FILTRATION TECHNIQUES

WHICH FILTRATION TECHNIQUES CAN IMPROVE VIRUS PROTECTION IN HVAC SYSTEMS?

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How can the spread of a virus be limited onboard?

INTRO

Epidemics raise questions about the spread of viruses in HVAC systems. In order to take preventive measures, it is important to understand how viruses can spread.

This whitepaper is about available filtration techniques that claim to limit the spread of viruses in HVAC systems. Heinen & Hopman has examined the available options with one question in mind: which filtration techniques could improve virus protection in HVAC systems?

> **The best way to reduce risk is by utilizing qualified technology.**

CHAPTERS

SUMMARY

Filter system buyers should be aware that there are only a few accepted standards for equipment designed to disinfect air or surfaces with UV light or oxidizing agents. By examining the filtration techniques in this paper, it is made clear that either UV-C light or an appropriate HEPA filter can minimise the risk of virus transmission in HVAC systems.

Even if SARS-CoV-2 is not airborne, the next virus may be.

When installing a virus protection system to minimise the risk of airborne viruses, bacteria and germs spreading through the onboard HVAC system, it is recommended for new build HVAC systems to use a UV-C lamp that uses only UV-C in the wavelength of 254nm. Suitable filters should always be fitted to protect the UV-C light from pollution.

For refit purposes, a custom solution may be required based on the available space in the existing system.

The UV light improves the general hygenic situation in an air handling unit and also protects your crew and passengers against symptoms such as headache, lethargy, excessive fatigue, irritations of the mucous membranes and running eyes. However, it is still important to maintain the air ducts properly.

Ionization has been shown to be efficient in removing small particles (including ultra-fine dust) from the air stream. This is done by applying an electrical charge to the particles. These particles will stick to an oppositely charged part upon impact, such as the inside of the channel, or in a controlled way by using a charged filter (precipitation). Note that many ionization units produce ozone as a result of the electrical charges applied. When the ionisation units produce ozone, they are classified in the same category as ozone generating equipment.

By exploring the topic of filtration, we will give you a better understanding of the available options, including:

- Particle filtration;
- UV-C light filtration;
- UV-C light filtration with oxidizing effects;
- Ozone generators;
- Ionization.

> **How to use filtration on board?**

PART 1
BACKGROUND INFORMATION

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SPREAD OF VIRUSES

Virus transmission can take place in several ways. The World Health Organization (WHO) states(1) that viruses spread from person to person through small droplets from the nose or mouth that are spread when an infected person coughs, exhales, sneezes etc. These droplets land on objects and surfaces around the person. People can contract the virus by touching these objects and then touching their eyes, nose or mouth. People can also catch the virus if they breath in drops from a person who coughs, exhales, or sneezes.

During the pandemic virus SARS-CoV-2 in 2020, studies suggest that viruses are primarily transmitted through contact with respiratory droplets (>5-10μm) rather than through air through droplet nuclei (<5μm). Transmission through droplet cores is referred to as airborne transmission. Drop cores can remain in the air for a long time and be transferred to others over a distance of more than 1m.

To date (June 2020), no scientific reports or studies have reported that coughing or sneezing produces these types of aerosols that cause droplet cores to contain viruses and therefore spread viruses in the air in the HVAC system.
While the WHO states **(2)** that viruses are primarily transmitted through respiratory drops caused by CLOSE personal contact with a person, many companies want to take precautions to limit airborne transmission through the HVAC system. The main purpose of this paper is to inform about possible filtration techniques, its working principle, efficiency and design precautions. Ultimately, a conclusion can be drawn about the most effective way to minimise airborne particulate transmission particles in HVAC systems.

PARTICLE SIZES

To visualize the size of particles that we want to remove from the HVAC system, the following image is shown:

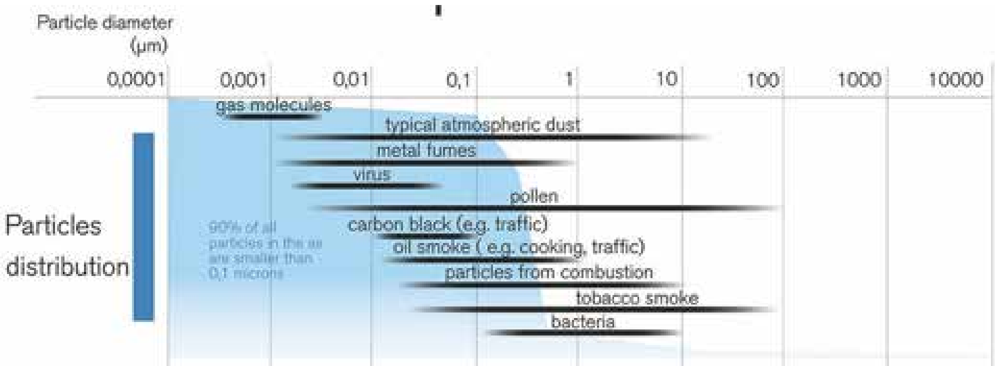


Image 1: Particle sizes

PART 2
PARTICLE FILTRATION

PART 2
PARTICLE FILTRATION

WORKING PRINCIPLE

Particle filtration can take place in various ways. The mechanisms used by the filter can be divided as follows:

- Straining
- Impingement
- Interception
- Diffusion

Straining
Straining is the simplest form of filtration. Particles are transported by the airflow. Particles that are too large to pass between media fibers are collected by the filter.

Impingement
Large particles with a high density are most likely captured by impingement mechanics. Air passes next to the filter fibers and intertia causes the particle to separate from the flow and collide with the fiber.

Interception
Interception occurs in synthetic media. The particle follows the airflow and is collected by the fiber due to the difference in electrostatic charge.

Diffusion
The smallest particles are collected by diffusion. The particles follow irregular parts and are not bound to the airflow (Brownian motion). The irregularity increases the change of colliding with a fiber.

