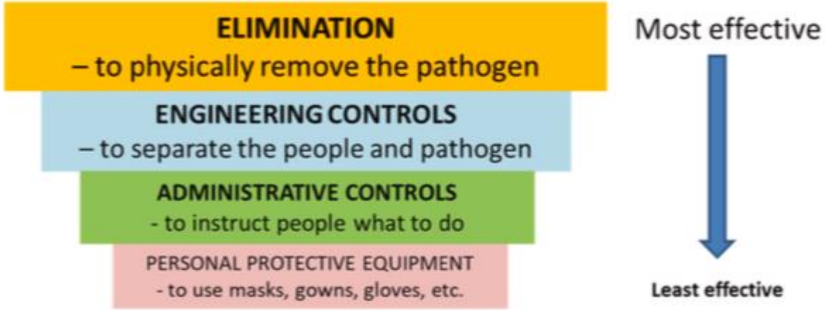
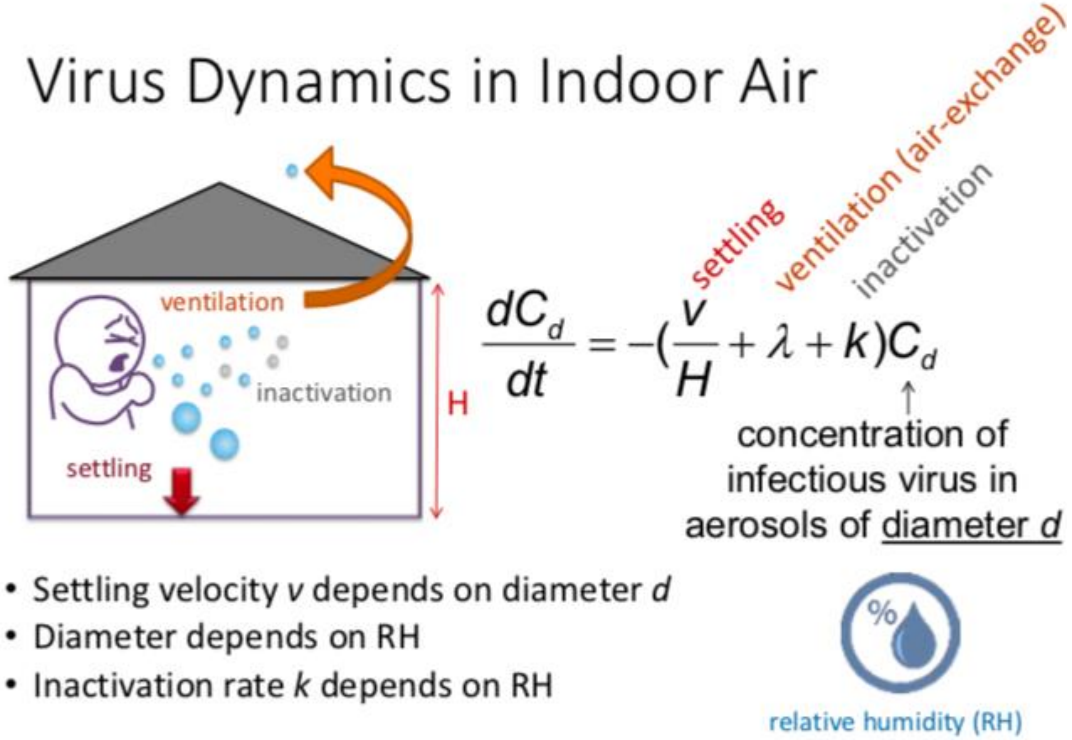
Engineering measures

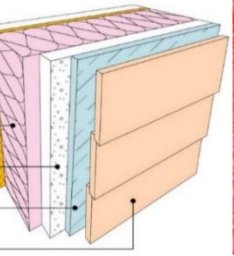


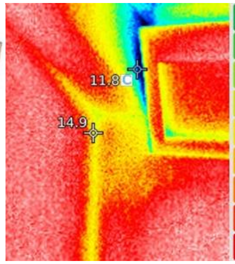
Traditional infection control pyramid adapted from the US Centers for Disease Control (CDC, 2015).

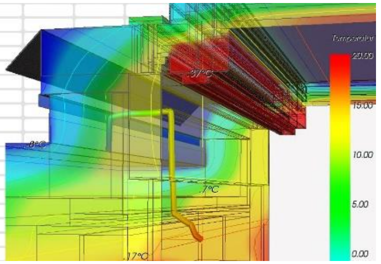


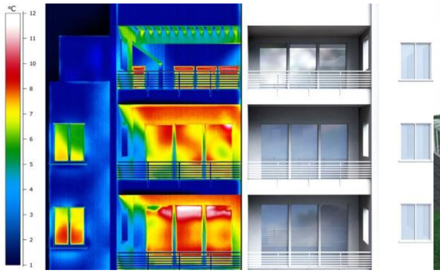
Ventilation, filtration and germicidal UV

Natural and mechanical ventilation









	Window Opening	Natural Ventilation	Mechanical Ventilation (VMC)
IAQ (Indoor Air Quality)	Renewal dependent on user	Renewal dependent on climate conditions	Controlled renewal
Energy Consumption	Equivalent to 1 air change per hour (but could be more)	Random, equivalent to 0.8-2 air changes per hour	Controlled
Comfort	- External noise - Air drafts	- External noise - Air drafts	- Guaranteed insulation - Guaranteed diffusion

- The ventilation of environments serves to maintain comfortable air quality in spaces through air exchange.
- Ventilation is the (intentional) movement of air due to natural phenomena or automated systems that are directly controllable.
- In the first case, it is called natural ventilation, generated by wind or other related factors. In the second case, it is called mechanical (controlled) ventilation.
- The advantage of natural ventilation lies in the fact that, with appropriate building design, its management is very economical and more suitable for non-working environments.
- The advantage of mechanical ventilation is that it can guarantee performance when required and is therefore more suitable for working environments.

The air exchange rate is necessary to maintain a comfortable environment because it ensures the presence of "clean" air and helps control the humidity level within the environment. The air exchange rate should be aligned with the air needs of the people in a given environment or the volume of the space itself, depending on the purpose of the space. It is important to ensure:

- A specific number of air changes per hour
- Good air quality
- Proper air distribution (no short-circuiting, no stagnant areas).

The hourly air exchange rate is defined by the ratio between the airflow rate q_v (in m^3/h) and the total net volume of the space:

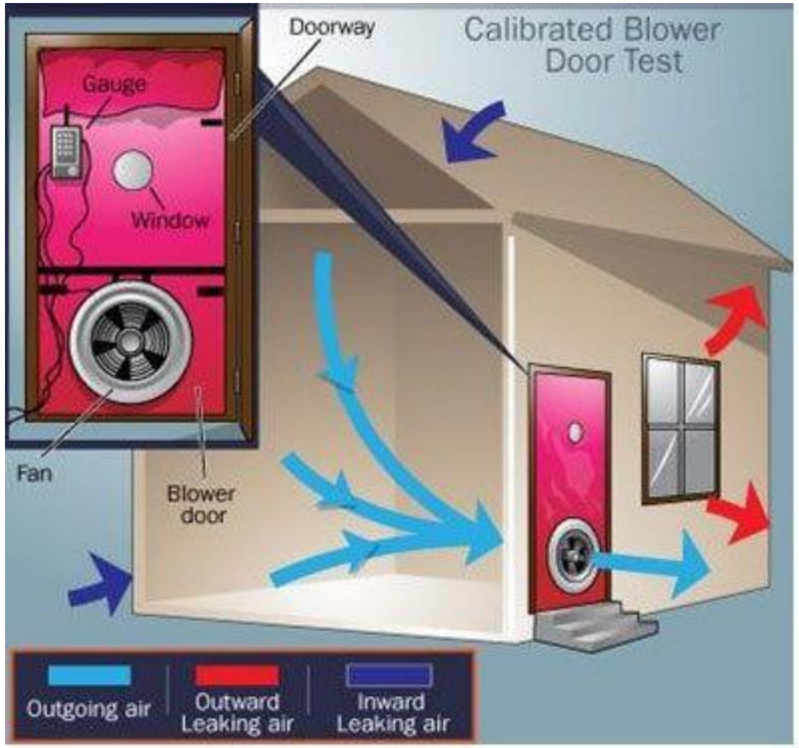
$$n = \frac{q_v}{V}$$

For residential buildings, an air exchange rate of $n = 0.3 - 0.5\,\mathrm{h}^{-1}$ can be assumed, as prescribed by UNI 10344 for naturally ventilated spaces. For all other buildings, the hourly air exchange rates reported in UNI 10339 are applied.

Inside any environment, air enters through two different phenomena:

- **Ventilation**: The voluntary introduction of air into a confined space.
- **Infiltration**: The unintentional introduction of air (into an environment), for example, due to "drafts" through windows and installations.

Blower door test



Ventilation improves the comfort level within a confined space by affecting indoor air quality (IAQ).

Air is considered of acceptable quality when it does not contain specific pollutants in harmful amounts, or when at least 80% of the occupants express satisfaction with it (ASHRAE Standard 62/1989).

This subjective perception varies from person to person, and judgment can be altered by habituation: for example, after an hour of class in a school classroom, students do not complain about poor air quality, but the teacher for the next lesson, coming from the hallway where the air quality is better, does.

Air quality must meet the following criteria:

- It should be evenly distributed throughout the space.
- It must ensure the minimum air exchange under all conditions.
- It should carry out filtration with the effectiveness required based on the type of usage to minimize the levels of dust and pollutants.

Over the years, there has been a progressive deterioration of Indoor Air Quality (IAQ).

Causes…

- The need to reduce energy consumption in the construction sector (low air permeability).
- Significant changes in furnishings (new materials for furniture, coverings, etc.), construction products, and work and recreational equipment (photocopiers, printers, etc.).

Consequences…

- Increase in the type (i.e., pollutant species) and quantity (i.e., concentration) of pollutants.
- Prolonged exposure to even very low concentrations of chemical contaminants can cause toxic effects (with long exposure times).
- Exposure to a contaminant refers to both the concentration of the pollutant (i.e., the amount of substance present in a homogeneous or heterogeneous mixture relative to a defined mass or volume of the mixture) and the duration of time during which the exposure occurs.

In all confined environments, the air should have a quality sufficient to ensure a negligible risk to occupants.

There is no universally recognized definition of air quality... For civilian environments, it is common to use the definition provided by ASHRAE, which states that air is considered of acceptable quality when it does not contain specific pollutants in harmful amounts, or when at least 80% of the occupants express satisfaction with it (ASHRAE Standard 62/1989).

The air quality in external and workplace environments is subject to legislation aimed at limiting exposure to pollutants: in particular, **Legislative Decree 626/1994**, **Legislative Decree 25/2000**, and **Ministerial Decree 20/02/2004** organize the regulations regarding chemical pollutants in work environments, defining a list of occupational exposure limit values.

The air quality in public and private buildings (i.e., the civil sector) is not regulated by specific laws, and it is up to designers to implement actions to reduce the risk of exposure to pollutants for building occupants, with particular attention to vulnerable groups and weak categories. Some standards are issued by municipalities within the framework of the **Regulations on Hygiene and Health**, which set parameters for the healthiness of living spaces.

The main effects of indoor pollution on human health concern:

- **For the respiratory system**: asthma, bronchitis, respiratory diseases, legionellosis, allergic alveolitis, etc.
- **For the skin and mucous membranes**: irritations, atopic dermatitis, sensitization, etc.
- **For the nervous system**: headaches, drowsiness, dizziness, fatigue, etc.
- **For the immune system**: allergic reactions, humidifier fever, etc.

Sick Building Syndrome (SBS) is a condition without a uniquely determined cause, characterized a combination of disorders associated with one or more individuals in workplaces or residences.

Symptoms: headaches, drowsiness, difficulty concentrating, fatigue, nausea, eye irritation, nose, throat, respiratory problems, skin rashes, dryness, and throat irritation.

Ventilation, classified into natural and mechanical, is used to ensure air exchange within confined spaces and thus improve comfort levels.

Natural ventilation is achieved through openings in the building envelope. The highest effectiveness is obtained if windows are placed on opposite walls. However, the airflow and the quality of the incoming air (which may be polluted) cannot be controlled. Additional problems may include external noise and cold drafts. Typically, hot air enters during the summer and cold air during the winter, resulting in energy losses.

In contrast, **mechanical ventilation** allows control over the amount of air introduced and avoids unpleasant drafts. The presence of filters and controlled humidity levels improve both air quality and comfort. Additionally, there is a guarantee of process continuity. When only natural forces are used, the chosen ventilation system is called **passive**. When mechanical systems are also used, the ventilation process is known as **hybrid**.

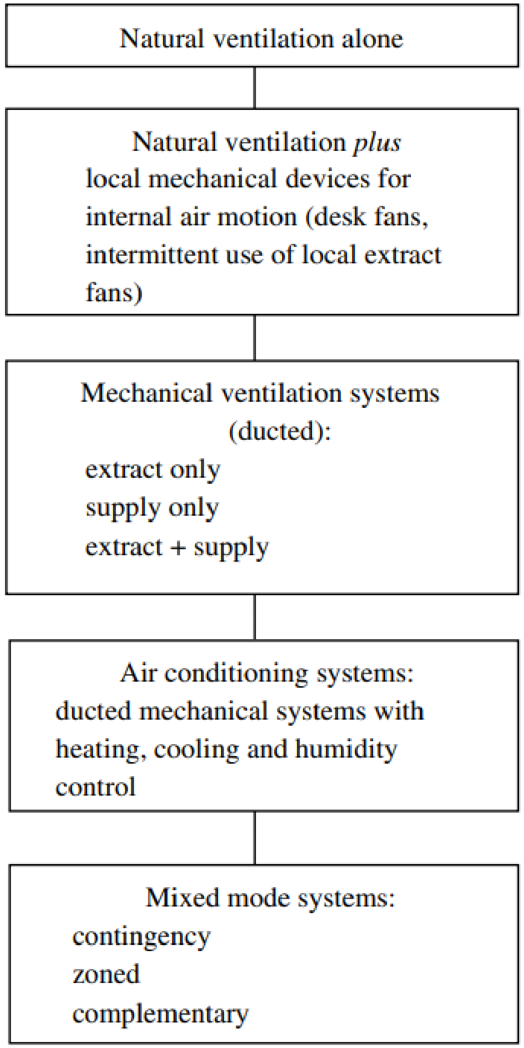


Figure 1.1 Hierarchy of ventilation systems

Natural ventilation

Natural Ventilation

Advantages

- Low cost
- Easy to manage
- Sustainability (does not require electricity for fans, which can account for 25% of electricity consumption in a mechanically ventilated building)
- Occupants prefer not to be completely isolated from the external environment

Disadvantages

- Difficult to design (random factors such as weather, user behavior, etc.)
- Not controllable
- Limited effects in very hot and humid climates
- Higher energy losses

Air movements for natural ventilation and infiltration are due to pressure differences: when there is a pressure gradient between two spaces, the pressure tends to equalize through the movement of air (mass transfer) from the higher pressure point to the lower pressure point.

The "natural" driving forces that maintain a pressure difference are primarily two:

- Wind (wind-induced ventilation)
- Buoyancy forces (buoyancy-induced ventilation)

With reference to the static wind pressure upstream of an opening, the time-averaged pressure due to wind flow, p_v, entering or exiting through a surface is given by:

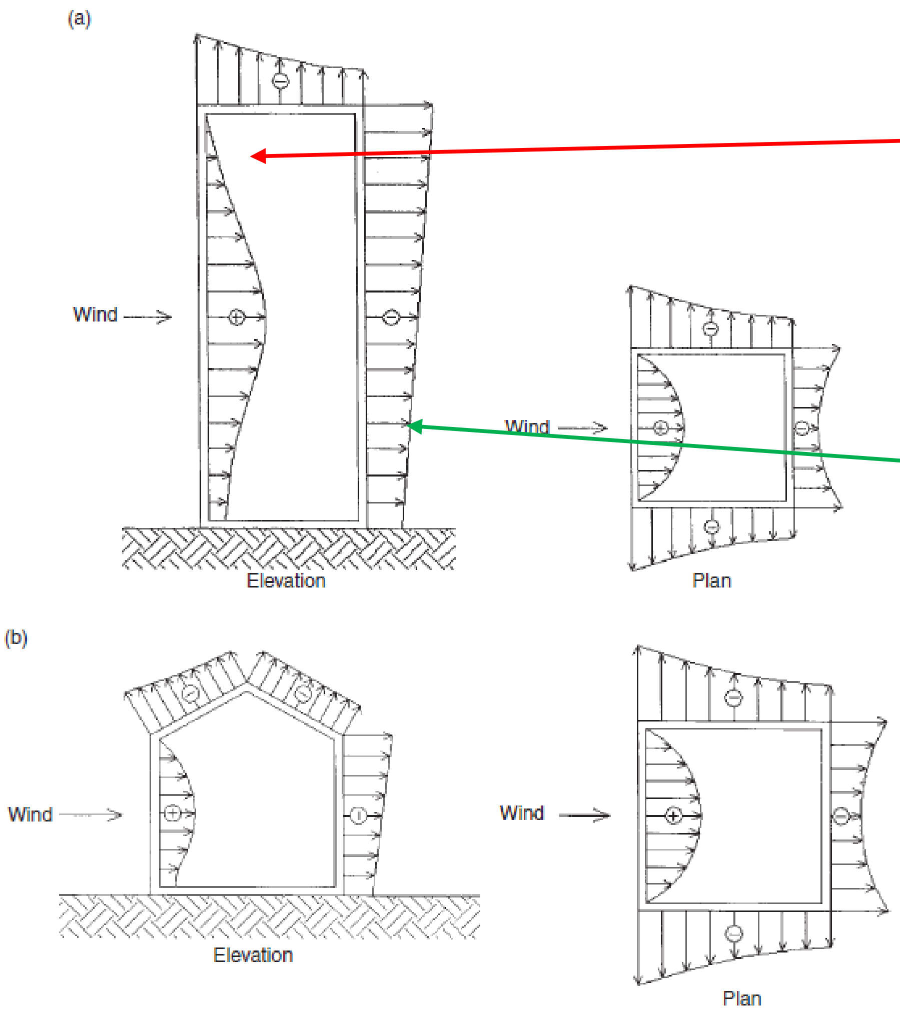
$$p_v = C_p \frac{\rho_0 \overline{V}^2}{2}$$

where C_p is the static pressure coefficient, $\overline{V}$ is the mean wind speed at the reference level, usually the height of the building or opening (m/s), and ρ_0 is the free stream density (kg/m^3).

