Mitsubishi Electric Guide to Indoor Air Quality (IAQ)

Information Guide 74

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Mitsubishi Electric Guide to Indoor Air Quality (IAQ)

This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today.

This guide accompanies a series of seminars, all of which are CPD certified.

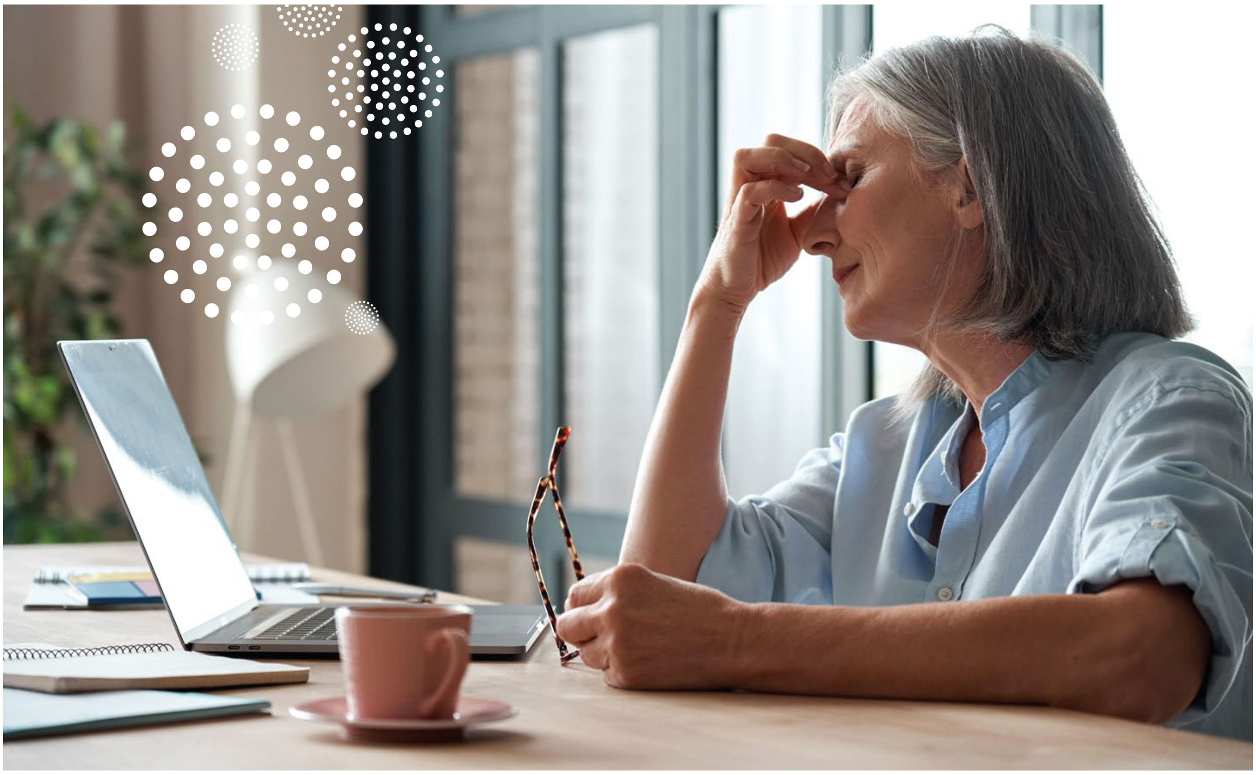
Contents

Introduction

With a greater focus on health in our workplaces and homes, the issue of indoor air quality (IAQ) is gaining more attention. Building services professionals play a key role in the design and delivery of systems that support good IAQ. Updates are underway of Part F of the Building Regulations (that deals with Ventilation), highlighting government's new focus on air quality and health.

However, provision of good indoor air quality should not simply focus on limiting the risks of illness. With the right systems and good maintenance strategies in place, the indoor environment can support better long-term occupant wellbeing and productivity. A number of reports from the construction and property sector call for greater focus on air quality in the workplace as a result.

This Guide considers the definition of indoor air quality, current legislation on IAQ and its impact on building services, and also looks at the technologies and techniques that can support good IAQ.



What do we mean by indoor air quality?

The key factors that contribute to indoor air quality are: the presence of pollutants (from outdoor air and produced inside buildings); humidity; temperature and air movement.

The World Health Organisation (WHO) has long recognised air quality as a significant factor in human health. Its detailed guidance[1] is aimed at **"protection of health from a number of chemicals commonly present in indoor air"**.