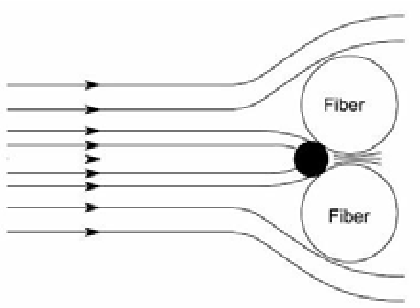


Image 2: Straining

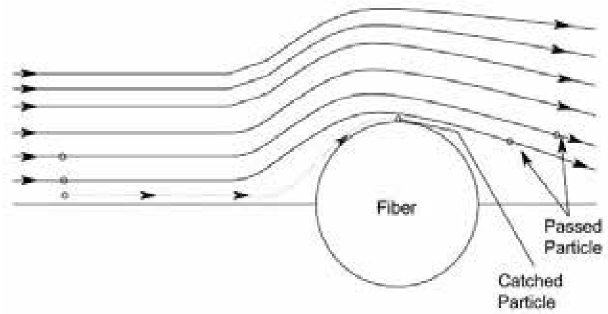


Image 3: Impingement

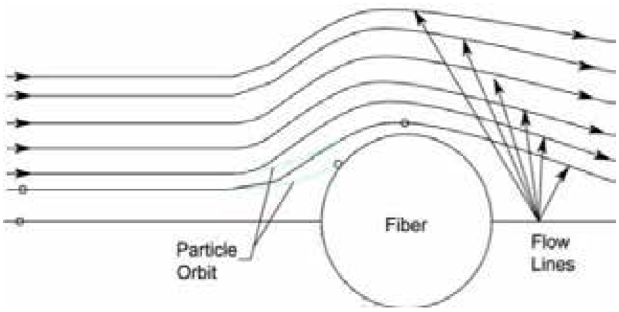


Image 4: Interception

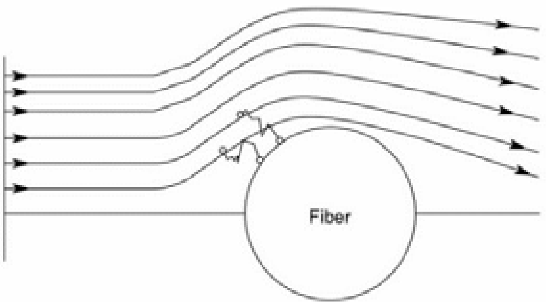


Image 5: Diffusion

SYSTEM EFFECTIVENESS

Filters according to ISO 16890

Standard filter types can be grouped in the groups as placed in table 1 - Filter groups acc. ISO16890. The groups in these filters are based on the filter size and filter efficiency in this range. Note that particles smaller than 0,3μm are not included in the ISO standard.
For example: ePM2,5 80% filters 80% of the particles in the range 1,0 – 3,0 μm.

Group name	Size range μm	Efficiency required
ISO Coarse	3,0 - 10,0	<50%
ISO ePM10	3,0 - 10,0	>- 50%
ISO ePM2,5	1,0 - 3,0	>= 50%
ISO ePM1	0,3 - 1,0	>= 50%

Table 1: Filter groups acc. ISO 16890

Note: Although the ISO 16890 standard is the latest approved standard in terms of filter classes, most people are still used to the classes in the "old" standard (EN779:2012).
The following table provides a comparison of both standards.

Group name	ISO ePM1	ISO eOM2,5	ISO ePM10	ISO coarse
G3	-	-	-	>80%
G4	-	-	-	>90%
M5	-	-	>50%	-
M6	-	50-65%	>60%	-
F7	50-65%	65-80%	>85%	-
F8	65-80%	>80%	>90%	-
F9	>80%	>95%	>95%	-

Table 2: An indication according to the note above, this cannot be considered as absolute values

High efficiency particle filters (EPA, HEPA and ULPA)

HEPA filters have been tested on the particle size of 0.3μm. This is the so-called 'worst case particle' and indicates that larger particles are more easily collected by the HEPA filter **(6)**. HEPA filters are also divided into different classes. The classes are based on the particle size efficiency of 0.3μm. The filter groups are classified according the standard
EN 1822.

Filter group	Class	MPPS integral values		MPPS local values	
		Efficiency (%)	Penetration (%)	Efficiency (%)	Penetration (%)
EPA	E10	85	15	-	-
	E11	95	5	-	-
	E12	99,5	0,5	-	-
HEPA	H13	99,95	0,05	99,75	0,25
	H14	99,995	0,005	99,975	0,025
ULPA	U15	99,9995	0,0005	99,9975	0,0025
	U16	99,99995	0,00005	99,99975	0,00025
	U17	99,999995	0,000005	99,999975	0,000025
MPPS: Most penetration particles					

Table 3: Filter groups acc. EN 1822

WHERE TO USE

The following table shows the filter classes and the application of the filter class:

Group name	Typical application
Coarse < 40%	simple application (e.g. insect screens for compact machinery)
Coarse 45 - 95%	- pre-filters and circulation filters for civil defense shelters - exhaust filters for spray painting booths, kitchens, etc.
ePM10 50 - 60%	outside air inlet filters for rooms with low purity requirements (e.g. factories, warehouse facilities, garages)
ePM10 65 - 95%	- pre-filters and circulation filters in central ventilation stations - final filters for air conditioning of sales rooms, department stores, offices and certain production plants
ePM1 50 - 95%	- final filters for air conditioning of offices, production plants, control centres, hospitals, EDP centres - pre-filters for filter classes E11 to H13 and activated carbon

Table 4: Filter classes and application acc. ISO 16890

EN1822	Typical application
E10 E11 E12	- final filters for rooms with high and highest purity requirements (e.g. for laboratories, for foods processing, pharmaceutical, fine mechanical, optical or electronics plants or medical facilities)
E12 H13	- final filters for clean rooms, Classes 10,000 or 100 - final filters in civil defense shelters - exhaust air filters in nuclear plants
H14 U15 U16 U17	- final filters for clean rooms, Classes 10 or 1

Table 5: Filter classes and application acc. EN1822

DESIGN PRECAUTIONS

While it is possible to achieve high efficiency with regard to filtration methods, there are more aspects to be considered. The higher the filter class, the higher the filter costs and pressure losses, which in the AHU installation can lead to a higher cost of ownership ((re)placement, operational costs due to pressure losses). HEPA filters generally require more space and are therefore not always an option.

3

PART 3

UV-C LIGHT

PART 3
UV-C LIGHT

This filtration system is also known as: UVGI (Ultraviolet germicidal irradiation)

WORKING PRINCIPLE

UV light is electromagnetic radiation with a wavelength from 10nm (nanometer) to 400nm and invisible to the human eye.

Three types of UV light are classified within the electromagnetic spectrum:

- UV-A
- UV-B
- UV-C

UV-A

Long wave (400-315nm), known as “blacklight” or applied in sunbeds. These UV rays can penetrate deeply into our skin, and are thought to cause most of our wrinkles, skin ageing and dark spots.

