APPLICATION: SAFETY CEMENT

INADEQUATE EXPLOSION PREVENTION SYSTEMS IN THE CEMENT INDUSTRY

BACKGROUND

The combustion process in cement production has the potential to cause dangerous explosions in the kiln and preheater systems.

Many cement plants unknowingly operate their safety interlocking at very high levels. They also display over-reliance on slow gas analysis systems, which is very risky.

CHALLENGE

Fortunately, explosions in the cement industry are very rare, but they can happen and when they do, it only takes a split second.

This is why time is of the essence when it comes to protecting people, machinery and production against explosion risks.

Safety is, of course, the primary concern. However, an inadequate explosion prevention system that fails to comply with enforced explosion prevention standards, such as the International Electrotechnical Commission (IEC) 60079 or the National Fire Prevention Association (NFPA) 69 Standard in the US, can have serious consequences for your insurance policy, including the possibility of voiding it. This will be regardless of the process filter being a bag filter or an ESP.

SAFETY FIRST

A safe production environment can be achieved through the adoption of the international standard ISO 45001. This standard is crucial for the health and safety of personnel at a cement plant. Additionally, a cement plant's health and safety management system must include explosion prevention procedures. To prevent costly and possibly fatal explosions, many aspects of operating a safe plant need to be considered, including:

1. Following legislation and safety standards
2. Nourishing a "Safety First" culture
3. Implementing good engineering practices
4. Installing a robust explosion prevention system
5. Following good production and operational practices
6. Following equipment manufacturers' instructions for maintenance
7. Educating and training plant personnel on safety, including refresher training
8. Recording all safety incidents and near-misses, as well as being proactive about avoiding their reoccurrence

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COMPLEX EXPLOSION CALCULATIONS

The most common cause of gas explosions in a cement production line is incomplete combustion that results in high concentrations of carbon monoxide (CO) gas. Another possible cause is when a kiln is burning natural methane (CH4) gas and the flame goes out.

For potentially explosive gases (like CO), many physical factors like temperature, pressure and oxygen levels will determine if an explosion will occur at a given concentration. Therefore, determining whether a specific situation will cause an explosion is quite complex.

The minimum concentration of a particular combustible gas or vapour necessary to support its combustion in air is defined as the Lower Explosive Limit (LEL). There is also an Upper Explosive Limit (UEL) where explosions no longer occur. Operating above the UEL is not relevant for cement production.

LEL for CO is 12.5 Vol%

LEL for CH4 is 5.0 Vol%

Any gas concentration above the LEL can lead to an explosion if oxygen is present and the gas is ignited.

SAFE SYSTEMS OFFER SECURITY

All cement plants must operate an explosion prevention system that monitors all the potential dangers that can lead to an explosion. Such dangers include pressure levels, temperature, unreliable gas analysis equipment, gas leakages and loss of burner flame.

In response to a potential threat, the explosion prevention system responds by facilitating safety interlocking, alarms, explosion vents and isolation dampers. It is also important that operators and plant personnel are trained in handling such explosion threats.

If one of the system components fails, shows an incorrect reading or is too slow, the explosion prevention system may fail to respond to a potentially dangerous situation.

ONE SIZE DOESN'T FIT ALL

Some 'general' safety interlocking levels are widely used in the cement industry. These general interlocking levels has been derived from equipment supplies or in connection with process modifications. While these levels can vary quite a lot, they are commonly used at around 1.0 Vol% of CO or CH4. However, documentation supporting the calculation of this particular safety limit is generally hard to find.

There is never one clear answer to the question, "What is a safe interlocking level?" because the evaluation of a given process condition for explosion potential is complex. Yet, well-established regulations and standards do exist and can help in setting up a safe and well-documented safety interlocking level.

To prevent explosions in a cement kiln system, gas analysis measurements are essential for checking whether a process is operating safely. Most cement plants often don't know how they determine or calculate their safety interlocking levels for dangerous gases like CO.

The measurement should take place in the downcomer, right after the last cyclone where the combustion process, from a production and safety point of view, must be completed. Safety interlocking levels of CO and CH4 are based on these gas analysis readings.

