An tÚdarás Sláinte agus Sábháilteachta
Health and Safety Authority

DRAFT Code of Practice for Indoor Air Quality

Safety, Health and Welfare at Work (General Application) Regulations 2007 - XXXX

Version – Draft for Public Consultation

Note: Suitable photos/graphics to be included in final version

Contents

Foreword

The Health and Safety Authority (the 'Authority'), with the consent of XX, Minister of State at the Department of Business, Enterprise and Innovation, publishes this code of practice entitled Code of Practice for Indoor Air Quality, in accordance with Section 60 of the Safety, Health and Welfare at Work Act 2005 (the '2005 Act').

This code of practice provides practical guidance as to the observance of the provisions of the Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. XX) as amended by XX. This code of practice comes into operation on XX. Notice of the publication of this code of practice was published in Iris Oifigiúil of XX.

As regards the use of codes of practice in criminal proceedings, Section 61 of the 2005 Act provides as follows:

- 61. (1) Where in proceedings for an offence under this Act relating to an alleged contravention of any requirement or prohibition imposed by or under a relevant statutory provision being a provision for which a code of practice had been published or approved by the Authority under Section 60 at the time of the alleged contravention, subsection
  (2) shall have effect with respect to that code of practice in relation to those proceedings.

- (2) (a) Where a code of practice referred to in subsection (1) appears to the court to give practical guidance as to the observance of the requirement or prohibition alleged to have been contravened; the code of practice shall be admissible in evidence.

  (b) Where it is proved that any act or omission of the defendant alleged to constitute the contravention— (i) is a failure to observe a code of practice referred to in subsection (1), or (ii) is a compliance with that code of practice, then such failure or compliance is admissible in evidence.

- (3) A document bearing the seal of the Authority and purporting to be a code of practice or part of a code of practice published or approved of by the Authority under this section shall be admissible as evidence in any proceedings under this Act.

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Secretary to the Board Health and Safety Authority

SECTION 1

1.0 Introduction

1.1 Background

Workers spend a significant amount of time indoors and the quality of air within indoor work environments has a direct impact on the health, wellbeing and productivity of those workers. Contributing factors to poor indoor air quality (IAQ) include poor external air quality, inadequate or poor ventilation and exposure to a range of chemicals, biological agents and other contaminants in the workplace air. Poor indoor air quality can cause a variety of short-term and long-term health problems.

As was evident during the COVID 19 pandemic, ventilation/ air filtration was an important factor in reducing the risk of aerosol transmission of the SARs-CoV-2 virus (virus that caused the COVID 19 disease).

The code provides a practical risk assessment approach to assist employers with making a reasonable determination of IAQ in their workplace. Parameters for CO2, air changes per hour, temperature, humidity, and ventilation rates are included to enable baseline assessments. The code addresses risk assessment competency in terms of workplace complexity and provides advice on investigating IAQ complaints.

The code differentiates between requirements under the General Application Regulations and other legislation/ codes of practice. Requirements in other legislation for chemical agents, legionella, asbestos etc. positively affect IAQ so it is important that these aspects are dealt with holistically by employers when addressing IAQ rather than in isolation.

The code also provides detailed general information on ventilation, air filtration and carbon dioxide monitors.

1.2 Scope of this Code of Practice

This code is relevant to all places of work but excludes sector specific guidance or detailed technical aspects of ventilation, which are set out in other standards. It aims to provide practical guidance on improving and managing indoor air quality in the workplace, specifically:

- to employers and employees on improving indoor air quality;
- on improving ventilation in workplaces;
- on establishing a set of acceptable values for specific chemical and physical parameters;
- describing mechanisms to identify evaluate and control these indoor air quality issues.

This code provides assistance on the observance of the requirements of the Safety, Health and Welfare at (General Application) Regulations (S.I. No. 254 of 2018) as amended by S.I. XX – hereafter the 'XX'.

In line with Section 2(6) the 2005 Act, all employer duties, for which guidance is provided in this code, should be carried out as far as is reasonably practicable.

This code does not apply to the use of hazardous substances or exposure to those substances regulated under the ***Safety, Health and Welfare at Work (Chemical Agent) Regulations 2001-2021*** and ***Safety, Health and Welfare at Work (Carcinogens) Regulations 2001-2019.*** Employers must complete separate chemical risk assessments under these Regulations.

Some substances with Occupational limit Exposure Values listed in the **Code of Practice for the Chemical Agents and Carcinogens Regulations** may be relevant for the purposes of assessing indoor air quality.

This code does not apply to the Safety, Health and Welfare at Work (Biological Agents) Regulations 2013 and 2020 (S.I. No. 572 of 2013 as amended by S.I. No. 539 of 2020) and its Code of Practice. Employers must complete separate biological agent risk assessments under these Regulations.

