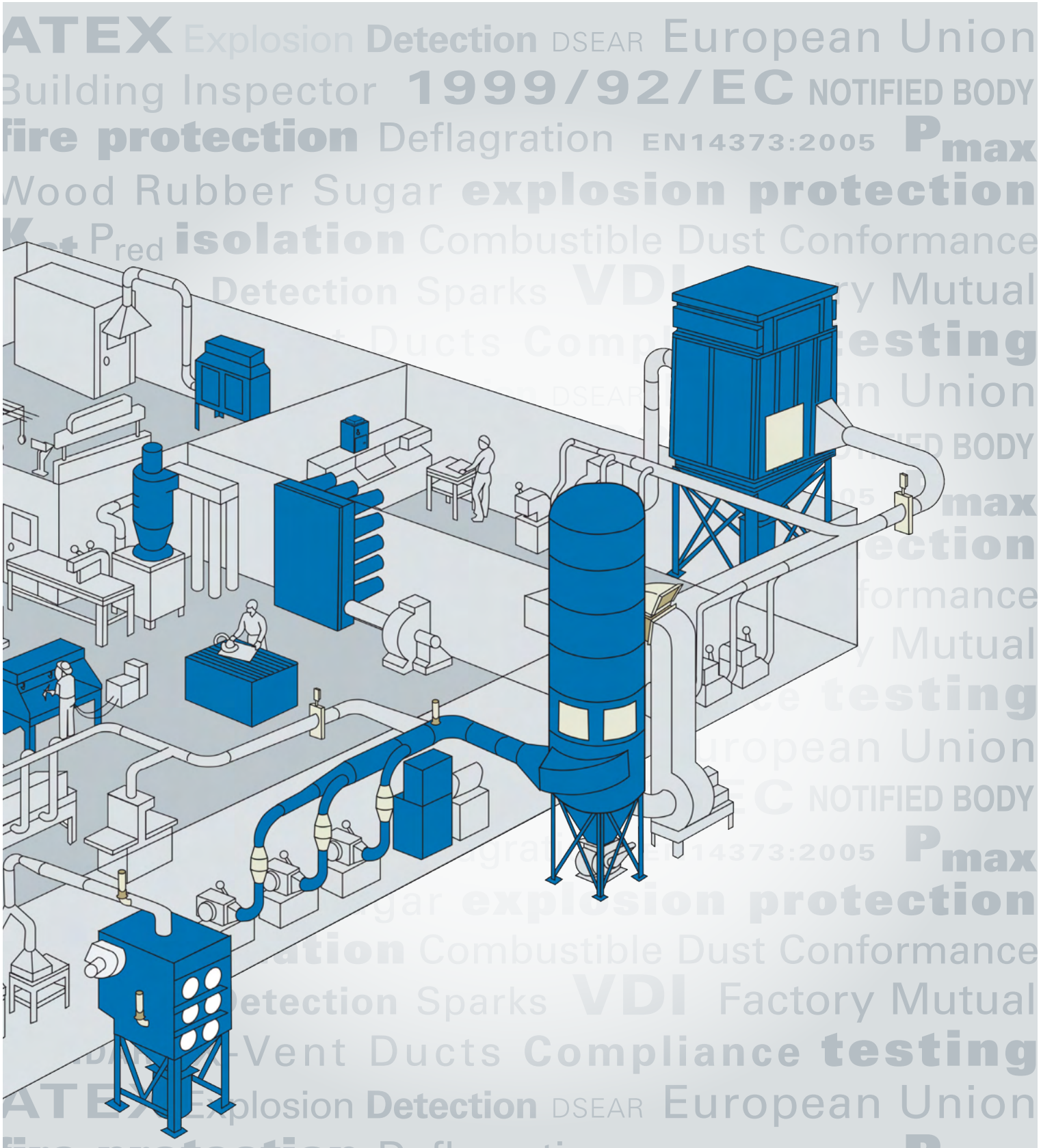
Donaldson
FILTRATION SOLUTIONS

DUST COLLECTORS AND COMBUSTIBLE DUST MANAGEMENT



WHAT IS COMBUSTIBLE DUST?

Combustible dusts (also known as explosive dust) are fine dust particles that have the ability to disperse in air and have the potential to catch fire and/or cause an explosion. Examples include most solid organic materials (sugar, flour and wood, etc.), metals and more.

Many manufacturing processes create very small particles of dust that may become airborne, where they settle on surfaces and in crevices throughout the plant. Eventually, these particles that are not regularly cleaned not only create a housekeeping issue, but these dust particles can represent an explosion hazard.

When a combustible dust encounters an ignition source, there is the potential for a fire or explosion.

In manufacturing facilities that generate or handle dust, **it's an important responsibility** of the process owner **to manage combustion risks**, and is essential for them to have a comprehensive plan to mitigate these potential risks. The creation of a mitigation plan to help manage combustible dust will therefore be required by most facilities – including many that may not traditionally have considered their dust as 'combustible'. Along with studying legislation requirements in your region, one of the first steps is to understand 'Is my dust actually combustible?'

Sending a sample of your dust to a qualified lab is usually a good place to start. If it's shown to be combustible, further tests will determine if it's explosible, how quickly that can happen, and how much force it can carry. This information will help direct the selection of equipment needed to help mitigate these hazards.

HOW CAN YOU HELP PREVENT DUST EXPLOSIONS?