The value of C_p at a point on the surface depends on the pressure distribution:

- The geometry of the building
- The wind velocity (i.e., speed and direction) relative to the building
- The building's exposure, i.e., its position relative to other buildings, topography, and ground roughness in the wind direction.

Wind-induced ventilation

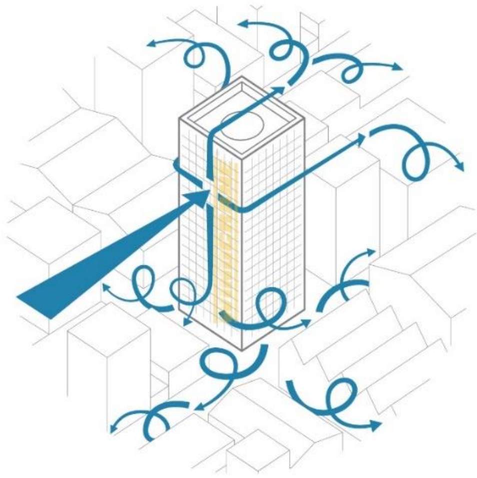


The windward side is subject to positive wind pressure coefficients due to the impact of the wind and its deflection on the surface.

The leeward side is subject to negative pressure coefficients due to the separation of the boundary layer from the sharp edges that connect the roof and the

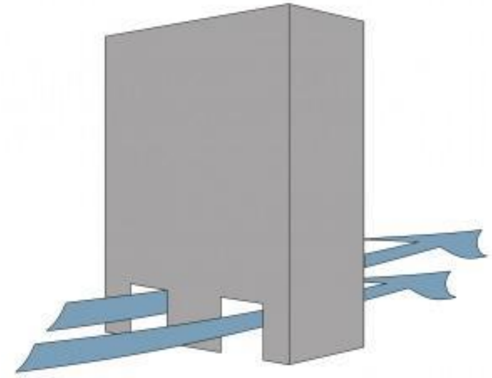
The pressure coefficients on the side faces of a building can be positive or negative depending on their inclination relative to the prevailing wind.

If openings are placed in a building, the pressure differential between the various facades triggers an internal airflow that can be used to ventilate the building. The different pressures are caused by the wind, the temperature difference, and the density between the inside and outside.

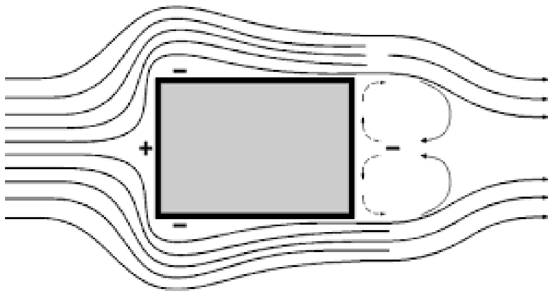


The effects of ventilation are evaluated through simplified models to study the relationships between urban layouts and variations in ventilation parameters. In building organization, several recurring situations arise due to ventilation:

- **Turbulence effect**: This occurs when a building is taller than the surrounding buildings. In the exposed part of the building, the pressure is higher than in the lower part, which is protected by other buildings. These different pressures create turbulence.



- **Tunnel effect**: This happens when zones with different pressures communicate through openings on the building's walls. The airflow increases in speed, causing discomfort.



- **Corner effect**: This occurs at the corners of facades when the wind passes from one zone to another with different pressures, separated by a building. This creates corner currents that usually extend over an area with a radius equal to or smaller than the width of the building.

Buoyancy-induced ventilation

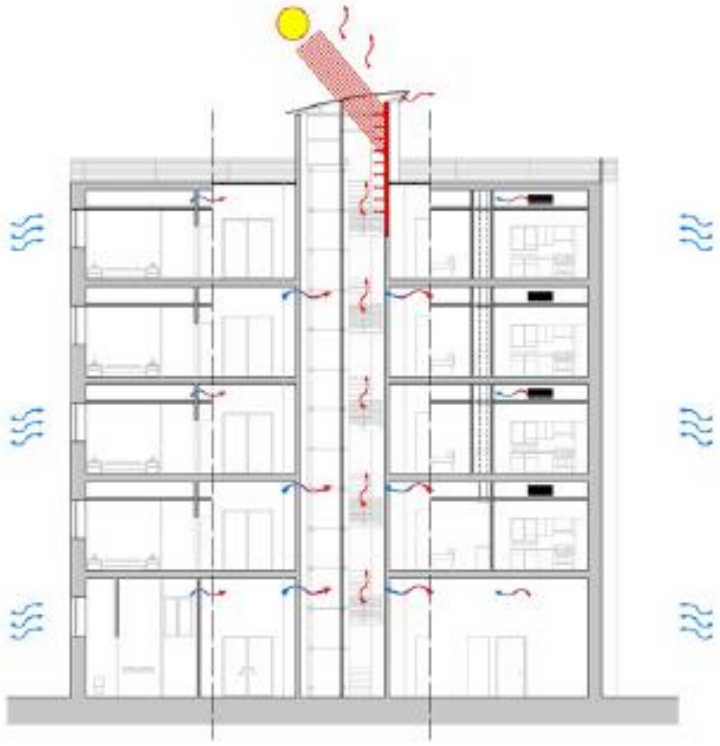
Stack effect

The stack effect is generated by the vertical stratification of air at different temperatures. Warm air, being less dense, rises upward, while cold, denser air stays below. This difference generates a pressure gradient, which becomes useful for triggering upward ventilation.

Ventilation due to the stack effect depends on the temperature difference between the lowest and highest points of the air stratification. This type of ventilation can be activated in the absence of wind.

It uses the density difference that forms between indoor and outdoor air, caused by the air temperature and the vertical distance between the inlet openings (at the bottom) and the outlet openings (at the top).

To achieve good ventilation, a significant temperature difference (DT) between inside and outside (nighttime cooling) and adequate chimney height are necessary.

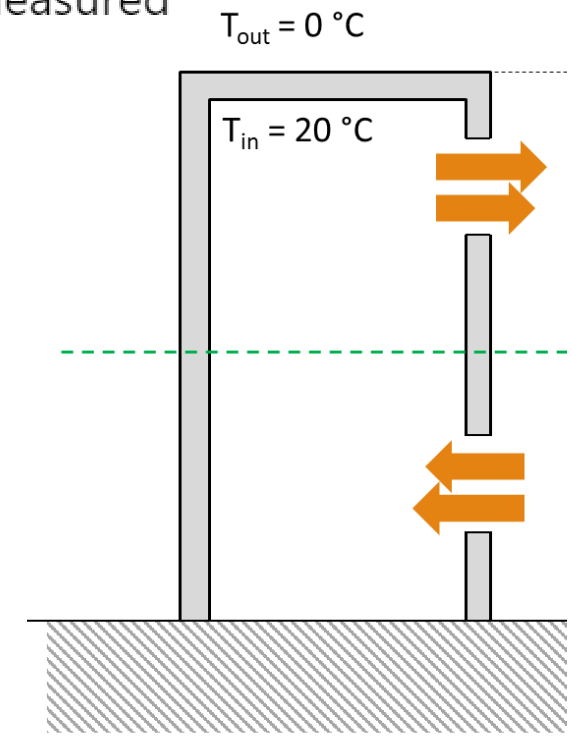


In the case of buoyancy-induced ventilation, the air mass is set in motion due to the variation in air density.

This is referred to as the "stack effect" generated by the vertical stratification of air at different temperatures.

Suppose we want to study the stack effect of the thermal zone shown in the figure, assuming a winter regime.

By placing the reference height z_0 at the neutral point, where the internal pressure equals the external pressure, the internal and external pressure behavior as a function of height z' (measured relative to z_0) can be written as follows:



On the internal side:

$$p_{int}(z') = p_0 - \rho_{o,int} \cdot g \cdot z'$$

On the external side:

$$p_{ext}(z') = p_0 - \rho_{o,ext} \cdot g \cdot z'$$

Considering air as an ideal gas, the air pressure p can be related to its temperature T:

$$pV = mR_sT$$

We can deduce a relation between air density ρ and its temperature:

$$\rho = \frac{m}{V} = \frac{p}{R_sT}$$

Using the mean pressure p_m of the location:

$$\rho_{int} = \frac{m}{V} = \frac{p_m}{R_sT_{int}}$$
$$\rho_{ext} = \frac{m}{V} = \frac{p_m}{R_sT_{ext}}$$

Ventilazione indotta dalle forze di galleggiamento

- Near the ground (z' < 0), the external air tends to penetrate the building, pushing the warm air inside.On the upper floors (z' > 0), the internal pressure on the building envelope exceeds the external pressure (Δp > 0), causing warm air to escape.

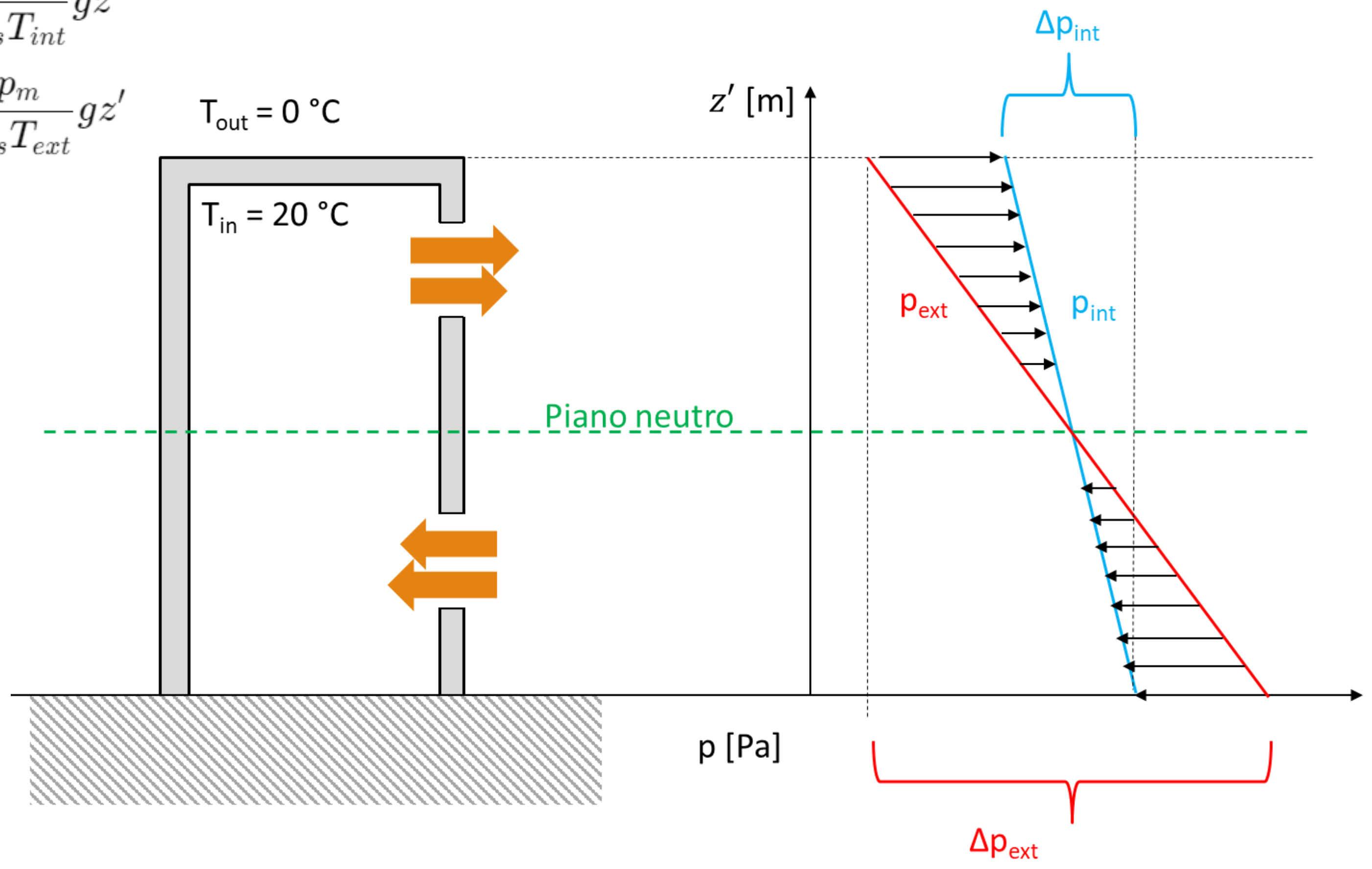
Inserting these values into the equations:

$$p_{int}(z') = p_0 - \frac{p_m}{R_s T_{int}} g z' \rightarrow p_{int}(z') = p_0 - \frac{p_m}{R_s T_{int}} g z'$$

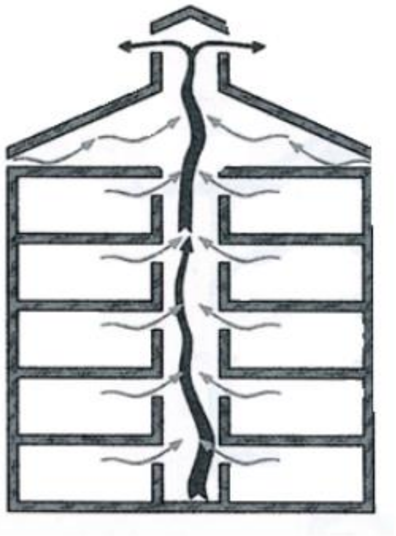
$$p_{ext}(z') = p_0 - \frac{p_m}{R_s T_{ext}} g z' \rightarrow p_{ext}(z') = p_0 - \frac{p_m}{R_s T_{ext}} g z'$$

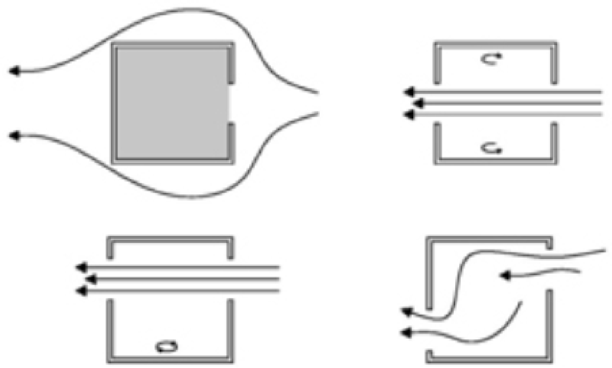
and subtracting them, we obtain:

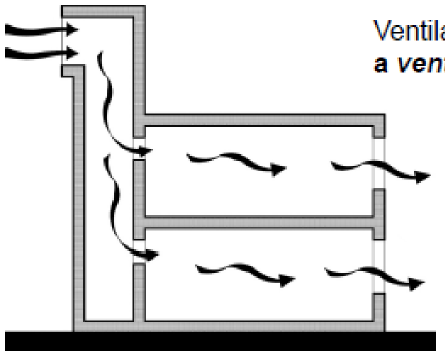
$$\Delta p_{int-ext} = \frac{p_m}{R_s} g z' \left(\frac{1}{T_{ext}} - \frac{1}{T_{int}} \right)$$



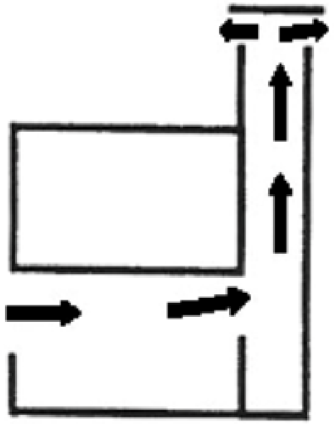
Ventilazione passante verticale
indiretta da atrio







Ventilazione passante verticale a torre:
a vento



Ventilazione passante verticale a torre:
a effetto camino

Mechanical ventilation

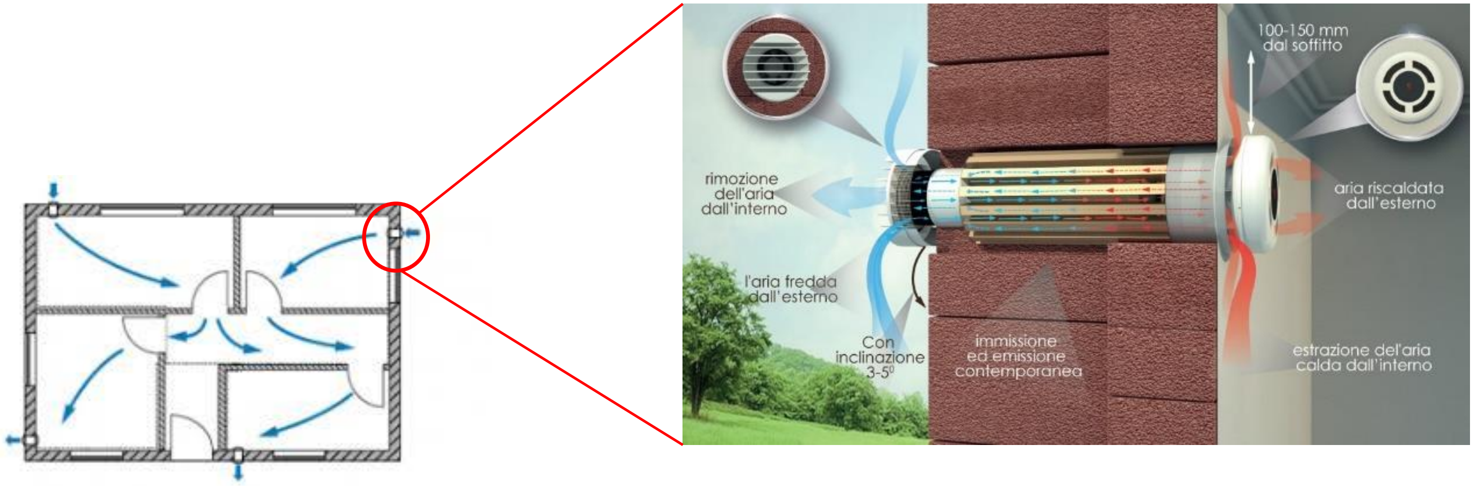
Standards for building ventilation:

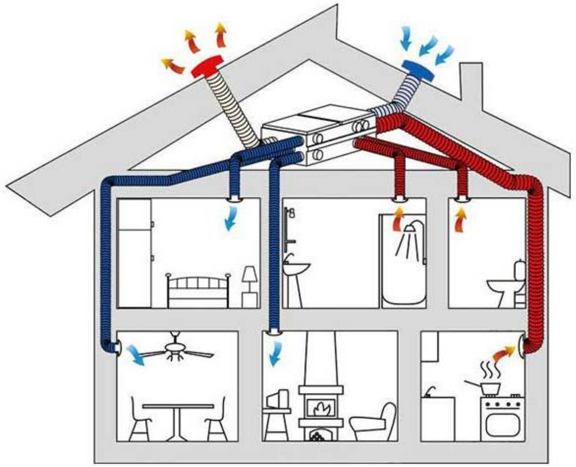
- **UNI EN 13779** – Ventilation of non-residential buildings - Performance requirements for ventilation and air conditioning systems.
- **UNI EN 15242** – Ventilation of buildings - Calculation methods for determining airflows in buildings, including infiltration. It contains a calculation method for assessing air exchange due to window opening.
- **UNI EN 15251** – Criteria for the design of indoor environments and for the evaluation of the energy performance of buildings, concerning indoor air quality, thermal environment, lighting, and acoustics.
- **UNI TS 11300** – Standard for calculating building energy needs. It presents a calculation method for assessing heat losses due to ventilation.

