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Artificial Intelligence for Wellness

Ventilation and Air Cleaners for Schools

What you need to know – A guideline for creating safe and healthy environments in schools

Introduction

It's been unprecedented times for everyone. Every single person has been impacted in some way or form from the COVID-19 pandemic. We're now getting ready to enter the next stage, to a post-Covid world and for most building administrators and facilities management, it can be quite confusing, complicated and sometimes a contradictory task to create building environments that people feel safe and comfortable to come back to. The education sector is no exception. Teachers and students. Staff and personnel. Everyone involved within our education system would like to confidently return to a healthy setting. However, there's so much information out there that it can be utterly daunting to conclude exactly what the correct path is to take for your school. The general consensus among the scientific community is proper and increased ventilation.

Dozens of the world's top experts in how diseases spread have called for big improvements to the air in buildings. The problem is likened to the health crisis caused by contaminated water in Britain's cities in the 1800s. *39 scientists from 14 countries, are demanding universal recognition that infections can be prevented by improving indoor ventilation systems. They want the WHO to extend its indoor air quality guidelines to cover airborne pathogens, and for building ventilation standards to include higher airflow, filtration and disinfection rates, and monitors that enable the public to gauge the quality of the air they're breathing. They say current rules on ventilation are failing to stop infections, including COVID-19. Now they argue there's evidence from studies of cases in restaurants, ships and schools that respiratory infections can be passed through the air.

What if your current ventilation system is out-dated and/or unable to increase air flow? What if you're unable to ventilate naturally and open windows due to weather or polluted outside air? And if you are able to open windows, what if you're not able to create any cross ventilation? Are opening windows really enough? Should our classrooms and spaces have air purifers/air cleaners? If so, which filtration technology is optimal? What would an expert recommend if he or she were to take a close look at our particular school? That's what this guideline is here to assist with. To help answer these frequent and critical questions and assist schools on what plan of action is best suited for their environment.

What are the current regulations in the UK?

It is the not the purpose of this paper to go into the specific details of each building regulation requirement. Architects, engineers, and other designers will be sufficiently aware of these regulations and are best suited to advise whether specific solutions will comply with these regulations or not. However, it's important for education administrators, school business leaders, head teachers and facility management teams to have at least some familiarity with the regulations out there as they prepare their schools with different methods of improving ventilation and air purification/air cleaning.

There are several guidelines and regulations that come into play in regards to the education sector in the UK. BB101 is specific to schools and covers ventilation, thermal comfort, and indoor air quality. Minimum temperatures in classrooms are given which means opening windows during winter may not be feasible. Maximum CO2 levels are described which indicates proper ventilation is required as well as being a measure for general IAQ. BB101 also lists recommended minimum levels of other pollutants such as NO2, Ozone, and VOC's. Ozone in particular should be carefully considered as some air filtration technologies can produce Ozone which can be harmful to human health. Schools are also included in the general UK Building Regulations and must adhere to both Part F and Part L of these documents. Part F mandates that adequate means of ventilation must be provided for people in the building with specific fresh air requirements for each type of space and building. Part L concerns fuel and power. For instance, there are energy efficiency requirements when mechanical ventilation is utilised over natural ventilation. HEPA filters will be described later in this document but one of the drawbacks to installing a HEPA filter is the added resistance will increase energy consumption, possibly causing the mechanical ventilation system to not comply with Part L requirements. Not all indoor air quality solutions are feasible so it's important that solutions considered will comply with building regulations. BB93 is another guideline that designers need to adhere to, and this concerns noise levels. BB93 has set maximum dBA levels for each type of space within a school. A standard classroom can have maximum NR35 as the upper limit of indoor ambient noise. If you intend on installing an air purifier or air cleaner in the classroom then choosing one that produces minimal noise or is equipped with multiple fan speed levels will be important.

