VIRUS-FREE OFFICE BUILDINGS

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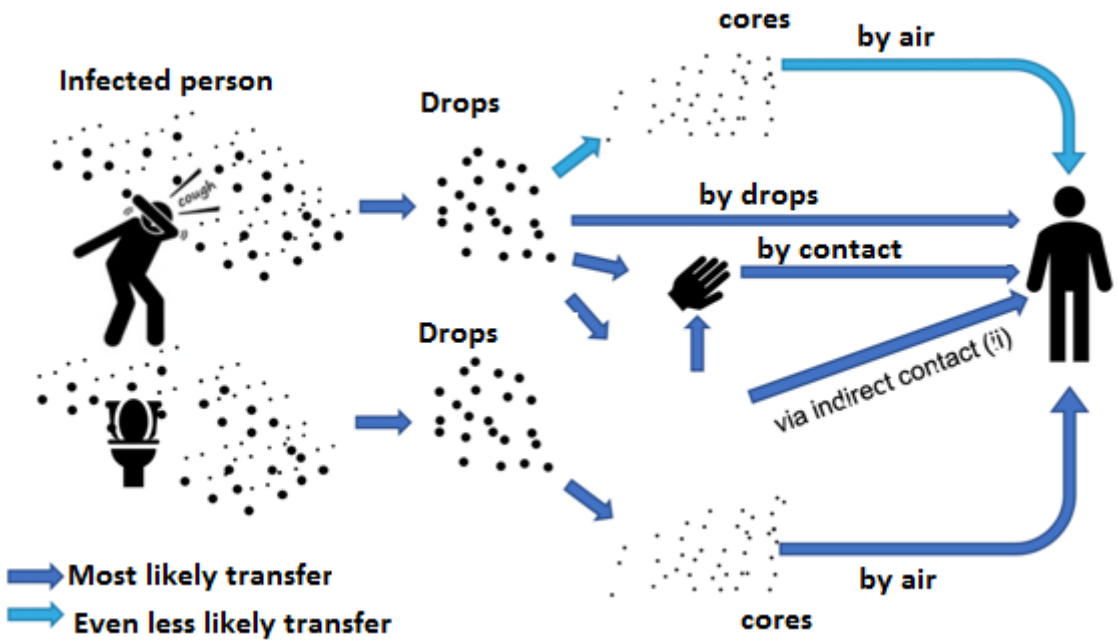
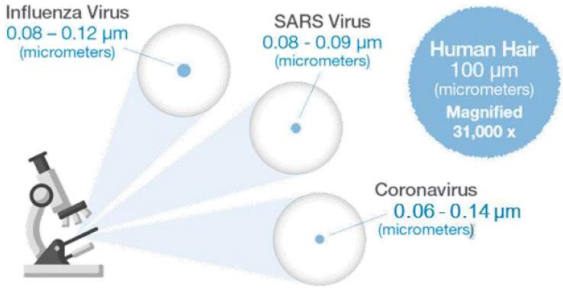
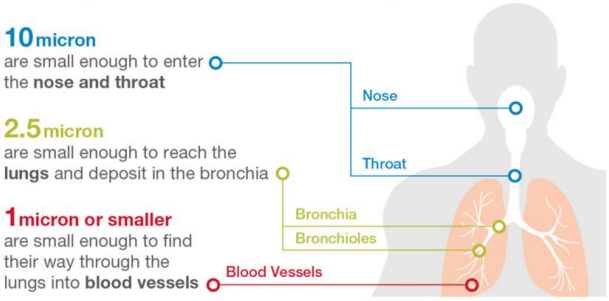
1 Introduction

Viruses are very small particles that can spread through air or contact.

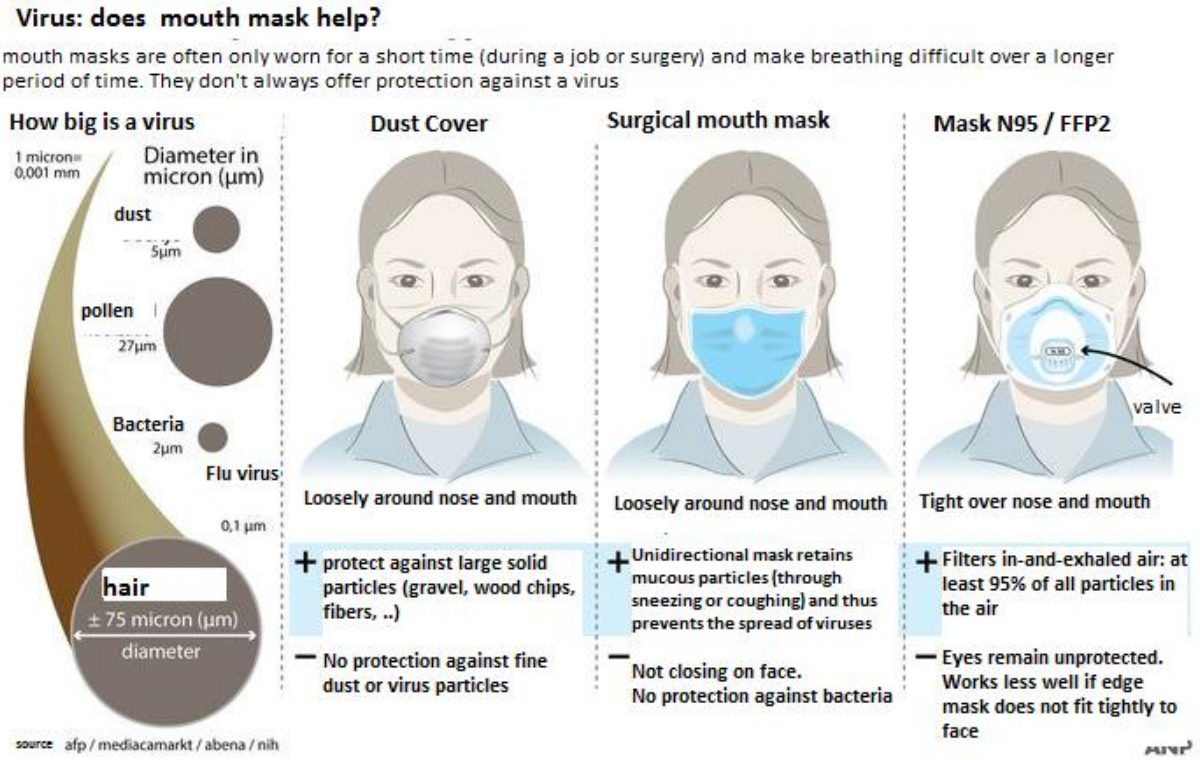


The coronavirus can be up to 0.06 µm small, which means that it can be absorbed into the blood vessels when ingested through the eyes, nose, mouth, etc.





