



Bringing clean air to life:®

# High Performance Filtration Solutions

A photograph of a complex HVAC system with various ducts, pipes, and fan units. A semi-transparent red rectangular box is overlaid on the right side of the image, containing white text.

The MASTER PLAN  
for Building Managers  
on how to Reliably  
Reduce Virus-laden  
Aerosols

AAF, the world's largest manufacturer of air filtration solutions, operates production, warehousing and distribution facilities in 22 countries across four continents. With its global headquarters in Louisville, Kentucky, AAF is committed to protecting people, processes and systems through the development and manufacturing of the highest quality air filters, filtration equipment, and associated housing and hardware available today.

# What's Inside

## The MASTER PLAN for Building Managers on how to Reliably Reduce Virus-laden Aerosols

<b>1</b>	<b>The importance of ventilation and filtration to minimize virus load</b>
<b>1.1</b>	How to minimize virus load in a room
<b>1.2</b>	Ventilation – The more the better!
<b>1.3</b>	The MASTERPLAN for building managers to reduce risk during a pandemic
<b>2</b>	<b>The powerful first reaction – Use of Air Purifiers</b>
<b>2.1</b>	Air Change Rate (ACR) as a measure for good ventilation
<b>2.2</b>	Product Recommendation: AstroPure
<b>2.3</b>	THE CUSTOMER BENEFIT
<b>3</b>	<b>The risk reduction oriented sustainable solution – Upgrade of existing filtration systems</b>
<b>3.1</b>	Manufacturer's Declaration of Conformity

<b>3.2</b>	It is the system efficiency that counts – and not the single filter element!
<b>3.3</b>	THE CUSTOMER BENEFIT
<b>4</b>	<b>The early warning system for good Indoor Air Quality – Use of Sensors technology</b>
<b>4.1</b>	Monitoring of PM levels in real-time
<b>4.2</b>	More confidence for building visitors
<b>5</b>	<b>Maintaining Air Systems</b>



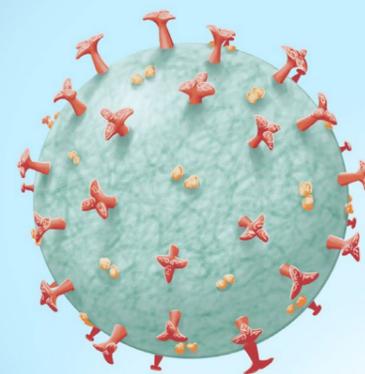
# 1. The importance of ventilation and filtration to minimize virus load

The control or containment of aerosols by means of efficient filtration is synonymous with the containment of the viral load in the air, which consequently leads to a reduced risk of COVID19 infections.

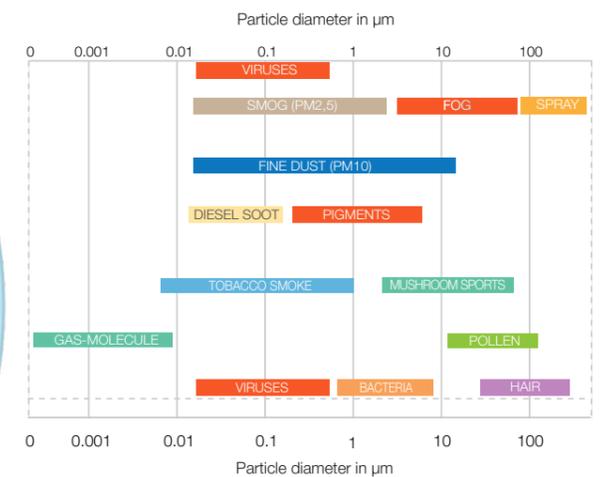
Usually single viruses are not emitted by infected persons but in form of small virus loaded saliva (spit) droplets while breathing and speaking. Depending on environmental conditions, these droplets are drying quite quickly resulting in virus loaded aerosols in a size range of 0,3 – 1,0  $\mu\text{m}$ .

According to today's knowledge a single corona virus is in the size range on 0,12 - 0,16  $\mu\text{m}$ .

Liquid droplet  $>1 \mu\text{m}$  (saliva - water, sugar, salts, proteins) when exhaled, drying out to aerosols down to  $< 1 \mu\text{m}$



Corona virus  
Ø approx. 0,13  $\mu\text{m}$



## 1.1. How to minimize virus load in a room

So far ventilation of rooms and buildings was focusing on adjusting room temperature and humidity, removing unpleasant odors and dust particles, as well as reducing the CO2 concentration. All together is considered as good Indoor Air Quality (IAQ) achieved by suitable ventilation and filtration.