It is essential for manufacturing process managers to understand dust hazards and ensure they manage combustible dusts in their facilities. Once you have determined the combustibility of your dust, you can develop a plan to mitigate the risks in your process.

Dust collection systems are key to helping prevent combustible dust explosions, which can have catastrophic consequences such as destruction of facilities, injuries and loss of life.

A well-designed, maintained, and operated dust collection system is an integral part of your effort to manage risks and comply with standards and regulations.

ONE OF THE KEY STEPS IN MITIGATING YOUR EXPLOSION RISK IS SELECTING THE RIGHT DUST COLLECTION CONFIGURATION.

With our decades-long experience in providing high-quality dust collectors that have become an integral part of many plants' combustible dust mitigation strategies. We can help review your mitigation strategies and integrate Donaldson dust collector equipment into your dust management and control strategy.

Please note that this document is intended to help your understanding of typical combustible dust management strategies and some of the components involved. A combustible dust management plan includes many other aspects, including but not limited to housekeeping practices, employee training, etc.

For more information, please visit our website **donaldson.com/combustible-dust**

SOME EXAMPLES OF COMBUSTIBLE DUST

(non-exhaustive list)

Agricultural Dusts

Alfalfa
Apple
Beet root
Carrageen
Carrot
Cocoa bean dust
Cocoa powder
Coconut shell dust
Coffee dust
Corn meal
Cornstarch
Cotton
Cottonseed
Garlic powder
Gluten
Grass dust
Green coffee
Hops (malted)
Lemon peel dust
Lemon pulp
Linseed
Locust bean gum
Malt
Oat flour
Oat grain dust
Olive pellets
Onion powder
Parsley (dehydrated)
Peach
Peanut meal & skins
Peat
Potato
Potato flour
Potato starch
Raw yucca seed dust
Rice dust
Rice flour
Rice starch
Rye flour
Semolina
Soybean dust
Spice dust
Spice powder
Sugar (10x)
Sunflower
Sunflower seed dust
Tea
Tobacco blend
Tomato
Walnut dust
Wheat flour
Wheat grain dust
Wheat starch
Xanthan gum

Carbonaceous Dusts

Charcoal, activated
Charcoal, wood
Coal, bituminous
Coke, petroleum
Lampblack
Lignite
Peat, 22% H20
Soot, pine

Chemical Dusts

Cellulose
Cellulose pulp
Cork
Corn
Adipic acid
Anthraquinone
Ascorbic acid
Calcium acetate
Calcium stearate
Carboxy-methylcellulose
Dextrin
Lactose
Lead stearate
Methyl-cellulose
Paraformaldehyde
Sodium ascorbate
Sodium stearate
Sulfur

Agricultural Products

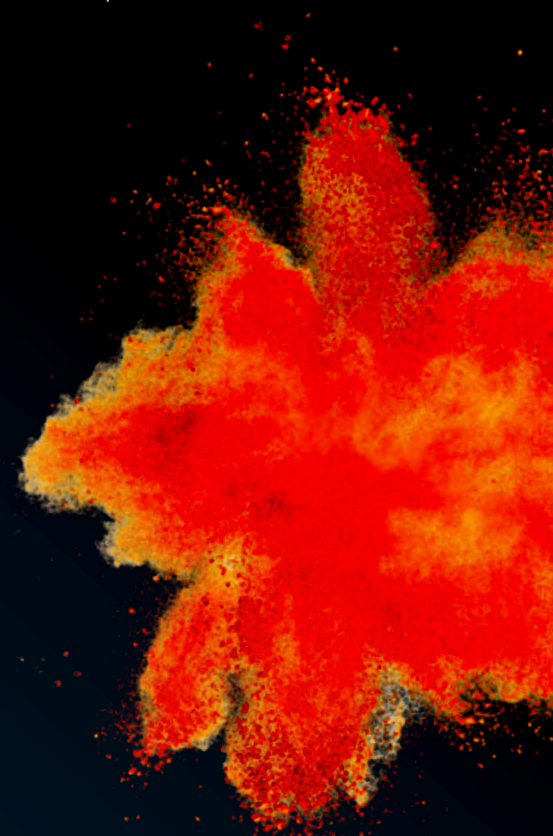
Egg white
Milk, powdered
Milk, nonfat, dry
Food flour
Starch, corn
Starch, rice
Starch, wheat
Sugar
Sugar, milk
Sugar, beet
Tapioca
Whey
Wood flour

Metal Dusts

Aluminum
Bronze
Iron carbonyl
Magnesium
Zinc

Plastic Dusts

(poly) Acrylamide
(poly) Acrylonitrile
(poly) Ethylene (low-pressure process)
Epoxy resin
Melamine resin
Melamine, molded (phenol-cellulose)
Melamine, molded (wood flour & mineral filled phenolformaldehyde)
(poly) Methyl acrylate
(poly) Methyl acrylate, emulsion polymer
Phenolic resin
(poly) Propylene
Terpene-phenol resin
Urea-formaldehyde cellulose, molded
(poly) Vinyl acetate/ ethylene copolymer
(poly) Vinyl alcohol
(poly) Vinyl butyral
(poly) Vinyl chloride/ ethylene/vinyl acetylene suspension copolymer
(poly) Vinyl chloride/vinyl acetylene/emulsion/copolymer
Polymers



COMBUSTIBLE DUST MANAGEMENT

As a process owner, you are responsible for the selection of your combustible material management strategy and to assure compliance with all applicable codes and standards.