Wearing face masks is recommended for direct contact between people, but they are not 100% safe. Even the best mouth masks on the market may still allow 5% of the viruses to pass through.



Viruses can survive on objects for quite some time, making contact transmission a real cause of the spread. This ranges from 4 hours on copper (money), to 24 hours on paper and cardboard, and up to 5 days on plastic and stainless steel (door handles, lavatory taps, …).

2 Measures package 1: measures to avoid transmission via human contact

To prevent viruses from spreading quickly between the different users of a building, it is important to reduce this spread by applying several hygiene measures and including them in the maintenance contract or work regulations.

- Cleaning door handles: to be included in the maintenance plan and to be applied on a regular basis
- Mobile phones must be disinfected before leaving or entering the building/ the zone
- Wash your hands at any changed activity (office work, break, sanitary stop)

To be provided by Facility Manager

To be included in work regulations

To be included in work regulations

3 Measures package 2: measures to avoid transfer via contact between building and people

3.1 Measures at the level of common parts and control (switches, buttons, doors, etc)

Automation of certain parts of the building will lead to less contact and less potential contamination. It will also help to reduce the measures in package 1.

Especially in the common areas where every building user circulates several times a day, it is best to be automated. Within the architectural concept, not only the entrance doors can be automated, but also all other interior doors that are encountered in a specific zone. It will not be possible in budget terms to apply this to the last door of individuals office. Potential contamination through contact may only occur in a specific zone (ex. only 1 floor or section of the building).

Automatic sliding door

Automatic door

Within the concept of techniques, the automatic doors are controlled via a badge system, which reduces contact with door handles.

The use of motion detection for lighting also excludes contact with switches. Here, the use of push buttons will be limited to specific rooms.

Badge reader

Motion detector

3.2 Measures at sanitary level (Toilets, sinks …)

In addition to the entrance hall, the sanitary rooms are the most visited areas by the largest number of people in a building. These rooms must be equipped with the available techniques to avoid contact as much as possible.

- Urinals with automatic flush instead of push button
- Water taps with infrared detection so that no one should touch the water tap. This also saves water if a manual water tap must be closed according to the measures, after drying the hands with paper.
- A self-closing and opening toilet seat avoids contact with another source of viruses, fecal matter that comes into contact with the toilet seat via splashing water.
- By using an automatic toilet with self-cleaning seat and automatic flushing, you can avoid full contact with hands.
- The application of a motion detection to control the lighting avoids any contact with switches.

Automatic flushing (IR-detective)

Automatic water taps (IR-detective)

self closing/ opening toilet seat

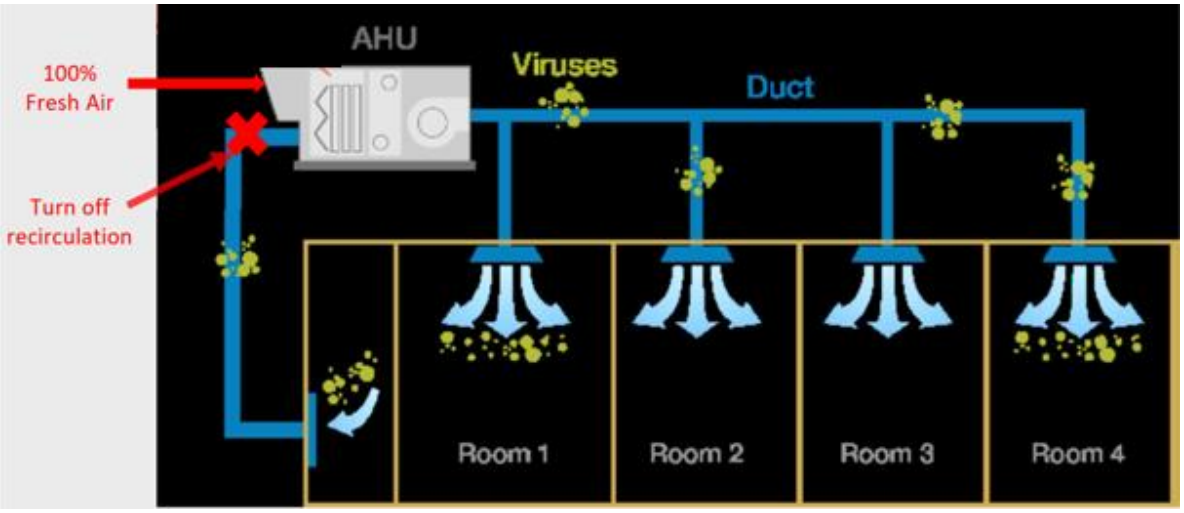
Automatic toilet

Motion detector

4 Measures package 3: measures to avoid transmission via the HVAC system

Viruses can be spread via air. There is no action that can be taken against direct contact, which happens usually locally (infected person next to a healthy person). This is based on the personal hygiene of each individual. (sneezing in a handkerchief or in the sleeve, up to wearing mouth masks). When an infection is detected, the infected person must isolate himself and leave the working environment. (Possibly homework)

Viruses are spread through the ventilation via indirect contact and can infect an entire building. The solution to this problem is a good HVAC concept.