LAYING DOWN THE LAW

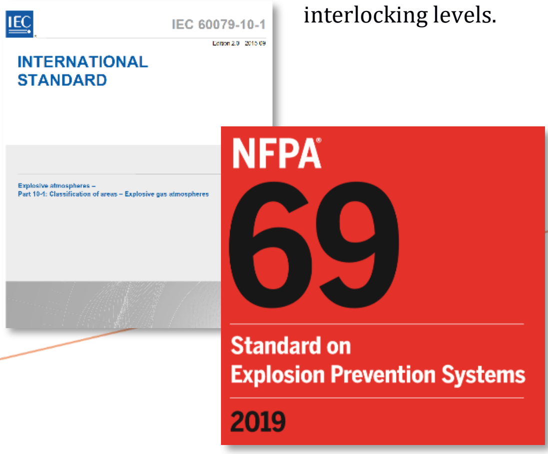
As a minimum, cement plant permits require local rules and legislation are followed. And while legislation generally varies from country to country, most countries ensure legislation entails rules for safety, fire and explosion prevention, including on-site inspections.

Various international and national standards provide the foundation for safe cement plant operations and explosion prevention. In most countries, fire inspectors visit production facilities regularly to make sure the legislation and relevant standards are followed, helping cement plant owners to operate safely.

Internationally, the most commonly enforced standard is IEC 60079, Explosive Atmospheres. In the US, it's the NFPA 69 Standard on Explosion Prevention Systems.

"Neither of the above-mentioned standards differentiate between the use of an electrostatic precipitator (ESP) or a bag filter"

It's important to note that neither of the above-mentioned standards differentiate between the use of an electrostatic precipitator (ESP) or a bag filter. Explosion risk is related to the process conditions and this is often overlooked by cement plants using bag filters. The vast majority of cement plants worldwide operate with bag filters and it's not uncommon that they wrongly operate with no safety interlocking or higher interlocking levels.



INADEQUATE EXPLOSION PREVENTION SYSTEMS IN THE CEMENT INDUSTRY

The IEC 60079 and the NFPA 69 Standard on Explosion Prevention Systems address the potential of a condition that may cause an explosion in an atmosphere found within a process system. An ignition can originate from a number of places in a cement kiln system – an ESP is just one of them.

While the relevant standards vary in content and definitions, one definition remains common. It is the Critical Safety Factor (CSF) of 25%. The CSF is referred to as Xcrit or k, depending on which standard you observe.

Using the LEL of CO and CH_4, the Critical Safe Value (CSV), of the gases in the process can be calculated as CSV = LEL x CSF.

CSV for CO is 12.5 Vol% x 25% = 3.13 Vol% for CO gas

CSV for CH_4 is 5.0 Vol% x 25% = 1.25 Vol% for CH_4 gas

However, the individual CSVs don't take gas analysis response times and process dynamics into account. These factors need to be considered to calculate an appropriate safety interlocking value.

The potential effect of two or more gases being combined is out of scope for this article.

PROCESS DYNAMIC

Process dynamic (PD) is defined as how fast a given gas concentration can change in a given process. The PD value is process- and situation-dependent and can differ from plant to plant.

In a real-life example, the PD for CO has been recorded at 0.20 Vol% per second, but it can be larger or smaller. It's a number that needs to be evaluated based on a logged record of CO PD over an extended period of time.

$$\text{Critical response time (CRT)} = \frac{\text{Critical safe value (CSV)}}{\text{Process dynamic (PD)}}$$

The critical response time (CRT) for CO can be calculated as:

$$\text{CRT (CO)} = \frac{3.13 \text{ Vol\%}}{0.20 \text{ Vol\%/s}}$$

CRT (CO) =16 seconds

The CRT denotes that it takes only 16 seconds before the process reaches the CSV at a CO concentration of 3.13 Vol% Therefore, the CO analysis has to be faster than 16 seconds in order to respond in time to prevent an explosion.

A gas analysis system with a response time longer than 16 seconds compromises the safe interlocking of CO. If this is the case, a cement plant will not be operating in compliance with explosive gas standards (IEC 60079 or NFPA 69), exposing itself to a potentially dangerous safety risk as well as the possibility of a voided insurance policy.