The work of WHO informs the legislation of countries around the world (including the UK) and identifies the safest allowable levels of chemicals that can be present in the air. WHO research highlights the impact of Particulate Matter (PM) which is a pollutant that can be present in liquid or solid form in the air.

Particulate Matter (PM) is categorised by size: PM10, PM2.5 and PM1. These types are based on the size of the particulates. PM is produced from traffic sources (diesel and petrol engines) and dust from roads and industrial processes. However, Particulate Matter is also produced in our homes from activities such as cooking, smoking, using paints and even air fresheners and candles. Wood-burning stoves are also a key source of PM.[2]

The smaller sizes of PM are considered the highest risk to humans since they can enter deep into the lungs and blood stream. WHO states that, in the European Region, exposure to Particulate Matter "decreases the life expectancy of every person by an average of almost one year, mostly due to increased risk of cardiovascular and respiratory diseases, and lung cancer."[3]

However, not all pollutants in buildings enter from the outside. There are numerous sources in our workplaces (and homes). These include cleaning products, carpets, furniture, printers and photocopiers. Added to excess humidity that may lead to the formation of mould, these factors can make for a cocktail of unhealthy air.

Indoor air quality and legislation - Part F of the Building Regulations

Part F of the Building Regulations deals with Ventilation, and in April 2021 it is undergoing a significant consultation and review by government[4]. The proposed updates for regulations concerning ventilation of homes and non-dwellings reflect a wider understanding of the impact of air quality on human health. Proposed updates of Part F focus on issues such as monitoring for pollution, filtration of recirculated air and the ability to offer higher ventilation rates if required.

The proposals for dwellings and non-dwellings include the table below which shows exposure limits and times for external pollutants which are regarded as particularly harmful to health.

Pollutant	Exposure Limit	Exposure Time
Carbon Monoxide	10mg/m³	8 hour average
Sulphur Dioxide	350µg/m³ (microns per m³) 125µg/m³	1 hour average 1 day average
Nitrogen Dioxide	200µg/m³ 40µg/m³	1 hour average 1 year average
Benzene	5µg/m³	1 year average
Lead	0.5µg/m³	1 year average
$PM_{2.5}$	25µg/m³	1 year average
PM_{10}	50µg/m³ 40µg/m³	1 day average 1 year average

Note: Proposed updates to Part F (Ventilation) for dwellings and buildings other than dwellings and is based on Schedule 2 of the Air Quality Standards Regulations.

It is clear from the proposed updates that there is a greater recognition that outdoor air is not necessarily 'fresh'. Therefore, regarding ventilation simply as a means to introduce more outdoor air into an occupied space is not always of the most benefit to occupants.

For example, in the current Part F of the Building Regulations 2010 (Section 4.6) the document states: **"It is assumed within the Approved Document that the outside air is of reasonable quality"**. However, as most building services professionals are well aware, this is certainly not always the case.

So, while the proposed new Part F for non-dwellings states that an important characteristic of building ventilation is that it supplies "a minimum level of outdoor air for occupant's health" there is a proposed requirement that ventilation systems "minimise the ingress" of outdoor pollutants.

The proposed update also includes a requirement for indoor air quality monitoring in offices. The rules would not apply to rooms that accommodate more than 15 people, or to large volume spaces such as atria. CO_2 monitors are cited as an example technology, though the proposals do point to "other means of measuring air quality", but do not supply details on what those might be.

Proposed updates for Part F in non-dwellings also highlight a growing awareness of the link between air quality and ventilation with the spread of “infectious agents transmitted as aerosols”, which are specifically mentioned in the draft update documentation but not in the current Part F.

For instance, the proposed required ventilation rate for occupied space in offices is 10l per second, per person or 1 litre per second, per m^2 floor area, whichever is the higher. Further, the proposals include a requirement of 1 litre per second, per m^2 of floor area in unoccupied spaces. This would therefore include hallways and corridors, which would be a step change.

In addition, each office must be equipped with the ability to increase the general ventilation of each occupied room by 50%. This is so that the ventilation system can operate at a higher rate for several months if required.

The document states that: **“This may be beneficial to reduce the spread of airborne infection in offices in a period when airborne illness is prevalent”**.

Recirculating air is discouraged in the proposed Part F update, unless the ventilation system includes an ultraviolet filter, HEPA filter or other “germicidal filter”. Where a system is designed to recirculate air, it must either include these filters or be able to switch to full fresh air mode. However, full fresh air mode would create its own issues with poor indoor comfort and excessive energy use during colder periods of the year.

There are also proposed new rules targeted at spaces where members of the public can gather and engage in activities likely to create higher levels of risk from airborne contaminants.