4.1 Measures at level of Hygienic ventilation

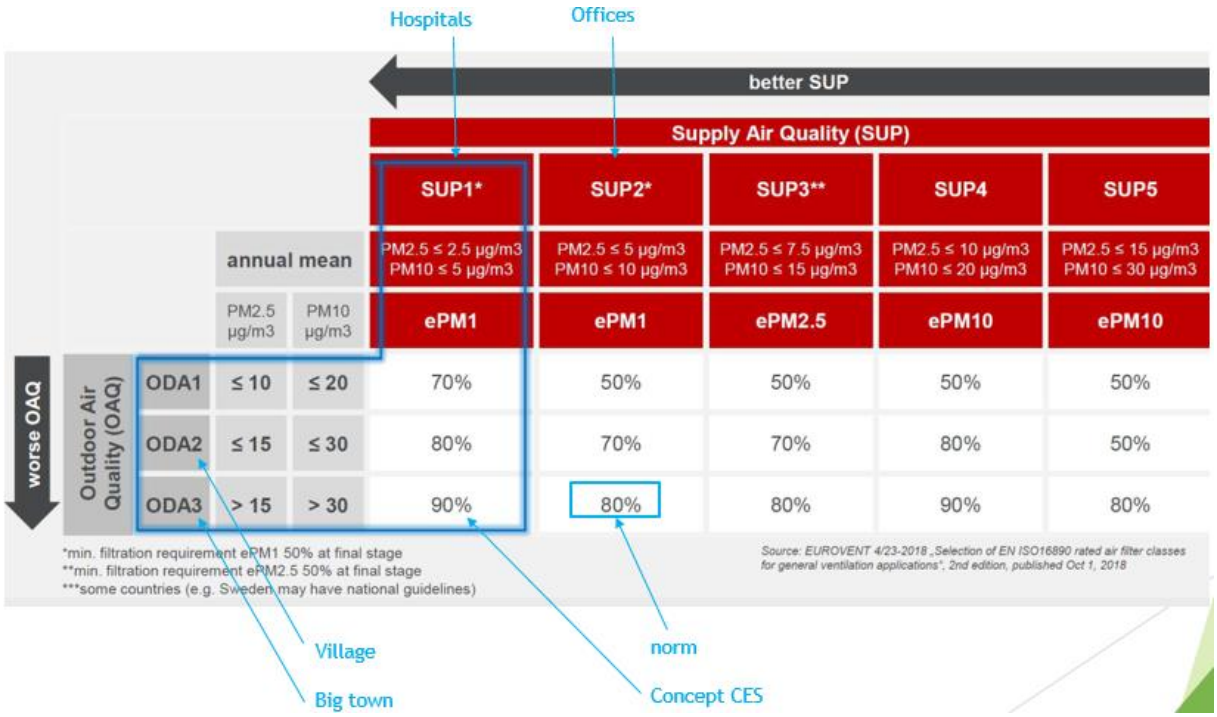
4.1.1 Filtering

To frame the influence of this HVAC concept, a comparison is made between a normal office building and the requirements in the most critical areas of hospitals (clean rooms and operating rooms).

Category	Description	General Ventilation	Industrial Ventilation
SUP1	WHO (2005) guidelines limit values **multiplied by a factor x 0,25 (annual mean for PM2.5 ≤ 2.5 µg/m³ and PM10 ≤ 5 µg/m³)**.	-	**Applications with high hygienic demands.** Hospitals, pharmaceutics, electronic and optical industry, supply air to clean rooms...
SUP2	WHO (2005) guidelines limit values **multiplied by a factor x 0,5 (annual mean for PM2.5 ≤ 5 µg/m³ and PM10 ≤ 10 µg/m³)**.	**Rooms for permanent occupation.** Kindergardens, offices, hotels, residential buildings, meeting rooms, exhibition halls, conference halls, theaters, cinemas, concert halls...	**Applications with medium hygienic demands.** Food and beverage production...
SUP3	WHO (2005) guidelines limit values **multiplied by a factor x 0,75 (annual mean for PM2.5 ≤ 7.5 µg/m³ and PM10 ≤ 15 µg/m³)**.	**Rooms with temporary occupation.** Storage, shopping centers, washing rooms, server rooms, copier rooms...	**Applications with basic hygienic demands.** Food and beverages production with a basic hygienic demand...
SUP4	WHO (2005) guidelines limit values **(annual mean for PM2.5 ≤ 10 µg/m³ and PM10 ≤ 20 µg/m³)**.	**Rooms with short-term occupation.** Restrooms, storage rooms stairways...	**Applications without hygienic demands.** General production areas in the automotive industry...
SUP5	WHO (2005) guidelines limit values **multiplied by a factor x 1.5 (annual mean for PM2.5 ≤ 15 µg/m³ and PM10 ≤ 30 µg/m³)**.	**Rooms without occupation.** Garbage room, underground car parks...	**production areas of the heavy industry.** Steel mill, smelters, welding plants...

According to European standards, this shows a difference in the air quality category of supply air to the rooms (SUP 1 for hospitals & SUP 2 for offices). The outdoor air quality is currently highly polluted and is categorized (even in smaller villages) within ODA3 depending on dust particles in the air. The European ErP standard requires a filtering of at least 80% ePM1. This means that at least 80% of all particles between 0.3 and 1 µm must be retained. In hospitals, this value is set at 90%.

Even before the corona pandemic, CES recommends a combination of an F7 + F9 filter for a decent indoor office climate. This combination results in a filtering of 90% ePM1, and hence this concept was already comparable to the standard of hospitals.