Controlled mechanical ventilation (VMC) systems continuously ensure air exchange while guaranteeing control over indoor air quality (IAQ).

The system can take on different configurations, depending on the building's intended use, the size of the rooms (surface areas, volumes), and the required airflows.

For small rooms, localized systems can be used, in which a supply or exhaust fan is installed directly on one of the walls of the room to be ventilated or mounted on a window.

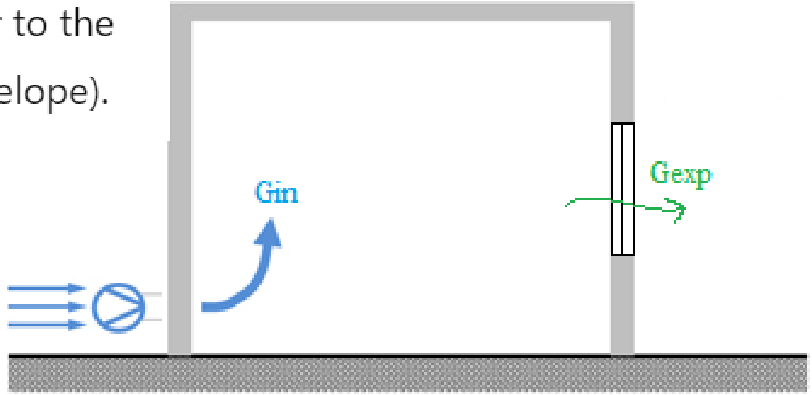


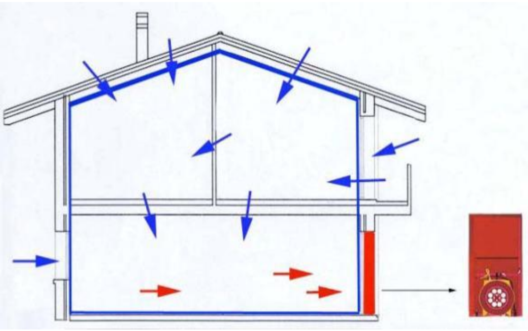


It is noted that:

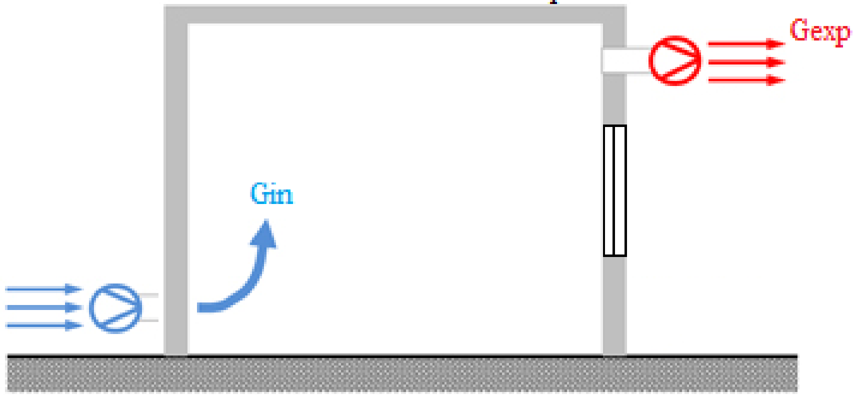
- **In extraction**, the balancing of airflows occurs through **infiltration** (i.e., drawing renewal air from the external environment due to negative pressure through the "weak points" of the building envelope).
- **In supply**, the balancing of airflows occurs through **exfiltration** (i.e., expelling polluted air to the external environment due to overpressure through the "weak points" of the building envelope).

Solo ventilatore di immissione

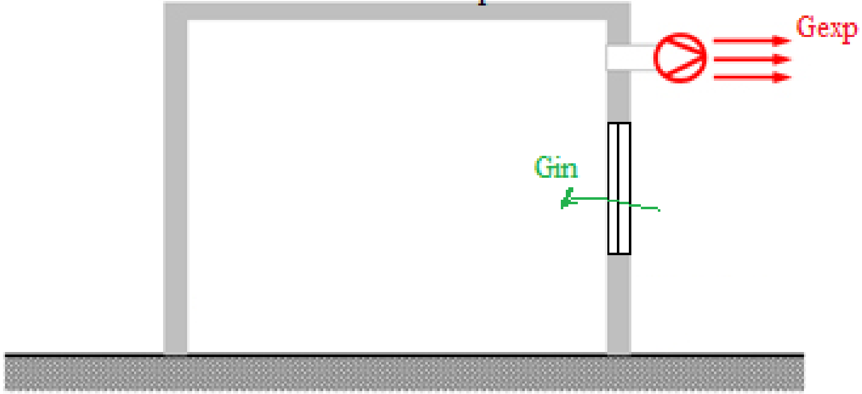




Ventilatore di immissione e di espulsione



Solo ventilatore di espulsione



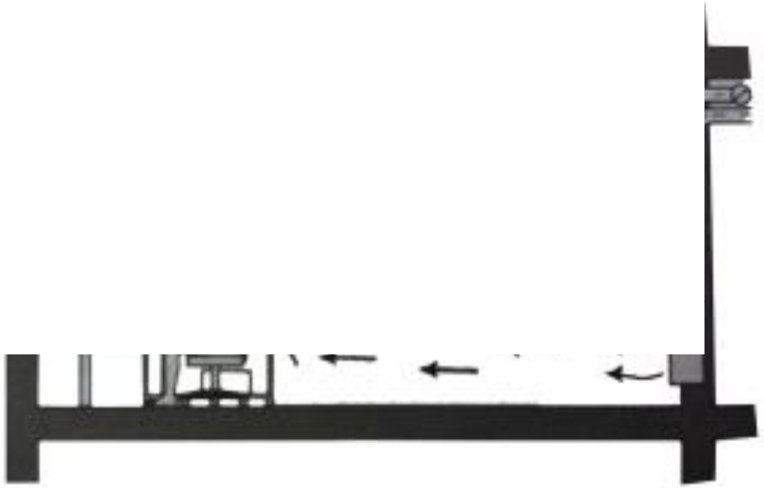
The main task of ventilation is to introduce a certain amount of air into a confined space to improve the indoor air quality (IAQ) already present.

To achieve this, it is necessary not only to ensure the correct airflow rate but also to distribute it evenly throughout the environment.

There are two main strategies for introducing air into a space:

- Mixing ventilation
- Displacement ventilation

Ventilazione a miscelazione



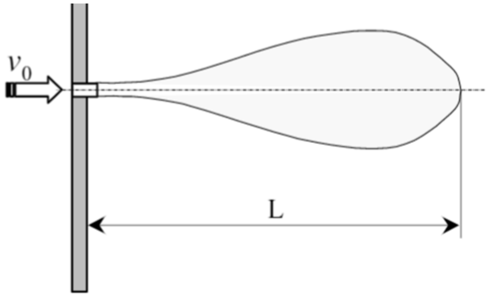
Ventilazione a dislocamento

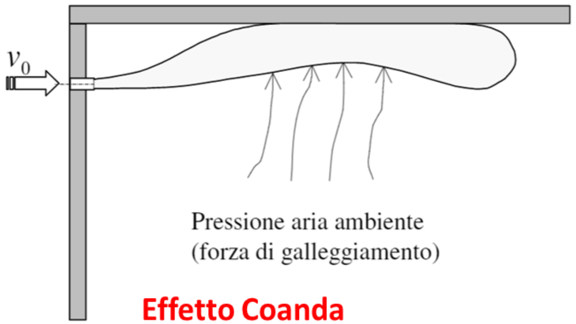
Mixing ventilation It is used to homogenize the air temperature and pollutant concentration in the environment through a high-speed, turbulent jet without invading the occupied zone. The jet causes air movement, which in turn mixes with the air already present in the room.

An essential element is the correct design of the jet: the type of jet and the type of diffusion terminal are crucial to achieving a comfortable distribution of air in the environment.

We define **throw or jet range** as the distance at which the maximum air velocity along the jet axis, considered isothermal, due to the jet's expansion and the consequent mixing with the ambient air, has reduced to a threshold value (0.15 – 0.20 m/s).

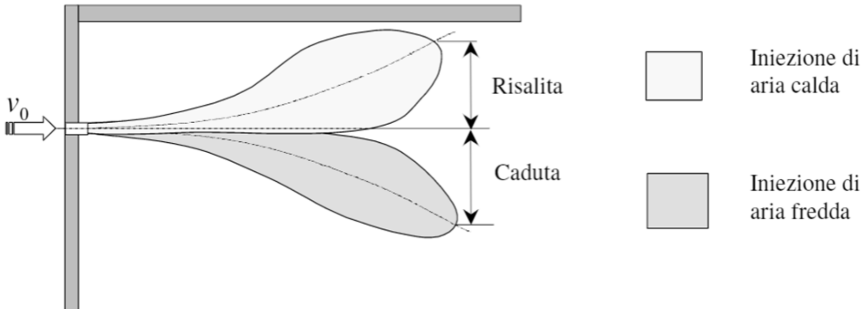
The air movement depends on both the supply diffusers and the relationship between inertia forces and buoyancy forces (speed and temperature). It is necessary to know the jet throw and the maximum acceptable jet velocity in the occupied zone.





Effetto Coanda
(aumento del lancio e diminuzione caduta)

Issues:
- Formation of drafts
- Short-circuiting of air between supply and extraction
- Stagnant air



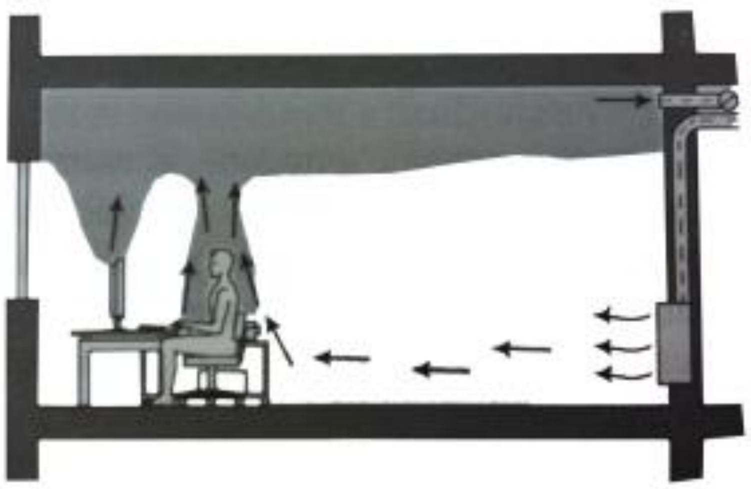
Displacement ventilation This type of ventilation is based on the presence of vertical gradients of temperature and contaminants in the environment.

It has high values of ventilation and temperature efficiency, resulting in high IAQ (Indoor Air Quality).

The basic principle is to take advantage of the density difference in the air; as the air heats up, it moves upward. Clean air is introduced from the bottom through a diffuser, at low speed and at a temperature lower than the ambient air.

The height that separates the two zones, referred to as the neutral plane height, is a key design parameter.

With displacement ventilation, the air introduced into the room must be cooler than the air already in the environment. If warmer air were introduced, it would rise upwards, nullifying the entire process and eliminating the effect of the thermal sources on which this ventilation is based.



Ventilazione a dislocamento 75

AIR FILTRATION

2. Merv Filters:

Minimum-Efficiency Reporting Value measures the efficiency with which filters remove particles of specific sizes by trapping airborne particles in a network of fibers. Merv filters are available in a range of efficiency ratings, from 1 to 16. The higher rating help filters remove the particles efficiently. They can reduce or eliminate airborne allergens, dust particles, mold spores, and bacteria.

Features

- MERV 1 to 4 controls large particles such as dust, spray paint dust, lint, and carpet fibers and is applicable for window air conditioning units in homes.
- MERV 5 to 8 controls mold spores, hair spray, and dust. It is mainly used in commercial buildings, residences, and industrial workplaces since it offers 90 percent efficiency on particles 3 to 10 micrometers in size.
- MERV 9 to 12, primarily used in residences, hospitals, and commercial buildings, helps to control humidifier dust, lead dust, vehicle emissions, and welding fumes.
- MERV 13 to 16 is applicable in general surgery suites, smoking lounges, and commercial buildings with superior HVAC systems that control airborne bacteria, most tobacco smoke, and pollutants released through sneezing.
- High-quality, thick pleats filters trap and block as much as 98 percent of particles as small as 0.3 microns.

Benefits

- It provides clean, healthy air with a higher filter efficiency and can capture smaller particles.
- Protects HVAC equipment from small dust particles.
- The higher MERV filters have higher resistance and are capable of fine filtering.
- Improves the lifespan of your HVAC system.

Challenges

- High static pressure makes the heating and cooling system inefficient or pleats so close together that the filter faces loads and needs to be changed much more frequently.
- Increase the pressure in the duct system.
- Higher capacity filters may need a complete overhaul of the design during the retrofit of legacy HVAC systems.
- Increase the energy use of the system leading to higher energy consumption.
- Reduces the air flow causing comfort problems.
- Possibility of freezing the air conditioner coil and potential damages to the compressor.

TOPICS

1. INDOOR AIR QUALITY (IAQ)
2. IMPORTANCE OF AIR FILTERS
3. FOUNDAMENTALS OF AIR FILTERS
4. OUTDOOR AIR CATEGORIES ODA & SUPPLY AIR CATEGORIES SUP
5. EUROVENT ENERGY EFFICIENCY CLASSIFICATION
6. COVID-19 INDUSTRY RECOMMENDATIONS
7. CASE STUDIES

The impact of IAQ on the burden of diseases (BoD) is measured by the means of a so-called disability-adjusted-life-year (DALY).

This time-based measure combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health.

The total estimated burden of disease attributable to IAQ in the European Union is approx. 2 million DALYs per year, which means that two million years of healthy life is lost annually.

It is worth noticing that, according to latest estimation carried out by French economists, the cost of 1 DALY can amount up to 100 000 EUR.