ANALYSER RESPONSE TIME IS KEY

For an interlocking system relying on a gas analysis measurement to prevent explosions, the response time is extremely important. The gas analysis system needs to measure faster than the CRT to prevent an explosion.

Some of the fastest process gas analysers available on the market are laser-based, cross-duct, in-situ analysers. This type of analyser can make accurate measurements with a response time as little as two seconds. However, these seemingly perfect types of analysers can't tolerate high dust loads because low visibility prevents their light-based lasers from working effectively. The dust tolerance is typically around 25-50 g/m^3, which is far too low for an installation in the downcomer of a cement kiln preheater.

An extractive system can be operated in high-dust concentrations, but typically has a response time of 30-60 seconds or even longer. A faster response time can be achieved with some extractive systems by measuring at a higher sample flow rate. Measuring at a higher flow rate can, however, lead to increased risk of contamination, resulting in a lower run factor, which in turn requires more maintenance.

The following equation can be used to evaluate what response time is required to operate according to current safety standards:

Interlocking Limit (IL) = CSV - (PD x Analyser Response Time)

Analysers with a response time of 5 seconds or 10 seconds will provide an IL for CO of:

IL CO (10 s) = 3.13 Vol% - (0.2 Vol%/s. x 10 s) = **1.13 Vol% CO**

IL CO (5 s) = 3.13 Vol% - (0.2 Vol%/s x 5 s) = **2.25 Vol% CO**

On next page a graphical presentation of the various values can be seen in fig. 1.

LEL: Lower Explosion Level
CSF: Critical Safety Factor (25%)
CSV: Critical Safe Value for a gas
CRT: Critical Response time for an analyser
PD: Process Dynamic

"potentially dangerous safety risk as well as the possibility of a voided insurance policy."