Diluting indoor air with fresh virus free air is reducing the overall virus load. This dilution can be achieved either by natural ventilation (opening doors and windows) or mechanical ventilation via air handling units supplying fresh air to the room respectively remove potentially virus-laden air from the room.

With regard to the global pandemic and the knowledge about virus-laden aerosols, the purpose of ventilation and filtration has of course not changed nowadays, but previously less considered parameters are moving into focus.

With regard to virus-laden aerosols, good ventilation today is characterized by the fact that the virus concentration in the room air is diluted as much as possible by suitable ventilation and, secondly, virus-laden particles are completely removed from the room air by suitable filtration.

Limiting factors of natural ventilation and mechanical ventilation:

Natural ventilation	<ul style="list-style-type: none"> <li>• Pressure or temperature difference necessary to induce air flow</li> <li>• Not always possible due to building limitations (e.g. locked windows)</li> <li>• Due to comfort and energy reasons, only possible to a limited extent during winter times</li> </ul>
Mechanical ventilation	<ul style="list-style-type: none"> <li>• Not available in all buildings.</li> <li>• Increase of air change limited by comfort reasons.</li> <li>• Upgrade of installed filters to HEPA level usually impossible due to high pressure drop</li> <li>• Recirculation should but can't be completely avoided due to CO2 limits and energy considerations</li> </ul>

### 1.2. Ventilation – The more the better!

As we know the higher the aerosol concentration in a room, the higher is the infection risk. Consequently this means the more often the complete air in a room is changed, the less is the risk for infections.

From all we know the Air Change Rate (ACR) should be at least 4 to 6. This means in other words at least one complete air change every 10 to 15 minutes. By natural ventilation this is difficult to realize, particularly during the cold season, as ACR often are even below the level of one air change per hour.

For this reason mechanical ventilation methods are used to achieve the necessary ACR. Suitable air filters installed in ventilation systems like Air Purifiers, but also centralized Air Handling Units, ensure at the same time the efficient removal of harmful particles.

However, besides the use of ventilation and filtration equipment, it is always recommended to do burst ventilation during the absence of people. With burst ventilation it is possible to achieve an ACR higher than 10, but of course all limiting factors of natural ventilation methods need to be taken into account.

Consequently building managers need to meet various requirements that can contradict each other.

1. As many air changes as possible.
2. Highest possible filtration efficiency at lowest possible energy costs.
3. A wpleasant environment in terms of temperature, humidity, odors, CO2 concentration and noise for all building occupants.
4. Quick and easy to install solutions without the need of rebuilds.

AAF is able to provide solutions and recommendations that help to meet the above requirements. This is summarized in the following master plan, which not only helps the building manager with recommendations for the short-term maintenance of the building's usability, but also offers support in the implementation of long-term solutions.

### 1.3. The MASTER PLAN for building managers to reduce risk during a pandemic

To reliably reduce virus-laden aerosols and hereby achieve good and healthy Indoor Air Quality even during a pandemic scenario AAF recommends a three-step plan, that not only provides immediate safety but also long-term oriented solutions. Following this plan enables building managers to switch from reactive to proactive mode.

#### Step #1 The powerful first reaction – Use of air purifiers

Air purifiers are limiting or even reducing aerosol concentrations thanks to efficient HEPA filters and the reliable creation of required Air Change Rates. An air purifier operated in a room immediately lowers the risk of an infection to a very minimum. Air purifiers are not only useful for buildings without a proper ventilation system. Even with ventilation systems in place air purifiers tremendously increase protection against virus-laden aerosols and thanks to HEPA filters – moreover also against viruses “travelling alone”.

#### Step #2 The risk reduction oriented sustainable solution – Upgrade of existing filtration systems

In buildings served with central air handling units a large amount of air is recirculated. By the installation of a suitable combination of air filters it is possible to achieve filtration efficiency levels close to HEPA efficiencies already after one air change at still reasonable cost. This not only provides short-term protections, but also long-term protection throughout the complete life cycle of the filter elements.

#### Step #3 The early warning system for good Indoor Air Quality – Use of Sensors technology

By implementing sensor technology to the ventilation system building managers are getting back into the driver seat. Sensors not only monitor the air quality in real-time, it is even more possible to start predictive activities before the air quality is reaching a critical level. And by the way, acting predictively also helps to save energy costs.