Bad ambient air quality affects the burden of diseases (BoD) most

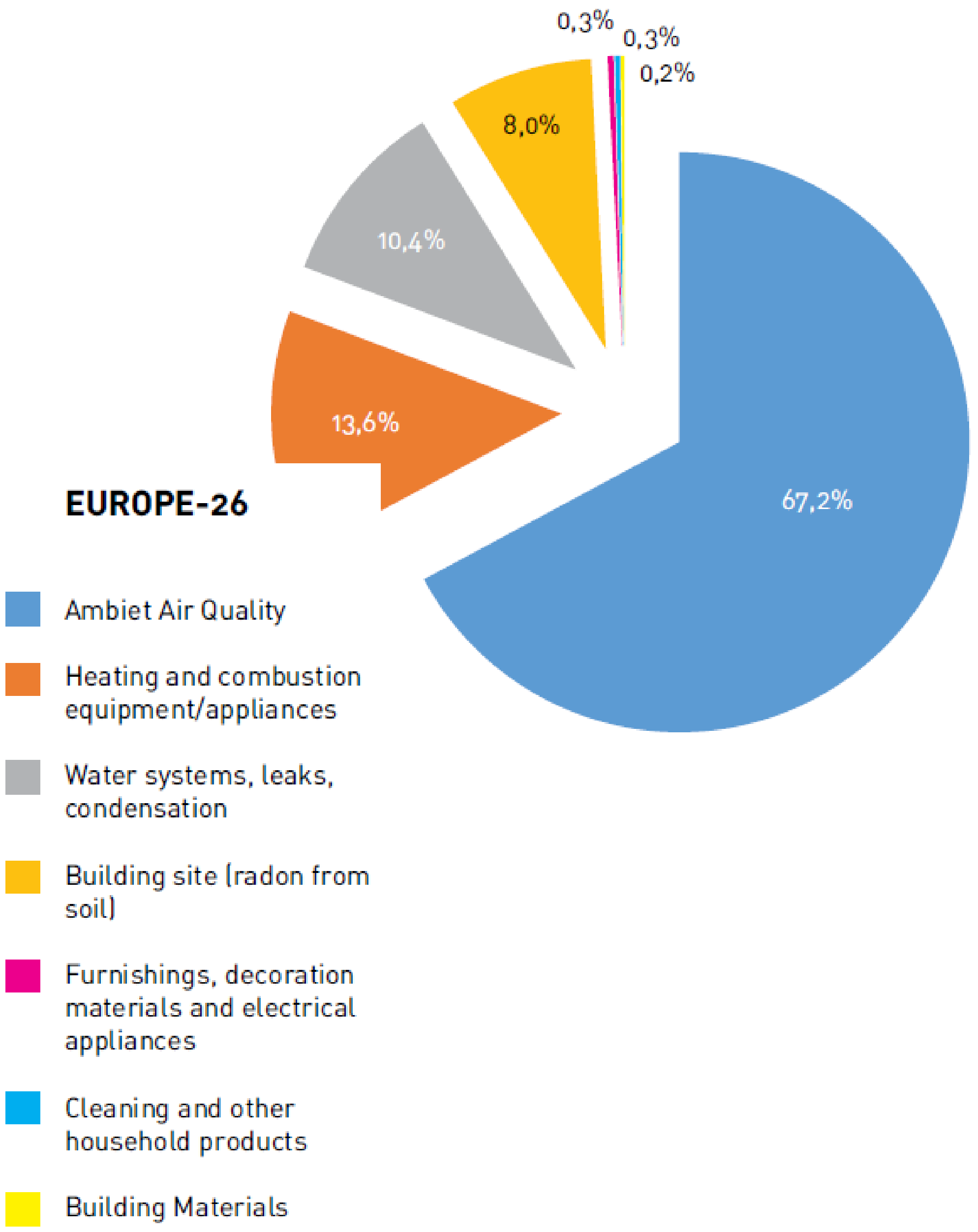
Outdoor air pollution plays a significant role for indoor air exposures.

Due to ventilation providing continuous air exchange in buildings, the indoor air exposure to fine PM originates mostly from outdoor air, especially in areas affected by heavy traffic.

The second most important source of exposure comes from the indoor combustion of solid fuels for cooking and heating (if present).

What is often not acknowledged is that in strongly polluted areas (e.g. heavy industry zones, city centres with heavy traffic) without air filtration, over 90% of ambient PM levels monitored outdoors, occurs indoors.

Applying correctly selected, efficient air filters in ventilation systems can significantly reduce the impact of PM exposure on the Burden of Disease (BoD).



CLEAN AIR BENEFITS

- Cleaner lungs
- Improved Mood
- Lower Medical Cost
- Improved Productivity
- Better Immune System
- Longer Life Span
- Better Sleep
- Improved Digestion
- Better For Your Blood Pressure
- Reduced Allergies & Asthma Symptoms

USING THE RIGHT FILTER

Using the right air filter will help you to maintain healthy indoor air quality and save energy (by using the Eurovent’s new energy classifications.

Choose the right air filter for the lowest energy usage and highest indoor air quality.

Today, all air filters can be graded from A+ (lowest energy consumption) to E (highest) .

The classification, (EN ISO16890) will give you: a filter’s annual energy consumption, initial efficiency and minimum efficiency

FOUNDAMENTALS OF AIR FILTRATION

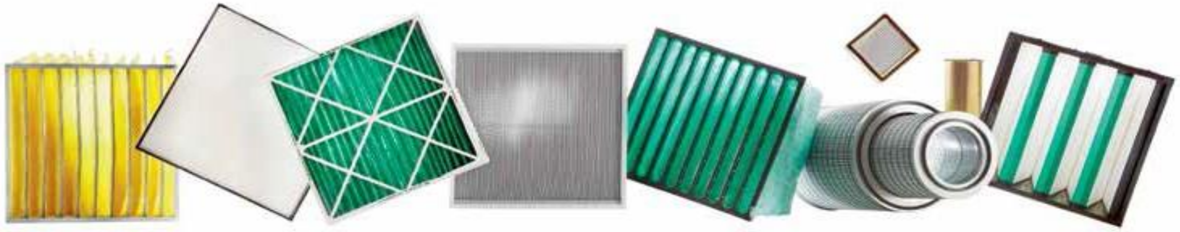
European standard defining the filtration performance of filters for general ventilation was the EN 779:2012 till end of 2018.

From 1/1/2019 we have the new global standard EN ISO 16890:2016.

Both standards deal with the evaluation of the filtration effect of coarse and fine dust filters used in general ventilation.

In EN 779:2012, the efficiency classification for medium and fine filters is based on 0,4 µm particles, while the new EN ISO 16890 defines the efficiency for various fractions of particle size: PM10, PM2.5 and PM1.

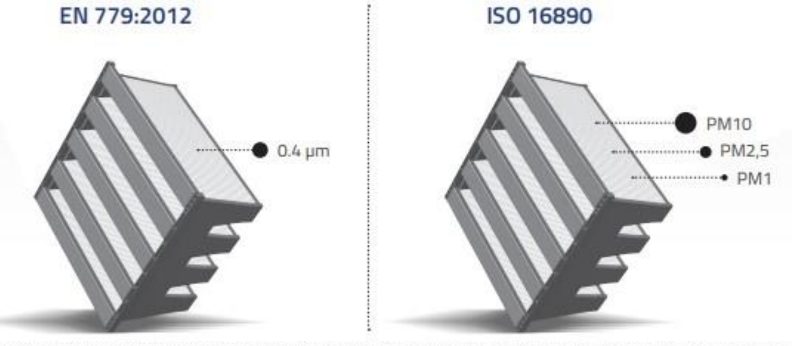
Both standards deal with the evaluation of the filtration effect of coarse and fine dust filters used in general ventilation.



Main differences in test method between EN 779:2012 and EN ISO 16890:2016

EN779:2012

- Efficiency based on one particle size, 0,4 µm
- Dust feeding and particle efficiency measure in steps up to 450 Pa final pressure drop gives average efficiency ex. 85%
- Discharging of a piece of filtermedia in IPA-liquid (Isopropanol), class F7 – F9
- Minimum Efficiency (ME) defines the filter in classes F7 – F9 Ex.: ≥ 35% is class F7
- Test dust: ASHRAE
- Air flow rate: 3400 m^3/h (0.944 m^3/s)
- No relation to real environment.



Reference particle sizes according to EN 779: 2012 and ISO 16890 standards

EN ISO16890:2016

- ePM_x – efficiency of particle fraction with a diameter ≥ 0,3 µm and x µm

Efficiency	Size range µm
ePM_{10}	$0,3 \leq x \leq 10$
$ePM_{2,5}$	$0,3 \leq x \leq 2,5$
ePM_1	$0,3 \leq x \leq 1$

- Average efficiency = average value of initial efficiency and discharged (conditioned) efficiency.
- Final pressure drop: 200 Pa (Coarse), and 300Pa (ePm_x)
- Discharge of a complete filter in IPA-vapor
- Test dust: ISO A2/AC Fine (≈ double dust holding in grams)
- Air flow rate: 3400 m^3/h (0.944 m^3/s)
- More equal to real environment.

EN 779:2012 Standard

Filter Type	EN 779 Class	Average Arrestance (Am) (%)	Average Efficiency (Em), 0,4 µm (%)	Final Test Pressure Drop (Pa)	Minimum Efficiency 0,4 µm (%)
Coarse filter	G1	50 ≤ Am < 65	-	250	-
	G2	65 ≤ Am < 80	-	250	-
	G3	80 ≤ Am < 90	-	250	-
	G4	90 ≤ Am	-	250	-
Medium filter	M5		40 ≤ Em < 60	450	-
	M6		60 ≤ Em < 80	450	-
Fine filter	F7	-	80 ≤ Em < 90	450	35
	F8	-	90 ≤ Em < 95	450	55
	F9	-	95 ≤ Em	450	70

The quality of any filter essentially depends on the percentage of dust transported through the filter that is actually collected.

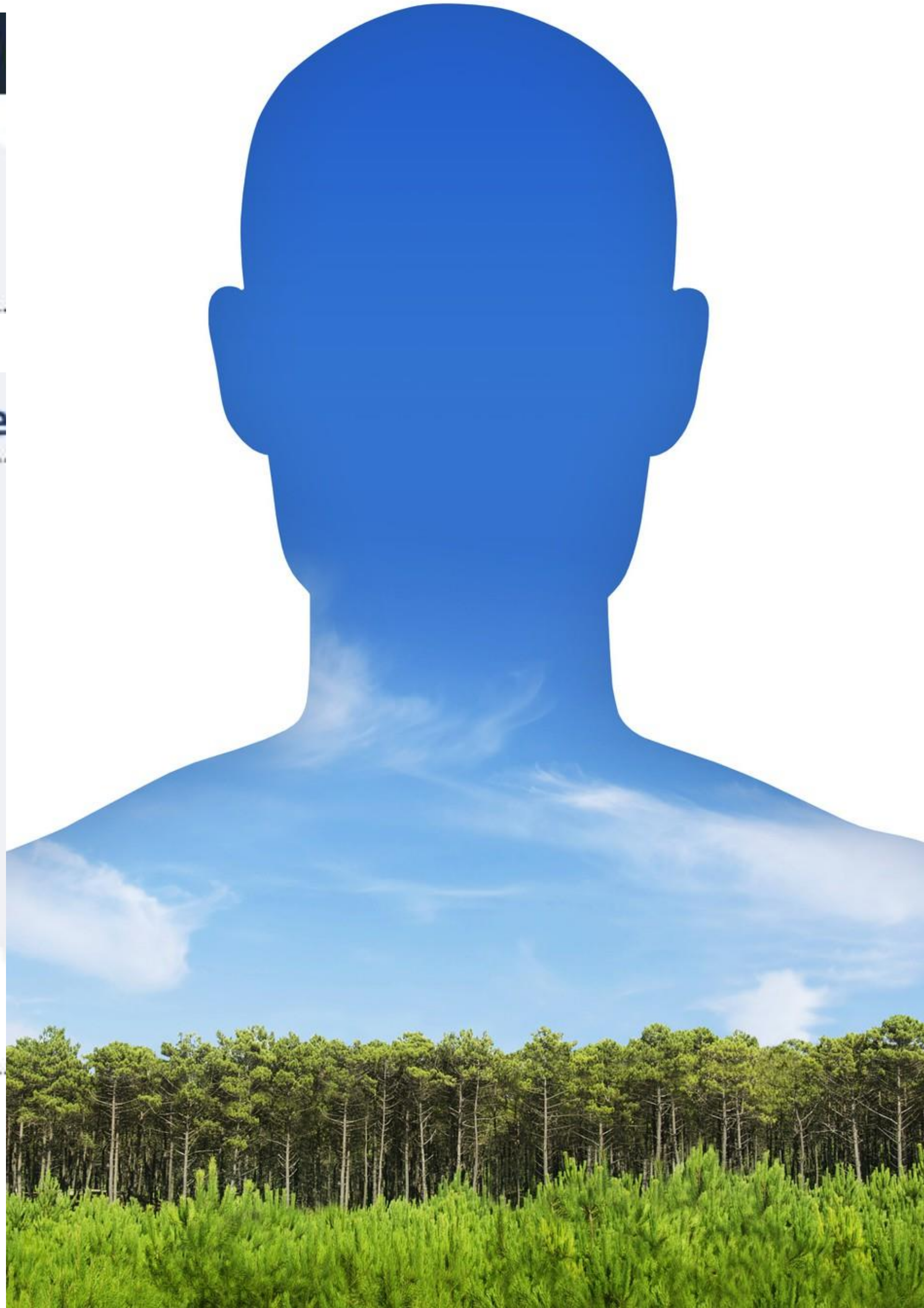
For coarse filters, the filter effect is evaluated by measuring the initial gravimetric arrestance when challenging the filter with synthetic test dust using ASHRAE-test dust.

For fine filters, the filter effect is evaluated by measuring the efficiency against 0.4 micron DEHS droplets.

EN ISO 16890:2016 Standard

OLD STANDARD **EN 779**	NEW STANDARD **ISO 16890**
Filter classes F7-F8-F9 M5-M6 G2-G3-G4	Four ISO groups ISO ePM_1 ISO $ePM_{2,5}$ ISO ePM_{10} ISO Coarse

ISO ePM_1	ISO $ePM_{2,5}$	ISO ePM_{10}	ISO Coarse
ePM_1 95%	$ePM_{2,5}$ 95%	ePM_{10} 95%	ePM_{10} 45%
ePM_1 90%	$ePM_{2,5}$ 90%	ePM_{10} 90%	ePM_{10} 40%
ePM_1 85%	$ePM_{2,5}$ 85%	ePM_{10} 85%	ePM_{10} 35%
ePM_1 80%	$ePM_{2,5}$ 80%	ePM_{10} 80%	ePM_{10} 30%
ePM_1 75%	$ePM_{2,5}$ 75%	ePM_{10} 75%	ePM_{10} 25%
ePM_1 70%	$ePM_{2,5}$ 70%	ePM_{10} 70%	ePM_{10} 20%
ePM_1 65%	$ePM_{2,5}$ 65%	ePM_{10} 65%	ePM_{10} 15%
ePM_1 60%	$ePM_{2,5}$ 60%	ePM_{10} 60%	ePM_{10} 10%
ePM_1 55%	$ePM_{2,5}$ 55%	ePM_{10} 55%	ePM_{10} 5%
ePM_1 50%	$ePM_{2,5}$ 50%	ePM_{10} 50%	
Requirement ≥50% Initial Efficiency ≥50% Discharged Efficiency	**Requirement** ≥50% Initial Efficiency ≥50% Discharged Efficiency	**Requirement** ≥50% Initial Efficiency No discharge requirement	No discharge requirement



Comparison of EN 779 and EN ISO 16890 rated filter classes

EN 779: 2012	EN ISO 16890 – range of actual measured average efficiencies		
Filter class	ePM_1	$ePM_{2.5}$	ePM_{10}
M5	5% - 35%	10% - 45%	40% - 70%
M6	10% - 40%	20% - 50%	60% - 80%
F7	40% - 65%	65% - 75%	80% - 90%
F8	65% - 90%	75% - 95%	90% - 100%
F9	80% - 90%	85% - 95%	90% - 100%

Sellection of EN 779 and EN ISO 16890 rated filter classes

Filter class		Remarks
EN 779:2012	EN ISO 16890-1:2016	
M5	$ePM10 \geq 50$	
F7	$ePM2.5 \geq 65$	If not the last filter stage
F7	$ePM1 \geq 50$	If the last filter stage
F9	$ePM1 \geq 80$	

HEPA FILTERS

In high risk environments, which include laboratories, hospitals, isolation rooms and quarantine space the use of HEPA (High-Efficiency Particulate Air) filters is mandatory!

HEPA filters also should feature a dedicated containment system (so called Bag-in-Bag-out) to facilitate their replacement without physical contact with contaminated material.

HEPA filters international standards is EN1822-1:2019 (part of ISO 29463)

Usually, each single HEPA filter is tested according to standards by the manufacturer before dispatching and comes with a test report and a label showing the test results.

BS EN 1822-1 2019			ISO 29463-1 2017		
Filter class and group	Overall value		Filter class and group	Overall value	
	Efficiency (%)	Penetration (%)		Efficiency (%)	Penetration (%)
E10	≥ 85	≤ 15			
E11	≥ 95	≤ 5	ISO 15E	≥ 95	≤ 5
			ISO 20E	≥ 99	≤ 1
E12	≥ 99.5	≤ 0.5	ISO 25E	≥ 99.5	≤ 0.5
			ISO 30E	≥ 99.9	≤ 0.1
H13	≥ 99.95	≤ 0.05	ISO 35H	≥ 99.95	≤ 0.05
			ISO 40H	≥ 99.99	≤ 0.01
H14	≥ 99.995	≤ 0.005	ISO 45H	≥ 99.995	≤ 0.005
			ISO 50U	≥ 99.999	≤ 0.001
U15	≥ 99.9995	≤ 0.0005	ISO 55U	≥ 99.9995	≤ 0.0005
			ISO 60U	≥ 99.9999	≤ 0.0001
U16	≥ 99.99995	≤ 0.00005	ISO 65U	≥ 99.99995	≤ 0.00005
			ISO 70U	≥ 99.99999	≤ 0.00001
U17	≥ 99.999995	≤ 0.000005	ISO 75U	≥ 99.999995	≤ 0.000005

Filter efficiency is for most penetrating particle size (MPPS)

EPA

HEPA

ULPA

World Health Organisation (WHO) set these annual mean Indoor Air Quality:

- Annual mean for PM2.5 < 10 µg/m3
- Annual mean for PM10 < 20 µg/m3

No recommendations for PM1 concentration.

In next tables we can see the OUTDOOR AIR CATEGORIES ODA1 ODA2 ODA3 and then SUPPLY AIR CATEGORIES

ENERGY EFFICIENCY CLASSIFICATION

THE ENERGY USE IN KWH/ANNUM IS CALCULATED DUE TO THE FORMULA IN EUROVENT REC 4/21-2018.