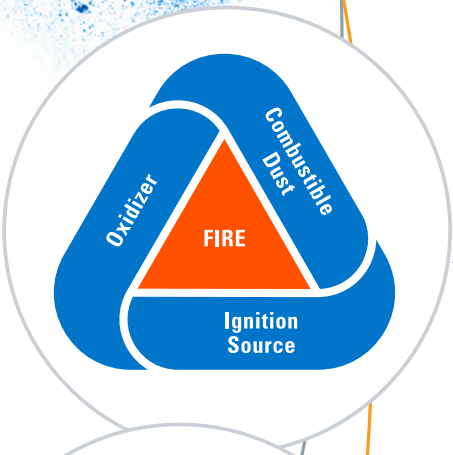
UNDERSTANDING THE BASICS

One of the steps is getting the dust under control; it is essential for manufacturing factory managers to understand the risks of combustible dust and ensure they manage combustible dusts in their facilities.

Many process requirements may make elimination of combustible dust, mist, or fumes impractical. However, it may still be possible to manage the dispersion of dust within your plant by using an appropriate and effective industrial ventilation system including dust collection.

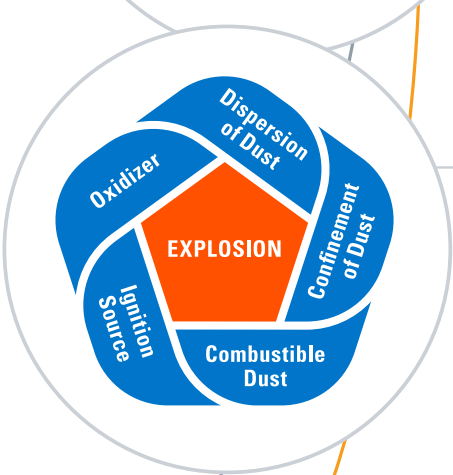
Some of the key questions about the probability and potential consequences of a combustion event include:

- What levels of combustion risk do my dusts represent?
- Where are nuisance dusts released in my facility, and how can I reduce them?
- How can I lessen the chance of combustion occuring?
- How can I minimize the damage if a dust-related fire or explosion occures?



FIRE TRIANGLE

Fire management strategies traditionally focus on the control or elimination of one of the three key elements necessary for a fire — often represented by the "fire triangle." Managing one or more of the elements in the triangle can decrease the fire risk.



EXPLOSION PENTAGON

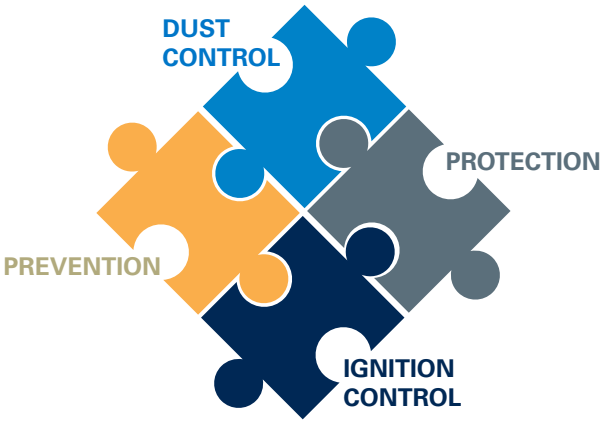
Explosion risk management strategies consider a slightly expanded set of elements often represented as an "explosion pentagon." In addition to the key elements from the fire triangle — fuel, heat, and oxygen, the explosion pentagon includes two additional elements necessary for an explosion: "Dispersion of Dust" and "Confinement of Dust."

As with fire management strategies, the management or removal of one or more of the elements in the explosion pentagon can reduce the explosion risk.

While many explosion management strategies focus on controlling the same elements in the fire triangle, explosion risk management strategies that focus on the dispersion of dust, or the containment of dust alone, may require a separate strategy to address any remaining fire risks.

FOUR THINGS TO CONSIDER

WHEN REVIEWING YOUR COMBUSTIBLE DUST MITIGATION STRATEGY



PREVENTION MEASURES

- The equipment has separator devices to remove foreign materials capable of igniting combustible dusts.
- Material Safety Data Sheets for the chemicals which could become combustible dust under normal operations are available to employees.
- Employees are trained on the explosion hazards of combustible dusts.

DUST CONTROL MEASURES

- The dust-containing systems (ducts and dust collectors) are designed so that fugitive dusts are not allowed to accumulate in the work area (i.e. no leaking).
- The facility has a housekeeping program with regular cleaning frequencies established for floors and horizontal surfaces, such as ducts, pipes, hoods, ledges, and beams, to minimize dust accumulations within operating areas of the facility.
- The working surfaces are designed to minimize dust accumulation and to facilitate cleaning.
- Ensure proper maintenance and regular inspection of any equipment in contact with potential explosive atmospheres.

IGNITION CONTROL MEASURES

- Electrically-powered cleaning devices such as vacuum cleaners and electrical equipment are approved according ATEX regulations.
- The facility has an ignition control program, such as grounding and bonding and other methods, for dissipating any electrostatic charge that could be generated while transporting the dust through the ductwork.
- The facility has a Hot Work permit program.
- Non-smoking areas are indicated with “No Smoking” signs.
- Duct systems, dust collectors, and dust-producing machinery are bonded and grounded to minimize accumulation of static electrical charge.
- The facility selects and uses industrial trucks that are approved for combustible dust locations.