#### KEY LEARNINGS

- A single corona virus is in the size range on 0,12 - 0,16 µm.
- The corona virus is usually emitted in form of virus laden aerosols in a size range of 0,3 – 1,0 µm.
- Good ventilation is diluting virus-laden indoor air, which consequently leads to a lower infection risk.
- The more ventilation the better!
- The Air Change Rate (ACR) should be at least in the range of 4-6 air changes per hour.
- Burst ventilation of rooms in the absence of people is always recommended.

The MASTER PLAN for building managers to reduce risk during a pandemic should include:

- STEP 1: Consider the use of air purifiers
- STEP 2: Upgrade existing filtration systems
- STEP 3: Use of Sensor technology to monitor IAQ

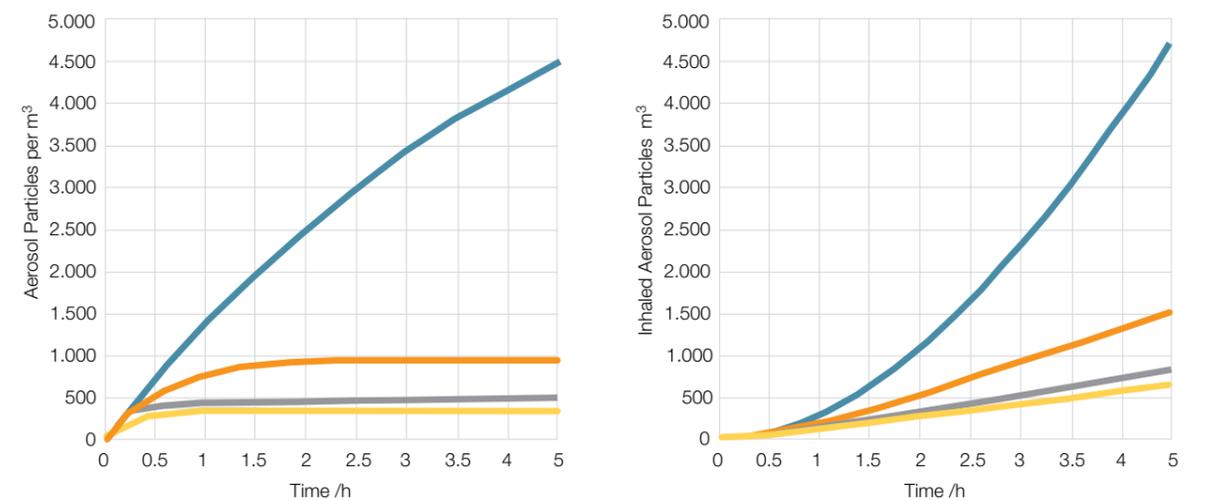


## 2. Step 1: The powerful first reaction – Use of Air Purifiers

Facility managers currently face the situation that there is uncertainty across the group of building occupants whether it is safe to enter and stay in the building with a larger group of people. Especially during the cold season, when regular ventilation with fresh air is rather inconvenient.

For sure fresh air supply is always recommended. However with low temperatures it is relatively difficult to keep a suitable frequency of ventilation by opening windows and doors.

In this case the use of air purifiers is recommended to achieve the required ACR to lower the aerosol concentration which consequently leads to a lower infection risk. Below graphics demonstrate the increased particle concentration & inhaled particles in a room as a comparison of different levels of ventilation scenarios.



Source of diagrams: *Beispielhafte Risikobewertung für verschiedene Alltagssituationen*; Autoren: Anne Hartmann, Martin Kriegel; Technische Universität Berlin, Hermann-Rietschel-Institut; DOI: <http://dx.doi.org/10.14279/depositonce-10714>; Version 1: 04.11.2020

### 2.1. Air Change Rate (ACR) as a measure for good ventilation

As above graphs demonstrate good ventilation respectively a low risk of infection is clearly depended on the number of air changes and it applies the higher the ACR the better. The ACR is calculated according to following formular:

$$ACR = \frac{V}{V_{Room}}$$

ACR - Air Change Rate (1/h)

$V_{Room}$  Volume of room (m<sup>3</sup>)

V Volume flow (m<sup>3</sup>/h)