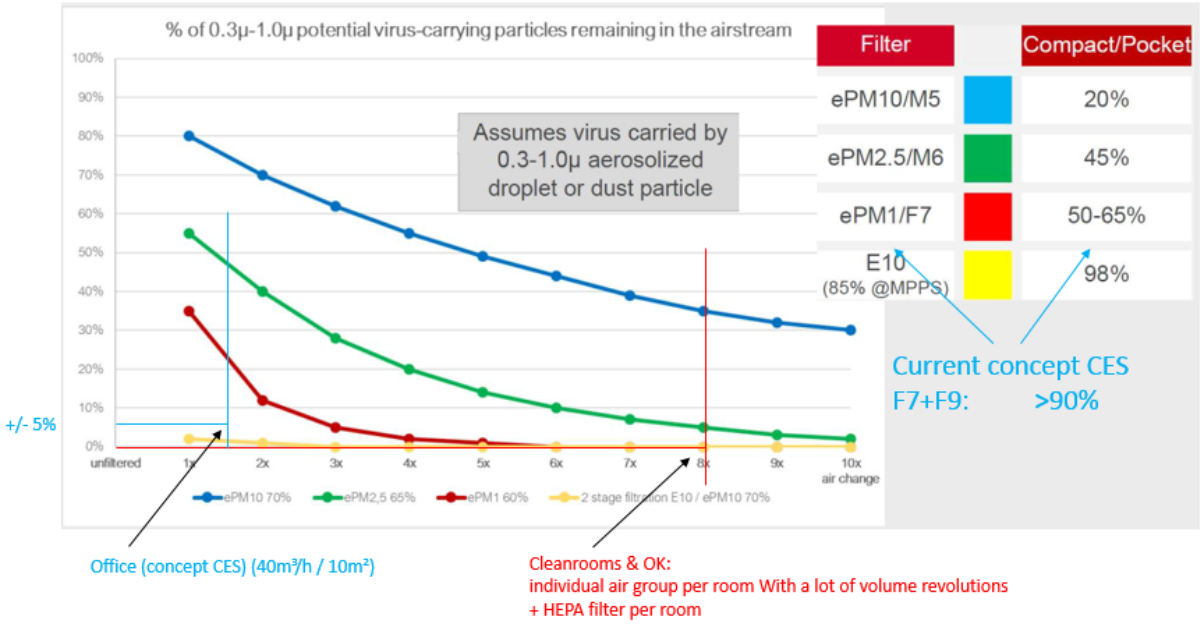


Several studies have shown that with a greater flushing of the rooms the amount of dirt particles decreases with the same type of filter. The more the air rotates per hour, the more the dirt particle passes through the filter and the higher the chance that the dirt particle is collected. This cohesion can be seen in the graph below.

To come to an acceptable result, good filters can be provided, or many rotations can be foreseen, or a combination of both.

For ORs, a HEPA filter is provided per room and intensive ventilation of 8 and more rotations is applied, where the probability of virus spread is 0%.

In an office environment it is inconceivable (based on location and flexibility) to provide a separate air handling group per room. At normal office flow rates, we come to +/- 1.5 rotations per hour. With an air filter F7 + F9, up to 95% of all dirt particles will be stopped. What is still a relatively high chance that viruses will spread.



Below are some examples of filter combinations to filter "only" 95% ePM1. A correct combination of a number of filters, type of filter and the related pressure loss is the consideration to be made.

1ste Filter	2de filter	Filter	Needed rotation to absorb 95% ePM1	Comment
55% ePM_1		F7 filter: 75Pa	> 4 x (110m³/h pp)	not feasible because of channel size and energy consumption
98% ePM_1		E10 filter: 150 Pa	< 1 x	efficient, but filter will always be dirty -> intensive and expensive maintenance
70% ePM_{10}	55% ePM_1	M6 filter: 90Pa F7 filter: 75Pa	> 3 x (110m³/h pp)	the global pressure drop is rising slightly, but still large channels and energy consumption
65% $ePM_{2,5}$	85% ePM_1	F7 filter: 150Pa F9 filter: 130Pa	> 2 x (54m³/h pp)	280Pa pressure drop, good direction, but not yet the ideal solution
60% ePM_1	98% ePM_1	F7 filter: 65Pa E10 filter: 150Pa	< 1 x	215Pa pressure drop and> 99% eMP1 is stopped

Overview of the different types of filters and their performance:

NBN EN 779 (2012)	EN ISO 16890	
G2	Coarse 40%	
G3	Coarse 55%	
G4	Coarse 70%	
M5		ePM10 60%
M6		ePM2,5 60%
F7		ePM1 50%
F7		ePM1 65%
F8		ePM1 75%
F9		ePM1 85%

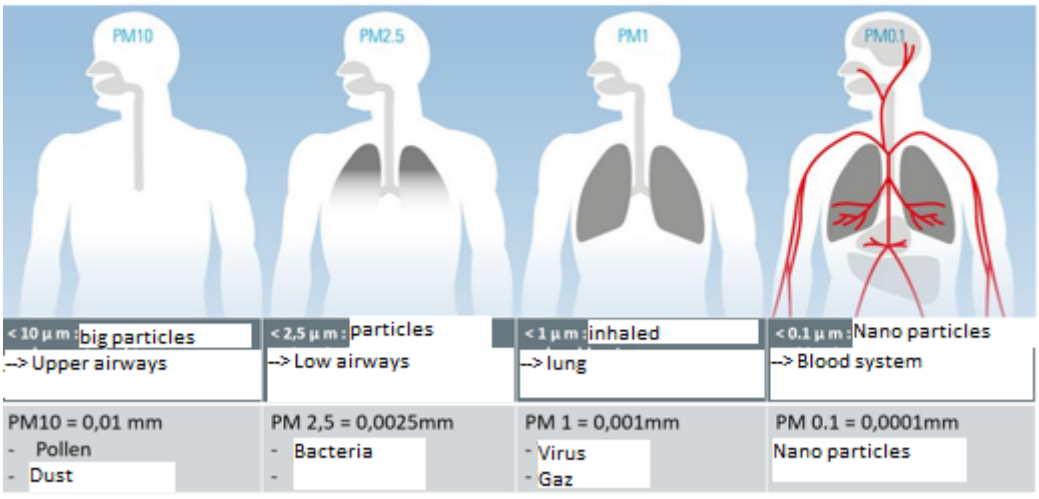
E: EPA - vb 95% ePM_1 : <5%
H: HEPA - vb 99,65% ePM_1 : <0,05%
U: ULPA - vb 99,995% ePM_1 : <0,01%

A combination of the classic office filters can only result in a maximum of 95% ePM1 filtering.

Better concept high-end filtering
ePM_1 95%

5% go through → not flawlessly

Attested for particles between 0,3µm and 1µm
cfr. Virus: 0,06 à 0,12µm



→ HEPA filter will better stop viruses

The addition of a HEPA filter is required to stop viruses.

The addition of this HEPA filter drastically reduces the risk of viruses, but also affects energy consumption. The table below shows the comparison of pressure losses of an office air handling unit with the same air handling unit with additional HEPA filter.

