BRCGS

Global Standard
FOOD SAFETY

UNDERSTANDING AIR QUALITY IN FOOD PRODUCTION

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Contents

Introduction

The food and beverage industry is well regulated and there are strict controls on how manufacturing facilities must operate to ensure that food is produced free of contaminants and safe to consume.

Air quality and hygiene are paramount to ensure both the safety of food production and for the environment for staff working in food and beverage facilities. However, there is little guidance on what air quality is required in these facilities and what specification or classification of air filtration is needed to achieve it. This document will assist sites in carrying out internal risk assessments and provide the key facts that should be considered.

This publication has been written with reference to the Eurovent 4/23 standard which defines the recommended air filtration efficiencies dependent on application and outdoor air quality. Eurovent is Europe's industry association for indoor climate, process cooling, and food cold chain technologies. Its members from throughout Europe represent more than 1,000 companies, who provide independent standards for the industry. It also gives guidance surrounding the change in air filter classifications from the old EN 779:2012 standard to the current EN ISO 16890-1:2016. The standards provide clear, independent advice regarding what filtration efficiencies are needed for most industrial applications, including the food and beverage industry.

This publication will help you to define your outside air quality, the supply air category to achieve, and identify the right filter choices for your facility.

There are four stages to air filtration within a production facility:
First stage - which is typically used to filter out coarse or larger particles
Second stage - is used to remove fine particles.
Third stage - used where the process within the manufacturing area requires a high degree of cleanliness or a cleanroom is present.
Fourth stage - if required, would utilise molecular filters to remove presence of nuisance/irritant or toxic odours.

The guidance is aimed at individuals and teams responsible for food production facilities, sites seeking more information on sections of the BRCGS Global Standard Food Safety, or anyone tasked with reviewing and assessing current filtration and air quality within their site.

Air quality standards in food manufacturing

ISO 16890-1:2016, Eurovent 4/21-2019 and Eurovent 4/23-2022 are all internationally recognised standards. By using these standards a site can ensure that ventilation systems provide the quality of air necessary for food and employee safety and that the outdoor air quality is taken into account when specifying the correct air filter.
The standards are:

- **EN ISO 16890-1:2016** *Air Filters for General Ventilation – Part 1: Technical Specifications*, requirements and classification system based upon particulate matter efficiency.

  This standard provides an overview of test procedures, specific requirements for assessing and marking the filters and documenting the results. It refers to particulate air filter elements for general ventilation.

- **Eurovent 4/21-2019** *Energy Efficiency Evaluation of Air Filters for General Ventilation Purposes.* The aim of this standard is to certify filters based on their annual energy consumption. This is determined by a laboratory test procedure which can be the basis for an energy efficiency classification. The classification gives users guidance on the right filter to choose while ensuring full compliance with filtration standards.

  This standard ensures clear classification of filters which are rated for their efficiency at ePM1/ePM2.5 and ePM10 and awarded an energy classification between A+ and E.

  A product that is compliant with Eurovent 4/21 will come with specific Eurovent approved labelling on the box and as well as having a label on each filter. If you have any concerns the filter supplier must provide you with the independent test report for their products but they can also be verified at the Eurovent website.

- **Eurovent 4/23-2022**: *Rated Air Filter Classes for General Ventilation Application.* This standard provides guidance on selecting filters that are compliant with ISO 16890:2016. Guidance is based on the outdoor air quality while considering the environment applicable to the manufacturing process.

  The Eurovent 4/23-2022 standard also gives guidance on the performance of ventilation systems and the requirements for ensuring the required air quality is achieved. It provides a clear link to the quality of the air outside and the air inside the facility.

  When selecting air filters for your facility to be complaint with Eurovent 4/21 you should always ensure that the filters you are selecting are compliant with current air filtration standard ISO 16890-1:2016. The filters should carry the Eurovent labelling both on the physical product itself and on the packaging. It is also beneficial from a sustainability perspective to select filters that have an A or A+ energy rating.

Other air quality standards

- The EU's ATEX directives describe the minimum safety requirements for workplaces and equipment used in explosive atmospheres. **ATEX Directive 2014/34/EU** covers equipment and protective systems intended for use in potentially explosive atmospheres.

- **EN 1127-1** is a standard under the ATEX directive. This standard specifies methods for the identification and assessment of hazardous situations leading to explosion and the design and construction measures appropriate for the required safety levels.

- **EN 60079-10-2** is the standard concerned with the identification and classification of areas where explosive dust atmospheres and combustible dust layers are present, in order to permit the proper assessment of ignition sources in such areas.

- **EN 80079-36** *Explosive Atmospheres*. This standard specifies the basic method and requirements for design, construction, testing and marking of non-electrical Ex equipment, Ex Components, protective systems, devices and assemblies of these products that have their own potential ignition sources and are intended for use in explosive atmospheres.

- **EN 14460** specifies requirements for explosion resistant equipment which will be able to withstand an internal explosion without rupturing and will not give rise to dangerous effects to the surroundings.