Where we define qv = 0.944 m3/s, t = 6000 h/a and h = 0.5

$$W = \frac{q_V \cdot \overline{\Delta p} \cdot t}{\eta \cdot 1000}$$

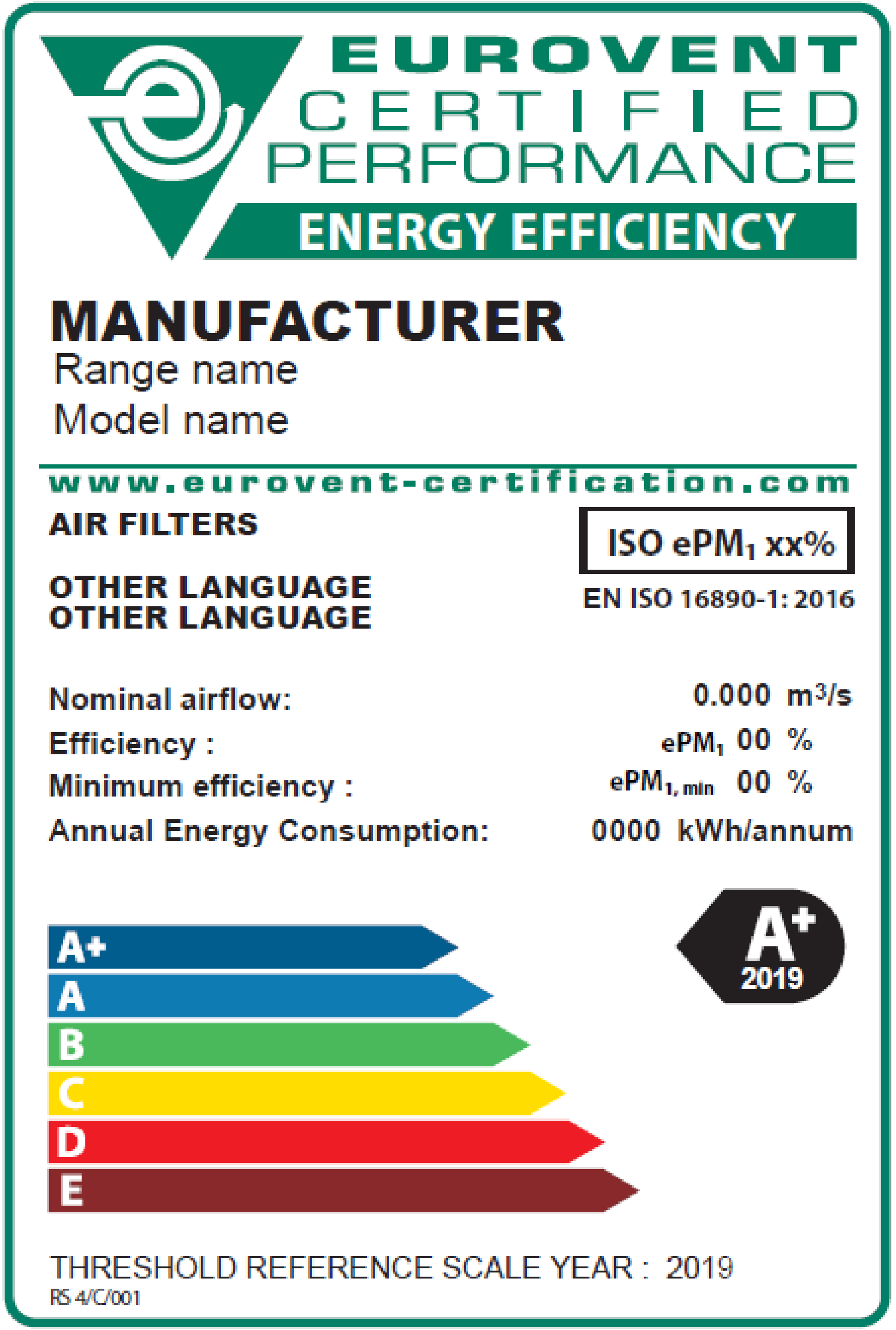
ANNUAL ENERGY USE FOR FILTER CLASSES

EUROVENT CERTITA RULES ALLOW ONLY 1% A+, 5% A, 15% B, AND 30% C CLASS FILTERS IN EUROPE. UPDATE OF EUROVENT ENERGY RATING EVERY 3 YEARS.

M_x = 200 g (AC Fine)	AEC in kWh/y FOR ePM_1 (ePM_1 and $ePM_{1,min}$ ≥ 50%)					
	A+	A	B	C	D	E
50 & 55%	800	900	1050	1400	2000	>2000
60 & 65%	850	950	1100	1450	2050	>2050
70 & 75%	950	1100	1250	1550	2150	>2150
80 % 85%	1050	1250	1450	1800	2400	>2400
> 90%	1200	1400	1550	1900	2500	>2500

M_x = 250 g (AC Fine)	AEC in kWh/y FOR $ePM_{2.5}$ ($ePM_{2.5}$ and $ePM_{2.5,min}$ ≥ 50%)					
	A+	A	B	C	D	E
50 & 55%	700	800	950	1300	1900	>1900
60 & 65%	750	850	1000	1350	1950	>1950
70 & 75%	800	900	1050	1400	2000	>2000
80 % 85%	900	1000	1200	1500	2100	>2100
> 90%	1000	1100	1300	1600	2200	>2200

M_x = 400 g (AC Fine)	AEC in kWh/y FOR ePM_{10} (ePM_{10} ≥ 50%)					
	A+	A	B	C	D	E
50 & 55%	450	550	650	750	1100	>1100
60 & 65%	500	600	700	850	1200	>1200
70 & 75%	600	700	800	900	1300	>1300
80 % 85%	700	800	900	1000	1400	>1400
> 90%	800	900	1050	1400	1500	>1500


EUROVENT
CERTIFIED
PERFORMANCE
ENERGY EFFICIENCY
MANUFACTURER
Range name
Model name
www.eurovent-certification.com
AIR FILTERS
OTHER LANGUAGE
OTHER LANGUAGE
ISO ePM_1 xx%
EN ISO 16890-1: 2016
Nominal airflow: 0.000 m^3/s
Efficiency : ePM_1 00 %
Minimum efficiency : $ePM_{1, min}$ 00 %
Annual Energy Consumption: 0000 kWh/annum
A+
A
B
C
D
E
A+
2019
THRESHOLD REFERENCE SCALE YEAR : 2019
RS 4/C/001

SOME EXAMPLES

SAVE ENERGY, MONEY AND THE PLANET

Using the right air filter will not only help you save money, but also maintain healthy indoor air quality. With the implementation of Eurovent´s updated and objective system for classifying energy efficiency, it will be easier for you to find the right air filter for the lowest energy usage and highest indoor air quality.

All air filters can be graded from A+ to E. Grade A+ stands for the lowest energy consumption and E for the highest. The classification, based on the filter test method **EN ISO16890:2016**, will give you a better understanding of annual energy consumption, average efficiency and minimum efficicency.

The energy consumption of air filters in general ventilation systems has become the focus of attention as energy prices increase, and as demands to reduce CO_2 emissions get tougher.

Classifying the air filters based on the new test standard will be more precise. Deciding the filter efficiency based on the indoor requirements is the first step in choosing the best energy efficient filter.

WHY A NEW ENERGY CLASSIFICATION?

The Eurovent energy classification was established 2011. There were a couple of upgrades during the past year including the grades A+ to E introduced in January 2015.

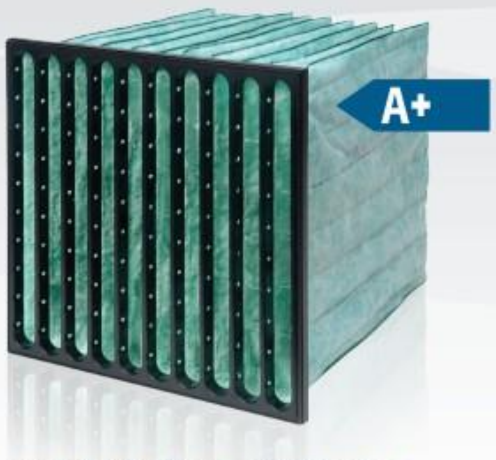
Air filter energy calculations were based on the EN779:2012 test reports. By introducing the global **ISO16890:2016**, an upgraded calculation method was needed.

During 2018, ISO16890:2016 became the only valid test standard in Europe. Beginning the 1st January, 2019, the energy classification for filters will be based on this standard.

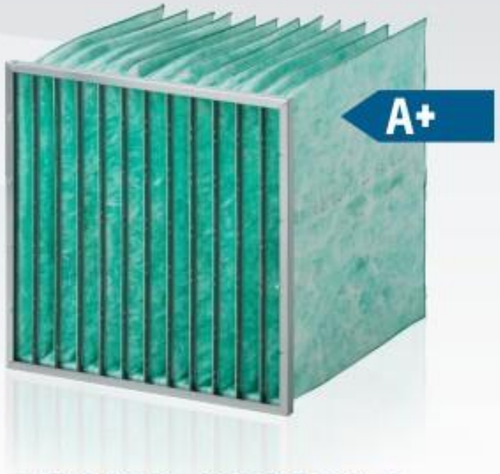
ALL AIR FILTERS REQUIRE A FULL TEST REPORT

More and more suppliers test their filters properly making i possible for customers to compare filter brands. By introduc ing the **2019 EUROVENT ENERGY CLASSIFICATION**, a participants of Eurovent Certita Certification are obliged t supply a full **EN ISO16890:2016 TEST REPORT**, as a bas to energy calculation, for every air filter sold in the market an published on Eurovent web site.

EUROVENT CERTIFIED PERFORMANCE ENERGY EFFICIENCY
CHECK ENERGY CLASS ON www.eurovent-certification.com



HI-FLO II XLT7/670 - ePM1 60% A+



HI-FLO M7 ES – ISO ePM1 60% A+

OPAKFIL ES7 – ISO ePM1 60% A+


COVID-19
INDUSTRY
RECOMMENDATIONS

Air filtration is one of the ways to fight the impact of harmful pathogens such as COVID-19.

Clean air should be introduced into our facility regularly to ensure a clean work environment.

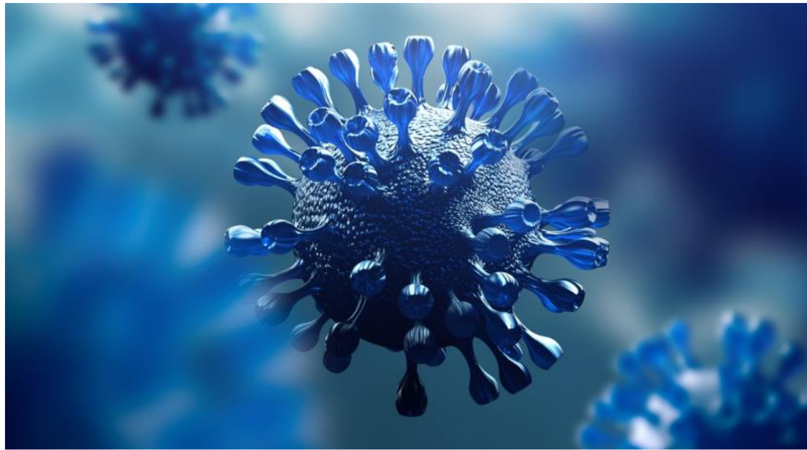
A high-efficiency air filtration solution can prevent infections in the air because it can trap and remove flu viruses from the air.

The effectiveness depends on the efficiency of the air filter.

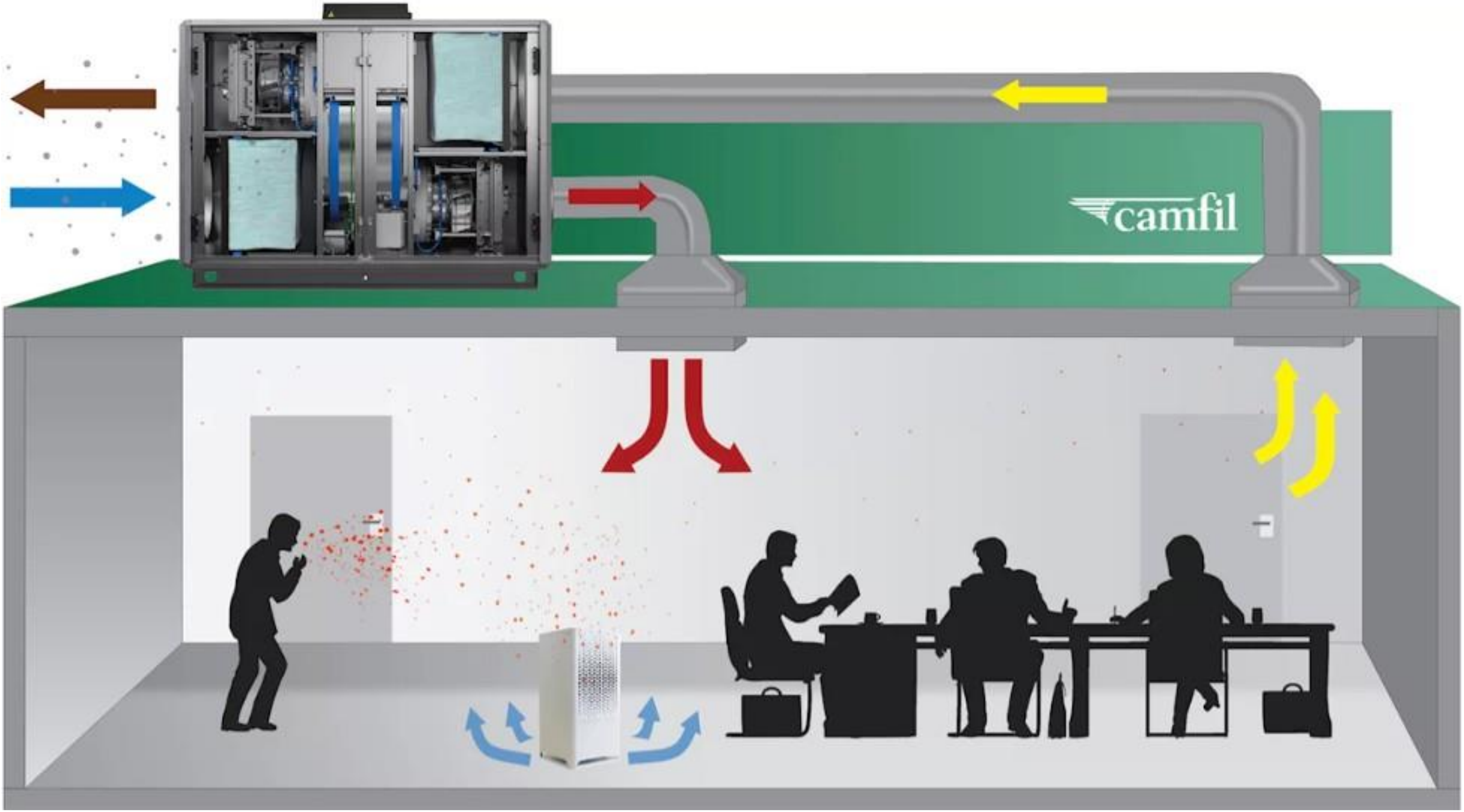
But as infectious droplets generally are larger than 1micrometer, the reduction of virus is significantly greater.

The virus captured in the air filter is strongly bound to the fibers in the filter media.

Once the virus is captured it will stay in the air filter and eventually dry out and die (refers to as inactive).



ENVIRONMENT EQUIPPED WITH PROPER AIR FILTRATION



AIR PURIFIERS

Technical especifications

Surface area covered: 100 m²

CADR*: 764,4 m³/h

Electrical supply: 220 - 240 VAC / 50 Hz

Consumed power: 68 W

Weight: 14 kg

Working temperature: 5 - 30 ºC

Size A x B x C: 767,5 x 440 x 330 mm

HORIZON AIR Sensor: Temperature, humidity PM2.5 levels

Control APP: No

*: Volume of air with hazardous particles that the equipment is capable of purifying in one hour.

HA-700

horizon AIR PURIFIER

FEATURES

Surface area covered:	100 m²
CADR*:	764,4 m³/h
Electrical supply:	220 - 240 VAC / 50 Hz
Consumed power:	68 W
Weight:	14 kg
Working temperature:	5 - 30 °C
Size A x B x C:	767,5 x 440 x 330 mm
HORIZON AIR sensor:	Temperature, humidity PM2.5 levels
Control APP:	No

*CADR: Volume of air with hazardous particles that the equipment is capable of purifying in one hour.

FEATURES

Suppression of ultra-thin particles (PM1.0)
Filtration of particles with up to 1 µm.