Office air handling air group

Filters and the supplementary pressure of an air handling group			
Pressure (Pa)			
	Filters		TOTAL air group
	new	polluted	
Prefilter	60	130	17,43%
Final filter	100	200	26,81%
TOTAL	160	330	746
Share filter	21,45%	44,24%	

Office air handling group with an HEPA filter

Filters and the supplementary pressure of an air handling group			
Pressure (Pa)			
	Filters		TOTAL air group
	new	polluted	
Prefilter	60	130	11,97%
Final filter	100	200	18,42%
Hepa-filter	229	340	31,31%
TOTAL	389	670	1086
Share filter	35,82%	61,69%	

Conclusion:

340Pa extra pression → 45% supplementary pressure

→ 25% more electrical consumption

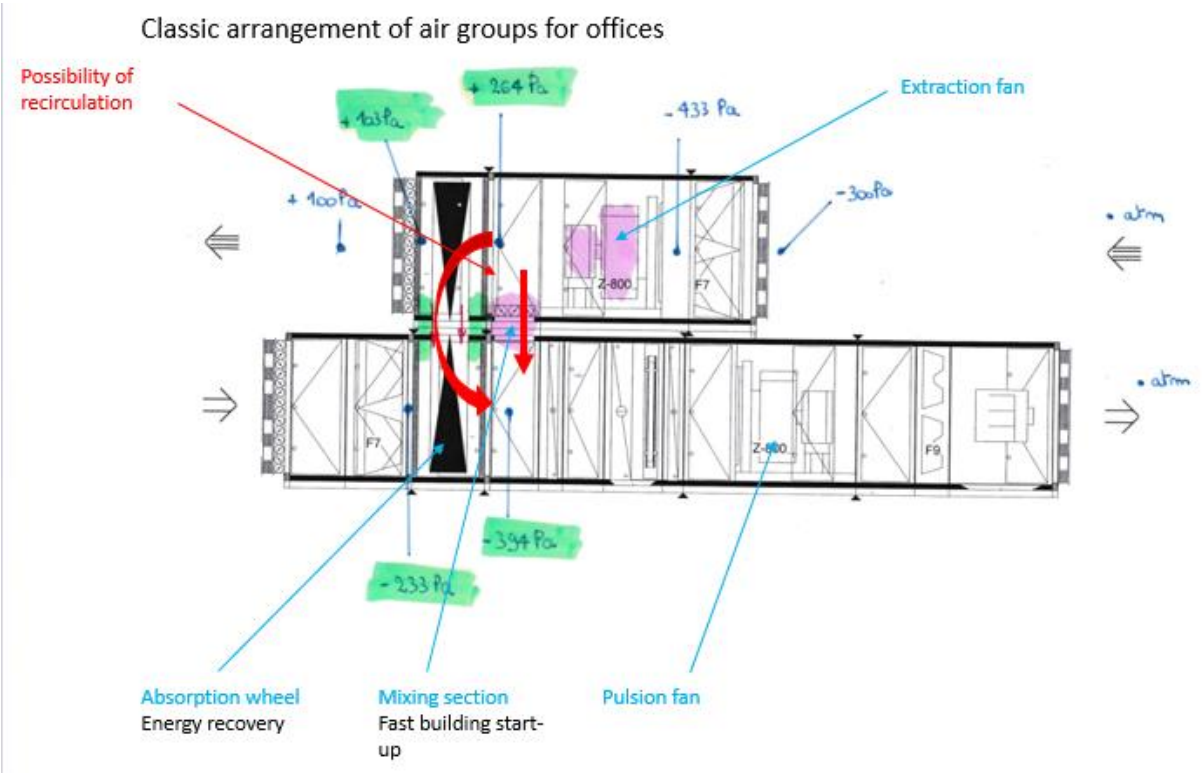
→ influence on primary energy (PEB)

Providing an empty section is not the solution for EPB since the engine must be supplied at this pressure and is decisive for EPB final declaration.

4.1.2 Avoiding recirculation

Recirculation is possible in a mixing section and in the energy recuperator.

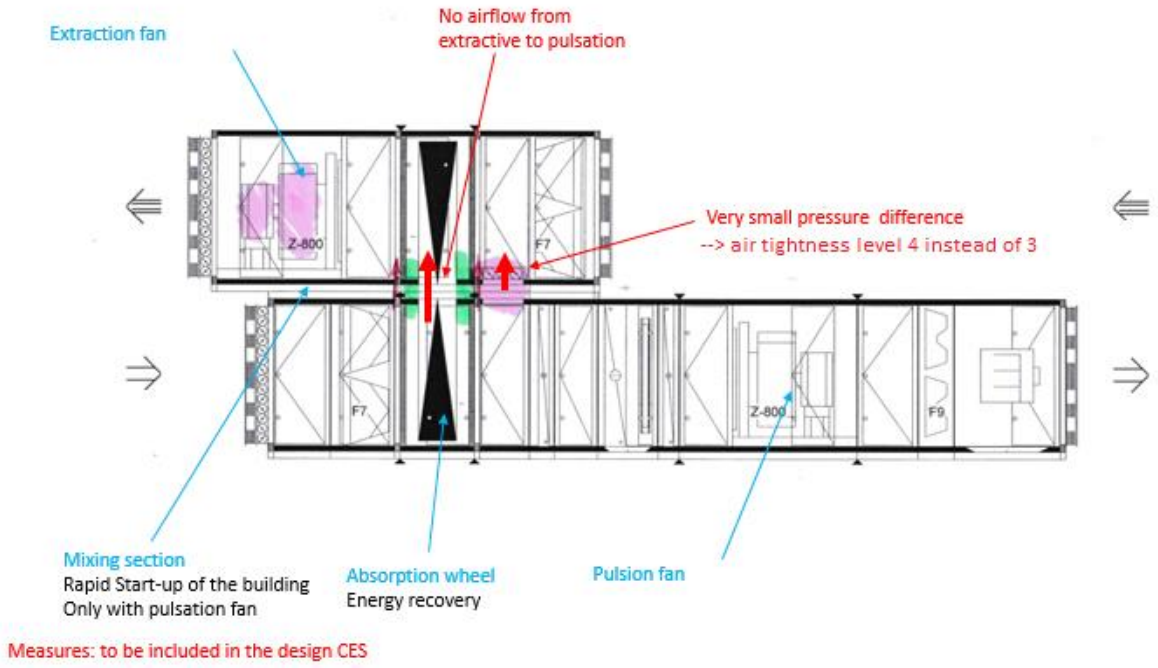
In a classic air handling unit, a leak is possible since the pressure conditions are disadvantageous, which encourages leakage.



Solution:

Moving the extraction fan on the other side of the energy recovery wheel.

Both at the height of the wheel and at the height of the possible mixing section, a possible leak will go to the blow-off side and therefore not leak to the supply air.



