosion diverter (as the only vent of system between mill outlet and filter inlet) with its vent opening above the building’s roof. However, the diverter is too far away from the filter’s inlet and the L/D ratio between mill outlet and diverter far too high, in addition to the separator not being equipped with a vent and also too far away from the mill outlet in terms of L/D. Due to the too high L/D ratio and in spite of its non-re-closing character the diverter may be damaged and form missiles.

The consequences to secondary equipment (bag-filter) protected by explosion venting. The dust explosion propagates from the first vessel also protected by explosion venting WITHOUT ISOLATION through a pipeline into the secondary vessel. Because the reaction is more violent and results in a higher pressure than in the first vessel, the second vessels were destroyed.

#### and another older ball mill system with a single, inadequately and dangerously positioned non-re-closing explosion vent

In this case the air/PF separation is achieved using a combination of a separator, a cyclone and a filter, with only the cyclone and the filter being equipped with a vent or vents, respectively, and hence, with no explosion diverter at the filter’s inlet. This results in 4 off interconnected vessels: mill, separator, cyclone and filter.

Due to the too high L/D ratio and the possibility of extreme propagation velocities and in spite of its non-re-closing character the vent is badly positioned and parts of the system, including the vent, may be damaged and form missiles.

The consequences when the application of EXPLOSION ISOLATION IS NOT APPLIED. The explosion was properly controlled by the applied constructional measure in the vessel, but the conveyor carrying the product to other equipment was destroyed.
Filter systems

In most cases, dust collectors in fuel grinding systems are not small. Containment is not an economical option for such big volumes. Although Oxygen reduction is an important contribution to safety, it cannot be relied upon in such an industry. Most filters working under dust explosion hazardous conditions are fitted with bursting panel devices or rectangular explosion doors installed in one or more of the side walls and, therefore, vented in a horizontal direction. The Explosion Diverter may allow a standard venting formula to be used as the filter does not have to cope with Pressure piling and flame jet ignition but it cannot rely on the vent area from the diverter and must have large areas of venting. This venting system must be near an area in which explosion venting can take place safely.

The Vent calculation below is for a relatively small filter, the filter is quite strong for a large rectangular construction at a Pred of 0.3barg. We have to keep the explosion pressure below this reduced explosion pressure by venting out through openings of over 4m² in total. The dust is a mid-range hazard with a Kst of 150 bar m/s and Pmax of 7.4barg. We calculate the dirty volume of the filter by removing the bags and clean volume above. We can only vent horizontally. The Flame can extend to nearly 50 metres and can be up to 14 meters wide. Since the dust can be blown out ahead of the flame front, a secondary explosion outside is normal and this explosion outside the filter can generate a pressure wave of 162 mbar, 12 meters from the filter wall.

**Damage Caused by Pressure Waves:**

The effects of fuel explosions upon buildings can be approximated from experience, as a static load equivalent to the maximum explosion pressure

- 140 to 210 mbar Not reinforced concrete or cinder block walls destroyed
- 160 mbar Lower limit for serious structural damage
- 170mbar 50% destruction of brickwork of houses

Even the furthest extent of the flame has a pressure of 20 mbar, sufficient to cause small damage to house roofs (roof tiles and gutters) & 1-10% of window glass broken.

Under these conditions, we need to design our plant as high and far away from associated plant or we have to organise our venting to result in a vertical or steeply inclined upward blast. Walkways have to be situated below the venting points or their access restricted during production.