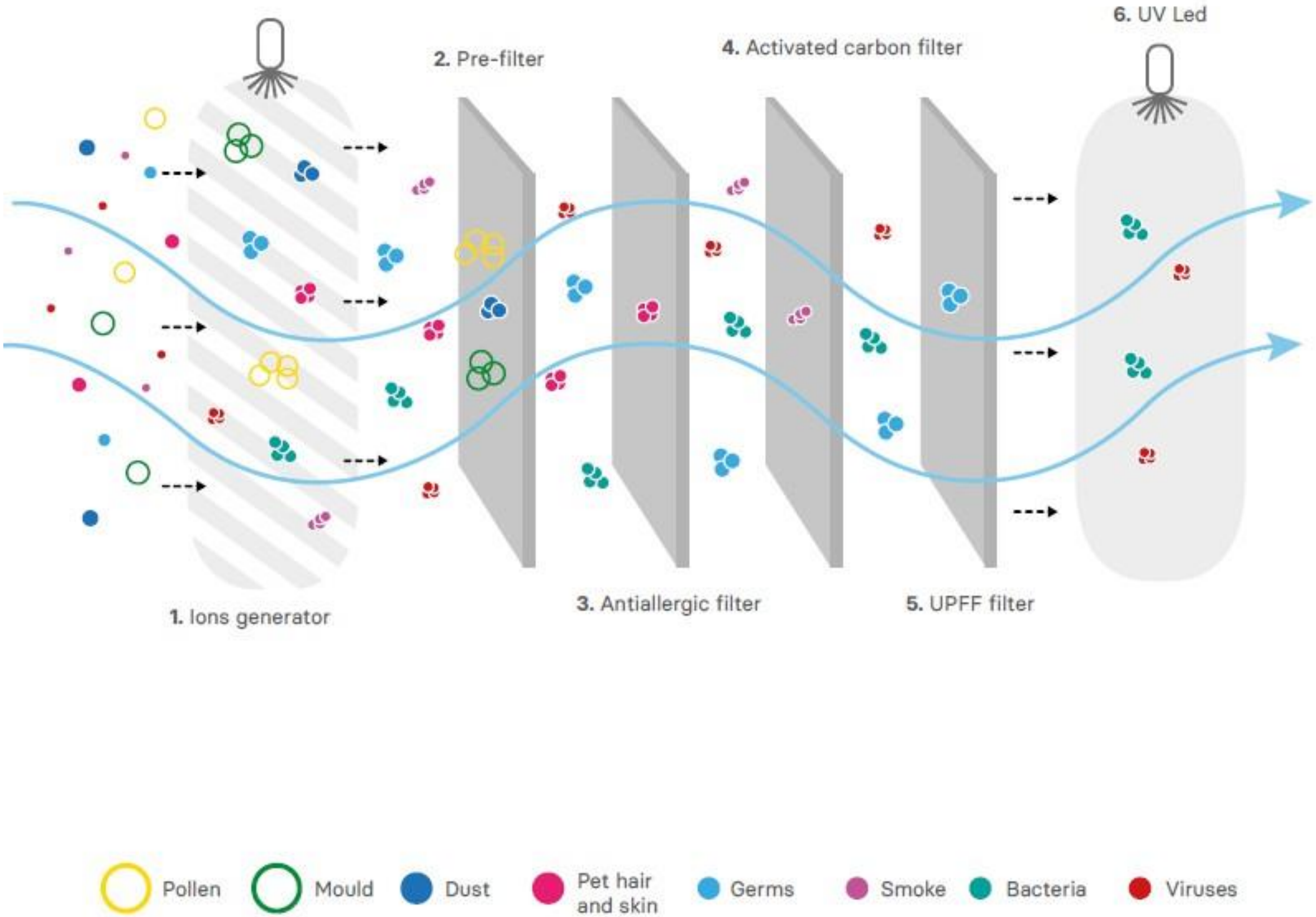
Double filtration
With a total of 8 filers installed in both sides of the equipment, it guarantees a clean air and a higher filtration rate.

Real-time air quality status
Air quality indicator pm 2.5 in a 4 colours led.
Blue – good (0 – 15 µg/m³)
Green – normal (16 – 50 µg/m³)
Yellow – bad (51 – 100 µg/m³)
Red – very bad (> 101 µg/m³)

Double air inlet and multiple discharge structure
The equipment sucks the air though two sides, filters it, and spreads it out towards multiple directions

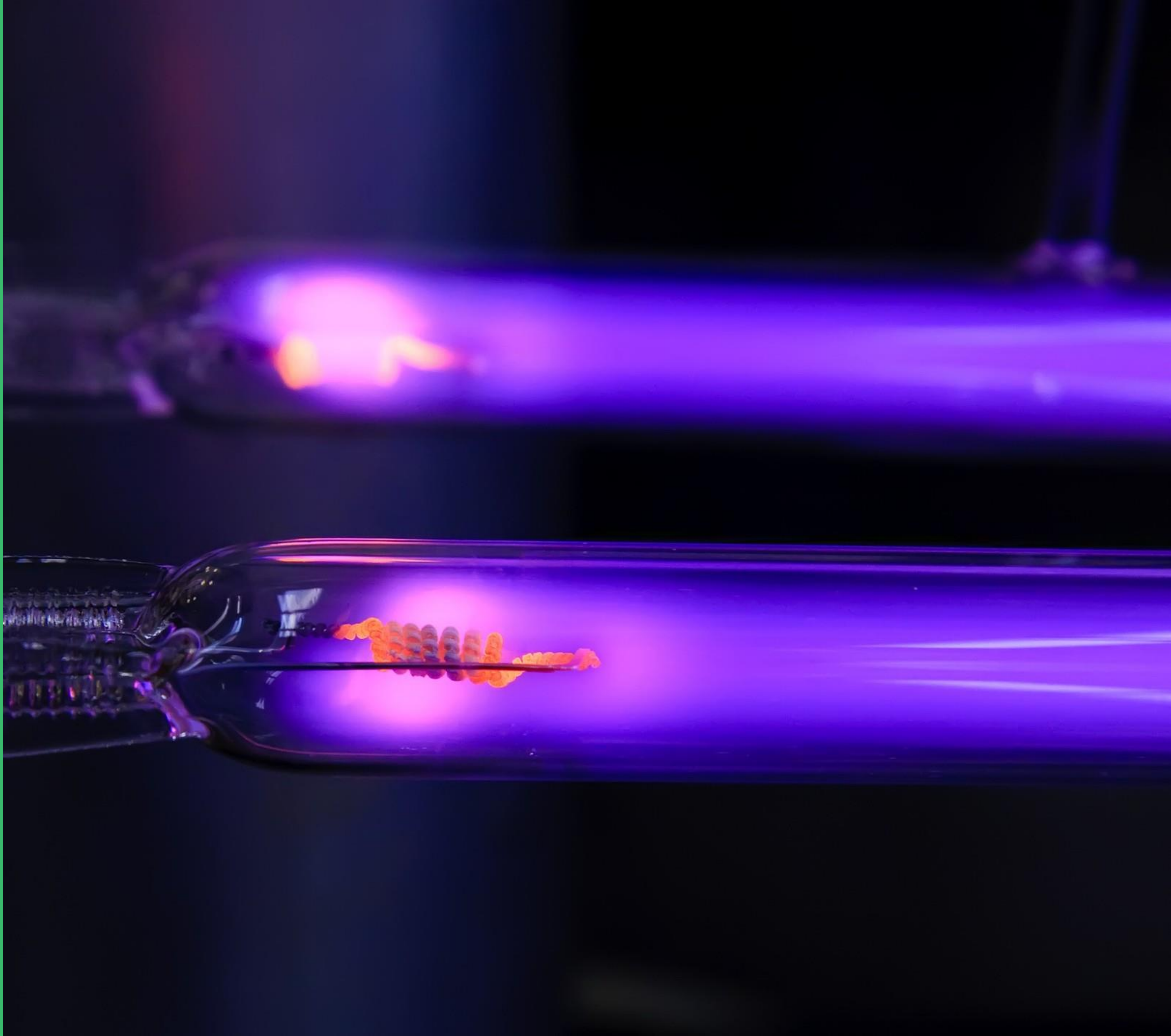
Double ultraviolet led (UV)
Ultraviolet radiation damages the DNA of many microorganisms and prevents them from reproducing.
In this way, bacteria, viruses and fungi can be eliminated without leaving any residue.

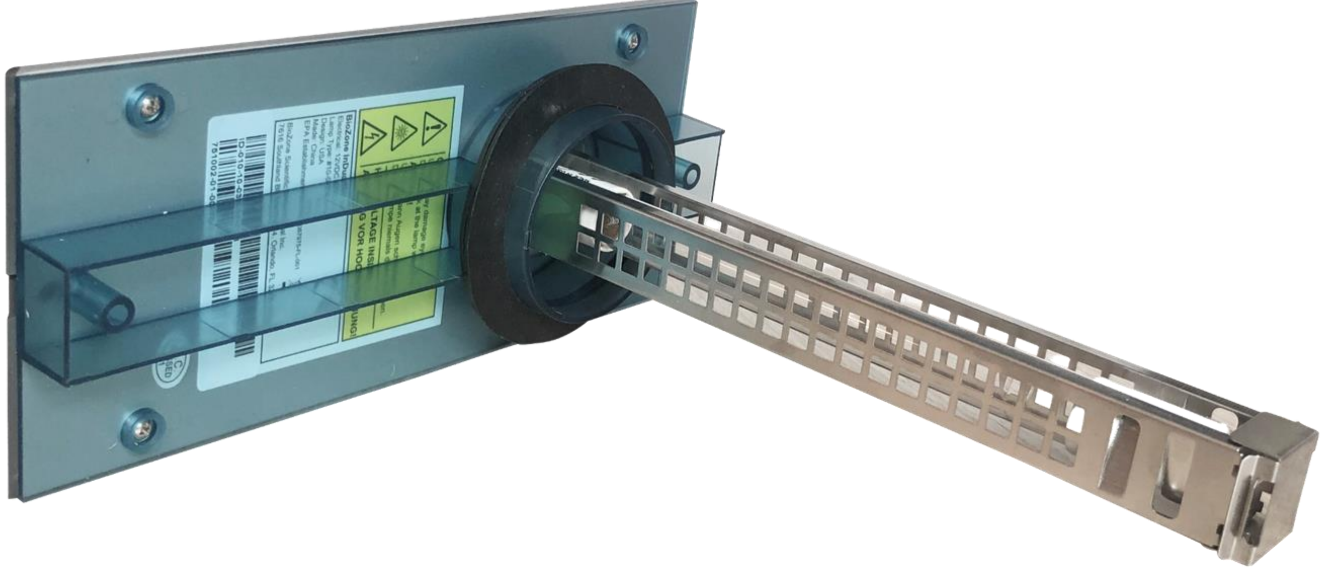
Ions generator
The ions generator groups the noxious particles from the environment in order to facilitate their filtration.



1. Ions generator
2. Pre-filter
3. Antiallergic filter
4. Activated carbon filter
5. UPFF filter
6. UV Led
Pollen
Mould
Dust
Pet hair and skin
Germs
Smoke
Bacteria
Viruses

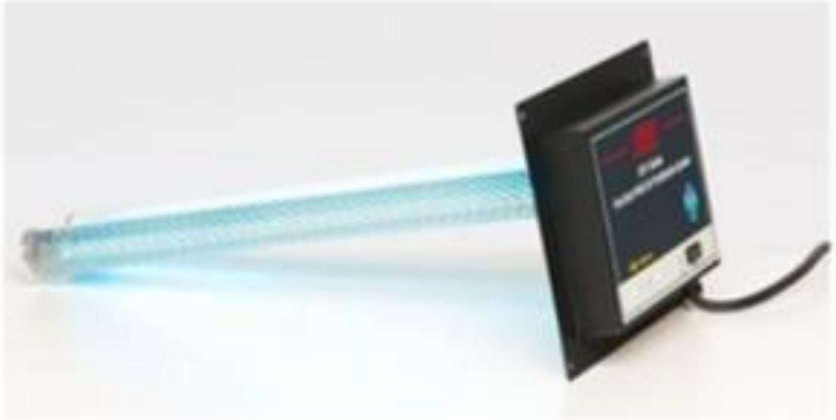
UV LAMPS





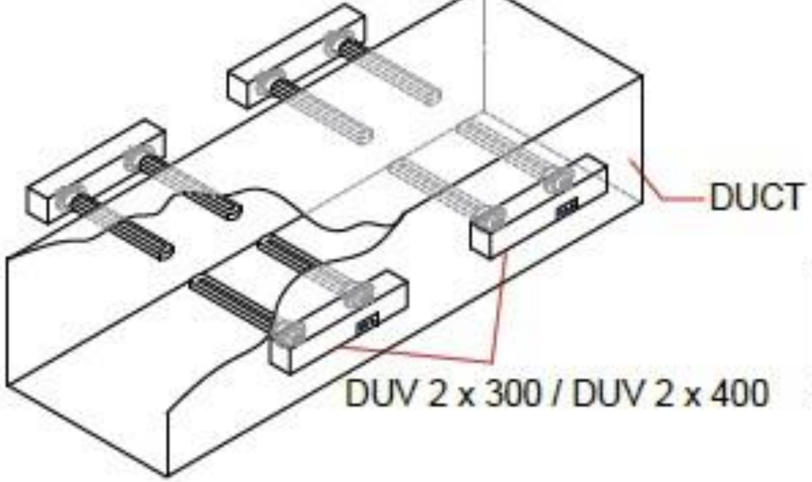
<u>C. Vessel Sterilizing and Cleaning Equipment, Thermal Cameras</u>

15. UV Air Treatment

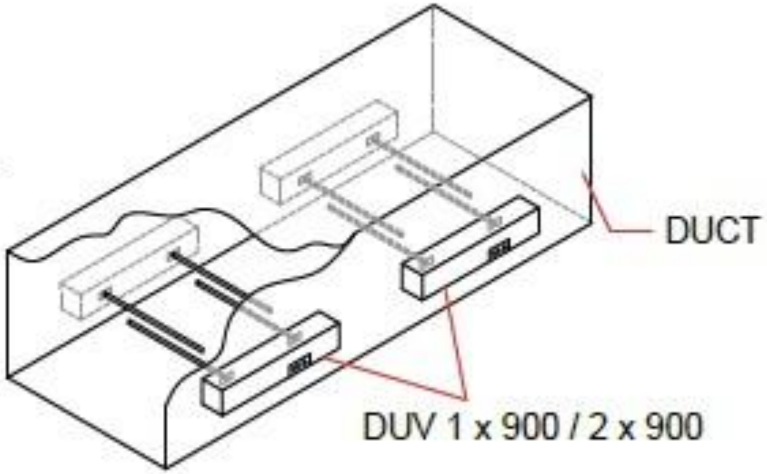


Geurbestrijder SNE FAP VBO serie

15 UV light treatment systems
15 Connection and (Scada) Control Skid
15 Spare lamp for UV light treatment systems



Τυπική εγκατάσταση
DUV 1 x 300 / 400. DUV 2 x 300 / 400



Τυπική εγκατάσταση
DUV 1 x 900. DUV 2 x 900

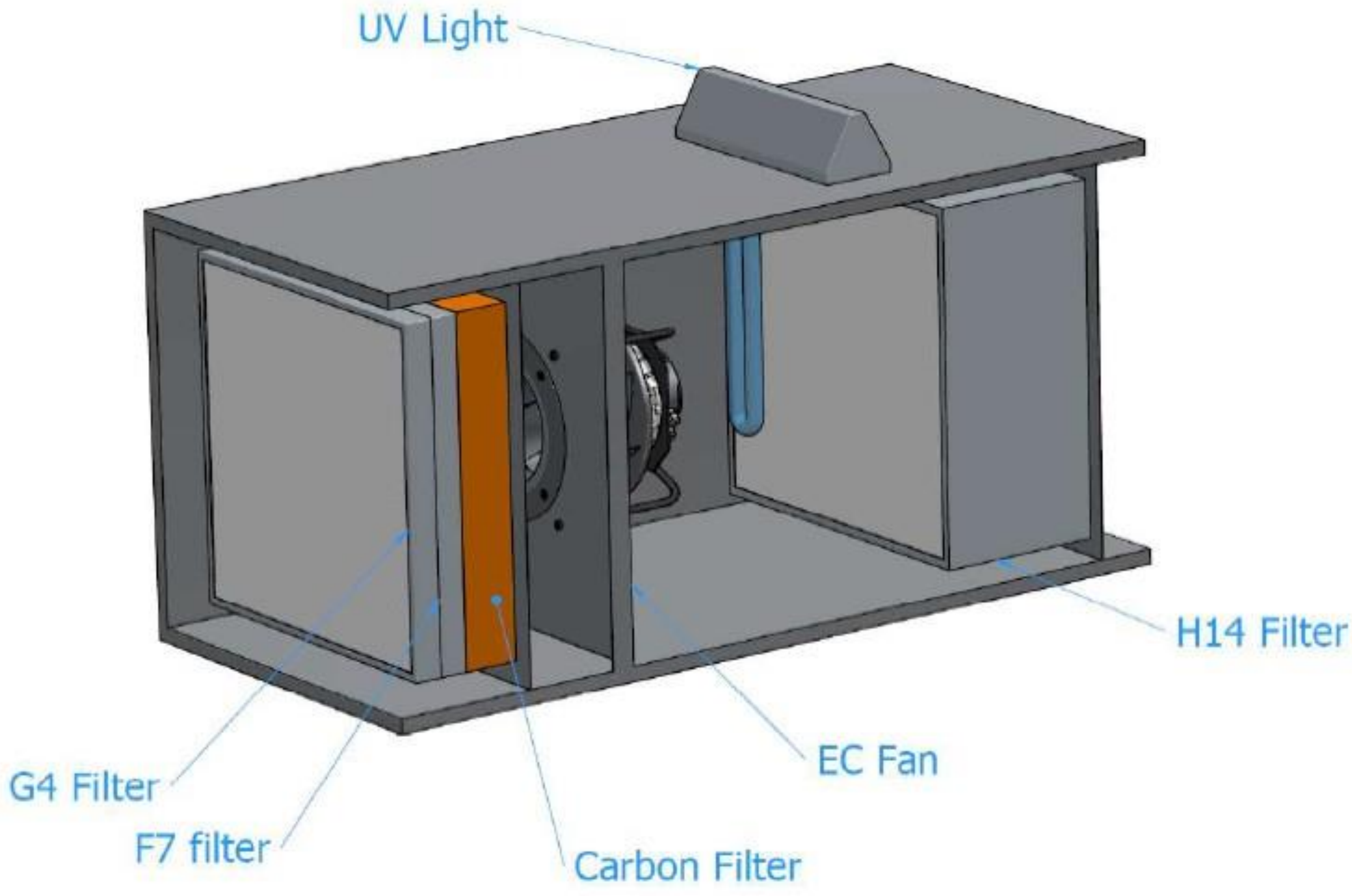
ΤΕΧΝΙΚΑ ΧΑΡΑΚΤΗΡΙΣΤΙΚΑ

- ♦ Λαμπτήρες U μήκους 300 & 400mm και T5 μήκους 900mm, με διάρκειας ζωής 12.000 ωρών.
- ♦ Πίνακας ελέγχου (Control Box) με φωτεινές ενδείξεις LED της λειτουργίας των λαμπτήρων και διακόπτη ON / OFF.
- ♦ Ακτινοβολία UV προς 360 μοίρες.
- ♦ Πολύ εύκολη & απλή εγκατάσταση. Ο πίνακας ελέγχου τοποθετείται εξωτερικά, στο κέλυφος του αεραγωγού ή του FCU.
- ♦ Εύκολη αντικατάσταση του λαμπτήρα με άνοιγμα του καλύμματος του πίνακα.
- ♦ Δεν είναι κατάλληλα για εξωτερική εγκατάσταση. Μόνο με σκέπαστρο βροχής.