Outdoor air quality

Air filtration efficiency within the facility should be based on two factors: outdoor air quality (referred to as ODA) and supply air quality. By understanding the outdoor air we can then select the filter that will provide the optimum safety for supply air (referred to as SUP) within a manufacturing facility while also referencing optimum sustainability based on the filters energy rating.

The quality of air outside a production facility is affected by pollutants such as car exhausts, factory emissions, pollen and road dust. Pollutants in the atmosphere are made of microscopic particles. The particles, known as particulate matter (PM), are the main contributor of air pollution.

EN ISO 16890-1:2016 splits outdoor air quality into three categories. These are based on the World Health Organization (WHO) annual mean limits for particle sizes of 2.5 µm and 10.0 µm:
- Annual mean for particulate matter $PM_{2.5}$ <5 $\mu g.m^{-3}$
- Annual mean for particulate matter PM_{10} <15 $\mu g.m^{-3}$

The limits are used as the basis for establishing the three ODA categories:
- **ODA1** Applies where the WHO guidelines and any national air quality standards or regulations for outdoor air are fulfilled (i.e. $PM_{2.5}$ <5 $\mu g.m^{-3}$ and PM_{10} < 15 $\mu g.m^{-3}$)
- **ODA2** Applies where pollutant concentrations exceed the WHO guidelines or any national air quality standards or regulations for outdoor air by a factor of up to 1.5 (i.e. $PM_{2.5} \leqslant 7.5$ $\mu g.m^{-3}$ and $PM_{10} \leqslant 22.5$ $\mu g.m^{-3}$)
- **ODA3** Applies where pollutant concentrations exceed the WHO guidelines or any national air quality standards or regulations for outdoor air by a factor greater than 1.5 (i.e. $PM_{2.5}$ >7.5 $\mu g.m^{-3}$ and PM_{10} >22.5 $\mu g.m^{-3}$).

How to establish outdoor air quality

Governments and environmental authorities around the world monitor air quality and the data for this can normally be found on a national or regional government website. For example, in Europe it is available on the European Environment Agency website.

Supply air quality categories

Food and beverage manufacturing facilities operate a process zoning structure to mitigate against the risk of cross contamination. Each zone within a facility may require a different stage of filtration and air quality supply The zones are:

Non-product zones

These are areas that have no food contact. These areas are often people occupied areas such as offices, meeting rooms and common areas. Air quality is important to ensure the health and wellbeing of staff.

Low risk zones

An area with emphasis on hygiene and prevention of foreign body and allergen contamination but where the pathogen risk is low.

High-care zones

An area designed to a high standard where practices relating to personnel, ingredients, equipment, packaging and environment aim to minimise product contamination by pathogenic micro-organisms.

High-risk zones

A physically segregated area, designed to a high standard of hygiene, where practices relating to personnel, ingredients, equipment, packaging and environment aim to prevent product contamination by pathogenic micro-organisms.

The Eurovent 4/23 standard outlines five supply air categories that define the quality of air needed for any particular zone or facility. These are:

- **SUP1** Zones with high hygiene demands for supply air such as controlled environments, hospitals, pharmaceuticals and electronics industries.
- **SUP2** Zones with medium hygiene demands, including food and beverage production (highlighted in green in Table 1). SUP2 refers to supply air with concentrations of particulate matter which fulfil the limit values stipulated by WHO (2021) guidelines multiplied by a factor of 0.5 (i.e. annual mean for $PM_{2.5}$ is ≤2.5 µg.m^{-3} and for PM_{10} is ≤7.5 µg.m^{-3}).
  SUP3 Zones with basic hygiene demands, including low-risk food and beverage production (highlighted in green in Table 1).
- **SUP3** refers to supply air with concentrations of particulate matter which fulfil the limit values stipulated by WHO (2021) guidelines multiplied by a factor of 0.75 (i.e. annual mean for $PM_{2.5}$ is ≤3.75 µg.m^{-3} and for PM_{10} is ≤11.25 µg.m^{-3}).
- **SUP4** Zones without hygiene demands such as general production areas (e.g. automotive).
- **SUP5** Production areas of heavy industry such as steel mills, smelters and welding plants.

Use Table 1 from Eurovent 4/23 to compare ODA and SUP values to identify the appropriate filter.