We will discuss the Pros and Cons of venting with reclosing doors versus their cheaper competition, vent panels in our section on Venting of Silos. Sufficient to say that if you believe that emergency inerting with CO₂ or N₂ is going to be successful, it’s unlikely to be efficient if the vacuum fan is still sucking in fresh air through the open vent panels and you have no containment in which to allow the inert gas to fill-the protected volume. Vents are best located below the bags to prevent blocking the flame discharge but if the vent panels stay open after the explosion event, the dirty bags will be the main combustible inside the filter and the inert gas cannot reach them! See our example below.
### Summary:

- **Coal Dust**
- **Standard Venting**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>$V = 109.7 \text{ m}^3$</td>
</tr>
<tr>
<td>Length / Diameter (eff)</td>
<td>$L/De = 1.72$</td>
</tr>
<tr>
<td>Resistance (overpressure)</td>
<td>$P = 0.30 \text{ bar}$</td>
</tr>
<tr>
<td>Explosion overpressure</td>
<td>$P_{\text{max}} = 7.5 \text{ bar}$</td>
</tr>
<tr>
<td>Product-spec. constant</td>
<td>$K_{\text{max}} = 150 \text{ m·bar/s}$</td>
</tr>
<tr>
<td>Activation overpressure</td>
<td>$P_{\text{stat}} = 0.10 \text{ bar}$</td>
</tr>
<tr>
<td>Vent area (equivalent)</td>
<td>$A = 4.28 \text{ m}^2$</td>
</tr>
<tr>
<td>Vent pipe (length)</td>
<td>$L_{A} = 0.0 \text{ m}$</td>
</tr>
</tbody>
</table>

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### Addendum:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recoil force maximum</td>
<td>$F_R = 152.7 \text{ kN}$</td>
</tr>
<tr>
<td>Recoil duration</td>
<td>$t_d = 1282 \text{ ms}$</td>
</tr>
<tr>
<td>Transferred impulse</td>
<td>$I_R = 102 \text{ kN·s}$</td>
</tr>
<tr>
<td>Flame range, horizontal</td>
<td>$L_{Fh} = 47.9 \text{ m}$</td>
</tr>
<tr>
<td>Flame range, vertical</td>
<td>$L_{Fv} = 38.3 \text{ m}$</td>
</tr>
<tr>
<td>Flame width</td>
<td>$W_F = 13.4 \text{ m}$</td>
</tr>
<tr>
<td>External pressure max.</td>
<td>$P_{\text{max}} = 162 \text{ mbar}$</td>
</tr>
<tr>
<td>At distance</td>
<td>$R_s = 12.0 \text{ m}$</td>
</tr>
<tr>
<td>Outside pressure</td>
<td>$P_a = 20 \text{ mbar}$</td>
</tr>
<tr>
<td>At distance</td>
<td>$R_x = 48.0 \text{ m}$</td>
</tr>
</tbody>
</table>
Optimal venting from a dust collector

The blast and its recoil force will cause some difficulties, both for the designers and the user, who at all times must keep people out of the designated safe vent area during the operation of the installation. Vented dust collectors are, therefore easier to integrate into the plant and easier to operate when the venting can be organised as shown in the picture below. The additional space on the side wall also reduces the probability of loose bags impeding the venting exhaust process.

- enclosure able to accept reduced explosion pressure
- air filtration elements
- extraction auger
- upper section comprising automatic jet filter cleaning system
- bars or grid preventing the filtration elements from obstructing the explosion venting
- rectangular air-cushioned explosion doors RLE
- venting alley

This configuration reduces the effects of recoil on the very high support structures and avoids the obstruction of the vent area by the internal bags.
Filter to Silo:

Typical areas where designs get it wrong- reduce the number of bag house hoppers in order to minimise the need for explosion isolation.

The rotary airlock is of the right design, yet inadequate.

Users usually understand the process function of the rotary airlock correctly; sections of a plant which are operated under different pressure conditions but must be connected for the transfer of process gases or material from one section to another can be connected via a rotary airlock. The rotary airlock will allow the desired flow rate to pass and minimize the transfer of undesired gas flow in the opposite direction. What some users don’t understand is that the airlock in most cases was also chosen by the designers for the purpose of providing explosion isolation.