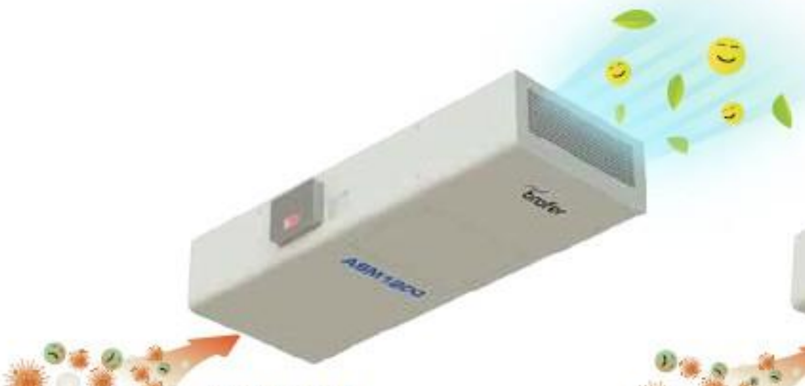
		DUV 1 x 300	DUV 2 x 300	DUV 1 x 400	DUV 2 x 400	DUV 1 x 900	DUV 2 x 900
ΙΣΧΥΣ	W	1 x 45	2 x 90	1 x 60	2 x 60	1 x 75	2 x 75
ΠΑΡΟΧΗ ΑΕΡΑ *	m^3/h	1.300	2.200	1.700	2.900	2.500	4.000
ΠΑΡΟΧΗ ΑΕΡΑ **	m^3/h	**650**	**1.100**	**850**	**1.450**	**1.250**	**2.000**
ΜΗΚΟΣ ΛΑΜΠΤΗΡΑ	mm	300		400		900	
ΑΡΙΘΜΟΣ ΛΑΜΠΤΗΡΩΝ	Nr	1	2	1	2	1	2
ΤΙΜΗ ΤΕΜΑΧΙΟΥ	€	**740,00**	**1.000,00**	**800,00**	**1.050,00**	**850,00**	**1.100,00**

* σε Δοσολογία **3.100** microwatt S / cm2. Για να αυξηθεί η δόση UV, εγκαταστήστε πρόσθετες λάμπες.
** σε Δοσολογία **6.200** microwatt S / cm2. Για να αυξηθεί η δόση UV, εγκαταστήστε πρόσθετες λάμπες.

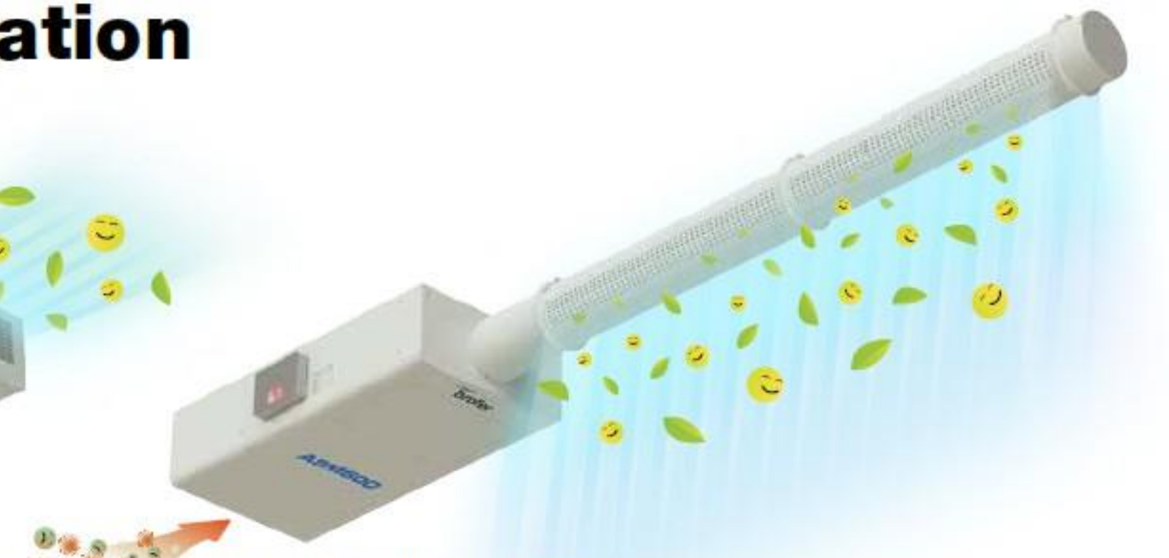
Filter box unit with UV lamp



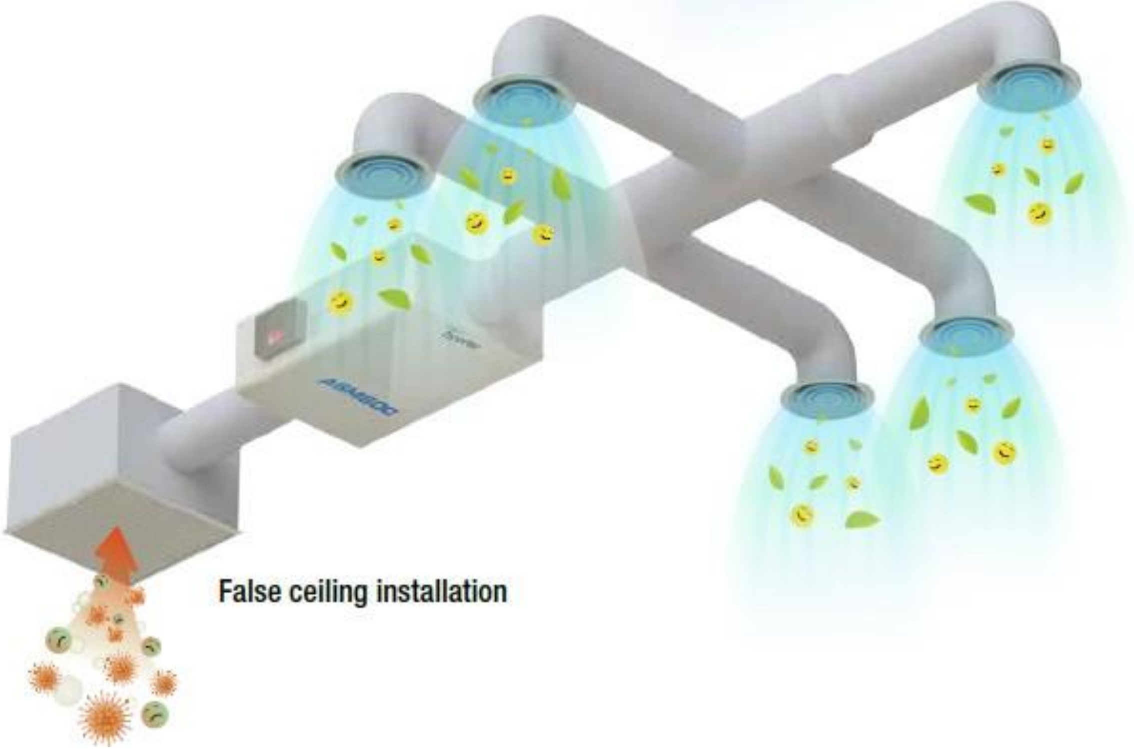
Type of installation



Not ducted



Ducted within the environment



False ceiling installation


domestic


bar


office


shop


school

Until recently, there has been little interest in revisiting the UV-C UV limits, since the only workers routinely exposed to UV-C wavelengths were arc welders and some scientists working with open arcs and specialized arc lamps, so the TLV®s were applied for risk assessments in those work areas.

This was of special interest to those working with upper-air ultraviolet germicidal irradiation (UVGI), where a frequent question was whether some scattered UV-C into occupied areas should really be of concern.

The preliminary studies began to suggest that thresholds were considerably higher than some published in the past using arc monochromators with 10–20 nm spectral bands for exposure.

Exposure of the forearm of Type II human skin to UV-C at 222 nm supported assertions that a larger cumulative dose was required to produce an observable cutaneous effect.

In a case study, a cumulative dose of 1500 mJ cm−2 at 222 nm did not produce an observable effect. Exposure at 6000 mJ cm−2 resulted in a faint yellowish color appearance to the exposed skin that was apparent almost immediately.

The experimental data from both skin and eye exposure studies support a substantial increase in the exposure limits at wavelengths less than 250 nm.

This initially comes as somewhat of a surprise to biologists who are well aware of the greater energy of UV-C photons compared to UV-B and who have studied DNA damage and cellular mutagenesis from 254 nm.

Yet, in practice, outdoor workers are routinely exposed to solar UV above the UV-B exposure guidelines.

The current exposure guidelines can be exceeded in midday midsummer within less than ten minutes.

An expert committee of scientists and physicians who had studied solar and ultraviolet photocarcinogenicity met at the International Agency for Research on Cancer (an Agency of the WHO—the World Health Organization) in Lyon, France, in 1992, and concluded that sunlight was carcinogenic in humans (Group 1), and: "Ultraviolet C radiation is probably carcinogenic to humans (Group 2A)."

A later IARC group particularly concerned about risks of photocarcinogenicity from tanning beds met in 2009; and, although the focus of their review appeared to be the risks of UV-A and UV-B from tanning beds, this group recommended updating all ultraviolet radiation (along with sunlight) to Group 1 (24, 30).

International Agency for Research on Cancer (2012) Solar and ultraviolet radiation. In A Review of Human Carcinogens, Part D: Radiation/IARC Working Group on the Evaluation of Carcinogenic Risks to Humans (2009: Lyon, France), pp. 35–101. IARC Monograph 100D, International Agency for Research on Cancer, Lyon.

1. UV Light:

Ultraviolet (UV) lights are devices that emit UV radiation. UV Light radiation can be used in HVAC systems to disinfect air and surfaces. The UV light breaks down the DNA of microorganisms, rendering them unable to reproduce and causing them to die. UV lights can reduce or eliminate airborne pathogens, including bacteria, viruses, and mold spores.

Features

- The main types of UV lights are low-pressure mercury vapor lamps and high-pressure mercury vapor lamps.
- Low-pressure mercury vapor lamps produce lower levels of UV radiation than high-pressure mercury vapor lamps, which makes them less effective in disinfecting air and surfaces.
- UV light installation is an in-duct (AHU) UV system. In-duct UV system processes the air as it cycles through return ducts, killing microbes by maximizing UV-C in all directions with the reflective surface of that section of the tubing.

Benefits

- Coil sterilization targets and fights microbial growth on tougher-to-reach areas, including grooves, fins, and seams, with the robust power of UV-C lighting.
- UV filters also reduce odors and VOCs (volatile organic compounds).
- Kills and eliminates germs, viruses and bacteria, mold, mildew, other allergens, and foul odors.
- Improves HVAC efficiency and reduces HVAC maintenance.
- Lowers energy consumption.

Challenges

- Higher installation costs occur with mostly a limited lifespan of one to three years.
- It is not a Fool-Proof / 100% Effective solution.
- Unable to target gases, fumes, and cigarette smoke.
- Only certain UV lights work in air purification.
- Direct exposure is hazardous to the skin and eyes considerably.
- If not installed properly in the HVAC system, it can be ineffective, leading to hazards or material decomposition putting occupants at risk.

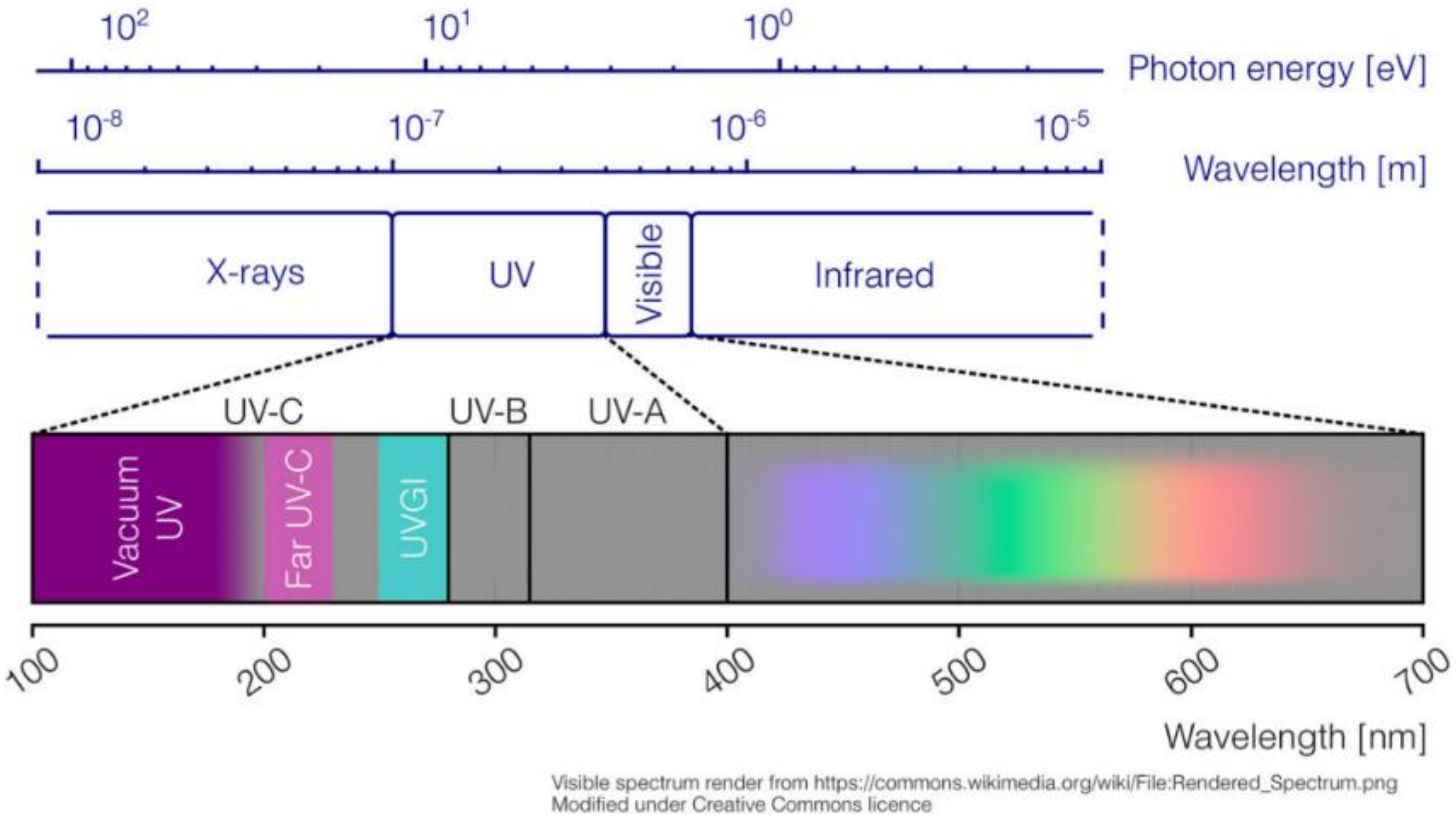
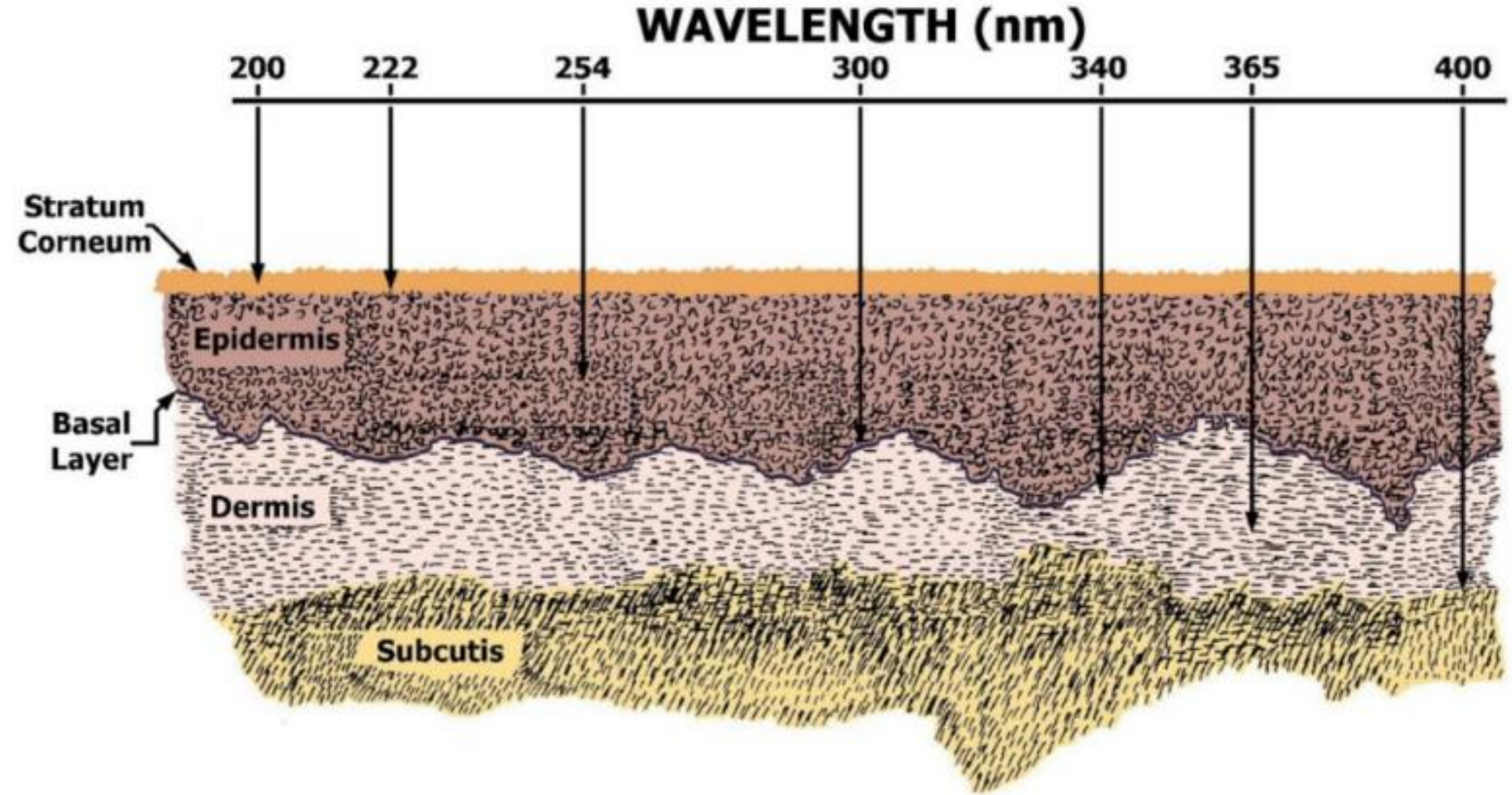


Figure 1. Electromagnetic spectrum and the position of ultraviolet radiation within it. Designations of the wavelength ranges that define UV-A, UV-B, and UV-C are shown, along with the sub-categories of UV-C (UVGI, Far UV-C, and VUV).