Compliance with the aforementioned legislation addressing chemical and biological agents in the workplace will significantly support the objectives of this code of practice.

Finally, this code **excludes** practical advice on Local Exhaust ventilation (LEV). Separate guidance on LEV is available at www.hsa.ie.

1.3 Definitions

Air changes per hour (ACH) is one measure of ventilation that estimates how many times the air in a room/space is replaced with fresh clean air per hour.

Air conditioning controls the air temperature and/or controls humidity and recirculates the air. Alone it does not provide fresh air or ventilation.

HVAC means 'Heating Ventilation and Air-Conditioning' and is often a descriptor used to mean a dedicated system that is used to control the condition of air being mechanically moved in a building or internal space

IAQ - Indoor Air Quality.

Local exhaust ventilation (LEV) - is an engineering system designed to capture contaminants (dust, mist, fume, vapour, gas) in the workplace at source and transport them to a safe emission point or to a filter/scrubber. It is not part of general ventilation. Local Exhaust ventilation will not be covered in this Code. Please refer to specific LEV guidance for employers here.

Occupational Exposure limit Value (OELV) – is defined as the limit of the time-weighted average of the concentration of a chemical agent in the air within the breathing zone of a worker in relation to a specified reference period (8 hour or a 15-minute reference period).

$PM_{2.5}$ - refers to inhalable particles that have diameter less than 2.5 micrometres (more than 100 times thinner than a human hair) and remain suspended for longer. These particles are formed as a result of burning fuel and chemical reactions that take place in the atmosphere.

PM_{10} . refers to inhalable particles, with diameters that are generally 10 micrometers and smaller.

Ventilation refers to the movement of outdoor air into a building, and the circulation of that air within the building or room while removing stale air to improve the air quality. This can be achieved through different means.

1.4 Relevant Legislation

Safety, Health and Welfare at Work 2005 Act

Employers have duties under the ***Safety, Health and Welfare at Work 2005 Act (No 10 of 2005*)** to provide a safe place of work. Under the Act, the principle of **risk assessment** is enshrined in **Section 19**. The 2005 Act provides for the provision of a hierarchy of control measures (elimination and substitution, engineering controls, administrative controls and PPE) to mitigate risks identified.

In the context of indoor air quality, **Section 8** of the Act requires employers to ensure that the workplace, articles, plant or machinery are designed, provided and maintained in a condition that is safe and without risk to health. The employer should also ensure, as far as it is reasonably practicable, the safety and the prevention of risk to health at work of employees relating to the use of any article, substance, ionising or other radiations or any other physical agent.

Section 8 requires the provision and maintenance of facilities and arrangement for the welfare of employees and requires employers to ensure the provision of information, instruction, training and supervision necessary to ensure, so far as is reasonably practicable, the safety, health, and welfare at work of employees.

In the context of indoor air quality**, Section 19** of the Act places a duty on those also in control of places of work (as defined in Section 15 of the Act). They may also have to carry out a written risk assessment to the extent that their duties may apply to persons other than their own employees. Section 15 of the Act states that this person shall ensure by virtue of any contract, tenancy etc., that the place of work and any article or substance provided for use in the place of work, are safe and without risk to health in so far as is reasonably practicable.

Employers also have a duty to co-operate under **Section 21** where a place of work is shared. Employers must co-operate in complying with and implementing the relevant health and safety statutory provisions and co-ordinate their actions in matters relating to the protection from and prevention of risks to safety, health and welfare at work for their respective employees.

Safety, Health and Welfare at Work (General Application) Regulations 2007

Regulation 6 of the ***Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007)*** require employers to make sure **sufficient fresh air** is provided in enclosed places of work. Consideration must be given to having regard to the working methods used and the physical demands placed on the employees.

Where present, mechanical ventilation systems must be maintained in good working order e.g. as part of a plant maintenance system, and operate in such a way that employees are not exposed to draughts which cause discomfort. Mechanical ventilation systems must also be cleaned regularly to avoid contamination. Regulation 6 also states that any deposit or dirt likely to create an immediate danger to the safety and health of employees by polluting the atmosphere is removed immediately.

Regulation 18 deals with general welfare requirements which impact indoor air quality. An employer must ensure every place of work is kept in a clean state and accumulations of dirt refuse, trade refuse and waste are removed by a suitable method as frequently as necessary to maintain an appropriate

level of safety and health. The floor of every workroom must be cleaned by a suitable method as frequently as necessary to maintain an appropriate level of safety and health.

1.7 References to Legislation and Standards

As legislation is always under regular review, where reference is made in this code of practice to legislation, the status of this legislation should be checked on the Attorney General's website at www.irishstatutebook.ie.

Where reference is made is a particular standard, the status of such standards can also be checked at the National Standards Authority of Ireland's website at www.nsai.ie.