Outdoor air			Supply air				
			SUP1	SUP2	SUP3	SUP4	SUP5
			$PM_{2.5}$ ≤1.25 µg.m^{-3} PM_{10} ≤3.75µg.m^{-3}	$PM_{2.5}$ ≤2.5 µg.m^{-3} PM_{10} ≤7.5 µg.m^{-3}	$PM_{2.5}$ ≤3.75 µg.m^{-3} PM_{10} ≤11.25 µg.m^{-3}	$PM_{2.5}$ ≤5 µg.m^{-3} PM_{10} ≤15 µg.m^{-3}	$PM_{2.5}$ ≤7.5 µg.m^{-3} PM_{10} ≤22.5 µg.m^{-3}
Category	**$PM_{2.5}$**	**PM_{10}**	**ePM_1***	**ePM_1***	**$ePM_{2.5}$***	**ePM_{10}***	**ePM_{10}***
+ODA1	<5 µg.m^{-3}	<15 µg.m^{-3}	70%	50%	50%	50%	50%
ODA2	≤7.5 µg.m^{-3}	≤22.5 µg.m^{-3}	80%	70%	70%	80%	50%
ODA3	>7.5 µg.m^{-3}	>22.5 µg.m^{-3}	90%	80%	80%	90%	80%

Table 1 Filter efficiencies required based on ODA and SUP values (recreated with permission from Eurovent)

* Denotes minimum final filter stage efficiency as per ISO 16890-1: 2016 (see section 3 for further information).

Based on the supply air categories, low-risk production and storage areas within a food factory require a supply air category of SUP3 with minimum filter efficiencies as detailed in Table 1. Anything above low risk/hygiene requires a supply air category of SUP2.

Minimum filter standard requirements in a food production facility

It is highly unlikely that a filter will ever come into direct contact with the food products in a manufacturing facility. However, the air that passes through the filter will do so. Because of this incidental product contact, you should consider the materials from which the filters are manufactured. They must be safe, and any off-gassing or shedding from the various materials must not impact the safety of the food or taint its smell or taste.

Most manufacturers offer a range of products of varying specifications, some of which are tailored for particular industry segments, including food and beverage. Therefore, wherever possible, you should confirm the following when selecting a product:

- Has the filter been tested to the latest international standard, ISO 16890-1:2016? The supplier should be able to confirm this with an official independent test certificate. This is the only way to ensure that the filtration used actually provides the correct level of protection and is of the required specification.
- Does the product have specific certification or independent testing that confirms its suitability and safety for use within food and beverage facilities? Examples include:
  - Food contact materials – Regulation (EC) 1935/2004 (or similar; this confirms its suitability for food contact)
  - VDI 6022: hygienic standards for ventilation and air conditioning systems (this gives guidelines on confirming hygienic design)
  - ISO 846:1997 – Plastics – Evaluation of the action of microorganisms (this confirms materials to be microbially inert).

Testing and classification standard for air filtration

ISO 16890-1:2016 represents how air filters are tested to ensure that the efficiency test result better represents the efficiency obtained when filters are used in real-life applications. The standard provides an intuitive and transparent filter classification system. Finally, because this is an international standard, the same classification system will be used and recognised globally.

For a site, the most important aspect is to understand the classification system. The grades G1 to F9 from the withdrawn EN 779:2012 are **no longer in use** therefore people should refrain from using filters that are still using this certification.

ISO 16890-1:2016 establishes an efficiency classification system of air filters for general ventilation based upon particulate matter efficiency (referred to as ePM). This classification system reports a simpler percentage efficiency than EN 779:2012 within one of four particle size ranges:

- **ePM_1** Filter efficiency for particle size range 0.3–1 μm
- **$ePM_{2.5}$** Filter efficiency for particle size range 0.3–2.5 μm
- **ePM_{10}** Filter efficiency for particle size range 0.3–10.0 μm
- **ISO coarse** Gravimetric filter arrestance for filters not able to achieve minimum 50% efficiency at ePM_{10}.

For each of the ePM ranges above, the filter efficiency will be reported as a percentage from 50% to 95% in 5% increments. Note that the efficiency has to be a minimum of 50% or the filter will be reported in the next particle size range (e.g. if a filter achieves an efficiency of less than 50% for ePM1 then the $ePM_{2.5}$ percentage efficiency will be reported for that filter).

Simply put, if a filter has a classification of ePM_1 = 70%, this means the filter has been tested and found to remove 70% of particles in the range 0.3–1.0 μm.

For ISO coarse, the efficiency of the air filters are reported in 5% increments (from 50% to 95%).

Filter specification

Supply air filter selection – what are the risks?

When carrying out a risk assessment to establish the efficiency of any air filtration used, a site should consider what it is trying to protect the process from. To do this, it needs to understand which airborne contaminants represent a threat and what filter efficiency is needed to provide reasonable protection.

Pathogens

Pathogens on their own are not an airborne threat, they are extremely small and can easily be carried on microscopic detritus and moisture droplets. *Legionella*, for example, is well known for being spread by poorly maintained ventilation equipment. However, *Legionella* is not airborne on its own; it requires a means of transport and this is normally moisture droplets from within the air handling unit. Other pathogens such as *Salmonella* are able to survive for long periods in dry conditions and because of this, they can be carried on very small dust particles and spread through the air. It is therefore imperative that the ventilation system is maintained in a hygienic condition and that the air filtration used provides protection from particles that can potentially carry micro-organisms.