Example of the proposed updates include:

Ventilation systems in non-domestic environments may be required to disperse airborne contaminants

Ventilation systems, including natural ventilation, should be designed to provide a minimum of 15 litres per second, per person of outdoor air in certain types of occupied rooms:

- Rooms where singing, loud speech or aerobic exercise or other “aerosol generating activities” are likely to take place
- Rooms where members of the public are likely to gather in large numbers
- Rooms which are maintained at low temperatures and low levels of humidity

This means that the proposed 15l per second, per person rule would include a broad range of spaces such as **gymnasiums, pubs, concert halls, nightclubs, shopping malls and hotels**.

Why does good IAQ matter?

Although the proposed updates to Part F indicate more awareness that IAQ is affected by both indoor and outdoor pollutants, they still focus on avoiding the worst effects of pollutants. Legislation around indoor air quality focuses on reducing the presence of certain hazardous pollutants present in indoor air, rather than on providing a standard that can be regarded as 'good'.

But avoiding 'bad IAQ' should be regarded as a minimum safety measure, rather than the final objective of system design.

A number of reports on wellbeing in the workplace indicate the health and productivity benefits of a good indoor environment (including air quality). One example is the World Green Building Council report *Health, Wellbeing and Productivity in Offices*. It states that: "a comprehensive body of research can be drawn on to suggest that productivity improvements of 8% to 11% are not uncommon as a result of better air quality."[5]

In the book *Creating the Productive Workplace*[6], Satish, MacNaughton and Allen highlight research undertaken into IAQ and strategic management capabilities of occupants. Studies conducted by Harvard TH Chan School of Public Health, showed that levels of indoor pollutants such as CO_2 and volatile organic compounds (VOCs) had a significant impact on occupant work performance. Better ventilation resulted in occupants performing better even at complex decision-making tasks.

The British Council for Offices' (BCO) *Roadmap to Health and Wellbeing*[7] reflects the growing body of evidence on IAQ and its impact on the workforce. The BCO advises assessment and monitoring of a range of environmental issues, including indoor air quality, advocating for an "indoor air quality management plan" for the workplace. This would include methods for logging complaints about IAQ from occupants, supplemented by automated monitoring around the building.

Building services technology - delivering IAQ

Ventilation is vital for delivery of good indoor air quality, and much of the legislation reflects this. However, air conditioning with high quality filtration can also play a significant role in good IAQ, and used alongside well-designed ventilation it creates a powerful combined technology for creating a healthy and productive indoor environment.

One of the challenges for engineers when considering IAQ is how to deliver a healthy indoor environment, while also maintaining building energy efficiency. Air changes in a building are the second-largest energy source of energy losses (with fabric being the largest).

However, while it is possible to insulate the building fabric to reduce energy loss, we must keep the air moving in order to ensure occupant health and comfort (and to meet regulatory requirements). Given the proposed potential updates to required ventilation rates this is an issue to bear in mind in the long-term.

Mechanical ventilation with heat recovery (MVHR) is an energy efficient option available for commercial buildings and dwellings. It offers the benefit of introducing outdoor, filtered air into a space, while recovering heat energy that would otherwise be lost.

MVHR allows the stale air in a space to be removed, but captures heat energy from the outgoing air to heat up the incoming air. The most effective systems can recover between **80%** and **90%** of the heat energy. This is achieved without the two air flows coming into contact with each other, which is an important consideration in the post-COVID office environment. Some heat recovery systems can further avoid the possibility of virus spread. For example, Mitsubishi Electric's Lossnay MVHR system has a paper core which has been tested using E-Coli bacteria, which is considerably smaller than the SARS (COVID-2) virus. A plastic core version of the system is also available.

Humidity and temperature are important elements of air quality, and air conditioning can ensure that these are maintained at the required levels in a building, in an energy efficient way. In addition, with the application of modern filters, air conditioning can also help to remove significant pollutants.

Building services technology - delivering IAQ

Part F of the Building Regulations highlights the importance of using filters. The Chartered Institution of Building Services Engineers - *CIBSE KS17: Indoor Air Quality and Ventilation*[8] provides information on types of filter and the respective diameter of particles they capture.