SECTION 2

2.0 Indoor Air Quality (IAQ) in enclosed places of work

Indoor air quality (IAQ) is an important component of a healthy workplace as many people now spend a considerable amount of their time indoors. IAQ can thus impact on job satisfaction, worker productivity, comfort and health.

IAQ comprises the indoor environment, including the composition of the air and comfort factors such as temperature and relative humidity. IAQ depends on a range of internal and external factors. 'Good' IAQ may be considered as air with no known contaminants at harmful concentrations. To enable good IAQ, there should be:

- provision of sufficient fresh air supply rates to dilute and remove contaminants,
- effective ventilation,
- low external pollutant/contaminant concentrations and
- low pollutant/contaminant emission rates from internal sources.

IAQ issues tend not to be simple and should be properly assessed by a competent person to identify causes and solutions.

Table 1: Workplace IAQ issues and potential sources

IAQ Issues/Pollutants	Potential Sources
Inadequate ventilation (insufficient outside air, insufficient airflow, inadequate circulation)	*Energy saving and maintenance measures, incorrect system design or operation, occupant tampering with HVAC system, poor office layout, system unbalanced etc.*
Temperature and humidity extremes	*Incorrect placement of thermostats, poor humidity control, system not designed to cope with climate extremes etc.*
Combustion contaminants - (CO), NO2 polycyclic aromatic hydrocarbons (PAHs) and particulate matter (PM_{10} & $PM_{2.5}$) -	*Can be a mix of indoor and outdoor sources e.g. malfunctioning boilers, stoves, generators, gas/kerosene heaters, vehicle exhaust emissions.*
Volatile organic compounds (VOCs)	*VOCs are potentially present in paints, stains, varnishes, solvents, pesticides, adhesives, wood preservatives, waxes, polishes, cleansers, lubricants, sealants, dyes, air fresheners, fuels, plastics, copy machines, printers, tobacco products, perfumes, dry-cleaned clothing, building materials and furnishings.*
Ozone (O_3)	*O_3 can result from outdoor sources, photocopying, air purifying and disinfecting devices.*

Asbestos	*Asbestos containing materials in pre-2000 buildings will release fibres if they deteriorate or are disturbed during renovation or maintanaince activities.*
Biological mircoorganisms (Bacteria, Viruses or Moulds) and biological allergens	*Person to person infection, wet or damp materials, cooling towers, humidifiers, cooling coils or drain pans, damp duct insulation/filters, condensation, bird droppings, rodents, dustmites on carpeting/upholstery, pollen etc.*
Heavy metals - Pb, Cd, Zn, Cu, Cr, As, Ni, Hg, Mn, Fe	*Outdoor sources, fuel-consumption products, incense burning, smoking and building materials.*
Particles and fibres	*Particles and fibres in the workplace can result through the deterioration of materials, construction & renovation activities and cleaning activities such as vaccuming & housekeeping.*
Radon	*Radon is a radioactive gas that is formed naturally in the ground by the radioactive decay of uranium which is present in all rocks and soils. Radon can enter the workplace from the ground through small cracks in floors and through gaps around pipes or cables. Workplaces in some parts of the country are more likely to have a radon problem. These parts of the country are called High Radon Areas (HRAs).*
Environmental tobacco smoke & E-cigarettes	*Environmental tobacco smoke used to be a significant indoor air pollutant. Smoking has been banned under the Public Health (Tobacco) Acts in the general workplace; with some exceptions, since 2004 and this has had a significant positive impact on indoor air quality and public health. However, employers should ensure that the designation of any outdoor smoking areas at the workplace does not affect indoor air quality due to inappropriate location with the potential for entry of ETS into the indoor working environment.* *In terms of E-cigarettes (vaping), as with use of any product or substance in the workplace, employers should complete a risk assessment on the use of E-cigarettes in their workplace and establish an E-cigarettes policy.*

2.1 Impact of external air pollution on IAQ

It is important that employers are aware of the potential impact of external air pollution on their indoor air quality.

Outdoor air can be polluted with a complex mixture of both manmade and natural pollutant sources. The mixture includes primary pollutants like nitrogen oxides and primary particles, which come directly from their sources such as fuel combustion in different sectors, including transport, energy, households, industry, and from agriculture.

The ambient air quality pollutants of most concern are Nitrogen Dioxide (NO2), Particulate Matter (PM) such as PM_{10} and $PM_{2.5}$, Ozone (O_3) and Polycyclic Aromatic Hydrocarbons (PAHs).

Secondary pollutants like ozone and secondary particles are formed through chemical and physical transformations in the atmosphere. Ground level Ozone for example is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC). This happens when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources chemically react in the presence of sunlight.