Explosion isolation can only be provided by rotary airlocks which have been designed for that purpose, i.e. to inhibit any trespassing of flame effects to the extent that an ignition source may not ingress from the section where the deflagration takes place, into the section at the other side of the explosion isolation system, i.e. the rotary airlock. In order to fulfil this requirement, the rotary airlock must have a maximum gap width between the vane tips of the rotor and the bore of the body of the airlock. Another requirement is that the rotary airlock possesses sufficient strength, i.e. pressure shock resistance, from pressure exposure either side, to prevent disintegration.
**How dangerous is all this?**

The possible passage of flames through the vane tip gaps may not be in compliance with the basic requirements for explosion protection. Ignition sources must not be allowed to transfer from one zone into another zone. However, the risk of flame passage causing a deflagration in the section above the rotary airlock is not high.

<table>
<thead>
<tr>
<th>Diagram</th>
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<tbody>
<tr>
<td><img src="image" alt="Diagram" /></td>
</tr>
</tbody>
</table>

The product layer height must be such - *(this must be ensured by e.g. a level indicator)* that under the pressure stress of the explosion, no flames can pass through the product. Level indication must be ensured as fail safe and as a double knock system by operation.

As a rule of thumb, the following numerical equations can be used which describes the correlation between the height of the product plug and the outlet diameter for different bulk density of products:

- **Bulk density BD > or = 1 kg/m³:** \( H = D \)
- **Bulk density BD < 1 kg/m³:** \( H = \frac{D}{BD} \)

Where:
- \( H \) is the height of the product plug in m,
- \( D \) is the outlet diameter in m,
- \( BD \) is the bulk density of the product in kg/m³.

The famous conditions in the explosion triangle (Fuel, Oxygen and an ignition source), which have to occur simultaneously, will not easily occur in this case:

- Although 21% \( \text{O}_2 \) (Oxygen) must be assumed at all times, and flame egress (ignition) may occur from the mill, an ignitable dust cloud (Fuel) between or under the feeder’s drop-off point and above the rotary airlock. Just at that particular moment, it is a remote possibility at best, since dust would be lacking in that zone, under normal conditions. Still, an ignitable in-flight dust concentration cannot be excluded altogether in this confined small volume.

The quality of a risk is generally considered as a combination of the possible frequency of an occurrence (which in this case is very low) and the potential damage (which in this case is great).

Any design approach without correctly functioning explosion isolation cannot be said to be explosion protected, unless every little bit of the design had the capability to confine deflagration-induced pressure.
During ATEX certification a positive test result will always stem from the narrow vane tip gaps and a sufficient number of vanes. A correct supplier will pass on this essential information when selling the equipment, as part of the clarification procedure, concerning the equipment’s intended use. The information must be clearly stated in the operation and maintenance instructions and is critically important for proper maintenance. It must be clear to the operators and the maintenance staff that the moment the vane gap gets larger, the rotary airlock will lose its capability to serve as an explosion isolation system. With typical raw fuels, wear will be such that the vane tip gap will soon widen and the rotary airlock, as a result, loses its flame stopping performance. Consequently, it can be assumed that the majority of rotary airlocks used for explosion isolation, even those which have been correctly selected and installed, do not qualify as explosion isolation system, after been in service for a very short period.
Silo Design

2 barg pressure shock resistant design with self-reclosing doors

-Versus-

Little containment with vent panels on a centralised de-dusting filter in wood processing

The higher the pressure shock resistance, the smaller the explosion vent open area required.

Typical in Thorwesten supply is the 2 bar g pressure shock resistant PF silo with flat roof in cement plant
**Simple mathematics:**