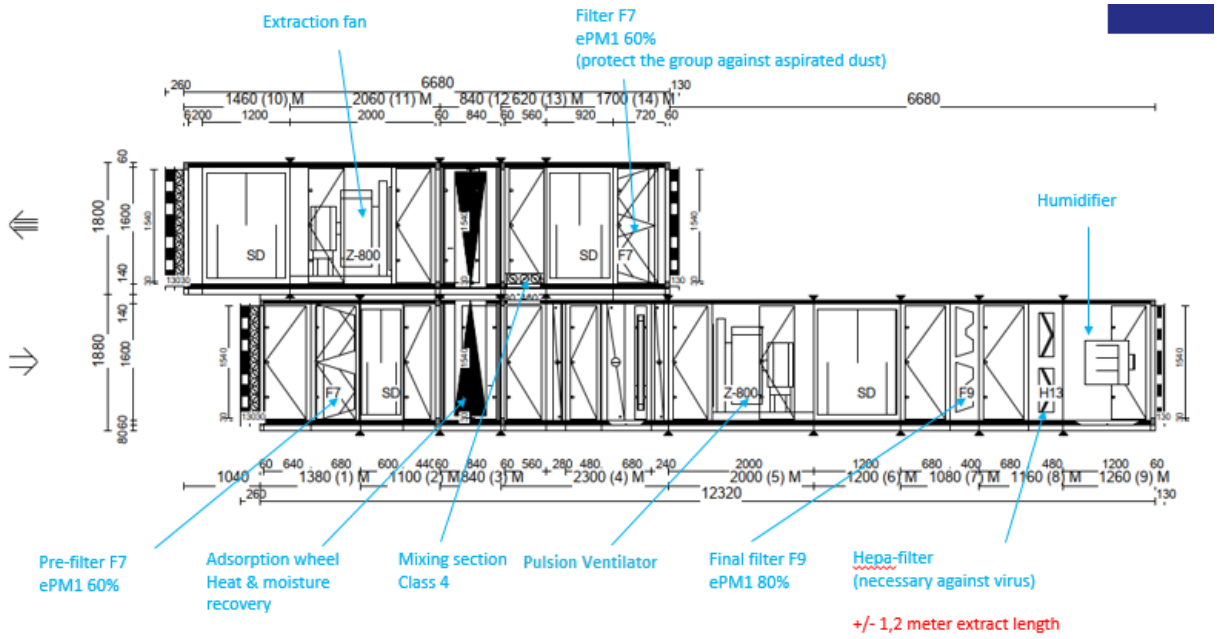
The mixing section is only used here for a quick start-up (heating) of the building after a night or weekend. In this setup, the mixing section cannot be used for air conditioning, which is also not the intention within the office concept. It is precisely this recirculation that should be avoided.

4.1.3 Summary

The table below compares a traditional office air handling unit with that of hospitals to come to a hybrid solution for offices. The yellow cells represent the difference between the "classic" air handling unit for offices and an air handling unit with more attention to avoid the spread and transmission of viruses.

	Office air handling group	Hospital air handling group	Office + hygiene air handling group
recirculation of air (extraction to pulsation)	Allowed	Not allowed	possible (only for start-up) if properly arranged
Filtering			
Supply Air Quality	SUP 2	SUP 1	SUP 1
Pre filter (example)	50%	50%	60%
Final filter (example)	80%	80%	80%
total filtering	90%	90%	92%
additional filter: gas filter (odors)	recommended	Theoretically required (usualy not done because of outside climate)	recommended (empty section for futur if there is some odor nuisance)
additional HEPA filter for supply air: (only cleanroom and OK)	n/a	H14 in each rooms	H13 filter
Cleaning of ducts	insufficient attention (does not happen in practice)	maintenance hatches for periodic cleaning	maintenance hatches for periodic cleaning
Fan Class	SFP2	SFP2	SFP2
Energy			
Energy recovery	absorption wheel	twin-coil for OK (plate exchanger, but also wheels)	absorption wheel
Tangible return	75 to 80%	50 àto60% (classic hygiene group) Erp2018 asks 68% --> exchanger twice the size --> pressure drop x2	75 to 80%
Latent return (moisture)	75% winter / 65% summer	0%	75% winter / 65% summer
construction			
material of the air groups - profiles	aluminium	Stainless steel 316 OR aluminum with coating + Stainless steel 316 cover "	aluminium with coating
material of the air groups - sandwich panels inner plates	"Aluzink (AISI 304 stainless steel for suction to the preheating battery) "	Stainless steel AISI 316	Aluzink (AISI 304 Aluzink (AISI 304 stainless steel for suction to the preheating battery + bottom plates in AISI 304 stainless steel)
condensate tray under EACH section	not required (single wheel, cooling coil and humidifier)	Present	not required (single wheel, cooling coil and humidifier) Flat stainless steel plate under each section
batteries	copper tube aluminum fins	copper tube copper fins	copper tube aluminum fins
Heating batteries	aluminium	Stainless steel AISI 316	Stainless steel AISI 304
Cooling batteries	Stainless steel AISI 304	Stainless steel AISI 316	Stainless steel AISI 304
register valves - airtightness class	Class 3	Class 4	Class 4
register valves - material (suction)	aluminium	Stainless steel AISI 316	aluminium
mounting elements	galva	Stainless steel or coated	Stainless steel or coated
Silencers - pulsation	standard (fixed)	extendable wings to the south if maintenance	standard (fixed)
hygiene certificate of conformity	not required	required	not required
hygiene implementation	standard	completely sealed with polymer	only bottom sealed
Cost price			
Cost price(l/m³/hbased on an air group of 24.700m³/h)	3,87	7,23	4,56
	base	1,87 x more expansive than basic	1,18 x more expensive than basic
Budgeting (based on an air group of 24.700m³/h)	21,25 l/m³	39,67 l/m³	25,01 l/m³

This hybrid air handling unit looks like this:



Comment : SD = silencers, can be placed in or outside the air group

4.1.4 Measures to be taken for the ventilation groups:

- Correct order of components to prevent recirculation
- Airtight valve (class 4) for the mixing section
- Pre- and-final filtering better than the strictest Eurovent requirement (SUP 1) (application of hospitals)
- HEPA-filter as 3rd grade filter (2 previous filters prevent pollution of this more expensive filter) or the use of an empty section in front of the HEPA filter if the buyer wishes to install a heavier fan later
- High-quality materials (ex: stainless steel AISI 304) of the air handling unit in function of more intensive maintenance
- Maintenance plan must be drawn up and followed up by Facility Manager