PROTECTION MEASURES

- The facility has an Explosion Protection Document completed with risk assessment on specific issues.
- Dust collectors are preferably not located inside of buildings (some exceptions).
- Rooms, buildings or other enclosures (dust collectors) have explosion relief venting distributed over the exterior wall of buildings and enclosures.
- Explosion venting is directed to a safe location away from employees.
- The facility has isolation devices to prevent deflagration propagation between pieces of equipment connected by ductwork.
- The dust collector systems have spark detection and explosion / deflagration suppression systems.
- Emergency exit routes are properly maintained.

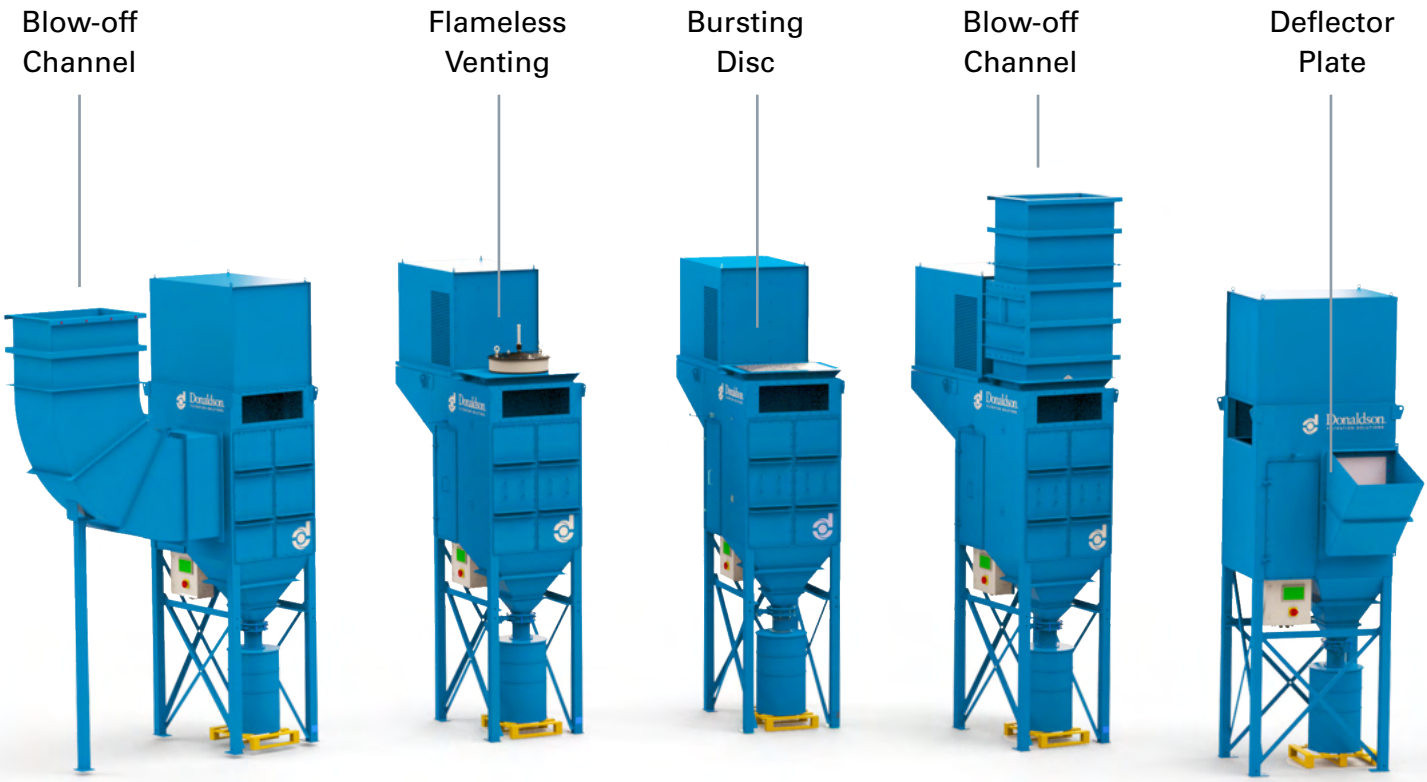
MITIGATION STRATEGIES

As a manufacturer and supplier of industrial filtration solutions, we can assist process owners/operators in the selection of filtration technologies. Although we can help review your mitigation strategies, we cannot, select fire and/or explosion mitigation strategies for process owners. To provide this support, we would need complete and accurate information on all potentially combustible contaminants and the fire and/or explosion mitigation strategies that you as a process owner/operator intend to pursue.

As the properties of your dust vary significantly according to your specific process and your specific atmospheric conditions, ATEX directives make it clear that the responsibility for evaluating the risks and creating an explosion protection document lies with the employer. Compliance with applicable codes and standards are the responsibility of the process owner/operator as well.

Among other considerations, the current directives (EC & EU) require owners/operators whose processes involve potentially combustible materials to have a current Explosion Protection Analysis, which can serve as the foundation for the process owner/operators hazard mitigation strategies.

EXAMPLES OF EQUIPMENT OPTIONS FOR DUST COLLECTION SYSTEMS:



UNDERSTANDING CODES AND STANDARDS

Many standards and codes may influence your decisions on dust control, including local, state, and European regulations. Knowing the regulations that apply to your facility is critical, and you should always research the regulation requirements in your area.