<table>
<thead>
<tr>
<th>Coal Dust Silo Body PSR = 0.3 barg</th>
<th>Coal Dust Silo Body PSR = 2 barg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume V = 416.0 m³</td>
<td>Volume V = 416.0 m³</td>
</tr>
<tr>
<td>Length / Diameter (eff) L/De= 2.46</td>
<td>Length / Diameter (eff) L/De= 2.46</td>
</tr>
<tr>
<td>Resistance (overpressure) P = 0.30 bar</td>
<td>Resistance (overpressure) P = 2 bar</td>
</tr>
<tr>
<td>Explosion overpressure Pmax = 8.4 bar</td>
<td>Explosion overpressure Pmax = 8.4 bar</td>
</tr>
<tr>
<td>Product-spec. constant Kmax = 150 m·bar/s</td>
<td>Product-spec. constant Kmax = 150 m·bar/s</td>
</tr>
<tr>
<td>Activation overpressure Pstat = 0.10 bar</td>
<td>Activation overpressure Pstat = 0.10 bar</td>
</tr>
<tr>
<td>Vent area (equivalent) A = 16.64 m²</td>
<td>Vent area (equivalent) A = 2.6 m²</td>
</tr>
</tbody>
</table>

With a 6m diameter roof = 28m²  
The circumference =18.8m.  
You need to either vent over half the roof surface or place 2 lines of vents around the circumference on the side of the silo. Vents on the side can get blocked by product this reduces the capacity of the silo. Maintenance access is more difficult. This is why most cement plants have traditionally utilized the 2 barg PSR silo.
The self-reclosing explosion door is designed to re-close automatically in order to prevent the ingress of atmospheric air into the vessel in the aftermath of a venting occurrence. Conventional explosion door designs have been and still are sold with a heavy hinged lid as their venting element.

Explosion doors with a low mass, low inertia venting element and the air cushion principle to stop and reverse its movement, were introduced by Thorwesten Vent, many years ago, as a first. The venting element of an explosion door, the door's lid, must fulfil contrary requirements: The hinged lid must be of low mass, so it offers a minimum of resistance and can be accelerated in milliseconds when opening. In spite of a design utilising the absolute minimum in terms of mass of construction material, the lid must be capable of withstanding enormous mechanical stress and pressure during a deflagration-induced opening. The lid must not disintegrate. No parts may turn into missiles.

After a deflagration, the explosion door’s lid must re-close automatically and be re-usable.

The compromise between a low mass design and mechanical stress resistance can only be achieved in connection with dampening of the deceleration of the lid’s fast motion, mitigating the torque that affects the vessel’s roof area. The air cushion of the air-cushioned explosion door TT Uni K is created by the fast movement of the explosion door’s lid during its opening movement, as a result of the vessel’s rapidly increasing internal pressure. The hinged lid rotates around the hinge axis and hits the 1st baffle plate. Before the lid can hit the baffle plate, an air cushion of ambient air too slow to escape is created. This air cushion is an effective brake. Due to the triple baffle plate arrangement, the creation of the air cushion is repeated twice when the lid, the 1st and the 2nd baffle plate collide and subsequently, when lid, 1st and 2nd baffle plate hit the 3rd baffle plate.
During the movements of the subsequent parts, a further brake effect is utilised, transferring the kinetic energy of the accelerated lid effectively into a decelerating force:

Each hit transfers the kinetic energy of the explosion door’s low mass lid into the significantly heavier baffle plates. Mass ratios are selected to reduce the remaining energy to the extent that the energy can be easily absorbed by a spring arrangement.

The springs’ recoil force dampens the torque applied to the vessel’s structure. The shifting baffle plates are stopped and their motion is reversed. The lid re-closes automatically, aided by gravity.

As long as the operational conditions inside the vessel are normal, the explosion door’s lid is held in position by means of one or more retaining devices. The retaining force applied by the retaining devices can be calibrated and adjusted. This allows a specified pre-setting of the activation pressure $p_{\text{stat}}$, up to 80 mbar g (= 1.1603 psi g, which equals 800 mm or 31½” WG)

The pressure value of $p_{\text{stat}}$ defines the value of slowly rising (static) pressure at which the explosion door’s lid retaining force would be exceeded. Upward deviations of the pre-set $p_{\text{stat}}$ will result in lesser venting efficiency and mechanical stress that could exceed the strength of the equipment. Setting, regular monitoring and, where necessary, correcting of $p_{\text{stat}}$ is of great importance. The manual for the venting system will have instructions for the correct maintenance regime.
The need for Vacuum breakers:

Heat from the explosion increases the air temperature and subsequently the pressure in the silo. Once the vents discharge the excess pressures the doors automatically close. If the air inside the silo is not replaced rapidly this will create a negative pressure in the closed Silo, sometimes with devastating consequences.