INADEQUATE EXPLOSION PREVENTION SYSTEMS IN THE CEMENT INDUSTRY

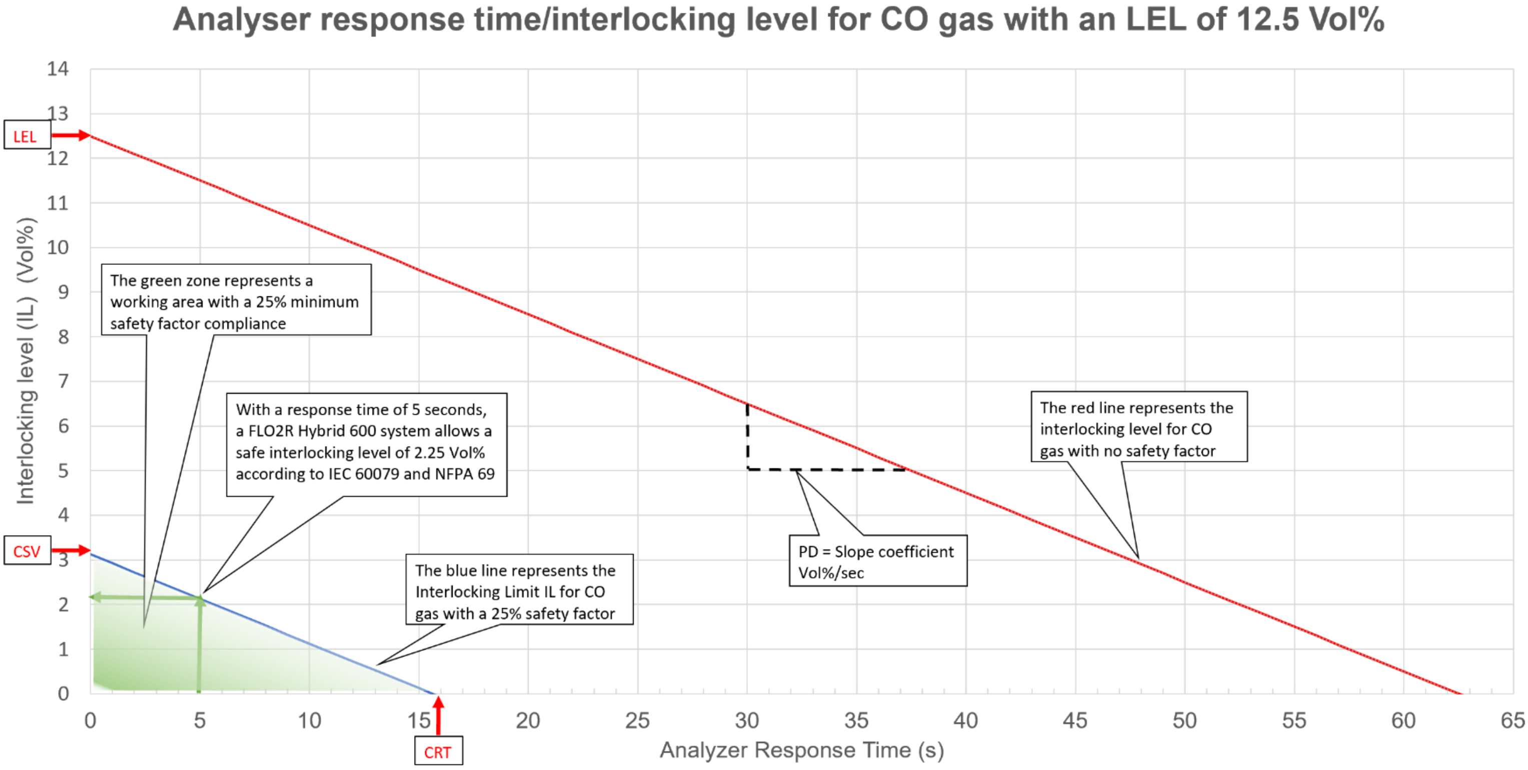


Figure 1: Correlation between analyser response time and possible interlocking level with a safety factor of 25%

THE CURRENT STATE OF PLAY IN CEMENT
Many cement plants have an inadequate explosion prevention system because they operate a gas analysis system that is too slow to sustain the interlocking limit that is used to operate. To evaluate if a plant is complying with current standards for explosion prevention, the following steps can be followed:

1. Confirm the location of the gas analysis system is in the downcomer, just after the last de-dusting cyclone and before any water spray. If placed further downstream from this location, the process retention time must be added to the calculation of IL.
2. Determine the response time of the analysis system. This is a simple physical test of the actual time on site and not based on equipment documentation.
3. Evaluate the PD of the process by checking the data log of the gas in the kiln system. Alternatively, document the PD recorded by process or equipment suppliers for the plant. As a last resort, you can use 0.2 Vol%/sec. However, be mindful that the real value can potentially be higher.
4. Calculate the Interlocking Level (IL) = CSV – (PD x Analyser Response Time)

The accurate evaluation of PD is critical. It should be calculated from measurements recorded by a capable gas analysis system and data logged in a control system based on a longer period of time. Make sure that periods of upset conditions are also included in the evaluation.

By using the above calculation, a qualified safety interlocking level can be documented. If the response time of the present gas analysis system does not allow for a practical and operative interlocking level, a faster gas analysis system must be considered.

Figure 2 shows the process response time of a conventional extractive gas analysis system (red line) as 45 seconds. On the other hand, the new, faster, laser-based gas analysis system, Hybrid 600™ (green line), has a process response time of 5 seconds. The conventional system doesn't register the CO concentration within the CRT of 16 seconds.

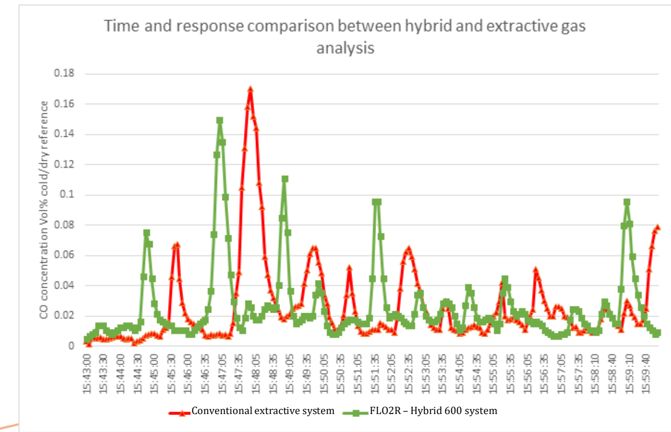


Figure 2: The difference in response time between an extractive analysis system and a laser-based Hybrid 600™ system from FLO$_2$R is 40 seconds.