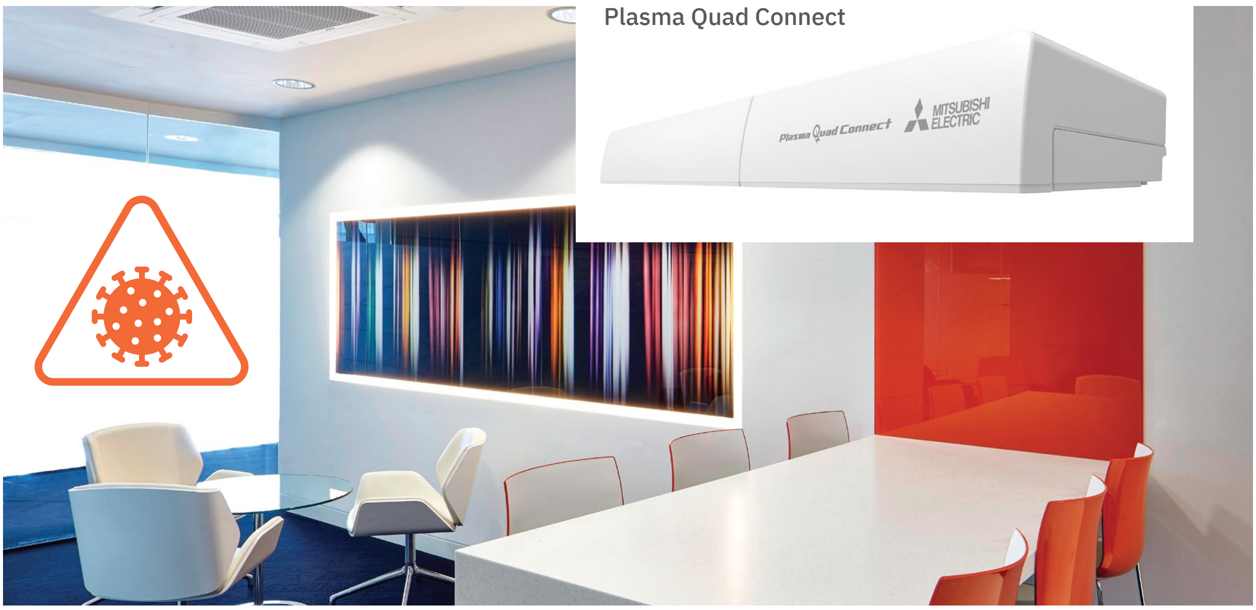
It is common to see filter classes G1 to F9 mentioned, and this relates to the standard EN 779. However, it should be noted that this was replaced in 2018 by ISO 16890 (Air Filters for General Ventilation[9]). The old standard only tested filters against a single size of PM. However, ISO 16890 assesses filters across a range of PM sizes with an indication of their arrestance (what percentage of particles the filter captures, shown in 5% increments). This approach provides more detailed information for specifiers.

For example, a filter will therefore be designated ePM 2.5, 75%. This means that it offers a 75% arrestance of particulate matter sized between less than or equal to 0.3 microns and equal to or greater than 2.5 microns. A minimum 50% arrestance is required for a filter to achieve classification.

New filter technology is also being developed. There are modern air conditioning filtration options available that can be retrofitted (in some cases) to support good indoor air quality. For example, electrostatic filters which offer a modern approach to cleaning indoor air. An example of this technology is the Mitsubishi Electric Plasma Quad Connect.

This technology uses electrostatic filtration to neutralise six key pollutants: viruses, bacteria, allergens, dust, mould and PM 2.5 and larger. The filter works like an electric curtain. As polluted air enters the indoor unit, it produces plasma to inhibit viruses and bacteria while also breaking down allergens, dust and mould. In a second stage, dust and PM 2.5 are electrically charged and removed with a strong electrical field.

The filter can be installed with new projects or retrofitted to a number of Mitsubishi Electric's indoor units (including the M Series, Mr Slim and City Multi ranges) for an easy and effective upgrade.



Improving IAQ in existing buildings

In new buildings, it is relatively straightforward to specify high levels of ventilation, filtration and air conditioning specifically to support good IAQ. But it is also possible to refurbish existing systems to raise the quality of the indoor environment for occupants.

Given the growing attention paid to indoor air quality, it is no surprise that managers of some older buildings might consider the purchase of standalone air purifiers. While these may seem to offer an easy solution, they may cause more problems than they solve.

Although they require no 'installation', air purifiers will draw unfiltered air across an occupied space to wherever they are placed, so indoor pollutants are moving around the occupants more freely, making them easier to inhale. At best, free-standing air purifiers are a last resort for removing indoor pollutants where no other solution is viable.

Ventilation systems should therefore be regarded as the backbone of good IAQ delivery. In buildings with no ventilation system, installation should be considered a priority.

If a ventilation system is already in place and the outdoor air is proven as bad, increasing the number of air handling units could be an option, or it might be more cost-effective to consider an upgrade of filters. For example, Mitsubishi Electric offers a range of premium filter options for ventilation systems, alongside those available for air conditioning systems, as previously mentioned.