External air pollution can be a major risk to health. In Ireland, the number of premature deaths attributable to air pollution is estimated at 1,300 people (*Air Quality in Europe 2020, EEA*). Both $PM_{2.5}$ and PM_{10} are capable of penetrating deep into the lungs but $PM_{2.5}$ can even enter the bloodstream, primarily resulting in cardiovascular and respiratory impacts, and also affecting other organs.

For Nitrogen Dioxide, Sulphur Dioxide, Ozone, these can irritate the airways of the lungs, increasing the symptoms of those suffering from lung diseases.

Atmospheric contaminants from external sources may impair indoor air quality following ingress to the workplace by the following means:

- **Natural ventilation**, such as through open windows and doors
- **Infiltration**, a process by which outdoor air flows enters through openings, joints and cracks in walls, floors and ceilings, and around windows and doors.
- **Mechanical means**, such as through outdoor air intakes associated with the heating, ventilation and air conditioning (HVAC) system; outdoor-vented fans that intermittently remove air from a single room, such as bathrooms and kitchens.

Air quality standards are set out in EU and Irish legislation. The Environmental Protection Agency and Local Authorities are the relevant responsible bodies nationally for environmental air quality legislation. The Environmental Protection Agency (EPA) monitors various air pollutants in Ireland to ensure Ireland meets these standards. Under the Air Pollution Act 1987, Local Authorities must take whatever measures they consider necessary to prevent or limit air pollution in their area. Emissions from industry are also regulated by Local Authorities or EPA depending on the type and size of the industrial process.

Complaints regarding environmental air pollution can be made directly to the relevant local Authority or EPA. For further details on making an environmental complaint, see https://bit.ly/3DwUoaY

2.2 Health effects associated with poor IAQ

Poor indoor air quality can cause a variety of short-term and long-term health problems. The health effects from IAQ problems can be wide-ranging and may include:

- headache,
- dizziness,
- nausea,
- fatigue,
- difficulty concentrating,
- sinus problems,
- congestion,
- irritation of the mucus membranes of the eyes/nose/throat, causing coughing/sneezing

- respiratory illnesses e.g. COVID 19, Legionnaires diease
- cancer from long term exposure to radon, asbestos etc

Factors other than indoor pollutants may also give rise to these short-term symptoms and complaints, such as poorly managed temperature, low or high relative humidity, ergonomic or lighting conditions, noise, overcrowding and work related stress.

For example, relative humidity should be kept between 40 and 60% indoors. For areas where the relative humidity is low, cases of dryness of the skin followed by itchiness are noted. In cases where the relative humidity is extremely low (under 20%), the contact with the dry air might cause drying up of the bronchial mucous which can lead to other health problems in the respiratory system e.g. asthma or allergies.

With high relative humidity, the temperature comfort in the room will cause problems such as increased growth of mold and bacteria that cause respiratory problems to arise, particularly in sensitive individuals. Therefore, it is important to note that some workers are more susceptible to poor IAQ, for example, workers with asthma, respiratory conditions or workers who are immunocompromised.

In terms of respiratory illnesses, Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. Most people who fall sick with COVID-19 will experience mild to moderate symptoms and recover without special treatment. However, some will become seriously ill and require medical attention. The virus can spread from an infected person's mouth or nose in small liquid particles when they cough, sneeze, speak, sing or breathe. These particles range from larger respiratory droplets to smaller aerosols.

Legionnaires' disease is a form of pneumonia which kills between 5 and 10% of those infected and is caused by Legionella bacteria. Legionnaires' disease is caught through breathing in air containing the Legionella bacteria in an aerosol that may not be visible. Aerosols can be formed from fine droplets generated from water containing the bacteria by, for example, running a tap or shower, flushing a toilet etc.

Sick Building Syndrome (SBS) is an imprecise term used to describe those buildings in which there is a prevalence of a range of symptoms causing discomfort and a sense of being unwell rather than a distinct illness. SBS complaints can be localized for a particular zone or room within a building. These symptoms usually disappear when the person leaves the building. SBS is a complex phenomenon, and although a number of potential contributory factors have been suggested, much of the evidence is circumstantial, and no single underlying cause has been found.

SECTION 3

3.0 Assessment and Control of IAQ

Under Section 19, of the Safety, Health and Welfare at Work Act, 2005, employers must carry out a risk assessment. A risk assessment is a systematic written process that should achieve the following:

1. Identifies the hazards in the workplace(s) under the control of the employer.
2. Assesses the risks presented by these hazards and;
3. Implements control measures to reduce the risk of these hazards causing harm.

This approach can be applied to assessing and controlling indoor air quality in the workplace. The risk assessment process is set out in **Tables 3 & 4** to identify, assess and implement control measures that will improve IAQ in the workplace.

3.1 Competence and IAQ risk assessment

Prior to carrying out a risk assessment, it is important to ensure that this is done by a competent person depending on the specific circumstances and type of workplace.