UV-B

Medium wave (315-280nm), for 98,7% absorbed by the ozone layer. UV-B light is responsible for the formation of vitamin D in our body. Long exposure will cause deformation of our DNA, resulting in sunburn.

UV-C

Short-wave (280 to 200 nm) ultraviolet energy. This type of UV light can be used to inactivate viral, bacterial and fungal organisms. The emitted energy disrupts the DNA of micro-organisms, rendering them harmless so they are unable to replicate and/or potentially cause diseases. UV-C lights can be installed in-duct or in the air handling unit to limit the spread of organisms through the HVAC system **(4,5)**. UV light itself is not effective against dust, pollen or odors.

Below UV-C is vacuum UV (10-200nm), this type of UV light is strongly absorbed by oxygen and is capable of breaking oxygen (o_2) into two single parts that, when they later combine, can produce ozone (O3). Breathing in ozone damages our lungs so most UV bulbs are given a special coating to counter this effect.

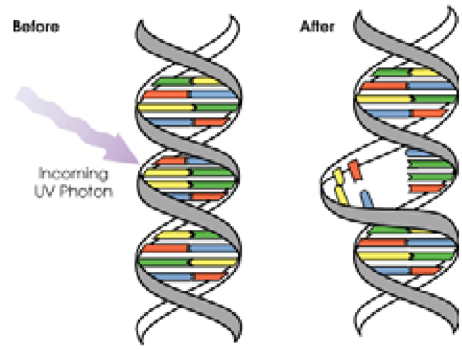


Image 6: Working principle UV-C

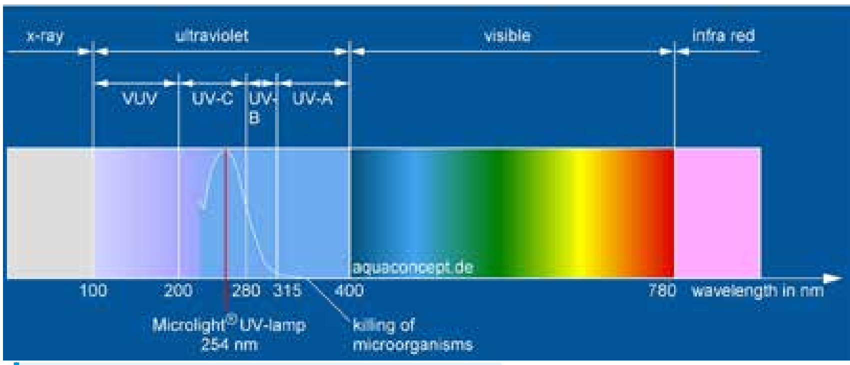


Image 7: Spectrum infrared to ultraviolet

SYSTEM EFFECTIVENESS

UV-C lamps have been proven to be effective against: micro-organisms (bacteria & viruses), fungi and pathogens. The effectiveness is based on several factors **(4,5)**:

1. **Dose**

   The ability of UV-C to inactivate microorganisms is a function of "dose". The dose is described as a product of UV irradiance [μW/cm²] and exposure time[s] on a given microorganism or surface. Dose is most commonly expressed in mJ/cm² (1mJ/cm² = 1000 μW/s/cm²).

   a. UV irradiance

      Ultraviolet radiation power on a surface per unit area, usually reported in microwatts per square centimeter [μW/cm²].

   b. Exposure time

      Exposure time is the time that a surface or microorganism is exposed to the UV radiation. For in-duct UV-C this is based on the air velocity that the organisms carry.

      Note: As a rule of thumb, an exposure time of at least 0.25s should be provided to avoid excessive power and system costs.

2. **Type of microorganisms**

   While UV-C light is effective against microorganisms, some are more susceptible than others. Therefore, the dose required to inactivate different microorganisms may vary depending on the type of organism.

3. **Light positioning**

   Positioning of the UV-C light has an effect on the effectiveness of the system. When the light reaches further, longer exposure times will take place and thus increase the effectiveness.

The IUVA (international Ultraviolet Association) provides a paper **(6)** describing the dose required for incremental logarithmic inactivation of bacteria and viruses.

WHERE TO USE THE SYSTEM

UV-C light can be used to disinfect the air from airborne microorganisms, or as surface disinfection to limit the growth of microorganisms in certain locations. The place where the UV-C light is most efficient depends on the application. Materials (plastics etc.) can be affected by photodegradation when exposed to UV light. This must be taken into account when selecting materials.

Air disinfection

Most likely, the microorganisms are spread by humans (e.g. sneezing, coughing). Microorganisms can be present in recirculated air if they have the ability to become airborne. To disinfect the air, UV-C lights can be placed in the air stream and radiate the air which passes through the lamps.

Surface disinfection

UV-C can be applied to system components to limit the growth of bacteria and mold. This type of application of UV-C is called surface disinfection. The static positioning of the components to be disinfected exposes them to an "infinite" exposure time. Therefore, it is relatively easy to limit this type of growth.

Locations in an HVAC system where bacterial growth can occur are generally: cooling coils, drain pans, plenum walls, humidifiers, energy recovery wheels, filters or other wetted surfaces. Cooling coils are particularly sensitive due to condensation between the fins. Contamination on the cooling coil can increase the pressure drop and reduces airflow and heat exchange efficiency.

Placement for AHU with recirculation*

The number of lights increases the air temperature. It is therefore recommended to place the UV-C lamps in front of the cooling block perpendicular to the airflow. This placement provides both surface disinfection for the cooling block and air disinfection.