Typical pathogen sizes are as follows:

- *E. coli* 0.2–1.0 µm
- *Salmonella* 0.5–1.5 µm
- *Listeria* 0.2–6.0 µm

Mould spores

Mould spores also need to be controlled but they tend to be larger than the pathogens discussed above.

Using the information in Section 2 and knowledge of the risks from which products need to be protected, a site should now be able to specify the filter efficiencies suitable for their facility.

Final filter efficiencies for food and beverage production facilities

The efficiencies given in Table 2 detail the minimum efficiency of the second or final stage of filtration in a supply ventilation system.

Risk/hygiene level	**ODA1**	**ODA2**	**ODA3**
Low risk/basic hygiene	$ePM_{2.5}$ = 50%	$ePM_{2.5}$ = 70%	$ePM_{2.5}$ = 80%
High care/high hygiene/high risk	ePM_1 = 50%	ePM_1 = 70%	ePM_1 = 80%

Table 2 Minimum required supply particle air filter efficiencies based on ODA

By using a filter with a classification as highlighted in green in Table 2, you can be confident that you are protecting your facility against critical contaminants by removing 70% or 80% of particulate between 0.3 and 1.0 µm.

Table 2 details the final filtration efficiency that should be used. To ensure that these filters provide maximum service life and a cost-effective solution, they should be protected by a suitable pre-filter. The minimum recommended efficiency for this filter is ISO coarse 65%.

It is also crucial to consider the installation of the filters selected. Poorly fitting filters and filter frames can allow unfiltered air to reach the food production area. When fitting the filters, you should ensure that there is no opportunity for air to bypass the filter stage because of either the condition of the air handling unit (AHU) and the filter frames or incorrectly sized filters.

It may also be necessary to consider further stages of filtration, including high-efficiency particulate air and molecular filtration.

HEPA filters

High-efficiency particulate air (HEPA) filters offer further protection from microbial contamination for very sensitive uses. For example, some aseptic filling facilities now require the surrounding air to meet a minimum specification and even reference the clean room specifications detailed in ISO 14644. Some manufacturers of aseptic filling equipment specify ISO Class 8 as a minimum requirement. Where such guidance is given, it is relatively straightforward to specify a suitable HEPA filter that will achieve ISO Class 8 (this assumes that the ventilation system and room itself are adequately designed and engineered).

HEPA and efficiency particulate air (EPA) filters may also be deemed necessary following a risk assessment for certain applications within the food industry. Minimum efficiencies may be specified by a customer, in which case, sites are recommended to ask their air filtration manufacturer for guidance on a suitable level of filtration.

HEPA filters are tested in a completely different way from other filters. When purchasing this type of filter, a site must ensure that it has been tested to BS EN 1822:2009 before it leaves the factory. An individual test certificate must be supplied with each filter detailing that each one has been individually tested. It is recommended that HEPA filtration is integrity-tested after installation and then on a periodic basis as per ISO 14644. This will ensure that the tested efficiency is being achieved in practice.

Supply air carbon/molecular filters

To be able to evaluate correct and adequate molecular filtration solutions as they are needed, both for air intake as well as exhaust air, the ISO 10121-2 test standard provides performance testing of complete molecular filtration solutions in relation to critical installation parameters such as concentration of target molecules, relative humidity and airflow volume. Certain contaminants are not present in the air as particles and can only be captured by a physical barrier. Pollutants such as nitrogen oxides (NOx) and sulphur oxides (SOx) that are present as gaseous molecules, particularly in urban environments, may require carbon filtration to achieve the required air quality standard within WHO air quality guidelines.

Table 3 details the cases when carbon/molecular filtration is likely to be required or deemed necessary to ensure suitable air quality.

	Supply air quality				
Outdoor air	**SUP1**	**SUP2**	**SUP3**	**SUP4**	**SUP5**
ODA1	Recommended				
ODA2	Required	Recommended			
ODA3	Required	Required	Recommended		

Table 3 Recommended and required carbon filter use

Carbon/molecular filtration can be installed as a third-stage dedicated carbon filter or as a second stage that provides a combined specification for both ePM (as in Table 2) and molecular filter capability.

It is recommended that any carbon filters used are tested to ISO 10121-2:2013, thus ensuring that their efficiency has been independently verified.

Exhaust and recirculation air molecular filtration

Molecular contaminants are not only coming from the environment surrounding a production facility. They can also be generated by the production processes or by raw materials. Considering the potential negative effects created by these different sources of molecular contaminants, which range from nuisance odours to irritation or "intoxication", it is important to treat the air that is recirculated inside and or exhausted out to atmosphere.

Food and beverage production is a clean process that usually requires aseptic conditions. In certain applications, these aseptic conditions are achieved through the use of sterilants/disinfectants which are used to either clean workshops, production lines or packaging.

Hydrogen peroxide (H2O2) or peracetic acid (CH3C03H) are two disinfectants used for cleaning that maintain aseptic conditions but they can be unpleasant to use. They come with a strong vinegar smell and can cause irritation to eyes and respiratory tract.