According to the Safety, Health and Welfare at Work Act 2005, a person is deemed to be a competent if that person possesses sufficient training, experience and knowledge appropriate to the nature of the work to be undertaken. Therefore, anyone involved in assessing indoor air quality must have the competency to do so.

The level of technical competency required will depend on the complexity of the workplace. For example, workplaces with multiple or complex ventilation systems in place would normally require expert technical advice. Complex measurements, sample analysis and interpretation of data may also be required depending on the specific circumstances of the workplace. S**ee Table 2 below**

Table 2

IAQ requirements depending on complexity of the workplace

Simple	For the assessment of relatively simple rooms or buildings, the following may be all that are necessary: • The absence of any obvious contaminant or uncontrolled hazard • The presence of natural ventilation from a clean source • Consultation with employees • Some local heating or cooling arrangements • Documentation of arrangements
Intermediate	For settings that are more complex, additional information will be required: • Identification of any contaminants or uncontrolled hazards • The source and content of natural ventilation • Information on performance of mechanical ventilation • Consultation with employees • Some local heating or cooling arrangements • A specification setting out the required performance of the natural or mechanical ventilation should be available • Documentation of arrangements
Complex	For the most complex settings, it is important that, where possible, a detailed written specification setting out the required performance of the natural or mechanical ventilation is available. This is to ensure that the users' objectives are met. These objectives must be clearly defined. They are not just in relation to indoor air quality for personal reasons but also may be for good manufacturing practice (GMP), food safety, infection prevention and general indoor environmental quality. In general, for complex settings, competencies from the fields of aerosol science, exposure science, ventilation engineering and /or computer modelling are often required. This is in addition to the specialist competencies of GMP and IPC and HACCP. The IAQ specification and requirements for this level of complexity are outside this current Code of Practice.

3.2 Identification of IAQ issues

An initial review of the indoor environment of the workplace should be carried out. This can be achieved by visual means, consultation and gathering appropriate information and data. Where mechanical ventilations system are not present, CO^2 monitors and a means for measuring temperature and relative humidity may be important to support the initial assessment. Table 3 will assist with this review process.

Table 3

Initial assessment of the indoor environment

Key area	What to look for (non- exhaustive)
Room or site layouts	**Identify the following:** • Areas/rooms where there is no natural ventilation or mechanical ventilation, • Areas/rooms that use mechanical ventilation if the system recirculates air and has no outdoor air supply in place. • How are canteens, toilets and changing areas currently ventilated i.e. by natural or mechanical means or combination of both?
Temperature and relative humidity	**Is there any data available on typical internal temperature and relative humidity levels?** For most people an acceptable temperature for office work lies within the range of **18 to 23ºC**. There is a legal lower limit to observe for sedentary office work under the Safety, Health and Welfare at Work General Applications legislation- **a minimum temperature of 17.5° C**, so far as is reasonably practicable, is achieved and maintained at every workstation after the first hour's work. For other sedentary work, at every workstation where a substantial proportion of the work is done sitting and does not involve serious physical effort, **a minimum temperature of 16°C** is, so far as is reasonably practicable, achieved and maintained after the first hour's work. The law also requires that means are available to enable persons at work to measure the temperature in any workplace inside a building. Optimum relative humidity levels are between **40% and 60%** relative humidity- but relative humidity levels should be kept between **30% and 70%.**

Data from CO_2 monitors	**What is the average CO_2 reading (from an appropriate CO_2 monitor) for relevant areas?** • A consistent CO_2 value below **1000ppm** is likely to indicate that an indoor space is adequately ventilated. An increase in CO_2 concentrations above 1000ppm require investigation and remedial action. • CO_2 levels consistently higher in the **1500ppm range** in an occupied room indicate poor ventilation. Concentrations above 1500ppm require immediate investigation and action. *See Section 4.1 on CO_2 monitors for detailed information*

Mechanical ventilation system (if present)	**Identify the following:**
	• Are there mechanical ventilation performance reports available?
	• Is the mechanical ventilation system being regularly maintained, cleaned and repaired, as per the manufacturer's instructions, by a trained and competent person? - Grills, vents, fans, filters and ductwork all need to be included.
	• Can physical features in the workplace, which might affect ventilation, be moved immediately?
	  ○ Is there large furniture or machinery in use which might impede cross ventilation air flow
	  ○ Are items blocking vents?
	  ○ Have trickle vents been covered over due to draughts?
	• Are filters part of your existing system? Where filters are used as part of a central ventilation system, are these the most efficient filter for the system e.g. MERV 13 to 16; ISO 16890 ePM1 rating 60-90%.
	• If filters are not part of your existing system, can they be installed? Not all systems can be retrofitted. Expert advice may be needed to ensure mechanical fans can cope with increased pressure drop.
	• Check if the ventilation system(s) are recirculating poor quality air to other poorly ventilated areas of the workplace, where workers are working?
	• Can the system be optimized to maximize air changes / fresh air intake? The amount of fresh air should be maximized. **Four to six air changes per hour** for an office space is normally recommended.
	• Ventilation rates of **10 liters per second (l/s) per person** in offices normally corresponds to indoor CO_2 concentrations below 1000 ppm. Recommended ventilation rates can vary (be higher or lower) for different settings.