As of July 2003, there are two directives issued by the European Union that are related to the protection of employees and equipment from risks related to potentially explosive atmospheres 1999/92/EC and 2014/34/EU (ATEX Directives) - and continues to communicate with industries on the hazards of combustible dust.

The European Union aims to reduce the risk from combustible dust and gas, risks in industrial plant settings and avoiding major accidents.

To be compliant with European regulations, you must meet other requirements and all applicable standards or codes.
Visit osha.europa.eu to find ATEX 1999/92/EC directives.

WHERE TO START?

Employers must follow the ATEX 137 workplace directive 1999/92/EC. This is the minimum requirement for improving the safety and health protection of workers potentially at risk from explosive atmosphere. It is the responsibility of the employers to follow this directive and take actions according to their needs (e.g. zoning, product selection, definition of the explosivity of the dust, etc.)

An Explosion Protection Document assessing the strategy to protect employees against explosion has to be written by the employer and kept up to date.

DONALDSON CAN DELIVER THESE TYPES OF UNITS TO SATISFY DIFFERENT RISKS OF POTENTIALLY EXPLOSIVE ATMOSPHERE:

Table 1

CUSTOMER ZONING	DONALDSON FILTER
non-zoned	no ATEX label required
zone 22	EX II cat 3D
zone 21	EX II cat 2D
zone 2	EX II cat 3G
zone 1	EX II cat 2G

Table 2

	Can work in potentially explosive atmosphere as mentioned in directive 1999/92/EC?	Can safely handle potentially explosive dust? (K_{st} & P_{max} limits apply)
TYPE 1	–	–
TYPE 2	–	✔
TYPE 3	✔	–
TYPE 4	✔	✔

1. NON-REINFORCED UNIT

Can be a completely standard unit or in case where the basis of safety is avoidance of ignition sources it can be supplied as an earthed unit.

2. REINFORCED UNIT

This unit is handling dust internally that has the potential to be explosive. It is known as a Reinforced Unit as it is typically a strengthened design. Equipment that is fitted inside the unit must comply with ATEX (eg. level probe, fans, motors etc.), and hence will be marked accordingly.

The unit may have some protective equipment such as a venting panel, flameless venting device or suppression device; these parts should comply with ATEX directive 2014/34/EU.

If this reinforced unit (as a complete assembly) is located in an atmosphere (external to the casing) that is designated non-hazardous, then the unit itself does not fall within the scope of ATEX and no ATEX marking / certificate is required for the unit. Also, at a future date it cannot be relocated in to a hazardous zoned area.

3. ATEX UNIT

An ATEX unit is a unit that will be installed inside a potentially explosive atmosphere. The unit as a whole will have to comply to ATEX directive 2014/34/EU. This unit will be labeled according to ATEX 2014/34/EU rules. The labeling of the unit will only concern the outside of the unit as no source of ignition is considered inside the unit.

4. REINFORCED AND ATEX UNIT

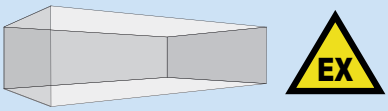
This unit is handling a dust / product that can create a potentially explosive atmosphere inside the unit and will be installed itself in a potentially explosive atmosphere. This unit will have an ATEX label, which applies to only the outside of the unit.

* See table 1
◇ See table 2

START

Is there an explosion risk in the area where the unit will be installed?

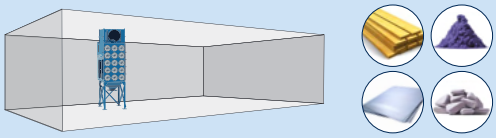
Cfr. directive 1999/92/EC.



NO

no ATEX equipment is required

Can the material handled lead to potentially explosive atmosphere?



NO

YES

Can a dust explosion be prevented?
e.g.: - avoidance of ignition sources
- inerting
- ...

YES

NO

non-reinforced & non-ATEX unit

reinforced & non-ATEX unit

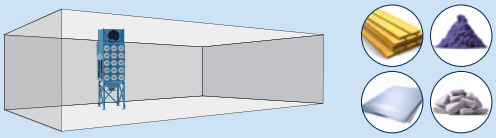
TYPE 1 ◇

TYPE 2 ◇

YES

ATEX equipment is required; check zone details*

Can the material handled lead to potentially explosive atmosphere?



NO

YES

Can a dust explosion be prevented?
e.g.: - avoidance of ignition sources
- inerting
- ...