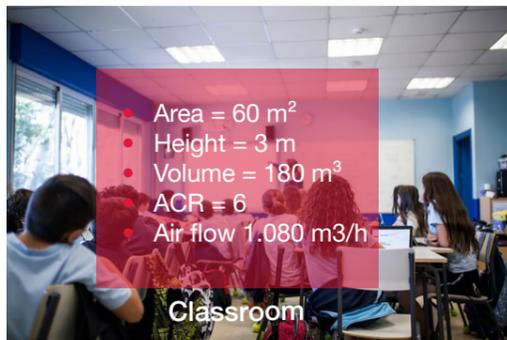
- Area = 12 m<sup>2</sup>
- Height = 2,5 m
- Volume = 30 m<sup>3</sup>
- ACR = 6
- Air flow 360 m<sup>3</sup>/h

Office



- Area = 30 m<sup>2</sup>
- Height = 2,5 m
- Volume = 75 m<sup>3</sup>
- ACR = 6
- Air flow = 450 m<sup>3</sup>/h

Meeting Room



- Area = 60 m<sup>2</sup>
- Height = 3 m
- Volume = 180 m<sup>3</sup>
- ACR = 6
- Air flow 1.080 m<sup>3</sup>/h

Classroom



- Area = 240 m<sup>2</sup>
- Height = 3,5 m
- Volume = 840 m<sup>3</sup>
- ACR = 6
- Air flow = 5 m<sup>3</sup>/h

Open Plan Office

Depending on the room volume it is up to the volume flow provided to achieve the desired ACR of minimum 6 air changes per hour. Professional Air Purifiers, like AAF's AstroPure, are able to provide volume flow rates, that can serve a huge variance of different room volumes. Here are some examples showing different room types with their desired air flow rates.

## 2.2. Product Recommendation: AstroPure

AstroPure is a totally self-contained stand-alone Recirculation Unit for areas where additional, extra high, filtration performance is needed against any type of contamination including viruses. AstroPure combines state-of-the-art H14 HEPA filtration with optionally available fluorescent UV-C irradiation to create total clean air solutions fulfilling all relevant guidelines such as the VDI 6022.

Depending on its configuration AstroPure provides air flow rates up to 6.000 m<sup>3</sup>/h. Together with the ability to take various filter combinations and variance of optional features, AstroPure provides herewith highest flexibility to meet all customer-specific requirements at point of use.

To allow economical and easy installation AstroPure is designed as a Plug & Play unit hence no modifications required at your premises.

Highly recommended to improve IAQ by recirculating indoor air and providing occupants with better health and comfort.

- A** Fan / Motor Unit
- B** HEPA Filter
- C** Prefilter
- D** Control panel providing indication for filter change, speed control and on/off switch
- E** Air outlet grill
- F** UV lamp
- G** 4-Wheel foundation



Shown here: AstroPure2000 providing air flows up to 2000 m<sup>3</sup>/h

## 2.3. The CUSTOMER BENEFIT:

AstroPure provides the suitable ACR + virus efficient filtration efficiency to any location. Besides that AstroPure is:

- Easy to instal
- Easy scalable
- Mobile and flexible to use
- Easy to maintain

Typical applications are:



## KEY LEARNINGS

- Especially during the cold season, when regular ventilation with fresh air is rather inconvenient, air purifiers ensure required ACR to lower the aerosol concentration which consequently leads to a lower infection risk.
- Volume flow performance of the air purifier needs to ensure a ACR of minimum 6 air changes per hour
- Professional Air Purifiers, like AAF's AstroPure with H14 HEPA filters are available with different volume flow rates suitable for a huge variance of room sizes.

## THE CUSTOMER BENEFIT:

AstroPure provides the suitable ACR + virus efficient filtration efficiency to any location. Besides that AstroPure is:

- Easy to install.
- Easy scalable.
- Mobile and flexible to use.
- Easy to maintain.



### 3. Step 2: The risk reduction oriented sustainable solution – Upgrade of existing filtration systems

HEPA (High Efficiency Particle) filters can easily catch submicron particles, even in the size range on single viruses, but generate relatively high pressure drop compared to filters usually used in air handling units. Although their installation would make a lot of sense in terms of filtration efficiency, the high pressure drop would require an upgrade of the fan and the whole air handling unit and duct work might run into air leakage problems.

That's why AAF recommends the AstroPure Air Purifiers with H14 HEPA Filters to cover any HEPA filtration requirements. Because these units are able to deal with the issues related to pressure drop and air volume flows.