	• If air recirculation systems are being used, can air filtration be increased to as high as possible without significantly diminishing design airflow/fresh air amount. HEPA filtration or the highest efficiency filter possible according to the HVAC manufacturer's specifications should be considered (MERV 13 to 16; ISO 16890 ePM1 rating 60-90%) where air is re-circulated If unsure about any of the above, contact the manufacturer or your service ventilation engineer. *See section 4.0 for further information on ventilation.*
Products, materials equipment, water systems present	**Identify the following:** • **Building materials, floor coverings and furnishings** e.g. insulation, fabrics, carpets, flooring. Many of these can release gases such as Volatile Organic Compounds (VOCs) that were trapped in the material as a result of their composition and or their manufacturing process. Newly furnished or carpeted rooms are likely to have poorer air quality if ventilation rates are not increased to address emissions. • **Equipment, tools and machines present** e.g. photocopiers and printers can release ozone; sealants or adhesives used for minor repairs can off gas. • **Water systems -** showers, cooling towers, humidifiers etc. Has a legionella risk assessment been carried out? Is circulating hot water normally at 50°C-60°C? Is cold water normally below 20°C?
Processes involving/using chemicals	**Identify the following:** • **Processes involving/using chemicals e.g. manufacturing, maintenance, or cleaning**. There must be specific chemical risk assessments for all these activities and control measures must be in place to reduce exposure to workers themselves and any others in the vicinity/nearby. • **Any process generated substances** present e.g. dust due to sweeping, construction dust, welding fume. There must be a specific risk assessments for all these activities and control measures must be in place to reduce exposure of the workers themselves and any others in the vicinity/nearby. *See further H.S.A guidance - Your Steps to Chemical Safety*

External air quality	**Identify the following:** • **Intake source (and quality) of the external air being used for ventilation. Is there available data on external air that may affect the workplace indoor air quality?** Readings between 1-6 on the EPA Air Quality Index (for Ozone, Nitrogen Dioxide, Sulphur Dioxide, PM2.5, PM10) would indicate good to fair external air quality. Readings of 7 to 10 on the Air Quality Index (for Ozone, Nitrogen Dioxide, Sulphur Dioxide, PM2.5, and PM10) would indicate poor external air quality. Unless the workplace is very close to a monitoring station, data from the Air Quality Index should be considered indicative only. • **Is there any adjacent industrial processes/ activities affecting indoor air quality?** Odors, fume, dust or vapors from adjoining buildings or activities can affect indoor air quality. These can vary depending on the nature of the business and resulting emissions.
Occupancy levels	**Identify the following:** • Quantify normal occupancy levels in relevant workspaces. In offices, 4.65 square metres should be the minimum amount of floor space allowed for every person employed in any room, including the area occupied by the office desk and chair but excluding filing cabinets and other office furniture. At least 11.3 cubic metres should be provided for each person at work in a room (other than an office) at any one time. When calculating the volume, no space more than 4.3 metres from the floor should be taken into account.
Level of activity within the enclosed place of work	**Identify the following**: • Normal work activities in each relevant workspace. • Type and frequency of maintenance, repair and cleaning activities.
Consulting with employees / safety representatives	**Identify the following:** • Areas that feel stuffy or smell bad.

	• Any complaints or health issues reported.
Radon	**Identify the following:** • Are occupied work areas at ground and basement level located in a High Radon Area - visit www.radon.ie and check the Workplace Radon Risk Map for Ireland.
Asbestos	**Identify the following:** • Is there an asbestos survey and register available (for pre-2000 building)? A **management asbestos survey and register** will form part of an employer's Asbestos Management Plan (AMP) and enable asbestos-containing materials (ACMs) to be managed correctly during normal occupation and use of premises. For further details on identification and management of ACMs, refer to H.S.A's **Practical guidelines on ACM management and abatement** at www.hsa.ie

3.3 Assessment and implementing control measures for IAQ

The information and data collected based on Table 3 will now assist with making a general assessment of the existing IAQ conditions within the workplace. This will enable an IAQ action plan to be developed to address any IAQ issues in the short, medium and long term.