Long-term IAQ: Measurement, control and maintenance

The proposed updates for Part F require installation of sensors to monitor indoor air quality, and some guidance (for example from the BCO) goes further in terms of making IAQ a building-wide objective.

Sensors offer a number of benefits beyond simple measurement. They can also help to track times of the day or the year when IAQ changes in the building, enabling the facilities team to control ventilation and air conditioning to respond accordingly. CO_2 sensors, for example, will also help to monitor occupancy levels in a space, operating ventilation and air conditioning only when required - enhancing energy efficiency.

Maintenance of ventilation and filtration systems is vital for long-term performance. As a minimum, manufacturers guidelines should be followed. However, there is additional guidance from organisations such as the Building Engineering Services Association (BESA) and CIBSE.

CIBSE KS 17: Indoor air quality and ventilation states that: “Indoor air quality levels can be increased by regular maintenance of ventilation plant.” This should include replacement of filters at the correct intervals as well as the cleaning of coil surfaces and ducts. CIBSE also points out that keeping filters up-to-date and ducts clean will also reduce the electrical fan energy consumption.

The most effective approach to ensuring IAQ is to incorporate a Planned Preventative Maintenance (PPM) programme to ensure that the work is carried out regularly, and any potential problems with the system can be solved before they lead to breakdown. The additional benefit of a PPM approach is that system owners get the best long-term value out of their equipment.

Conclusions

Getting indoor air quality right is more important than ever before. People want to feel safe and healthy in their workplaces and homes, so getting the basics of ventilation and air conditioning right, along with the most appropriate filtration, is a fundamental first step.

Modern ventilation, filtration and air conditioning technology is available that can achieve more than simply preventing poor IAQ. Applied intelligently, it can deliver high levels of occupant productivity and satisfaction - something that more building owners will value in the changing landscape of the workplace in the 2020's and beyond.

References

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2. https://www.parliament.uk/globalassets/documents/post/postpn366_indoor_air_quality.pdf

3. https://www.euro.who.int/en/health-topics/environment-and-health/air-quality/data-and-statistics

4. **Consultation on Part F of the Building regulations for dwellings and non-dwellings. Documentation can be found at:**

   https://www.gov.uk/government/publications/building-regulations-approved-documents-l-f- and-over heating-consultation-version

5. https://www.ukgbc.org/sites/default/files/Health%2520Wellbeing%2520and%2520Productivity%2520in%2520Offices%2520-%2520The%2520next%2520chapter%2520for%2520green%2520building%2520Full%2520Report_0.pdf

   (Page 8 for comments on IAQ)

6. **Creating the Productive Workplace: Places to work creatively by Derek Clements-Croome. Chapter 8, Effects: Indoor Air Quality on decision making (Usha Satish, Piers MacNaughton, Joseph Allen) p128 Publisher Routledge; ISBN 978-1-138096334-4**

7. **BCO Wellness Matters: A summary roadmap to health and wellbeing (June 2019)**

   https://www.bco.org.uk/Research/Publications/Wellness_Matters_A_summary_roadmap_to_ health_and_wellbeing.aspx

8. **CIBSE KS 17: Indoor Air Quality and Ventilation. See section 4.1.3 for types of filters and particle diameters:**

   https://www.gov.uk/government/publications/building-regulations-approved-documents-l-f- and-over heating- consultation-version

9. **Consultation on Part F of the Building regulations for dwellings and non-dwellings. Documentation can be found at:**

   https://www.gov.uk/government/publications/building-regulations-approved-documents-l-f-and- over heating- consultation-version

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If you would like to receive invitations to future CPD events, please email **livingenvironmentalsystems@meuk.mee.com**

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Note: The fuse rating is for guidance only. Please refer to the relevant databook for detailed specification. It is the responsibility of a qualified electrician/electrical engineer to select the correct cable size and fuse rating based on current regulation and site specific conditions. Mitsubishi Electric's air conditioning equipment and heat pump systems contain a fluorinated greenhouse gas, R410A (GWP:2088), R32 (GWP:675), R407C (GWP:1774), R134a (GWP:1430), R513A (GWP:631), R454B (GWP:466), R1234ze (GWP:7) or R1234yf (GWP:4). *These GWP values are based on Regulation (EU) No 517/2014 from IPCC 4th edition. In case of Regulation (EU) No.626/2011 from IPCC 3rd edition, these are as follows. R410A (GWP:1975), R32 (GWP:550), R407C (GWP:1650) or R134a (GWP:1300).

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