Air filters themselves are rated and classified according to ISO 16890 and EN 1822. These regulations generally just regulate fibre type filters that would be installed in a mechanical ventilation system so it's important to note that portable air purifiers are generally not regulated in this manner. While there are all sorts of recommendations when it comes to portable air purifiers, there are not specific regulations as to which portable air filter technology (the different types of technologies are described below) may or may not be used. Be sure to investigate the specific technology utilised in the air purifier because some may actually be more harmful to IAQ than beneficial. There will most likely be a time when air purifiers are better regulated but for now it's important that due diligence is taken.

Regarding UK education regulations and Covid, at this point there are only guidelines, not strict regulations beyond the previously mentioned. www.gov.uk posted guidelines on March 1st 2021 which go through recommended measures such as social distancing, mask wearing, ventilation recommendations, and more. Their guidelines mostly mimic the World Health Organisation's so will be covered in the next section.

Again, it's not the intention of this document to go into further detail on all the rules and regulations pertaining to ventilation and indoor air quality. But the above regulations and guidelines described above at least give you an idea of what needs to be considered in safe guarding your schools. One last thing to note is that there are different requirements for different spaces within schools. For example, chemistry labs will adhere to different levels of fresh air and noise levels than a special needs classroom. Ideally, schools will have access to personnel that are able to confirm current UK regulations are adhered to when implementing any changes and improvements to ventilation and air purification. It's recommended that any changes or additional equipment/filters/purifiers being implemented are reviewed by a professional.

What does the World Health Organisation (WHO) recommend?

The World Health Organisation (WHO) published its "Roadmap to improve and ensure good indoor ventilation in the context of COVID-19" in March 2021 which gives a useful (but at times a bit confusing) flow chart of the recommended measures to be taken as buildings began to see occupants return. Note their flow chart concerns buildings in general, not specifically for schools, but their recommendations are inline with most other experts, including our own, in regards to education.

Here's a summary of the WHO's non-residential settings strategies as it would pertain to classrooms:

In general, the best infection prevention technique and overall healthier IAQ is ventilation, i.e replacing stale air with fresh air. There are some caveats, but it's generally agreed in the scientific community that either ensuring ventilation is meeting the government regulation or increasing ventilation should be the primary goal of post Covid buildings. This should be achieved by natural, mechanical or hybrid ventilation. The WHO have separated their flow chart/guidelines into natural and mechanical sections (hybrid ventilation is a unit that serves as both natural ventilation and the ability to use mechanical ventilations if natural ventilation is not meeting fresh air, temperature, or CO2 requirements).

Natural Ventilation:

If possible open windows but ensure that the minimum fresh air rate is achieved (best determined by a professional). It's also important to achieve cross flow ventilation. If the internal door of the classroom is shut and windows are open on just one side of the classroom then you're only getting single sided ventilation and is not nearly as effective. If you're going to open windows, then you'll need some sort of opening (door or other means) to ensure ventilation is crossing the classroom. An added fan could help move air as well, but this is typically not feasible due to noise and space. If you're unable to achieve mandated fresh air rates (lots of older buildings may not have adequate fresh air rates through natural ventilation) or cross flow ventilation, then a portable air cleaner is recommended by the WHO. The WHO only mentions using purifiers with F8 filters as a minimum, but it's generally recommended that filtration/purifiers/cleaners are equipped with better filtration than this. Almost all air purifiers/ air cleaners on the market will have filtration ratings higher than F8. We'll cover this in a later. The WHO doesn't take noise levels or outside air pollution into consideration, but this is very applicable to schools and classrooms. Opening windows may not be recommended if the classroom is next to a busy road or in a city centre with above recommended pollution levels. While possibly feasible in the summer, opening windows will probably not be recommended in the winter when temperatures are too low. Thus, ensuring healthy IAQ with an air cleaner is highly recommended.