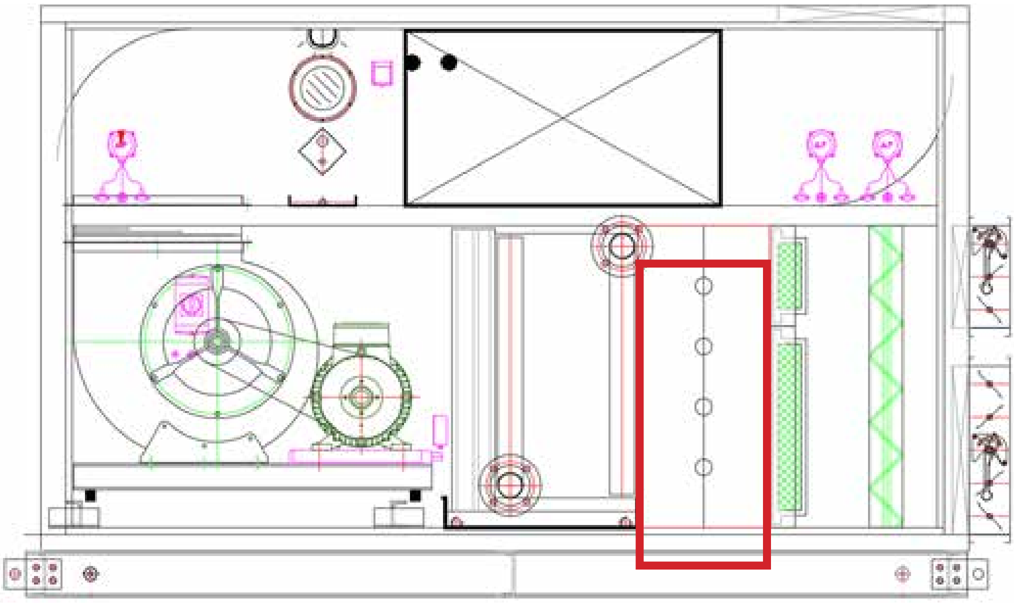


Image 7: Placement before cooling coil (red). Filters are placed before the UV-C lamps.

AHU with thermal wheel*

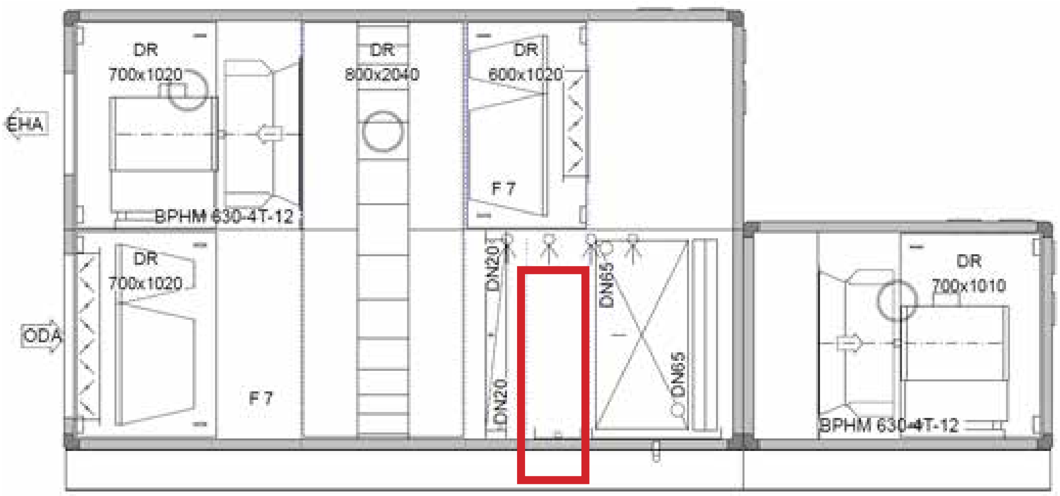
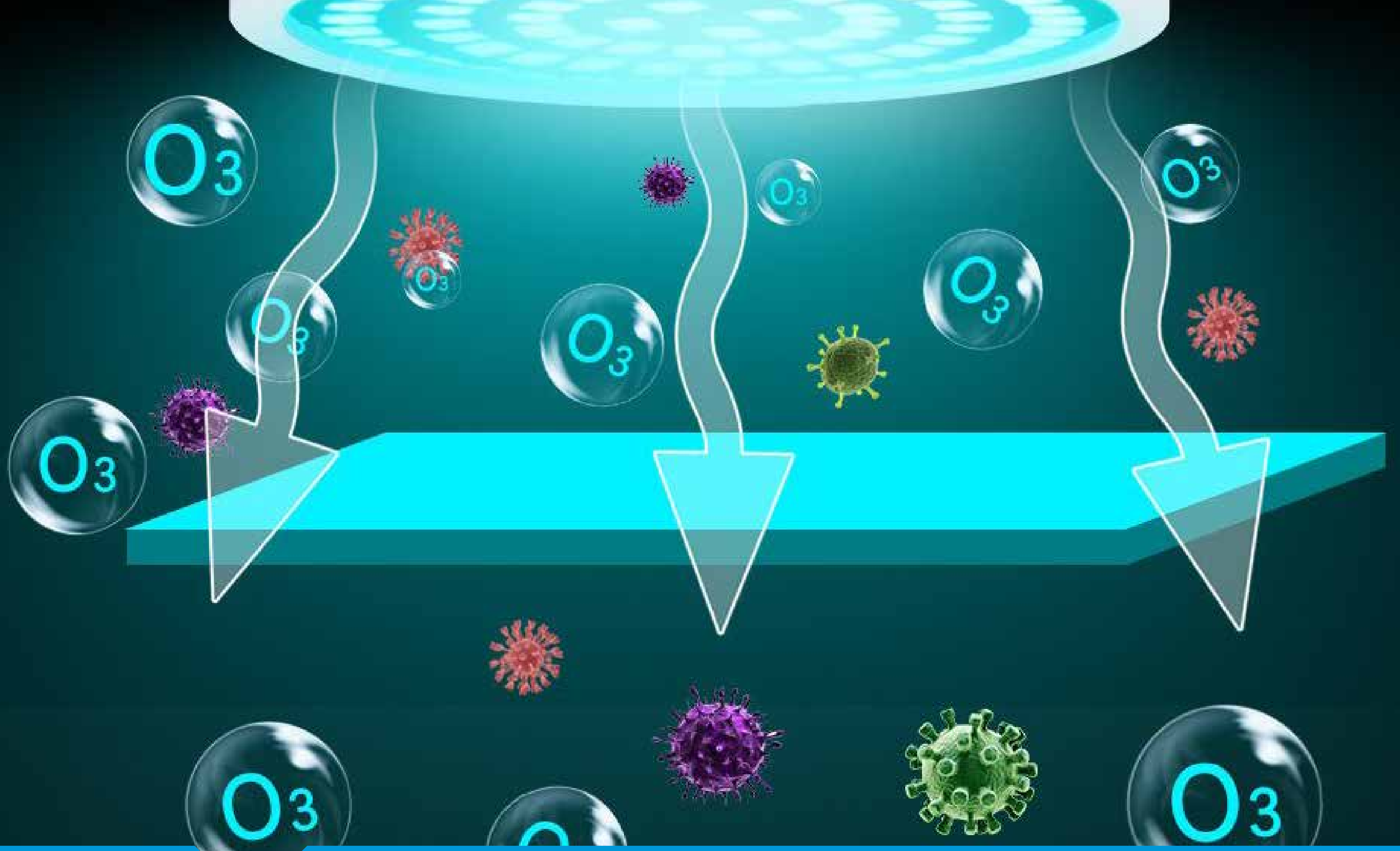


Image 8: Placement on the supply section before the cooling block (red).