YES

NO

non-reinforced unit, ensure correct ATEX category is ordered

reinforced unit, ensure correct ATEX category is ordered

TYPE 3 ◇

TYPE 4 ◇

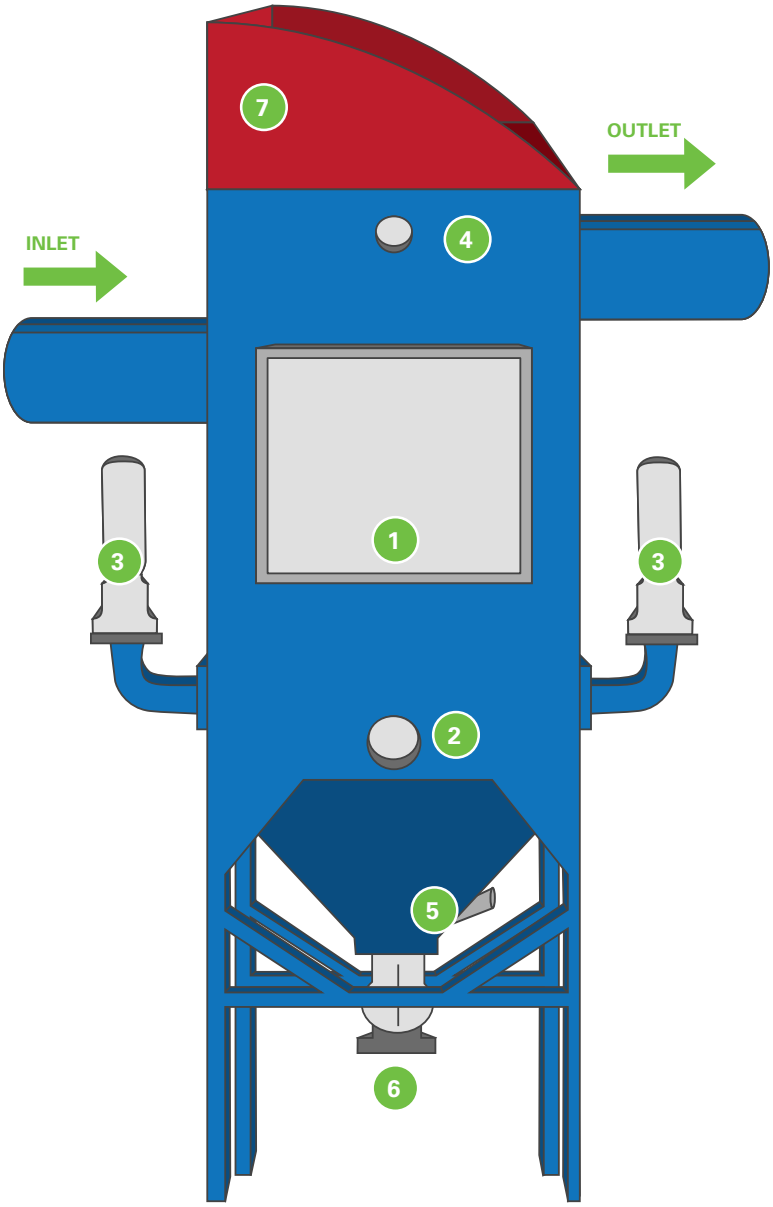
SAFE

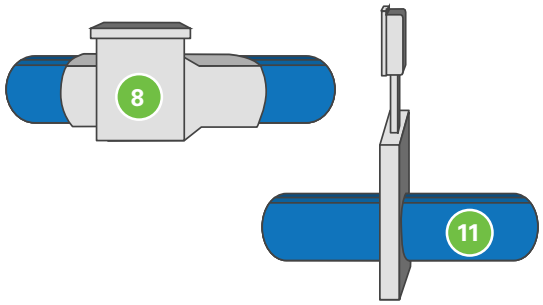
Update your Explosion Protection Document to reflect chosen basis of safety methods. Refer to Directive 1999/92/EC

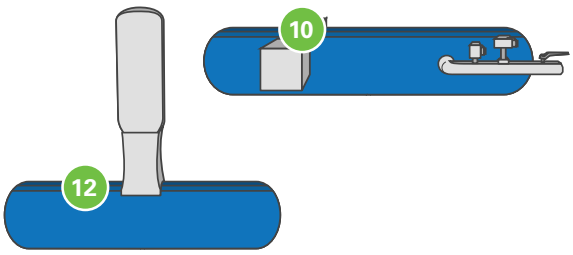
Note: If there is a gas explosion risk, we recommend to consult Donaldson.

EXAMPLES OF EXPLOSION/FIRE PROTECTION COMPONENTS FOR DUST COLLECTORS

1. Explosion Relief Panel
2. Detector / Sensor – Chemical or Actuated System Devices
3. Chemical Suppressant Delivery Device
4. Fire Extinguisher / Fire Suppression / Sprinkler Coupling
5. Sprinkler Overflow Drain
6. Rotary Valve / Airlock
7. Flameless Venting







8. Explosion Isolation Valve - Inlet
9. In-line Pre-Separator
10. Spark Detection & Extinguishing System
11. Actuated Knife Gate - Inlet / Automatic Fast-Acting Gate
12. Chemical Isolation Device - Inlet

			Some Components of Risk Management Strategies for:	
		Item #	EXPLOSION	FIRE
FIRE PROTECTION/SUPPRESSION				
Fire Extinguisher / Fire Suppression / Sprinkler Coupling		4		✔
Sprinkler Overflow Drain		5		✔
Automatic Fast Acting Abort Gate		10		✔
In-linePre-Separator		8		✔
Spark Detection & Extinguishing System		9		✔
EXPLOSION PROTECTION/SUPPRESSION				
MECHANICAL	Explosion Relief Panels	1	✔	
	Flameless Venting	12	✔	
CHEMICAL	Chemical Suppressant Delivery Device	3	✔	
	Detector / Sensor – Chemical or Actuated System Devices	2	✔	
DUST COLLECTOR ISOLATION				
INLET				
MECHANICAL	Actuated Knife Gate – Inlet	10	✔	
	Explosion Isolation Valve – Inlet	7	✔	
CHEMICAL	Chemical Isolation Device – Inlet	11	✔	
	Detector / Sensor – Chemical or Actuated System Devices	2	✔	
HOPPER				
	Rotary Valve / Airlock	6	✔	✔

DEFINITIONS (EN 13237:2012)

The process owner is responsible for the selection of your combustible material management strategy and to assure compliance with all applicable European Union directives, codes and standards.