It is therefore important to prevent the diffusion of molecules from these cleaners into the environment. Molecular filtration should be considered in the recirculation air system or localised air purification solutions. When properly designed and selected, molecular filters will be able to mitigate contamination and maintain good air quality.

Ethylene Oxide (also known as EO or EtO) is sterilant that is sometimes used to disinfect seeds and spices and can result in concentrations in the raw materials/ingredients to be processed. When the oxide is outgassed from the raw material it creates molecular contamination that could affect those who come into contact with it. General food production may generate some strong odours which, depending on the ingredient, can be perceived as a nuisance.

A properly designed molecular filtration solution, via a recirculation system, can help to mitigate ethylene oxide contamination within the premises. It can also be used to treat the exhaust air in order to protect the wider environment.

The diverse amount of molecular contaminants found in the food and beverage industry means it is important to select the right filtration media (i.e. activated carbon, impregnated carbon, impregnated alumina) but also to assess the performance of the solutions. Performance should be assessed using recognised standards such as ISO 10121 (parts 1 and 2) or ANSI/ASHRAE 145 (parts 1 and 2).

Extraction of dust from food and beverage processes

Dusts produced when manufacturing and processing food products create a number of significant challenges. Dust particles often become airborne, which can have an impact on health, degrade machine reliability and cause fires or dust explosions. Food dust particles vary in size, and some are so fine they are not visible to the naked eye.

It is essential for manufacturers to control the dusts generated in food and beverage manufacturing facilities that can:

- cause serious harm to human health and negatively impact the environment
- increase maintenance cost and cause unplanned stops
- cross-contaminate and proliferate the spread of pathogens and allergens

- become combustible and cause the kinds of devastating fires and dust explosions that harm workers, damage machinery, and destroy buildings and corporate reputations.

Preventing cross-contamination

Regular exposure to certain types of fine dust particles can produce minor allergic reactions on the skin. Conditions such as dermatitis are uncomfortable and require treatment and protective work wear however the respiratory issues that dust allergens can cause is far more serious. The finest dust particles become airborne easily and penetrate deep into the lungs if inhaled. They can cause life threatening conditions such as asthma or chronic health issues including lung cancer.

In the US, the Occupational Safety and Health Administration has regulations that govern employers whose processes generate dust and they will issue citations and fines for lack of compliance. Food industry employers are required to protect workers from exposure, and each food or beverage manufacturing application will have its own unique set of process conditions. Under these regulations, companies must control dust emissions into the indoor workplace atmosphere to comply with legal limits set for a particular material.

Travelling dust in a food processing plant can result in a pathogen outbreak from the spread of micro-organisms or allergen exposure. Preventing cross-contamination requires collecting and removing all contaminants before they become dispersed.

Primary and secondary filters

The best way to reduce exposure and cross-contamination from hazardous dusts is to install dust collection systems with good capturing devices and high-efficiency primary and secondary cartridge-style filters. Primary filter media should be selected for each application based on the dust, flow characteristics, and quantity. It is recommended that a HEPA filter be used in the primary filtration system or downstream as a secondary filter.

Secondary filters prevent hazardous dusts from discharging into the atmosphere and can be configured to prevent return air ducting contamination and the associated costs of cleaning hazardous dust leakage.

A wide, uniformly pleated filter allows the collected dust to release from the filter media, keeping the resistance lower through the filter for a longer time. When the pleats of the filter media are tightly packed, the reverse pulse cleaning system of the dust collector will not eject the dust that has settled in between the pleats. Tightly packed pleats increase the resistance of the air through the filters and diminish airflow. There are two basic categories of media commonly used in pleated cartridge filters. The choice is usually driven by dust type, operating temperatures and the level of moisture in the process:

- Nonwoven cellulosic blend media is the most economical choice for dry dust collection applications at operating temperatures up to 70°C.
- Synthetic polyester media or polyester-silicon blend is a lightweight, washable media that can handle dry applications with maximum operating temperatures ranging from 82°C to 129°C.

These filters are washable and can recover from a moisture excursion, but they are not intended for wet applications.

Standard and nanotechnology filter media treated with a flame retardant is recommended for applications considered a fire risk. Conductive or anti-static filters may be used where conveyed dusts generate static charges that require dissipation.

Cartridge filters with anti-static media shall also be used in explosive dust applications, lessen the risk of ignition sources due to static electricity charges. High-efficiency dust collection systems also use self-cleaning mechanisms that regularly pulse dust off the filters, allowing units to run longer between filter change-outs.

When a layer of nanofibers is applied on top of the base filter media, it promotes surface loading.