Table 4
Assessment and implementing controls to improve IAQ

	Outcome from Initial review (Table 3) – non exhaustive	Further Action / Control measures to be implemented
Natural Ventilation (no mechanical ventilation present)	All occupied areas have good natural ventilation and **CO_2 levels are well below 1000ppm**. No IAQ complaints from employees	**No further action** but CO_2 levels should be monitored.
	Occupied areas identified with little or no natural ventilation or an air conditioning system is present (recirculates unfiltered air only). CO_2 reading **above 1000ppm but below 1500ppm**. Employees may also have reported symptoms or made an IAQ complaint.	**Take action** to increase the amount of fresh air in the room e.g. opening windows for longer periods, installing vents to reduce CO_2 levels below 1000ppm. Consider air conditioning air cleaning unit with HEPA filtration to reduce air borne contaminants from being re-circulated. If feasible, consider installing mechanical ventilation in the medium to longer term.
	Occupied area with poor natural ventilation and CO2 levels above 1500ppm. Employees will most likely have reported symptoms or made a complaint about the IAQ.	**Take immediate action** to increase fresh air levels e.g. opening windows for longer periods, installing vents etc. If high CO_2 levels are persistent, occupancy levels may need to be reviewed and installation of a mechanical ventilation system should be considered in the short to medium term. As an interim measure, an air filtration system should be installed to address any risks from other airborne contaminants. Note - CO2 will not be reduced by air filtration systems – *see section 4.2 on air filtration systems*

	Natural ventilation present but complaints from employees of symptoms, odours etc. CO_2 levels below 1000 and temperature and humidity levels within acceptable parameters.	**Carry out investigation** to determine source giving rise to IAQ complaints. Specialist expertise may be required in identifying sources. *See Section 3.6 - Investigation of IAQ complaints*.
Ventilation (Mechanical)	Mechanical ventilation system (MVS) is being maintained, cleaned and serviced and **is operating correctly** i.e. correct ventilation rates for the occupied areas and providing appropriate air changes per hour. No IAQ complaints received from employees.	**No further action.** Ensure MVS is serviced by a competent person and kept in effective working order. See section 3.5 on training, instruction and information.
	An assessment of the MVS by a competent person has identified issues with the MVS e.g. poor performance, incorrect operation, noise, damage/deterioration, incorrect ventilation rates or air changes per hour, incorrect filters or overdue filter replacement, faulty controls, Intermittent airflow.	**Take action** to ensure that the MVS is repaired /cleaned/ optimised by a competent person to ensure it is working correctly and providing appropriate filtration, ventilation rates and air changes per hour.
Temperature and relative humidity	All temperature and relative humidity levels are within range.	**No further action** – keep under review.
	No data available for temperature and relative humidity.	**Take Action** – A means to obtain temperature measurements should be put in place. Humidity levels should be monitored especially if IAQ complaints are received.
External Air quality	No external air quality issues identified	**No further action** – keep under review.
	External air quality identified as poor	**Take action** - Address through suitable ventilation management until external air quality improves
	Workplace air quality is being impacted by poor environmental air quality e.g. odour or other industrial process from a nearby location.	**Take action** - Follow the environmental complaint resolution advice on the EPA website to resolve the issue. This may involve making direct contact with the other

		company/ person or the Local Authority/EPA depending on the source and type of location causing the air quality issue.
	Complaints of environmental tobacco smoke entering workplace	**Take action** - If the source is another workplace, a complaint can be made to the local HSE Environmental officer or Health and Safety Authority Contact Center.
	External building works planned e.g. use of paint coating to seal a flat roof.	**Take action** - Any external works that may affect internal air quality need to be planned correctly, fully risk assessed and managed to mitigate cross contamination of indoor environment.
Exposure to chemicals, process generated substances or biological agents	Work activities identified which involve the use of hazardous chemical substances and/or processes generating substances.	**Take action** - Any work activities involving the use of hazardous substances must have a specific chemical agent risk assessment completed. The application of specific ventilation and at source capture techniques such as local exhaust ventilation may be required for some activities.
	No significant use or exposure identified to hazardous substances except for the use of routine cleaning products.	**Take action** - A specific chemical risk assessment for any cleaning activities should be carried out.
	Potential for contracted third parties to use hazardous substances during renovations / maintenance activities identified.	**Take action** - Ensure all contracted third parties have completed relevant site and task specific chemical/dust risk assessments and their method statements have fully addressed mitigation and control of potential impacts on indoor air quality. For further information on chemical risk assessments – see https://bit.ly/3f8kzuA
Radon	Workplace located in a High Radon Area after checking EPA Workplace Radon Risk Map.	**Take action –** For further details on radon, testing and remedial options- see www.radon.ie