Mechanical Ventilation:

Ensure that the existing mechanical ventilation is achieving the minimum fresh air rate requirement. Look into possibly increasing ventilation by, for example, increasing the speed of the fans. If this is not possible then most likely you'd need to open windows to help bring in more fresh air. As mentioned in Natural Ventilation, opening windows is an unlikely solution year around so adding an air cleaner is recommended. Another option with mechanical ventilation is to replace the existing filters (they're most likely low grade panel filters) with higher quality filtration. This will most likely increase the pressure drop/resistance in the ventilation system so a professional would need to verify this as a solution. There are other situations where filters are recommended to be upgraded. For instance, with mechanical systems equipped with heat recovery and >3% leakage or with recirculation systems in place. It's not always feasible to replace these systems with higher grade filters because of the increase in resistance (as always, verify with a professional) so in these cases, a portable air cleaner is recommended.

In summary, increase ventilation if possible. Since this can be difficult in lots of cases and opening windows is not a year around solution, it's recommended to install portable air cleaners in schools (ground or wall mounted) to ensure all occupants are breathing the highest quality air.

Should we add Air Purifiers/Air Cleaners?

It's important to note that air purifiers are not a complete solution. The number one priority should be to increase ventilation as a remedy to decreasing the risk of infection and increasing the quality of air building occupants are breathing. But increasing ventilation is not always so simple. Is your current ventilation strategy providing the minimum fresh air rates regulations mandate? Is the outside air you're intaking into the space not already polluted? Does your school reside in a city centre or nearby to road traffic so as to inhibit the intake of low polluted, healthy fresh air? If opening windows is a necessity to achieve adequate fresh air rates, are you able to open these year around? Are you able to ensure cross flow ventilation every day? Are you able to ensure outside noise levels don't prohibit opening windows? If you're answer is no to any of these questions, then you should probably look into adding an air cleaner. They're relatively low-cost items that provide a major benefit to ensuring all occupants are breathing healthy air. Ensure you do your research before you choose your air cleaner.

What is in our air?

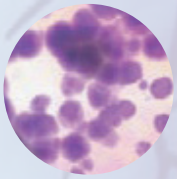
There is a wide range of particles in the air that we breathe, from relatively large – those form visible dust, reducing visibility and soiling buildings, to the very fine particles that can penetrate deep into our lungs or blood and have been found to damage health.

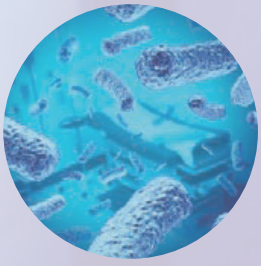
Three classes of air contaminates listed by the EPA:

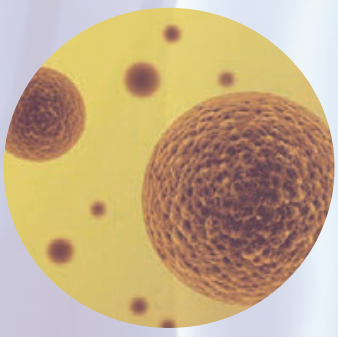
Particles
Dust, Pet Dander, Pollen

Microorganisms
Bacteria, Viruses, Mould

Gases
Odours, VOC's







What is the difference between the different Air Purifiers and Air Cleaning Technologies out there?

It's been determined that air cleaners and purifiers should be installed in each classroom and space in your school. You go online and are overwhelmed by all the choices and manufactures and filtration technologies to choose from. Air purifiers/air cleaners range in cost, noise, technology utilised... how are you supposed to determine which ones to purchase and install in your classrooms? While there are hundreds of manufactures, with a huge range in quality, luckily there are generally just a handful of filtration technologies utilised. This is a good start. Figure out what filtration technology is best, and this can help whittle down your choices to a more manageable size. Different filtration technologies attack or collect air pollutants differently and some are better suited for certain applications than others. Note that most air purifiers use a combination of the below filtration technologies. Let's review your options.