Combustible dust

Many solid food and beverage ingredients produce explosive dusts including sugar, starch, flour, spices, tea, grain and proteins. A dust explosion occurs when a confined and concentrated combustible dust cloud comes into contact with an ignition source. Good housekeeping and the installing of a well-designed dust collection system can prevent airborne dust from building up in the production area, on electrical equipment and on areas such as false ceilings. These measures help to negate the risk of a primary or secondary explosion. The primary explosion is the first point where an explosion occurs and is usually an isolated incident. A secondary explosion occurs when the primary explosion pressure disturbs any collected dust, creating a far more extensive and potentially deadly explosion.

In food manufacturing it is critical to know the explosive potential of the dusts, gases and dust/gas mixtures emitted during processing.

Recognising a dust hazard

The first step is to determine whether your dust is explosive as part of a hazard analysis. The ATEX Directive 2014/34/EU covers equipment and protective systems intended for use in potentially explosive atmospheres.

The EN14034 classifies dusts according to their explosibility, that is, their Kst values. Kst, also known as the dust deflagration index, is one of the parameters used to quantify the severity of a dust explosion. Kst is the normalised maximum rate of explosion pressure rise, measured in bar-meters per second.

Dust is rated in three classifications, from 1 – being the least combustible – to 3 – being the most combustible. Class ST1 dusts are rated below 200 Kst, Class ST2 dusts range from 200 to 300 Kst, and Class ST3 dusts are rated above 300 Kst. In addition to Kst, it is important to know other combustible dust properties such as Pmax (the maximum explosion pressure of a dust cloud, measured in bar), Pred (the maximum pressure developed in a vented enclosure during a vented deflagration) and MIE (minimum ignition energy).

These values may be determined following testing by authorised laboratory. A first estimation can be based on searching for similar materials previously tested, the results can be found in the GESTIS-DUST-EX database. A dust collection equipment supplier will need the Kst and Pmax values in order to correctly size explosion venting or suppression systems. MIE and ignition temperature data for the dust are needed to reduce the ignition risk and is also required for to validate what protective systems that can be used. Failure to provide this information is likely to increase your project costs, since the supplier will have to use worst-case estimates or may even refuse to provide the equipment. In addition to conducting explosibility testing to determine whether a dust is combustible, it is important to analyse other dust characteristics to determine the best dust collection system and filters for your food processing operation.

Other key dust properties to know include particle size, dust shape, gravity, moisture level and abrasiveness. Understanding these components leads to the optimal design of dust-control equipment.

In choosing dust control equipment consider standards such as EN 1127-1, or EN 60079-10-2. There are many standards that may be relevant depending on the situation and choice of equipment. Therefore it is important to work with a recognised professional company around this application.

Air filtration energy efficiency

The cost of running the ventilation system needs to be carefully considered. Ventilation systems within industrial facilities are among the largest consumers of energy and selecting the wrong type of filter can have a major impact on the total cost of running the system.
Air filters by their very nature and purpose provide a considerable resistance to the air flow; the fan therefore has

to move more air to be able to deliver the air flow required to the production area.

In recent years huge advances have been made in air filtration technology, in both the design of the filters and the advanced filter media now being produced. Air filter products should be supplied with data highlighting their energy efficiency. In Europe, for example, most filters are tested independently by Eurovent.

Air filters that are rated high (A to A+) for energy efficiency also tend to bring significant benefits in terms of service life. This can reduce the overall cost of running a system and save you money as well as providing reassurance that the technology used will deliver the required air quality. You should only use a filter that has been independently tested in accordance with Eurovent 4/21 and for which independent certification is available for both filtration and energy efficiency.

Many filter manufacturers have developed software that can provide accurate data for energy use, expected service life and total or lifecycle costs. Working with a supplier that can offer this assistance may provide significant cost savings and other benefits to the business.

Ideally, all motors with ventilation equipment should be fitted with inverters to give efficient control and flexibility. Any changes or upgrades to air filtration systems should be carried out along with performance measurement to prevent any negative impact on the operational performance of the ventilation system.

Maintenance, condition and hygiene monitoring

This section gives guidance on best engineering practice with regard to the ongoing maintenance, condition and hygiene monitoring of ventilation equipment. By following this advice when selecting filtration, you will give the ventilation system a comprehensive protection system to minimise contamination, hygiene issues and associated breakdown time.

Condition and hygiene monitoring to identify and resolve any issues will help to ensure that the ventilation equipment operates in a compliant and efficient way. This will protect both your product and your employees from any potential contamination hazards associated with poorly maintained ventilation equipment. Monitoring will also ensure that the equipment operates in the most cost-effective way through energy and waste reduction, and increased filter life and reliability, thus reducing the need for unplanned maintenance and associated downtime.