The above measures limit the virus spread to 99% via the ventilation in office buildings. The total package of measures for the air handling units has been drawn up taking into account:

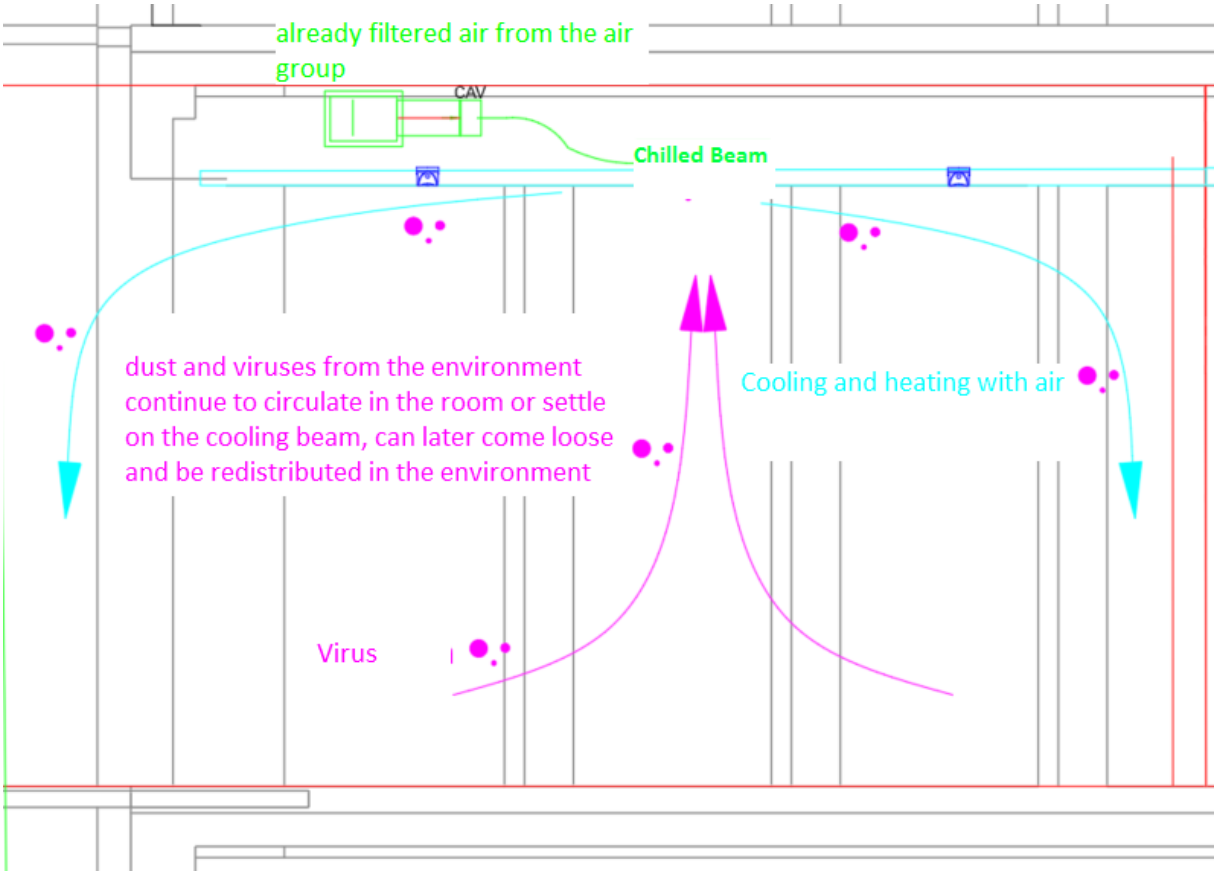
- Feasibility of the risk mitigation versus investment for office application (hospital application is 90% extra investment = “overkill”)
- Energy consumption and EPB

4.2 Measures at end unit level (air conditioning)

4.2.1 Impact when applying chilled beams

When chilled beams are used, an air circulation is usually obtained which is higher than the hygiene air. A possible virus is therefore absorbed more quickly via the air flow from the chilled beams than it is discharged via the extraction. These viruses can deposit like dust (to which they often attach themselves) in the chilled beams and being propagated later. Virus spread can therefore be immediate or delayed.

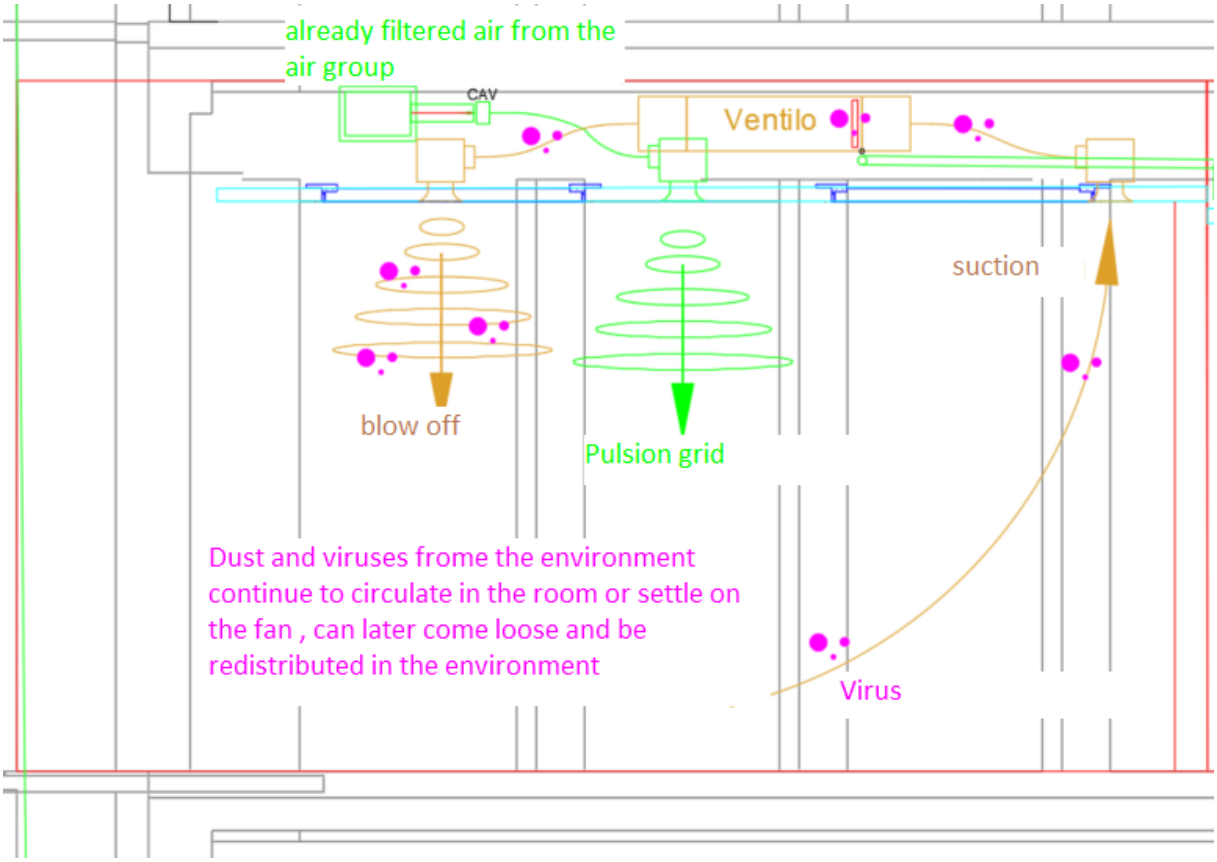
Due to an induced speed, viruses are spread more quickly in space. Especially in open-space offices and large spaces, the viruses present will spread through the entire room through sneezing of only 1 sick person, instead of being removed locally.