For buildings operating a centralized ventilation systems AAF is in addition recommending a filter upgrade that's coming close to HEPA filtration efficiency level while operating at much lower and manageable pressure drop levels.

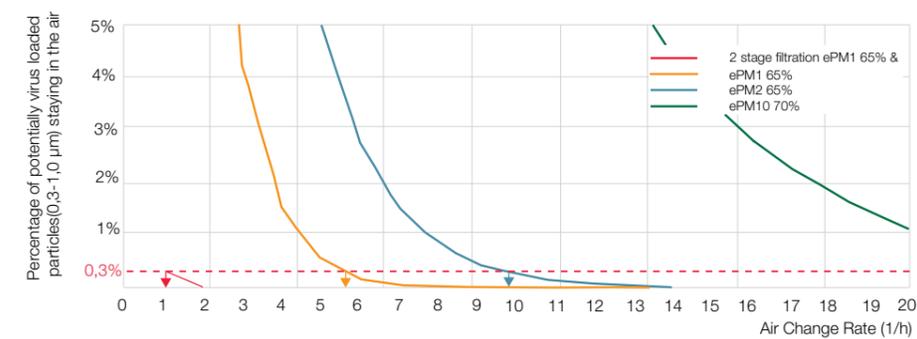
#### 3.1 It is the system efficiency that counts – and not the single filter element!

AAF is able to offer a filtration solution that is both highly efficient to reduce airborne viral carriers and cost-effective for AHU unit operators. **Our recommended combination of air filters is able to capture 99,7% of virus-laden aerosols in size range 0,3 – 1,0 µm within a single air change.**

Below table and graph show a comparison between a conventional 2-stage filtration system and AAF's recommended solution. This clearly shows that filtration efficiency against virus-laden Aerosols is depending on ACR and the filter classes of the installed air filter setup.

#### Filter upgrade reaching close to HEPA filtration efficiency

	Conventional 2-stage Filtration System ( standard configuration)	AAF's Recommended Solution for a two - stage filtration system ( with focus on aerosol reduction)
Stage 1	ePM10 70%	ePM1 65%
Stage 2	ePM1 65%	ePM1 95%
Combined Efficiency on virus-laden aerosols	73%	99,7%
Number of air changes needed to achieve 99,7% virus load reduction	4	1
Δpi initial combined pressure drop	145 Pa	170 Pa
Combined DHC ( Dust Holding Capacity)	1480g	2.850g



2 stage filtration with ePM1 65% + ePM1 95% classified filters reaches 99,7% efficiency already after one air change!

### 3.2. Product Recommendation: DriPak NX+ VariCel Aero V HXL



#### DriPak® NX+

**Initial dp:** 55 Pa  
**Efficiency:** ePM1 65% (ISO 16890)  
**Energy Rating:** A+ (Eurovent 4/21:2018)



#### VariCel® Aero V HXL

**Initial dp:** 115 Pa  
**Efficiency:** ePM1 95% (ISO 16890)  
**Energy Rating:** A+ (Eurovent 4/21:2018)

### 3.3. The CUSTOMER BENEFIT:

A combination of DriPak NX+ and VariCel Aero V HXL is coming close to HEPA filtration efficiency levels while operating at much lower and manageable pressure drop levels.

- Easy to install in already existing ventilation systems
- Low Total Cost of Ownership due to low pressure drop and high dust holding capacity

Typical applications are:

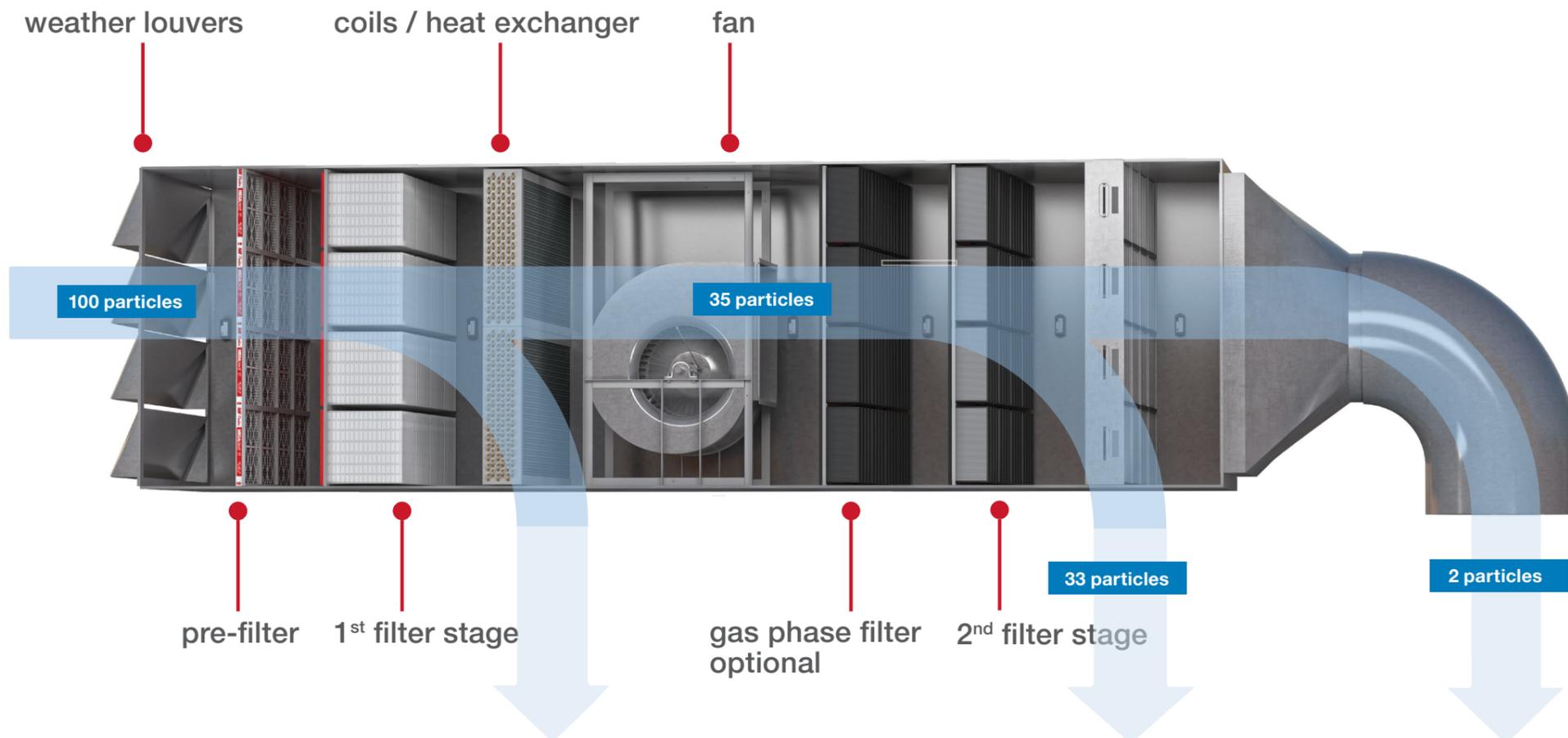


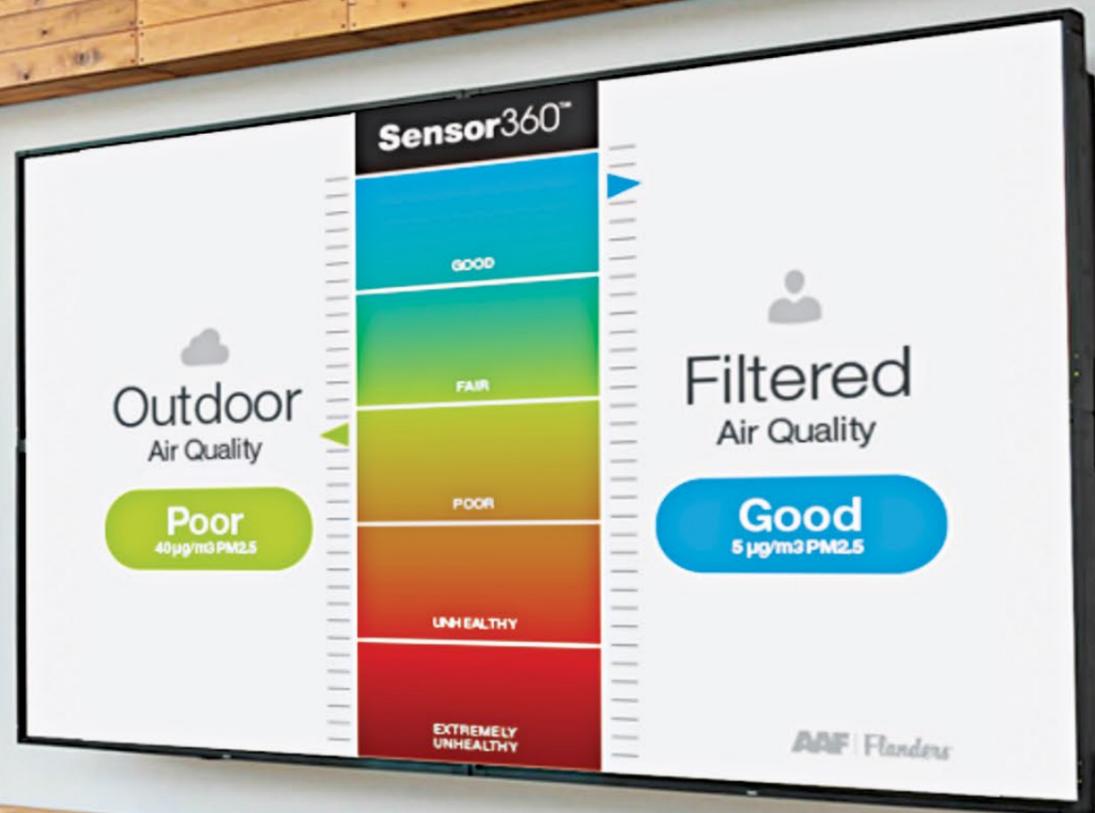
#### KEY LEARNINGS

- HEPA (High Efficiency Particle) filters can easily catch submicron particles, even in the size range on single viruses, but generate relatively high pressure drop compared to filters usually used in air handling units.
- For buildings operating a centralized ventilation systems AAF is recommending a filter upgrade that's coming close to HEPA filtration efficiency.
- The combination of AAFs DriPak NX+ & VariCel Aero V HXL air filters is able to capture 99,7% of virus-laden aerosols in size range 0,3 – 1,0 µm within a single air change. All this at still reasonable costs.

#### THE CUSTOMER BENEFIT:

- Close to HEPA filtration efficiency
- Operating at much lower pressure drop levels than HEPA filters