Wrong and ideal positioning on silo roof

Wrong:
- The vent area is reduced, since the direction of the blast will not be deflected by the short inclined connecting flange on the silo roof.
- The opening forces will hit the explosion door’s lid predominantly in the area close to the hinge axis. No beneficial leverage assists the lid in its opening movement.

Ideal:
- The explosion door is connected with the silo via the shortest possible duct, with no deflection of the direction of the blast.
- The opening forces will not hit the lid of the explosion door predominantly in the area close to the hinge axis. Beneficial leverage assists the lid in its opening movement.
- The inclination supports draining of rain, molten snow and ice in case heating is applied. The explosion door stays cleaner.
Safe Venting:

Explosion venting affects the area around and above the explosion vent in several ways. In dealing with the effects explosion venting has on the area around the explosion panel/door, the correct positioning of the explosion vent in terms of effective venting of explosions must prevail over safety considerations protecting the area around the explosion vent. The latter must be dealt with by appropriate means that do not affect the function of the explosion venting device or devices, e.g. organisational measures like declaring an area off limits, or constructional measures like installing a deflector shield.

Only in cases in which the use of the explosion vents would imply hazards affecting the surrounding area which cannot be dealt with otherwise, the positioning of the explosion vent may deviate from the correct position, but not from the instructions for its positioning shown in the manufacturer’s product description. In such cases, the effects decreasing the efficiency of the explosion venting technique must be taken into account and be compensated for. Vent ducts must be avoided. If this is impossible, vent ducts must be made the subject of design clarification with the Original Equipment Manufacturer at the earliest design stage.

Negative impact on the performance of explosion vent system, as a result of compromises in their positioning, may make compensations in the plant design necessary. In all cases in which the implications are unclear, or in the case that the installation conditions could cause the limits (indicated by the values specified in the manufacturer’s data sheet) to be exceeded, the manufacturer must be consulted. Not all suggestions (e.g. the use of vent ducts) given in the guidelines EN 14491 and NFPA 68 can be realised without special product knowledge, as their realization may cause additional effects leading to exposure of mechanical stress.
Please contact the OEM prior to installing explosion panel or doors for use not covered by the intended use, described in the Manual. In such cases, the conformity of the intended use with the intended use as per the certified type tests may still require confirmation from explosion protection experts familiar with the capabilities of the product.

The intended use of the explosion vents is covered by the certified type testing. Any use deviating from the intended use may cause serious consequences in terms of human loss, structural- and other damage, interruption of production and conflicts with the applicable laws. Any use of the vent deviating from the intended use causes the ATEX test type certificate and the manufacturer’s liabilities to become void.

In the case of use in geographical areas in which temperatures below + 1 °C can occur, the explosion door must be equipped with electrical heating. Retrofitting of electrical heating after the explosion door has been built without heating may not be recommended for cost reasons.

Regular maintenance of explosion doors must be an item of an organised inspection and maintenance regime. The details of this regime’s organisation, its execution and the registration of its execution must be fixed in writing and be in accordance with the instructions in the manual supplied with the explosion door. The same applies for the electrical heating system.

Explosion vents come with an indication switch. The switch must become an integrated part of a trip circuit, due to the fact that the explosion vent opens momentarily, initiating an open circuit. This switch signal must be utilised in a control system by others. The switch, and the alternatively available intrinsically safe switch, have been selected for reasons of compatibility with a series of selection criteria and cannot be replaced without voiding the conformity of the explosion vent with its type tested certified original version.