HEPA:

Generally, the most efficient fibre type filter on the market and most well-known. There's a range of quality but normally they capture 99.97% of all particulate matter >0.3 micron. Covid is between 0.6 and 0.14 micron but because viruses are typically airborne through larger aerosols, HEPA filters are able to capture a high percentage of viruses and other pollutants as well. They're not efficient at capturing ultra-fine particulate (the ones that penetrate most deeply into our bloodstream) though. The biggest drawback to HEPA is the resistance to air flow it causes. The longer the HEPA filter is in use, the higher the resistance. Thus, HEPA is great at capturing particles, but it also restricts the air flow of the fresh air you're looking to bring to the space. If an air purifier uses HEPA be sure to look at noise levels as the higher resistance can cause the fans to work harder thus produce more noise. Be aware that many filters state 99.97% efficiency however do all not perform at this level.

Ultraviolet, UV-C, or UVGI:

There are different names for UV based technology, but they all mostly use UV-C to help eliminate pollutants. UV-C in a portable air purifier would be utilised with another filtration technology, such as HEPA because UV-C is specifically designed to inactivate microorganisms such as bacteria, viruses, and mould. UV-C is very efficient at sterilising stationary surfaces, like cooling coils, but not as effective in ducted systems or portable units. This is because UV-C needs time to be effective. Similar to how it takes time to get a sun burn, UV-C needs time (and/or really powerful UV) to adequately eliminate the microorganism. Upper room UVGI units have been shown to be effective but portable units using UV-C will most likely not be as efficient because the air going through the portable filtration unit won't be slow enough to sufficiently attack microorganisms. Modern UV air filters produce very limited Ozone but be sure to verify this if you go the UV-C air purifier direction.

Electrostatic:

These filters come in a few different kinds of configurations but generally what they do is in a closed device, particles are positively charged. The air and positively charged particles then pass over negatively charged plates so as to attract and trap the positively charged particles. These are more designed to capture particulate matter so often these are combined with other filtration technologies but not always. Electrostatic filters can be effective, but the problem is that the negatively charged plates lose their efficiency as more and more particulate builds up on the plates. This means that the plates need to be cleaned very often. It's not always feasible to regularly clean these and then you have a filter that's not even nearly doing its job. This technology is not a popular as it once was, but you will see this technology on the market.

Bipolar Ionisation:

This technology has been around for decades, but it's use, and popularity have massively grown since the pandemic. But it's also the one that's least understood and tested as well. Bipolar Ionisation is different than most of the filtration technologies in that instead of trapping pollutants inside the filtration device, it shoots how chemicals into the space to attack and remove the pollutants directly from the space itself. Both positive and negative ions are shot out of the device into the space. Two things occur: one, hydroxyl radicals are created and used to attack microorganisms and gases essentially oxidising the pollutant converting it into harmless CO2 or water vapour. Two, the charged ions cause particulate matter to cling together to become heavy enough to fall from the air. It's been shown in laboratory tests to be very efficient at removing particulate matter, pathogens such as viruses, and even some gases/odours as well. But there are lots of sceptics from the scientific community about bipolar ionisation. For one, the lab tests don't seem to match up with the real world providing very inaccurate efficiency claims. Sceptics are also concerned that while being effective at attacking certain harmful pollutants, bipolar ionisation isn't also creating new ones. Every space is different with different combinations of particulates and pollutants in the air. For instance, it's impossible to predict how ionised particles will react to all the different types of VOCs in the space and what by-products oxidation is going to have. Out of all the filtration technologies it seems there's the most scepticism about any technology that is putting chemicals into the air to specifically attack the pollutants in the space. Just too unpredictable what the by-products will bring to our health. We would be in agreement that it's generally best to use a filtration technology that is completely chemical and ozone free and keeps all filtration within the device.

Activated Carbon Filters:

These filters are great at one thing: eliminating gases and odours. Which is why you'll typically use carbon filters in conjunction with another filtration technology. If gases such as NOx or odours are an issue, then an air purifier with a carbon filter (sometimes called VOC filters) is recommended. These filters use carbon, which essentially looks charcoal, like to absorb gases, fumes, and odours. Other elements are sometimes utilised, but carbon is the most common.