***Note:** this only applies to new builds. Existing situations require a case-by-case assessment of best practice.



PART 4

UV-C LIGHT COMBINED WITH OXIDIZING EFFECTS

PART 4

UV-C LIGHT COMBINED WITH OXIDIZING EFFECTS

This type of UV-C light is almost the same as that in chapter 3 - UV-C light. The difference is the production of radicals called oxidizers. These can be produced by the type of wavelength used or by using Advanced Oxidation Process (AOP). Ozone is the filtration technique on which this solution is based.

WORKING PRINCIPLE

The two ways producing of oxidizers in a UV-C light are by using the wavelength or by using Advanced Oxidation Process. Both methods are described below. Regarding the working principle of UV-C light, please refer to chapter 3.1 - “Working principle”.

Ozone generating UV-C light

When UV-light transmits UV light in the spectrum below 200 nm wave, it can react with the oxygen to break into separate oxygen molecules. This is a very unstable atom which, in combination with oxygen, forms O3 (ozone). The extra oxygen atom which is present in an ozone molecule naturally wants to bond with another particle (e.g. pollution). When the oxygen atom wants to form with the other particle, the oxidizing effect will eventually break down this particle.

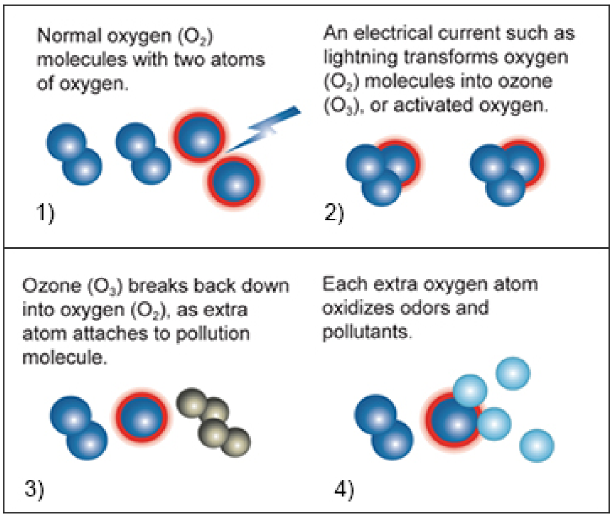


Image 8: Reaction principle Ozone

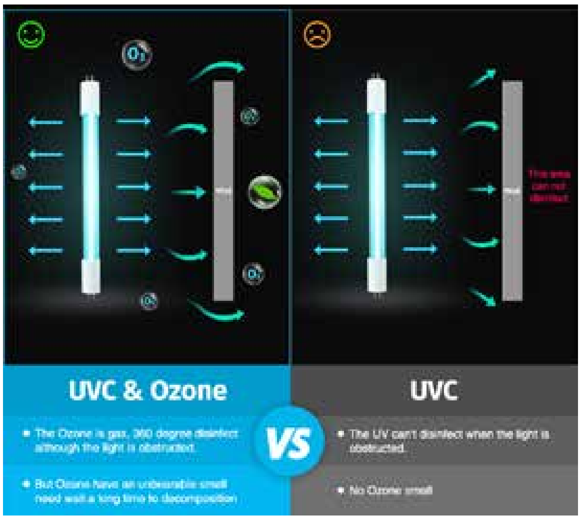


Image 9: The difference in UVC and UVC & Ozone

Advanced oxidation process (AOP)

Oxidation process is a chemical procedure to remove organic and some inorganic materials. The UV-C light is used to emit radiation on a specially made surface. This surface reacts with the energy of the UV-C light and uses this energy to produce oxidizers. The oxidation process is based on the oxidation power of radicals. The following table shows the redox potential of various oxidizing agents. The higher the number, the better the oxidation effects.

Agent name	Redox Potential [V]
Fluor (F)	2.87
Hydroxyde radical (OH)	2.86
Ozone (O3)	2.07
Hydrogen Peroxide (H2O2)	1.78
Chlorine (Cl)	1.36
Oxygen (O2)	1.23

When using AOP in combination with UV-C, the means H2O2 and O3 are usually used. The reaction principle is as described in chapter 4.1.1 Ozone generating UV-C light.

SYSTEM EFFECTIVENESS

UV-C light effectiveness is described in chapter 3.2 - System effectiveness.
The effectiveness of oxidizing agents on airborne contaminants and organisms depends on the amount of oxidizing agents and the amount of air passing through the light.

Analysing the review of scientific papers published by EPA **(8)** on ozone generators, it is made clear that ozone, in concentrations that do not exceed public health standards, is not effective in controlling indoor pollution. For ozone to be effective it must be above safety standard limits. **(9)**

The proven effectiveness for single pass air is generally less good compared to a UV-C lamp setup as described earlier. Because these setups cannot always be built in due to the dimensions, oxidizing UV-C lamps are a good alternative.