The switch must be connected and integrated in a control chain relating to the overall explosion protection concept of the protected plant by others. Without this integration the explosion is not in conformity with its type tested original version.
Prevention and Recommendations

The following special precautions are necessary to ensure safe operation of Cement coal fired systems:

**Inerting:** Note *inerting as process parameter is a prevention method and emergency inerting with CO₂, N₂, or otherwise, is a response to a potentially unsafe condition or response to a fire in the process.*

(a) Use of oxygen-deficient air in the pulverisers (indirect system) under normal operating conditions.
(b) Use of rock dust, carbon dioxide, or water systems in the pulverisers and dust collectors when shutdown occurs (taking into consideration that rock dust could contaminate the coal).
(c) Inerting with water sprays and steam when over-temperature conditions are observed. Care must be taken to prevent the development of a dust cloud which may then explode.
(d) Monitoring the process O₂ levels to qualify the inert atmospheric conditions.

**Removal of ignition sources:**
(a) Use of magnets and metal detection to remove tramp metal from the system.
(b) Cutting and welding operations should be carried out in accordance with recognized safety codes or guidelines (American Welding Society, American National Standards Institute [ANSI], NFPA, VDI, EN BSI “permit to Work” systems etc.)
(c) Electrical components should meet the Category appropriate to that Zone.
(d) Hot coal from storage areas should be discarded and not fed into the pulveriser. Particular care should be exercised during startup and shutdown.
(e) Proper control measures should be instituted to prevent spontaneous combustion.
(f) Grounding of dust collector bags
(g) Smoking and open heat sources should be prohibited in hazardous areas of the plant.

**Good housekeeping**
(a) Prevention of dust accumulations by control of spillage, leakage, and degradation of coals to fines during handling and resultant dust build ups.
(b) Cleaning and removal of extraneous combustible materials from the workplace.
(c) Design, implementation, and maintenance of dust tight equipment.
Explosion Protection For Coal in the Cement Industry
White Paper

Equipment design
(a) Small compact design of pulverisers, cyclones, dust collectors, and storage bins with a minimum of dead space.
(b) Elimination of dead spots, ledges, corners, or other areas where dust can accumulate in equipment or ducting.
(c) Storage bins designed with proper discharge angles and smooth internal surfaces and vibrators to facilitate removal of the coal.
(d) Auxiliary electric power systems available to operate key pieces of equipment in the event of a power failure.
(e) Use of over-temperature and overpressure controls to warn of a potentially dangerous situation.
(f) Fire and or explosion suppression systems can be installed on pieces of equipment susceptible to fires and/or explosions.
(g) Detection equipment can be installed to monitor carbon monoxide (CO) build up in the pulveriser, cyclone, storage bin, or dust collector. The design of the carbon monoxide monitoring system is based on the fact that CO build up is related directly to the oxidation rate of the coal. An analysis system is needed to compare the CO content of the incoming and outgoing mill air and indicate the difference. The principal advantage of this system is that it can detect CO build up and, therefore, may give the operator sufficient lead time to adjust operating conditions, apply emergency inerting and if necessary, shut down the mill to prevent an explosion.
(h) The use of explosion venting design should be considered for controlling the explosion damage.

Education and training: Written procedures should
(a) Be specific to prevent any variations in the interpretation and application by different operators.
(b) Be readily available to all operating personnel.
(c) Contain the necessary information for system checkout, warm up, and shutdown including short-term, long-term, and emergency operating conditions.
(d) Be modified immediately when operational changes are deemed necessary.
(e) Be reviewed regularly with all operators to prevent gradual changes in the actual operating practices. A safety meeting or group training session is helpful for this review and updating.
(f) Be established for fire fighting with periodic drills

Preventive maintenance
(a) A routine maintenance program should be developed for pieces of equipment sensitive to breakdown, such as motors, dampers, and fan blades.
(b) Periodic inspections should be carried out to ensure that key pieces of equipment are in good operating condition.
(C) Make sure that good monitoring include the raw coal yard
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