NOTIFIED BODY

an organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

A_V
(Vent Area)

ratio of required vent area A and venting efficiency Ef for the venting device [m^2].

P_{RED}
(Reduced Pressure)

resulting explosion overpressure generated by an explosion of an explosive atmosphere in an enclosure, after effective explosion venting or explosion suppression [bar].

K_{ST}
(Deflagration Index for Dust)

dust specific, volume independent characteristic which is calculated using the cubic law equation [bar m/sec] it defines the severity of the explosion of a combustible dust.

P_{MAX}
(Maximum Pressure)

maximum overpressure generated by an explosion of an explosive atsmosphere in an enclosure, after effective explosion venting or explosion suppression [bar].

P_{STAT}
(Static Activation Pressure)

the pressure that activates a vent closure when the pressure is increased slowly (with rate of pressure rise less than 0.1 bar/min) [bar].

TSP
(Total Suppressed Pressure)

pressure in an enclosure after a suppressed event.

COMBUSTIBLE DUST

dust able to undergo an exothermic reaction with air when ignited.

EXPLOSION

the bursting or rupturing of an enclosure or container due to the development of internal pressure from a deflagration.

HYBRID MIXTURE

mixture of a flammable gas or vapor with combustible dust.

LEL
(Lower Explosion Limit)

dust specific, lowest concentration of the explosion range at which an explosion can occur.

UEL
(Upper Explosion Limit)

dust specific, highest concentration of the explosion range at which an explosion can occur.

MIE
(Minimum Ignition Energy)

dust specific, lowest electrical energy stored in a capacitator which upon discharge is sufficient to effect ignition of most ignitable atmosphere under specified test conditions.

TEMPERATURE CLASS

classification of equipment, protective system for explosive atmospheres based on its maximum surface temperature.

or

classification of flammable gases and vapours based on their auto ignition.

Check 1999/92/EC & 2014/34/EU directives for more information.

Non-exhaustive list of examples of the relevant standards, codes & guidelines that impact dust collector decisions:

INDUSTRY AND APPLICATION SPECIFIC STANDARDS (1999/92/EC)

EN 1127-1

Explosive atmospheres
Explosion prevention and protection: Part 1
Basic concepts and methodology

EN 60079-10-1

Explosive atmospheres- Classification of areas- Explosive gas atmospheres

EN 60079-10-2

Explosive atmospheres- Classification of areas- Combustible dust atmospheres

EN 60079-0

Explosive atmospheres- Equipment- General requirements

EN 13237

Potentially explosive atmospheres-Terms and definitions- for equipment and protective systems intended for use in potentially explosive atmosphere

DESIGN STANDARDS (2014/34/EU)

EN 14373

Explosion suppression systems

EN 14491

Dust explosion venting protective systems

EN ISO 80079-36

Explosive atmospheres- Part 36: Non-electrical equipment for explosive atmospheres- Basic method and requirements

EN 14797

Explosion venting devices

EN 14986

Design of fans working in potentially explosive atmospheres

EN 15089

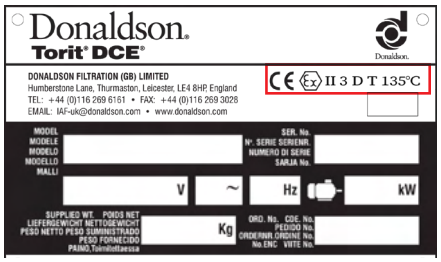
Explosion isolation systems

Many standards and codes may influence your decisions on dust control, including local, state, and European regulations. Knowing the regulations that apply to your facility is critical, and you should always research the regulation requirements in your area. A few commonly referenced standards for combustible dust risk management strategies include those issued by: ATEX, VDI, DSEAR, CRAM, DIN, EN, INERIS, etc.

Since each authority having jurisdiction may have a specific set of codes it references, you may need to have general knowledge of more than one standard or code. Some of the most commonly referenced standards are published by the European Union, including both design and operational standards focused on combustible dust (see above).

Since these standards are often cited by authorities, and have been adopted as code in many areas of Europe, they can be a good starting point for consideration in developing your combustible dust management strategy.

HOW DO YOU KNOW A PRODUCT IS ATEX CERTIFIED?



Hops (malted)