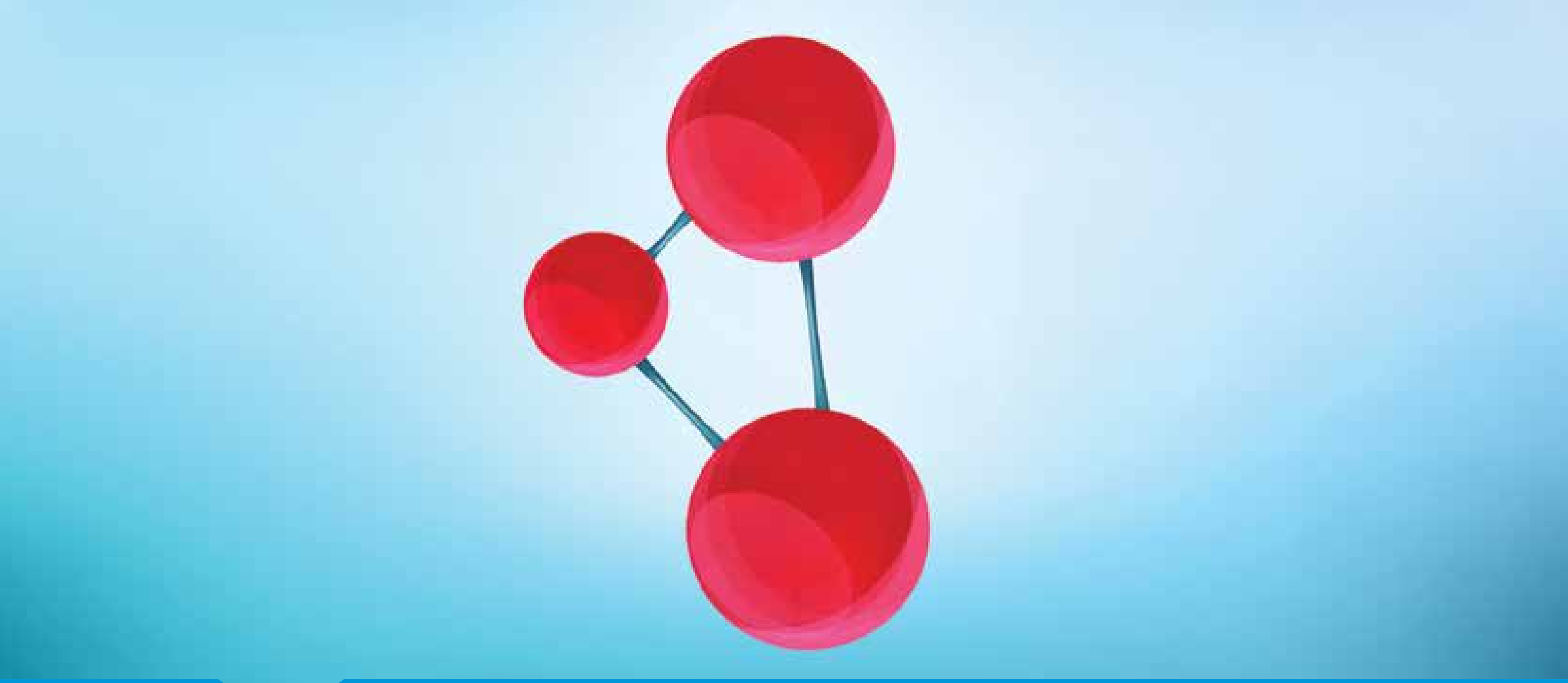
SAFETY/ DESIGN PRECAUTIONS

All safety measures that apply to standard UV-C lamps apply to oxidizing UV because it emits the same UV radiation.

In addition to the other safety precautions, it should be stated for oxidizing UV lamps that ozone must have time to react with other particles before entering the room. Therefore, the following items in this chapter must be maintained to ensure the operation of a safe system.

Oxidizing UV-C lamps should be placed as far away as possible from inhabited areas. This gives the ozone and other oxidants sufficient time to react with other particles and to break down into oxygen. If this cannot be sustained, it is strongly recommended to measure the amounts of ozone at the nearest air outlet. If the levels are too high, the lamp may turn off based on these values.

The lamp should be turned off when the fan is not running. This prevents any excessive formation of ozone or other oxidizing agents.



PART 5
OXIDATION/ OZONE GENERATORS

PART 5

OXIDATION/ OZONE GENERATORS

Instead of producing ozone by using techniques as described in the previous chapter, a generator can be used that is used to produce ozone.

WORKING PRINCIPLE

Ozone in ozone generators can either be generated by UV radiation (see chapter 4.1.1 Ozone generating UV-C light) or by electronic discharge called "Silent corona discharge". Silent corona discharge uses electric discharges to split the normal oxygen molecules into separate atoms. These atoms are reattached to O2 molecules to form ozone (O3). This is a more effective way of producing ozone because it is usually used in generators that have the special function of producing ozone.

SYSTEM EFFECTIVENESS

Manufacturers tend to claim that ozone, due to its highly reactive nature, readily adheres to pollution, odor compounds, viruses, bacteria and mold spores.

1. Particles

Ozone generators do not trap or filter particles such as dust, pollen etc. Generators with ionizing equipment can ionize these particulates to filter them. This type of equipment is not discussed in this document.

2. Mold & Bacteria

Ozone generators have been shown to be ineffective at stopping mold and are not recommended by public health agents **(10)**.

3. Volatile organic compound (VOC)

VOC is a name that describes the collection of hydrocarbons that easily evaporate in the air. With most VOCs it can take a long time to half the initial concentrations (half-lives). Some studies **(11)** have shown that ozone can be effective in large amounts for certain types of VOC (which contain unsaturated carbon-carbon bonds). These compounds can be found in cooking oils, air fresheners and detergents. The downside is that other hazardous by-products such as formaldehyde can be released in response to this VOC.

4. Odors

As described above, ozone is not effective against all VOCs. It can be effective against VOCs found in carbon-based cooking areas. Further evidence for removing odors from air is mixed. Fragrances can also be masked by the smell of ozone released into the air.

SAFETY/ DESIGN PRECAUTIONS

It is strongly recommended that you never use an ozone generator in a room that can be occupied. When an ozone generator is used, an ozone detection system must always be present to shut down the generator when the measured values exceed the maximum permitted safety levels.

Be aware that ozone can adversely affect some materials used in the AC system.

6

PART 6

IONIZATION

PART 6
IONIZATION

Names commonly used for ionization are plasma, cold plasma, bipolar ionization and needlepoint ionization. These are all the same technique but with different names.

WORKING PRINCIPLE #1 - THE IONIZATION PROCESS

Ionization is the process by which an atom or molecule acquires a negative or positive charge by gaining or losing electrons. This is the gain or loss of electrons achieved through the application of high electromagnetic radiation. When a particle becomes positively or negatively charged due to the loss of an electron, it is attracted to an oppositely charged part. This is either an oppositely charged filter (electrostatic precipitator) placed behind the ionizer or a nearby surface that the particle collides with.