INADEQUATE EXPLOSION PREVENTION SYSTEMS IN THE CEMENT INDUSTRY

INSURANCE WOES

Most cement plants have signed an industrial all-risk insurance policy or equivalent, which covers them in case of accidents. This kind of policy provides wider protection than general fire and similar peril policies because it covers all circumstances (except those specifically excluded). However, the general conditions found in these policies can contain important general clauses like this real-life customer example:

“SAFEGUARDS AND MAINTENANCE
The insured shall, at all times and as far as is reasonably practicable, take steps to safeguard the property insured and maintain it in a proper state of repair.
The insured shall also take steps to enforce the observance of all statutory provisions that manufacturers recommend and other regulations relating to the safe use and inspection of the insured property.

OBSERVANCE OF CONDITIONS
The due observance and fulfilment of the provisional conditions and endorsements of this policy by the insured insofar as they relate to anything to be done or complied by them shall be conditions precedent to any liability of the company to make any payment under this policy.”

What this means is a production plant that experienced an explosion may also risk having their insurance policy voided if they are found to be non-compliant with legislation, including regulations addressing explosion prevention.

A fast gas analysis system and knowledge of the actual process dynamics for a given process is the foundation for a safe working environment and the fulfilment of the general conditions of an insurance policy.

FAST GAS ANALYSIS – HYBRID 600™

FLO$_2$R offers Hybrid 600™ – a fast, laser-based gas analysis system suitable for high-dust applications. Its technology was developed in response to the need of a fast response time to operate a cement kiln system safely and ensures compliance with current standards for explosion prevention.

The Hybrid 600™ system has been designed especially for the cement industry and has an impressive response time of 5 seconds. It can tolerate temperatures up to 600°C and dust concentrations as high as 200 g/m^3. The Hybrid 600™ is ideal for installation after the last preheater cyclone in the downcomer.

Apart from being very fast, the Hybrid 600™ also features a non-contact laser analysis with low straightforward maintenance that requires service only by Allen-keys.

Learn more about the unique, patent-pending Hybrid 600™ system from FLO$_2$R at www.flo2r.com where you can download data sheets and other documentation.

If you have any questions or want to have a quotation for a fast and safe gas analysis system please contact us directly at sales@flo2r.com

SAFETY FIRST!

SAFETY FAST!!!

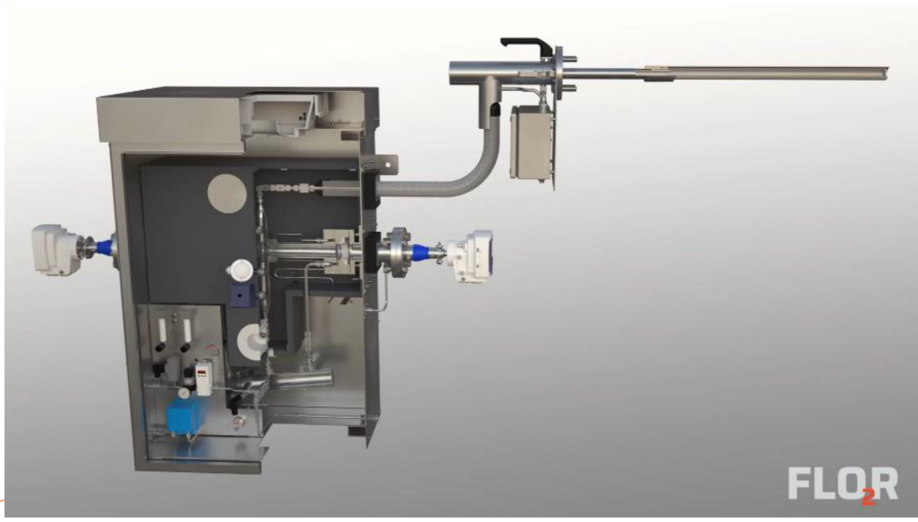


Figure 3: Hybrid 600 - fast gas analysis for cement safety applications. With the patent pending technology it enables none-contact laser gas analysis in high dust applications.

CONTACT
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