- Easy to install in already existing ventilation systems
- Low Total Cost of Ownership due to low pressure drop and high dust holding capacity





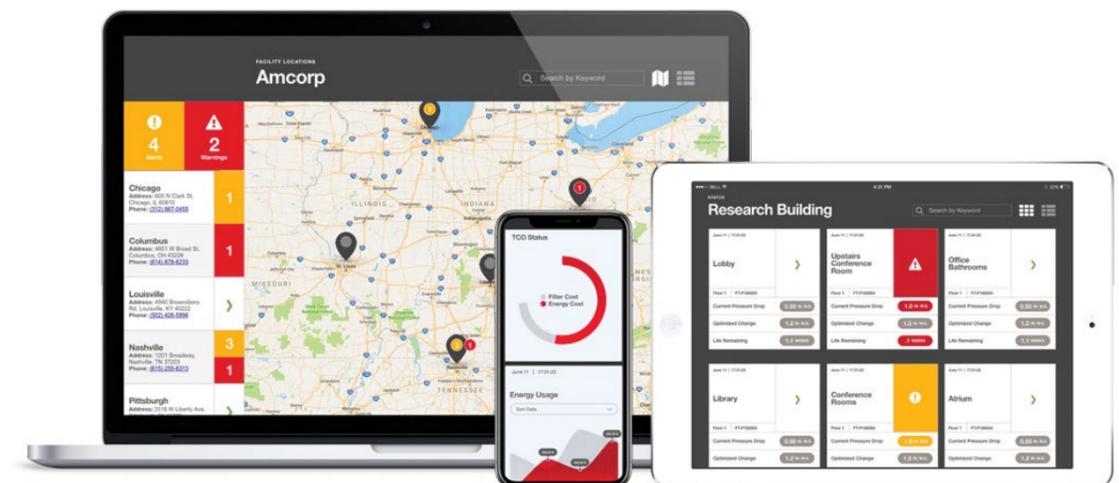
## 4. Step 3: The early warning system for good Indoor Air Quality – Use of Sensors technology

Assuming a building is ideally equipped with suitable air filters and a well operating ventilation system providing good protection against virus-laden aerosols. Wouldn't a real time monitoring of the air quality provide more confidence to building managers? For sure monitoring of viruses in the size range of 0.130 µm is only possible with high priced equipment not suitable for conventional use. However, as we know viruses are predominantly travelling on larger particles, the monitoring of Particulate Matter (PM) fraction sizes makes sense.