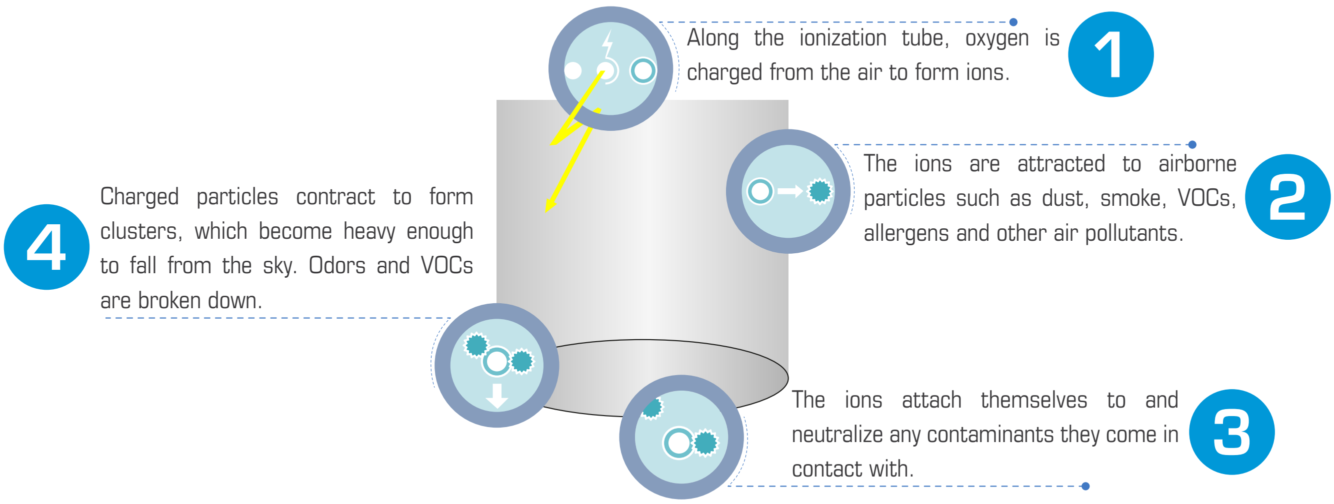


Image 10: Ionization process of oxygen

WORKING PRINCIPLE #2 - CREATION OF OZONE

While ionization and electrostatic deposition are effective against small particles (including ultra-fine particles), they do not remove gases or odors. Because they use high voltage to generate electrostatic fields, they often produce ozone as a byproduct (as discussed in the previous chapter). Although ozone is a byproduct, most suppliers will take advantage of the fact that the ozone produced is effective against odors by saying that the ionizer is effective against odors and gases. Keep in mind that this is not the ionization effect, but the effect of the ozone produced.

SYSTEM EFFECTIVENESS

As discussed above, the ionization is effective against small particles, including the ultra-fine particles and effective against viruses and bacteria present on these particles. If the ionization unit produces ozone or is equipped with a carbon filter, the system will also be effective against odors and gases. While ionization is effective against small particles, they do not eliminate them. They always drop onto a nearby surface or filter and do not render them harmless if they contain viruses or bacteria. If ionized particles are not captured by a filter or (electrostatic) precipitation, some of the particles fall on nearby surfaces (such as in the ductwork) and the rest continues into the air flow. Because these deposits build up, the particles still have the ability to resuspend in the flowing air stream if they are not removed.

SAFETY/ DESIGN PRECAUTIONS

Keep in mind that there are no standards for the efficiency of ionization units. If the equipment does not meet the UL 2998 standard for no ozone, it can be assumed to produce ozone. In that case, an ozone detection system must always be in place to check for excessive amounts of ozone. It must be such that the detection system shuts down the equipment in case it produces an excessive amount of ozone.

7

PART 7

DISCUSSION AND CONCLUSION

DISCUSSION

When filtration systems need to be installed, we recommend choosing an accepted standard for equipment designed for air/surface disinfection with UV-light or oxidizing agents. There are many applications on the market that claim performance with little or no scientific backup. Always ask the filter supplier for documents that document that the system will be effective the way you plan to use it.

By examining the techniques in this paper, it is made clear that either UV-C light or an appropriate HEPA filter can safely reduce virus transmission in HVAC systems.

Ozone generating equipment is only effective against airborne pathogens when it exceeds health safety limits. This carries the risk of ozone in an occupied space, with health risks.
Oxidizers produced will not be significantly beneficial for the elimination of VOCs, viruses, bacteria or odors when applied within health safety standards. However, the oxidizing agents can negatively affect parts of the HVAC systems.

UV-C light with a wavelength of only 254nm does not produce ozone or oxidizing agents and has the scientific evidence against airborne pathogens when properly applied. Therefore, the correct UV-C light is a safe way to limit the transmission of pathogens.
UV-C lamps can be used as surface disinfection or as an air disinfection against airborne pathogens. For air disinfection, the UV-C light is best placed on a part in the AHU where recirculated air is present, since most airborne pathogens are in the return air.

For new-build AC systems, it is easy to reserve the space required for UV-C to work as desired. However, this required space is often not available on systems that are already running. In that case, oxidizing UV-C lamps are a good alternative, as they do not require much space. Consider the efficiency and required safety precautions for oxidizing UV-C.

Ionizing filters do not kill viruses or bacteria, they make particles (including fine particles) heavier and drop them on nearby surfaces such as a channel. Particles can also be collected in a controlled manner by adding an extra filter. Deposits build-up still have the chance to resuspend in the air stream, therefore cleaning of the filter or nearby surfaces is necessary for proper operation. Many ionization units produce ozone as a by-product. Ozone should never be applied to an occupied space and the same precautions and safety measures should be applied as for the other ozone generating equipment.

HEPA filters have the disadvantage that they are expensive to replace and cause high pressure losses, increasing the operation costs of the system. Because of these drawbacks, HEPA filters are less often used as a filter application for HVAC on board ships.

CONCLUSION

For new build HVAC systems, the best way to reduce viruses, bacteria and other airborne pathogens in the HVAC system is to install UV-C lamps that emit UV-C only in the wavelength of 254nm. Since airborne pathogens are emitted by humans, they are most likely to be present in the recirculated air. This UV-C light shall, at the very least, radiate the air. Suitable filters should always be fitted to protect the UV-C light from pollution.
For existing HVAC systems where not enough installation space is available for this solution, oxidizing UV-C lamps are a good alternative. Drawbacks of this alternative are reduced system efficiency and safety risks.