4.2.2 Impact when using fancoils

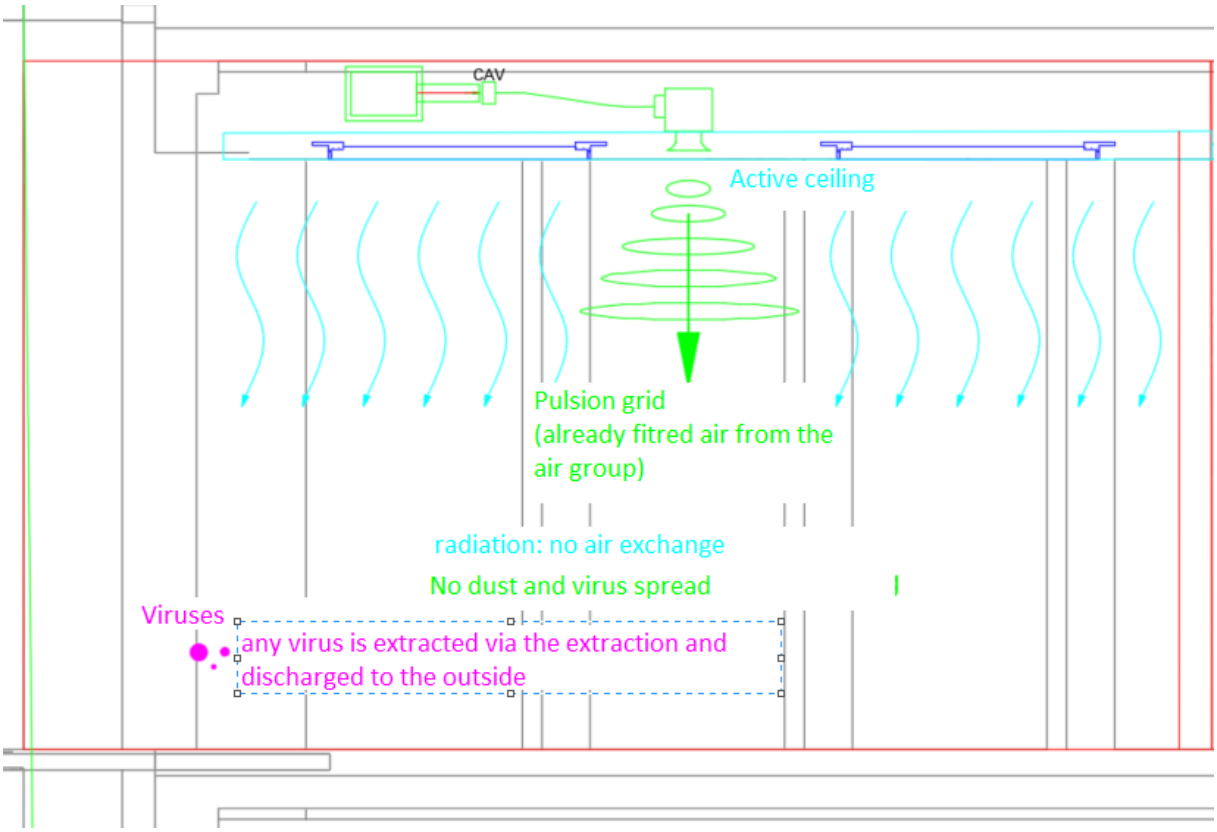
When using fancoils or variants such as: cassettes, satellites, VRV / F systems, … the same effect occurs as with chilled beams, but even more intensively. The air speeds are usually higher here. A possible virus is therefore absorbed more quickly via the air flow from the ventilator than that it is discharged via the extraction. These viruses can deposit like dust (to which they often attach themselves) in the fancoils and its filter and being propagated later. The filters used in fancoils are usually coarse filters and let the dust through more than the filters used in air handling units. Virus spread can therefore be immediate or delayed.

Because of a large air rotation through the fancoil and a swirling air distribution when blown out from the fancoil, viruses are spread more quickly in the room. Especially in open-space offices and large spaces, the viruses present will spread through the entire room through sneezing of only 1 sick person, instead of being removed locally.



4.2.3 Impact when using climate ceilings

When climate ceilings are applied, the heat exchange takes place by means of radiation. Radiation does not generate air currents that promote the spread of viruses. The only form of spread is through the extraction of hygiene ventilation. It is therefore also recommended to use an extraction per room in such a way that viruses cannot spread through other rooms (corridors).



4.2.4 Measures to be taken

Not only an air handling unit (without attention to recirculation and good filtering) can be a source of viruses, the end units can also transmit viruses due to air recirculation.

As end units, it is recommended to use radiation solutions so that there is no recirculation of air in the offices. The end units that comply with this for office buildings are climate ceilings.