CE 0891 Ex II 3 D IIC T135°C

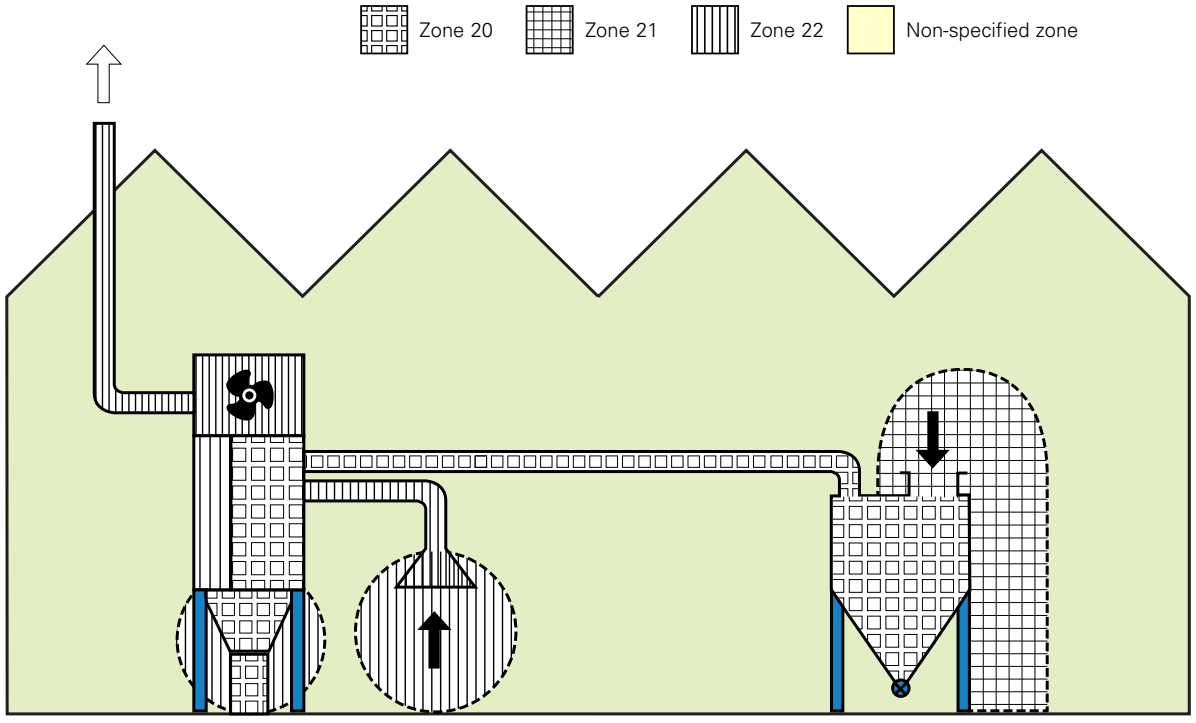
- 0891 — Notified Body Number (if applicable)
- CE — Specific marking for explosion protection
- II — Equipment group: I = mining II = above ground
- 3 — Equipment category 1, 2 or 3
- D — Suitable for dust (gases would be 'G')
- IIC — Equipment gas group, ie IIA IIB or IIC
- T135°C — Maximum surface temperature, (For gas atmospheres, temperature is shown as T rating or value).

T1	450°C
T2	300°C
T3	200°C
T4	135°C
T5	100°C
T6	85°C

IIA	least sensitive
IIB	medium
IIC	most sensitive

TYPICAL ZONING

(See EN 60079-10-2 for more details)



FREQUENTLY ASKED QUESTIONS

VENT TO ATEX ZONE?

Goal of ATEX is to eliminate all ignition sources where possible. Venting represents an additional ignition source, albeit due to rare malfunction. Therefore, venting to an ATEX zone should be avoided wherever possible. It is however permitted into Zone 22 and 21. The important requirement is that, it is the responsibility of the end user to formally assess the risk and make the final decision, which should be recorded in their Explosion Protection Document.

ZONING INSIDE DUST COLLECTOR – WHO IS RESPONSIBLE?

Zoning and the associated risk is influenced by how the dust collector is used, therefore zoning is always the responsibility of the end-user. There are numerous examples given in various EN standards to help end-users with their assessment.

WHEN A DUST COLLECTOR IS HANDLING A DUST THAT HAS THE POTENTIAL TO BE EXPLOSIVE, WHAT ZONES ARE USUALLY GIVEN TO THE DIFFERENT INTERNAL AREAS OF THE DUST COLLECTOR?

The dirty air plenum is typically considered a zone 20, and the clean air plenum is usually considered a Zone 22. Consequently, equipment fitted to these areas is classified as Cat 1D and Cat 3D respectively. Examples and explanations are given in EN 60079-10-2.

WHY DOES MY REINFORCED UNIT THAT IS HANDLING EXPLOSIVE DUST INTERNALLY, NOT HAVE ATEX MARKING?

In summary, ATEX covers the placing of equipment in an external ATEX classified zone, and only equipment with an ATEX zone externally requires marking. The potentially explosive atmosphere inside the dust collector is not covered by the requirement for ATEX marking. A more detailed explanation with examples of possible specification options is given in this document.

DONALDSON TESTS AND EVALUATES THE PERFORMANCE OF ITS DUST COLLECTORS IN THIRD-PARTY FIELD TESTS.

The image on the right represents a reinforced dust collector safely handling combustible dust explosion during a field test conducted at an independent research facility.

HAVE QUESTIONS ABOUT COMBUSTIBLE DUST? WE CAN HELP!

Donaldson can help you review your combustible dust mitigation strategy and choose the right dust collection configuration with our specific product offerings for fire and explosion prevention and protection solutions. We will work with you to identify different options and implement a customized dust management solution unique to your requirements.

Contact us to discuss a mitigation solution that fits your needs and learn more at **DONALDSON.COM/COMBUSTIBLE-DUST**

Donaldson
FILTRATION SOLUTIONS

Why Choose Donaldson?

Backed by more than 250,000 global installations over three decades, and a selected network of partners, no other manufacturer is more capable – or more trusted – to solve your dust, fume and mist collection challenges than Donaldson.

We offer a wide variety of solutions to reduce your energy costs, keep production at peak performance and at the lowest total cost of ownership.

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