UV-C against viruses

Now the question everyone thinks about; can UV purification systems be used to minimise SARS-CoV-2 transfer in HVAC systems? Short answer: we don't know yet. No research has been completed on how UV-C affects the SARS-CoV-2 virus and it has not yet been proven that the virus is airborne through HVAC systems. However, there are studies showing that UV-C can be used against other coronaviruses such as SARS.

UV-C has already been applied in China, where buses are illuminated with UV-C light to clean them, while UV-emitting robots clean floors in hospitals. However, more research is needed before a definitive answer can be given as to whether this could be a solution in the fight against SARS-CoV-2.

What we can already offer are answers to any questions you may have about installing a UV air purification system or the best position to install a UV lamp.

Your solution

Every ship has different requirements, so every ship and every air handling unit must be carefully analysed to find the right solution. For example, the location of the equipment may vary from system to system, so it should be analysed whether a hepa filter, a UV-C lamp, a oxidizing UV-C lamp or a combination is recommended.

In addition to these solutions, there are several other measures that can be taken regarding onboard HVAC systems that will improve virus protection.

Contact our sales department to find your best solution:
sales@heinenhopman.com.

QUESTIONS & ANSWERS

Most common questions are answered here.

Can other techniques be effective against viruses?
It may be possible. We recommend UV-C light as described in this paper as it has been scientifically proven to be effective for disinfecting air and surfaces.

Is UV-C light in combination with a catalyst the same as UV-C?
No, the working prinicple of UV-C with catalyst is based on oxidizing agents. However, for refit purposes, we may recommend oxidizing UV-C lamps due to the minimum space required for installation.

Is UV-C effective against odors?
No, UV-C itself cannot remove odors. Other techniques are available for this.

Are all UV light spectrum effective against viruses?
UV light in the UV-C spectrum has been proven to be most effective against viruses.

Am I protected against viruses when this technique is applied?
No, we minimise the risk of disease spreading through HVAC. This technique does not prevent direct transmission from person to person.

Does UV-C produce ozone?
UV-C itself does not produce ozone when the light emits UV-C in the spectrum of 254nm. Specific lamps with 'catalyzation' techniques are available. Keep in mind that all these types of lamps with a catalyst produce ozone.

How do I select a suitable filter to install in my air handling unit or duct?
Like a regular filter, a UV-C lamp can filter a certain number of units. For UV-C light, this is expressed at a dose required for a certain percentage of inactivation. This is expressed in $D_{\%}$ where % represents the survival rate. A dose of D_{90} is recommended for coronaviruses.

For other questions, please contact our sales department: **sales@heinenhopman.com**.

SOURCES

Writing this white paper we took advantage of the knowledge of our technical engineers who based their findings on education and over 50 years of experience. We also consulted the following sources:

1. World Health Orginazation. (2020, 29 March). Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations. Consulted on 21 April 2020: https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations
2. World Health Organization, (2020, 17 April). Q&A on coronaviruses (COVID-19). Consulted on 21 April 2020: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/q-a-coronaviruses
3. Fehr. A. R., & Perlman, S. (2015). Coronaviruses: An Overview of Their Replication and Patho-genesis. Coronaviruses, 1–23. https://doi.org/10.1007/978-1-4939-2438-7_1
4. American Society of Heating, Refrigerating and Air-Conditioning Engineers, & American Society of Heating, Refrigerating and Air-Conditioning Engineers. (z.d.). Ashrae Handbook 2011 - HVAC Applications - chapter 60. -, -:
5. American Society of Heating, Refrigerating and Air-Conditioning Engineers, & American Society of Heating, Refrigerating and Air-Conditioning Engineers. (z.d.). Ashrae Handbook 2016 - HVAC Systems and equipment 2016 - chapter 17. -, -:
6. Internation Ultraviolet Organisation. (2008). Fluence (UV Dose) Required to Achieve In-cremental Log Inactivation of Bacteria, Protozoa, Viruses and Algae. Consulted from https://www.iuvanews.com/stories/pdf/archives/180301_UVSensitivityReview_full.pdf
7. Perry, J. L., Agui, J. H., & Vijayakimar, R. (2016). Submicron and Nanoparticulate Matter Removal by HEPA-Rated Media Filters and Packed Beds of Granular Materials (20170005166). Consulted from https://ntrs.nasa.gov/search.jsp?R=20170005166
8. 7United States Environmental Protection Agency. (2019, 23 December). Ozone Generators that are Sold as Air Cleaners. Consulted on 20 April 2020, from https://www.epa.gov/indoor-air-quality-iaq/ozone-generators-are-sold-air-cleaners
9. National Center for Biotechnology Information (NCBI), Emergency and Continuous Exposure Limits for Selected Airborne Contaminants: Volume 1. Colsulted on 27 April 2020, from https://www.ncbi.nlm.nih.gov/books/NBK208281/
10. Mississippi state Department of Health. (2011, 13 september). Mold: Questions and An-swers. Consulted on 22 April 2020, from https://msdh.ms.gov/msdhsite/index.cfm/43.323.230.331.html
11. Britigan, N., Alshawa, A., & Nizkorodov, S. A. (2006). Quantification of Ozone Levels in In-door Environments Generated by Ionization and Ozonolysis Air Purifiers (ISSN 1047-3289). Consulted from https://aerosol.chem.uci.edu/publications/Irvine/2006_Britigan_JAWMA_03.pdf
12. International Ultraviolet Association. (2020). Advice(i.e., tips) for the selection and opera-tion of equipment for the UV disinfection of air and surfaces. Consulted from http://www.iuva.org/resources/covid-19/Advice-for-the-selection-and-operation-of-equipment-for-the-UV-disinfection-of-air-and-surfaces.pdf
13. American Society of Heating, Refrigerating and Air-Conditioning Engineers. (z.d.). Filtration / Disinfection. Consulted on 22 April 2020, from https://www.ashrae.org/technical-resources/filtration-disinfection#pco
14. EPA, United States Environmental Protection Agency. (2018, July). Residential air cleaners, a technical summary (EPA 402-F-09-002). Consulted from https://www.epa.gov/sites/produc-tion/files/2018-07/documents/residential_air_cleaners_-_a_technical_summary_3rd_edi-tion.pdf

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Heinen & Hopman encourages a more sustainable world. By providing eco-friendly solutions and services we offer our clients the option of reducing energy consumption and thus CO_2 emissions.

HEINEN & HOPMAN MANIFESTO APPROVED

“Do you require more information about filtration techniques? I am keen to help you further! ”

Eric Stoffelsen

- Sales Manager
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