### 4.1. Monitoring of PM levels in real-time

AAFs next-generation monitoring and facility management tool, Sensor360 enables building managers to understand and plan their air filter performance and maintenance in an entirely new way. Sensor360 is the first IoT (Internet of Things) patented technology platform that demonstrates the effectiveness of a building's filtration system by monitoring particulate levels in real-time. Additionally, by monitoring pressure drop, the facility manager can determine the changeout point for the building's filters that offers the best value and energy efficiency.

Sensor360 offers instantaneous monitoring of a filter system's performance, automatically tracking pressure drop and PM1, PM2.5, and PM10 particulate levels. This eliminates the need to manually audit and collect filter data from the facility's air handling systems, giving the user the ability to resolve potential IAQ issues before they negatively affect building occupants by receiving an alert from the Sensor360 app that particulate levels are at an unacceptable concentration.



## More confidence for building visitors

In addition, building occupants are able to see the quality of the filtered air they are breathing. With Sensor360 it is possible to run digital kiosks that display both indoor and outdoor air particulate levels. If for example installed in a building lobby, anyone who sets foot in the building recognizes that they are entering a clean, healthy environment.

### 4.2. The CUSTOMER BENEFIT:

Sensor360 can serve as an early warning system to monitor the Indoor air quality. Especially information on Particulate Matter concentration is an indicator to control the performance of the filtration system with respect to virus-laden particles

- First IoT with real-time filtration & Total Cost of Ownership optimization
- Predictive Insights at-a-glance for each air handling unit
- Intelligent data to improve operational efficiency



### KEY LEARNINGS

- As we know viruses are predominantly travelling on larger particles.
- Sensor360 is able to monitor PM levels in real-time.
- By monitoring pressure drop, the user can determine the changeout point for the building's filters that offers the best value and energy efficiency.
- This enables the user to resolve potential IAQ issues before they negatively affect building occupants.
- With Sensor360 it is possible to run digital kiosks. Building occupants are able to see the quality of the filtered air they are breathing.

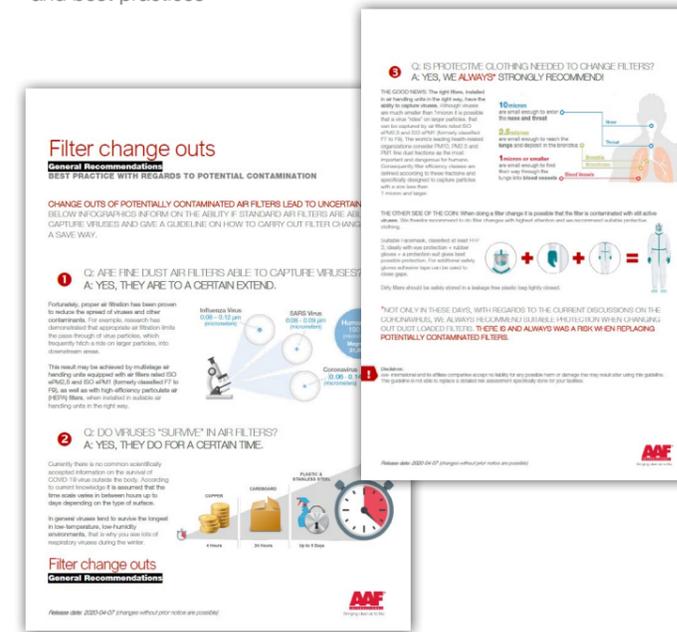
#### THE CUSTOMER BENEFIT:

Sensor360 serves as an early warning system to monitor IAQ. Especially information on Particulate Matter concentration is an indicator to control the performance of the filtration system with respect to virus-laden aerosols.

## 5. Maintaining Air Systems

When replacing potentially contaminated filters, there is always a risk. Not only in view of the current discussion about the coronavirus, we ALWAYS RECOMMEND suitable protection when changing dust-laden filters.

For more information check out our infographics with background information and best practices



**Suitable Facemask, classified at least FFP 3, ideally with eye protection**

**Rubber gloves.**

**A protection suit gives best possible protection. For additional safety gloves adhesive tape can be used to close gaps.**



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