When you formulate a maintenance regime, consider the following points:

- Establish a routine filter monitoring regime. The frequency will be dictated by the filter type, location and duty. Routine monitoring of any pressure drop. The differential pressure (the pressure between two points, or Dp) should be measured along with visual condition assessments.
- Routinely monitor HEPA filter condition and pressure drop. In addition, HEPA filters should be integrity-tested in accordance with BS EN ISO 14644. The frequency of the integrity testing is outlined in BS EN ISO 14644 and is dictated by the room classification.
- Routinely monitor any drive belts to ensure that they are in good condition, correctly aligned and that tension is being maintained.
- Monitor fan and motor bearings by means of vibration analysis at suitable intervals.
- Regularly monitor vibration mounts to ensure they remain in good condition and have good vibration suppression characteristics.
- Regularly check all coils to ensure they are in good condition and clean. Coils should be steam cleaned as necessary.
- Regularly check all interior surfaces and components of the AHU for condition and cleanliness. Pay particular attention to identify potential sites of microbial growth and corrosion.
- Monitor the exterior condition of AHU for cleanliness, unit integrity (air leak paths) and signs of corrosion.
- Conduct regular visual checks to identify any sign of moisture and water pooling. If any signs are found, intervene immediately to identify the source and take corrective action.
- Check all AHU pressure gauges and calibrate them annually to ensure accuracy.
- Carry out ventilation hygiene risk assessments by an authorised provider to highlight any potential risks from the ventilation system. As a minimum, this should be carried out annually or as per any local guidance and regulation.
- Clean AHUs regularly (six-monthly at a minimum) to remove any build-up of loose debris etc.
- Carry out additional deep cleans as necessary (normally when a risk of microbial contamination has been identified or the unit is heavily contaminated).
- Monitor air intake screens regularly, and clean or replace them as necessary.
- Check all controls for correct operation.

All of the above could have a potential impact on product safety and quality or employee health. If the risk dictates, do not use the equipment until corrective action has been taken.

Filter change frequency

There are several criteria that can be used when deciding how frequently to change your filters. Industry best practice suggest using one of the two following options: when the pressure drops (see Table 4) or time interval (see Table 5). There will be a standard to actual reference the below in more detail EN13053 which will be released in 2023.

The site's filter manufacturer should be able to advise on the most cost-effective solution and help establish the best frequency.

Air pressure drop

Changing filters based on air pressure drop is the optimal solution from all aspects. It is cost-effective while ensuring that filtration performance is not sacrificed. By regularly monitoring the air pressure drop across the filters, you can order replacement filters in a timely manner. You will then have the products available when the maximum economical air pressure drop is reached and filter changes become necessary.

Advantages	Disadvantages
This is the most cost-effective solution as filters are changed only when they have reached the end of their life There is no risk that the filter will be used beyond its specification and thereby affect the integrity of the filter performance Downtime is reduced as the time between changes is maximised and maintenance downtime is minimised. Additionally, the associated waste is reduced The labour associated with changing filters is reduced Changing at the maximum economical pressure drop (Dp) as specified by the manufacturer will ensure that the filtration provides the most energy-efficient solution	The frequency may not fit with the planned maintenance schedules Regular monitoring is required to confirm the filter's condition

Table 4 Filter change based on filter pressure drop

Time intervals

The preferred solution (based on air pressure drop, as described in Table 4) is not always possible because of planned maintenance schedules and the of risk unnecessary, unplanned downtime. By using a hybrid of both options you can achieve the most cost-effective solution, minimising both the direct and associated costs of changing filters.

If you choose the filter technology with care you can maximise the filter life to provide the benefits associated with the air pressure drop approach. With careful monitoring of the filters you can plan accurately when to change them, so that the change coincides with scheduled site maintenance and shutdowns.

Advantages	Disadvantages
Filter changes are easy to plan and schedule	The filter may be changed before the end of its life, resulting in excessive filter costs Filters may be changed beyond their maximum recommended Dp. There is a danger of filter collapse and a subsequent risk to air quality Increased filter changes may be needed compared with Table 4, resulting in higher filter costs, increased downtime, and higher maintenance and waste costs

Table 5 Filter change based on time interval

Choosing the right filter supplier

Section 3.5.3 of the Global Standard Food Safety, covering management of suppliers of services, needs to be considered when choosing the right filter supplier. Sites must be able to demonstrate that where services are outsourced, such as filter supply, that the service is appropriate and any risks presented to food safety, authenticity, legality and quality have been evaluated to ensure effective controls are in place.

When choosing a filter supplier sites should ask:

- Is the supplier technically competent and able to provide support when needed? Air quality and filtration are complex subjects, and a supplier who can demonstrate a high level of technical support and guidance is invaluable.
- Do the filters carry labels from the manufacturer (not necessarily the supplier) that can be used to verify compliance once they have been fitted? All filters should carry such labelling.