Photocatalytic Oxidation (PCO):

Similar to bipolar ionisation, PCO is another filtration technology that is using chemicals to attack pollutants in the air rather than trap and remove. Using UV-C to energise a catalyst, typically a titanium dioxide coated material, hydroxyl radicals are created which will seek to oxidise pollutants such at viruses and bacteria, converting them to harmless CO2 and water vapour. And similar to bipolar ionisation, we do not recommend a filtration technology that is using chemicals to attack other chemicals - and put more chemicals into the air.

Fogging Machines:

Repurposed to fight coronavirus, fogging is highly effective for rapidly disinfecting large or complex areas with a micro-fine chemical mist that settles on all surfaces and quickly evaporates/dries leaving the area sanitised and virus free. Disinfectant foggers fill the air in a room with tiny droplets, which then settle on all of the room's surfaces. Foggers could and are being used to help reduce the spread of viral infections. Foggers are also effective for odour control, pest control and mould treatment.

Even though they are effective killing viruses it doesn't mean they have been approved or considered safe with regards to human health - there are alternative ways to kill off pathogens that carry much less potential risk.

Disinfecting Filtration System (DFS) - Air Cleaner

DFS Technology is a comprehensive, high efficiency, three-pollutant category air filtration system. It applies a constant 12k to 15k voltage (low amperage) energy field throughout the filter. This energy field does two things:

1. Creates ionisation which causes tiny particulate to agglomerate together allowing the filter media to capture.

2. Barrages microorganisms like bacteria and viruses and breaks them down, essentially destroying them.

This results in 99.99% efficiency rate on all pollutants greater than 0.007 microns (40x smaller than HEPA capabilities), providing fresh, clean air to the space. No harmful by-products are produced. All filtration occurs within the filter but at half the resistance of HEPA, helping to keep noise levels to a minimum. The portable versions of DFS include an activated carbon filter to effectively eliminate all three types of pollutants. Most important though is that all filtration occurs within the filter outputting only fresh, clean air. A totally chemical free solution. Testing proved 100% efficiency compared to other air filters on the market.

INDIVIDUALLY TESTED Guaranteed EN 1822 Performance & CERTIFIED

Air Filtration Technology Summary

The above are generally the types of technology that air purifier and air cleaner manufactures utilise. They all vary in efficiency so hopefully this helps break this down to clarify which direction is best to go. Our stance (as with much of the scientific community) would be to avoid filtration technologies that are specifically designed to use chemicals (in most cases unstable hydroxyl radicals) to attack other chemicals. We recommended you strive for a completely chemical free zone with a cleaner that peforms to the efficiency claimed. You should also be sure to look at noise levels and ideally use a portable unit that has multiple speeds. Occupancy can differ so the flexibility to alter the speed (thus noise) of the portable unit could be crucial.

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Additional factors to note when implementing Air Purifiers and Air Cleaners

- Ideally be able to monitor IAQ as well with sensors and access to data.
- Install in a central location within the space if possible. Portable air purifiers are not as effective in corners of the room for example.
- Don't purchase off price. Generally, a low-cost air purifier off Amazon will not be an effective solution.
- How often do the filters need to be replaced?
- How much do replacement filters cost?
- Ensure your filters are giving the efficiency stated - most underperform.

Useful Links

www.transform-our-world.org/programmes/clean-air-for-schools

www.gov.uk

https://www.bloomberg.com/news/articles/2021-05-16/covid-is-airborne-scientists-say-now-authorities-think-so-too

*https://www.bbc.co.uk/news/science-environment-57102372

https://www.thetimes.co.uk/article/in-the-office-or-dining-out-how-clean-is-the-air-you-breathe-8l887ph2w?shareToken=67067a826125359db0eb8aa20f7b0f4f