WAVELENGTH (nm)
200
222
254
300
340
365
400
Stratum Corneum
Epidermis
Basal Layer
Dermis
Subcutis

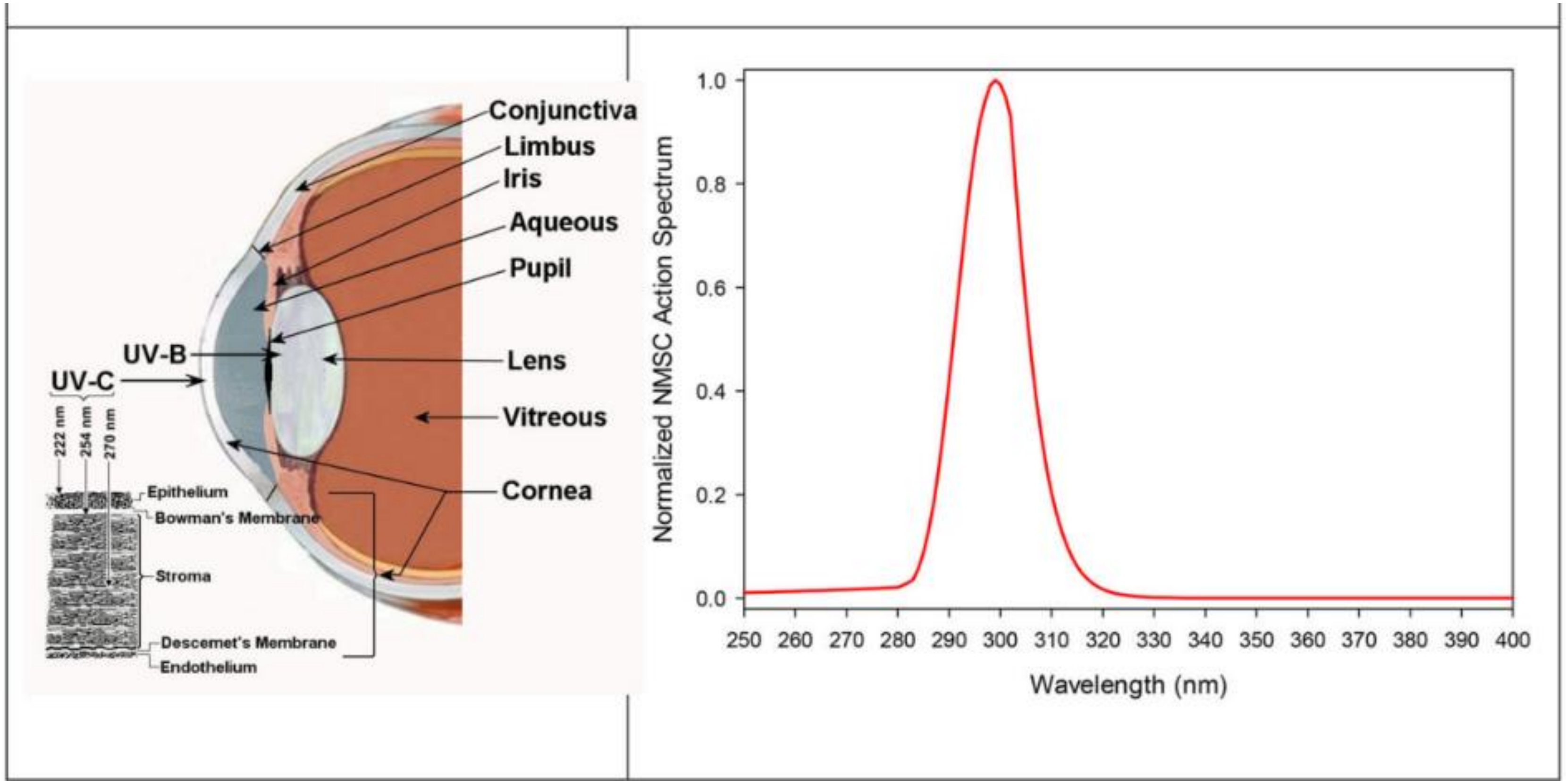


Figure 6. Effects of UV radiation on human tissues. (Top) Penetration of UV wavelengths into human skin. The arrows point to the estimated 90% absorption depths. UV-C wavelengths at 222 nm do not penetrate the stratum corneum; whereas, 254 nm penetrates into the upper epidermis. By contrast, UV-B wavelengths, such as 300 nm, penetrate to the germinative (basal) layer of the epidermis with sufficient energy to mutate DNA. The wavelengths of 340, 360, or 400 nm covering the UV-A penetrate deeply into the dermis but have lower photon energies that are far less damaging than 300 nm. (Lower Left) Penetration of UV wavelengths into the human eye. UV-C wavelengths at 222 nm hardly penetrate to the corneal epithelium; whereas, 254 nm penetrates well into the epithelium and into the stroma. The cornea blocks UV-C energy from reaching the lens (Oksala & Lehtinen, 1960) UV-B wavelengths, such as 300 nm, do penetrate to the lens, and oblique rays to the critically important germinative layer of the lens behind the iris and have sufficient energy to mutate DNA. UV-A wavelengths are strongly absorbed by fluorophores in the lens and protect the retina. (Lower right) International Standards Organization (ISO) standard action spectrum for non-melanoma skin cancer. This standard action spectrum was developed from extensive laboratory studies of skin cancer and measured spectral transmission of the stratum corneum and upper epidermis. Although it does not extend into the Far UV-C, it shows the significant risk of UV-B compared to UV-C. The risk for the far less penetrating Far UV-C would be still further reduced and vanishingly small (Data from ISO, 2016).

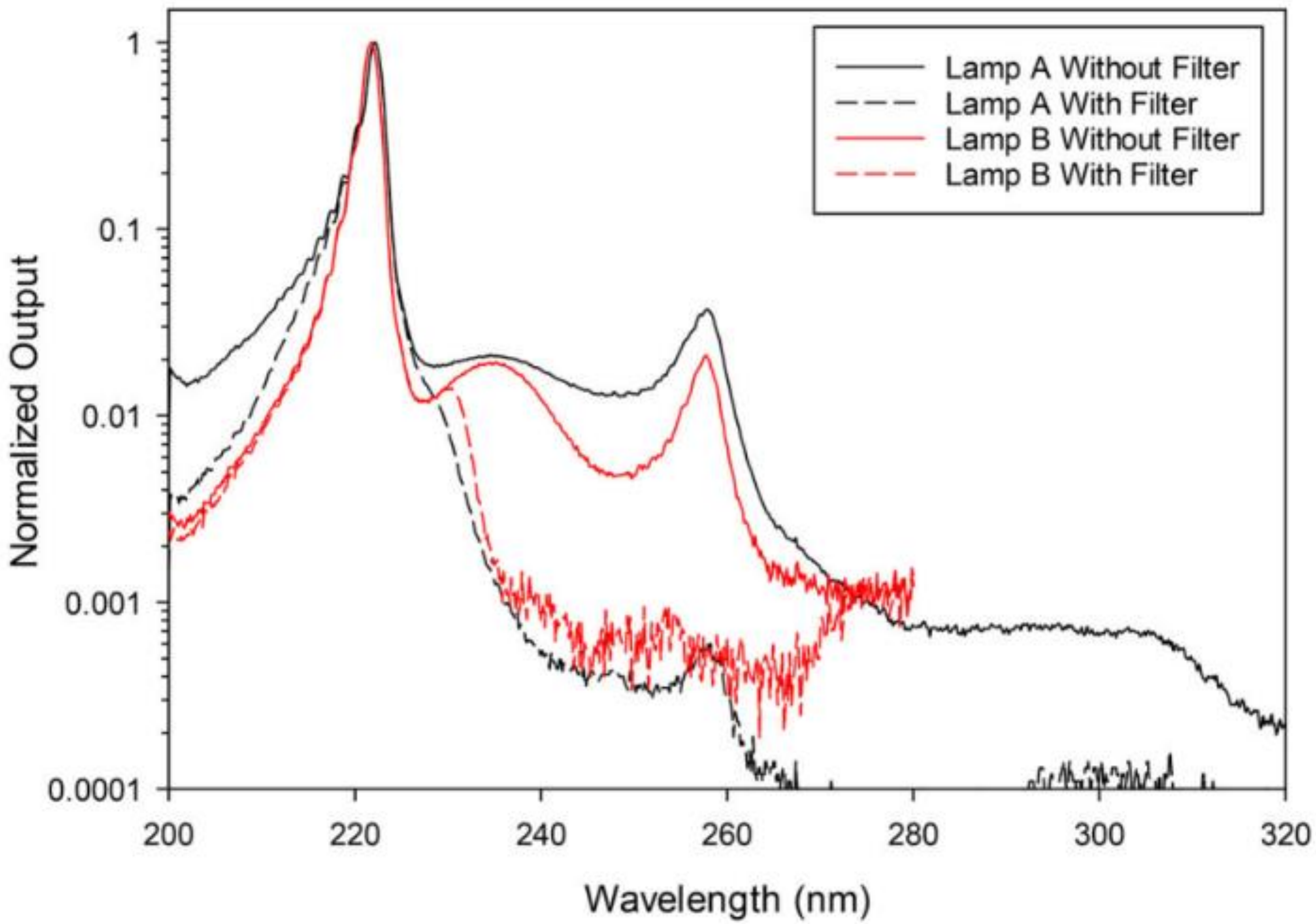


Figure 2. Emission spectra in the UV-C and UV-B ranges from commercially-available KrCl* lamps with and without optical filters. Normalized output presented on a log_{10} scale. For both lamps, the spectra were measured independently and normalized to output at the wavelength corresponding to peak output (*ca.* 222 nm).

The current reasoning is that the 8 h limiting irradiance should still be acceptable for the longer shifts because of dose-reciprocity failure beyond ~4–5 h.

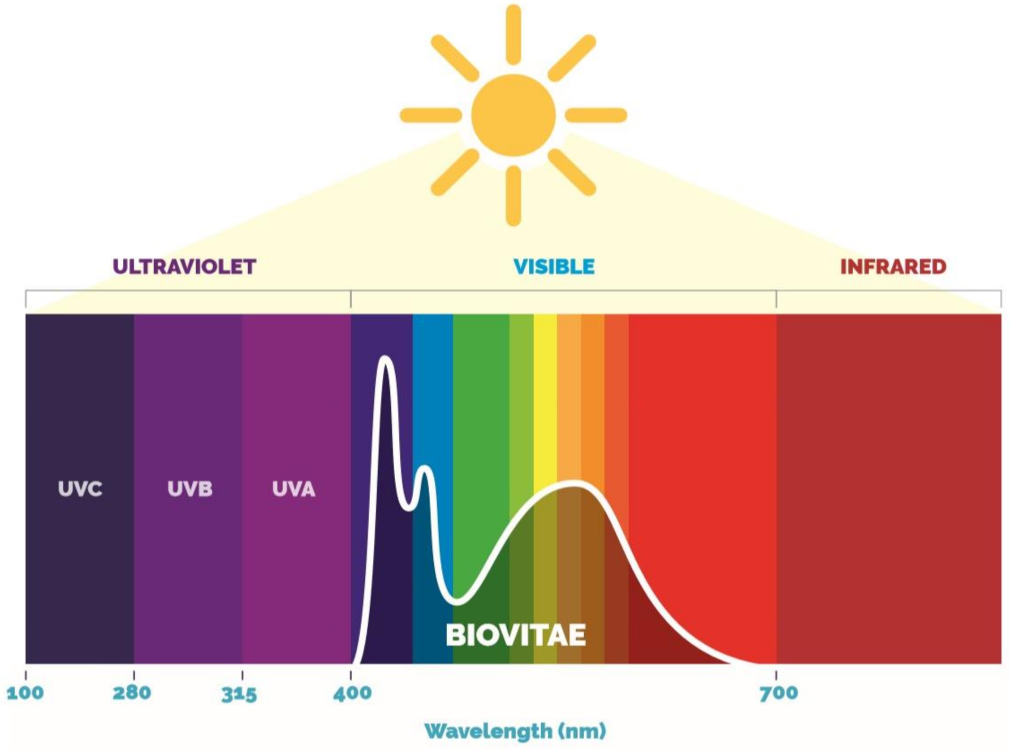
That is, a higher dose is required for longer durations for the same effect, and there is sufficient safety margin to readily accommodate these longer exposure durations.

Dose additivity beyond a day can be ignored because of cellular repair (e.g. overnight) and the safety margin for exposures at or below the TLV.

The constant replacement of epidermal cells and corneal epithelial cells and the location of germinative cells were carefully taken into account in the development of these limits.

The fortunate evidence is that the protection of these critically important cells is far better in the UV-C than in the UV-B.

LED (Biovitae)



FUNZIONA IN PRESENZA DI PERSONE

LED (UV-FREE) NESSUN RISCHIO DI ESPOSIZIONE

SANIFICA DURANTE LE ATTIVITÀ QUOTIDIANE


UV-C
405NM BLU-VIOLET
BIOVITAE

Ospedale Montevergine – Sala Operatoria – Dipartimento di Cardiologia Campania

IDI Istituto Demopatico dell'Immacolata- Roma

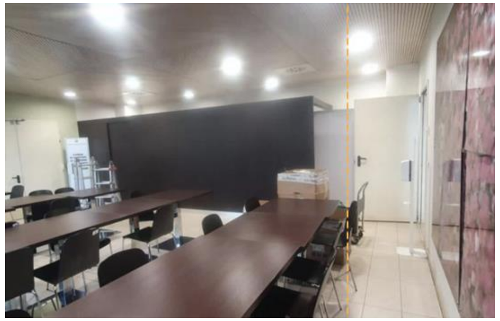
Ambulatorio – Corte dei Conti

ADR- Ospedale di emergenza dell'aeroporto di Roma Fiumicino

St. Walburg Elementary School - Germania

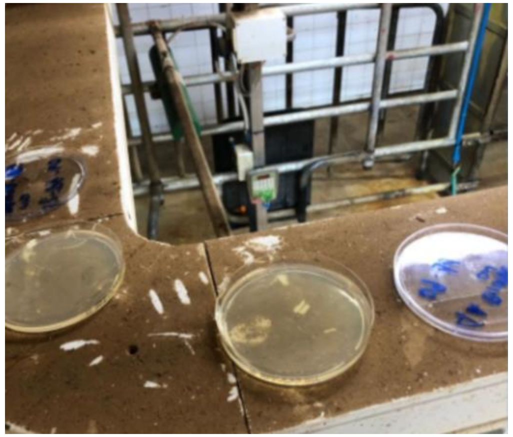
Liceo Moscato– Sant'Antimo, Italia

Università di Camerino – Italia



Policlinico Universitario Campus Biomedico - Roma

ALLEVAMENTI E TRASFORMAZIONE ALIMENTARE



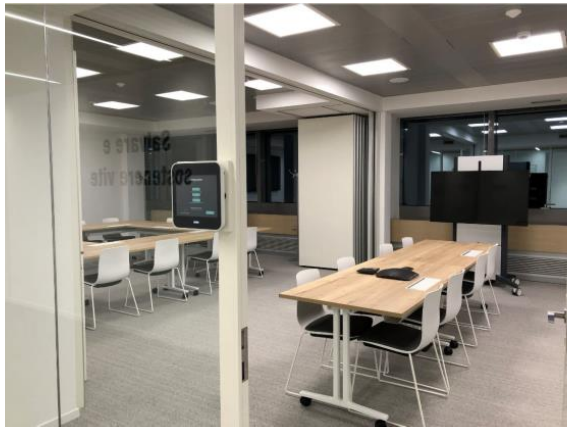
Allevamento di bufale- Fattorie De Vivo Italia

Fattoria La Granda- Genola, Italia

Allevamento di maiali irlandese

Caseificio Torricelle– De Vivo Agriculture factory- Salerno, Campania

UFFICI



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Prefettura – La Spezia

Lazio Innova Innovation Hub – Viterbo

RETAIL E SETTORE SPORTIVO

Lavazza Flagship Store – London

La Cooperativa – Cortina D'Ampezzo

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Sampdoria's Dressing Room – Genova