Abbreviations

AHU	Air handling unit
DHC	Dust holding capacity. Air filter with dust holding capacity
Dp	Differential pressure or pressure drop – difference in pressure between one point and another
EPA	Efficiency particulate air (used in relation to filters)
ePMx	Particulate matter filter efficiency (where x represents particle size 1.0, 2.5 and 10 μm)
HEPA	High-efficiency particulate air (filter)
KST	Dust Deflagration Index - measuring a specific dust cloud's explosibility K is a mathematical shorthand for a 'constant'. ST stands for 'staub' – the German word for 'dust'.
MIE	Minimum ignition energy
MIT	Minimum ignition temperature
ODA	Outdoor air
PM	Particulate matter
RECIRC	Recirculation air systems
SUP	Supply air
UCV	Ultra-clean ventilation
WHO	World Health Organization

Glossary

Arrestance	The amount of test dust that a filter captures, measured by weight.
Filter efficiency	The arrestance effectiveness of particles captured by the filter media which is measured in percent.
Filter media	The material used to provide filtration in a filter.
High-care zone	A zone (or area) designed to a high standard where practices relating to personnel, ingredients, equipment, packaging and environment aim to minimise product contamination by pathogenic micro-organisms.
High-risk zone	A physically segregated zone (or area), designed to a high standard of hygiene, where practices relating to personnel, ingredients, equipment, packaging and environment aim to prevent product contamination by pathogenic micro-organisms.
ISO coarse	Filter grade classification.
Low-risk zone	An area where the processing or handling of foods presents minimum risk of product contamination or growth of micro-organisms, or where the subsequent processing or preparation of the product by the consumer will ensure product safety.
Microbiological prevention process	A process to prevent and control microbial growth.
Minimum ignition energy	The minimum amount of energy released at a point in a combustible mixture that caused flame propagation away from the point, under specified test conditions. The lowest value of the minimum ignition energy is found at a certain optimum mixture. Minimum ignition temperature - the minimum ignition temperature (MIT) is the lowest temperature of a hot surface that will cause a dust cloud, rather than a dust layer, to ignite and propagate flame.
Pred	The maximum pressure developed in a vented enclosure during a vented deflagration.
Pmax	The maximum explosion pressure of a dust cloud, measured in bar.
Pressure drop	The difference in pressure between one point and another.
Outdoor air quality	The measured level of air quality measured in Particulate matter 2.5UM and particulate matter 10um in accordance with WHO guidelines. Referred to as ODA.
Outgassing	The release of a gas that was dissolved, trapped, frozen, or absorbed in some material.
Particulate matter	Pollution made up of particles in the air. These particles may include dust, dirt or soot.
Supply air quality	The air that is supplied through a heating ventilation air conditioning system to a specific area within a building.

Sources of further information

BRCGS Standards

BRCGS Standards are a series of globally recognised standards for food and packaging manufacturers, agents, brokers, storage and distribution companies.

Global Standard Agents and Brokers
Global Standard Consumer Products
Global Standard Food Safety
Global Standard Gluten-Free
Global Standard Packaging Materials
Global Standard Plant-Based
Global Standard Retail
Global Standard Storage and Distribution

BRCGS guidelines and training

BRCGS publishes a series of best-practice guidelines on topics including complaint handling, pest control, internal auditing, product recall, traceability and foreign-body detection. We also provide over 65 interactive courses developed and delivered by experts across the world and aimed at auditors, certification bodies and food safety professionals.

Details of BRCGS publications, training, courses and events can be found at brcgs.com. Certificated sites can find copies of BRCGS publications on BRCGS Participate.

Camfil

As a leading manufacturer of premium clean air solutions, Camfil provides commercial and industrial systems for air filtration and air pollution control that improve worker and equipment productivity, minimise energy use and benefit human health and the environment.
www.camfil.com

VDI 6022: Hygienic standards for ventilation and air conditioning systems. Funk L, 1999. Air Infiltration and Ventilation Centre.

European standards

EN 1822-5:2019 High efficiency air filters (EPA, HEPA and ULPA). Determining the efficiency of filter elements, NSAI (2000)

EN13053:2020 Ventilation for buildings and air handling systems, SIST (2020)

Materials and articles intended to come into contact with food – Regulation (EC) 1935/2004, EU (2004)

ATEX Directive 2014/34/EU

EN 14460 : 2018 Explosion resistant equipment

EN13053 : Ventilation for buildings and air handling systems 2023 version – To be published 2023.

ANSI/ASHRAE 145 (part 1 and part 2)

Eurovent standards

Eurovent 4/21 – 2019 Energy performance classifications and certifications for filters that are compliant with ISO 16890:2016

Eurovent 4/23 – 2022 Selection of EN ISO 16890 rated air filter classes for general ventilation applications. Eurovent.

ISO standards

BS EN ISO 80070-36:2016 Explosive atmospheres, part 36

ISO 16890-1:2019 Air filters for general ventilation – Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM).

ISO 14644-1:2015 Cleanrooms and associated controlled environments – Part 1: Classification of air cleanliness by particle concentration.

ISO 846:2019 Plastics – Evaluation of the action of microorganisms.

ISO 10121-2:2013 Test methods for assessing the performance of gas-phase air cleaning media and devices for general ventilation – Part 2: Gas-phase air cleaning devices (GPACD).

World Health Organization

Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2021.

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