	Workplace is not located in a High Radon Area after checking EPA map.	**No further action** but it is recommended to carry out a radon test of the ground and basement areas of the workplace.
Asbestos (for pre-2000 buildings)	An asbestos survey and register is available and a recent check on the condition of the asbestos containing materials (ACMs) was carried out by a competent person in accordance with the asbestos management plan.	**No further action** but a further condition check should be scheduled in accordance with the asbestos management plan. A competent specialist contractor should remove ACMs prior to any refurbishment, maintenance or demolition activities.
	An asbestos survey and register is available but no condition check has been completed of ACMs.	**Take action -** Arrange to have a condition check of the ACMs carried out by a competent person and update the asbestos register. Implement an asbestos management plan
	No asbestos survey available.	**Take action -** A competent person should carry out an asbestos management survey. The survey and register should be maintained.
	All asbestos containing materials have been removed.	**No further action.** For further information - see H.S.A **Practical guidelines on ACM management and abatement** at www.hsa.ie
Legionella	A legionella risk assessment has been completed for relevant water systems and all controls/ parameters are acceptable e.g. suitable hot and cold-water temperatures, showers regularly purged and showerheads cleaned/disinfected, no pipe dead legs or stagnant water etc.	**No further action** required but keep parameters and controls under review e.g. water temperatures
	No risk assessment for legionella has been completed and there are potential water systems at risk.	**Take action -** A competent person should carry out a legionella risk assessment.

		For further information on control of legionella – see H.S.A guidance here

Short, medium and longer-term actions to improve IAQ should be documented following the risk assessment process.

It will also be important to carry out a reassessment if there are any significant modifications made to the workplace, which may affect ventilation.

3.4 Enhanced IAQ measures for COVID 19

An employer should review existing IAQ control measures if circumstances change e.g. workplace outbreak/ increased levels of COVID 19 in the community.

Enhanced IAQ control measures may include:

- Increasing ventilation rates/ air changes per hour to enhance dilution and fresh air intake.
- If relying on natural ventilation alone, air rooms between uses or regularly throughout the day i.e. opening windows and doors to maximise ventilation.
- Maintaining CO_2 concentration levels below 1000ppm, insofar as is practicable. Note - in the context of SARS-CoV-2 transmission, CO2 measurements are not a reliable proxy of risk to airborne exposure to the virus so adherence to other public health measures are critical.
- Increase or introduce appropriate air filtration systems.
- Disable unfiltered recirculating air e.g. Air conditioning units.
- Keeping toilet/rest/changing room extractor fans functional and running.
- Extending the hours of mechanical ventilation system - when the workplace is unoccupied it can be run at lowest setting, or at least for extended periods before and after use/occupancy such as activating it two hours before the building is occupied and two hours after the building has emptied. This ensures that occupied areas are well ventilated before occupancy each day.
- Demand controlled mechanical ventilation are set to only circulate air when a certain threshold is passed, usually the amount of CO_2 build-up in the room, or the ambient room temperature. Disable if possible if it is not possible to bypass this system, then set the threshold to the lowest possible setting (e.g. 400ppm or less of CO_2) so that the system remains ventilating at a nominal speed.
- Communication of enhanced control measures to all employees to ensure that the enhanced measures are implemented and maintained for the required intervention period.

In addition to enhanced ventilation management, any additional public health measures for COVID 19 as set out by Government must be followed.

Enhanced measures may also be required if there is an external event such as a significant local fire. This may involve increased filtration of intake air or increased use of air filtration systems until the external air reverts to normal.

3.5 Information, training, instruction and supervision

The results of the risk assessment must be made available to all employees and any others likely to be affected.

All the control measures must be communicated so employees and others know what to do to implement these measures to maintain good IAQ. Training is necessary in relation to the correct operation of ventilation systems.

Training is also required for any servicing, cleaning or maintenance of ventilation systems or air purification systems. This would be the responsibility of the service provider unless in-house technical competence is available.

Supervision is required to ensure that the control measures are being used correctly e.g. open windows, staff do not adjust settings unnecessarily.

3.6 Investigation of IAQ complaints

An employer should establish a complaints procedure to promptly investigate any IAQ concerns from employees. An employers' existing complaints procedure for addressing health and safety concerns should be sufficient to address common IAQ complaints.

A complaints procedure should include a process for receiving an IAQ complaint and record the nature of the complaint, its occurrence and any reported signs and symptoms from employee(s). The procedure should set out the approach to investigating an IAQ concern. One of the first steps in this procedure should be to try to identify the source, which may be obvious such as new equipment, busier carpark etc.

However, for cases that are more complex and depending on the IAQ issues involved, it may be necessary to obtain specialist expertise e.g. occupational hygienist, environmental scientist, and aerosol scientist. Only some cases require air sampling and analysis as part of an investigation and this must be done in conformance with recognised measurement, analytical and reporting standards.

For example, if sampling air for presence of formaldehyde, 10% of the occupational exposure limit value (OELV) for formaldehyde as set out in the Code of Practice for the Chemical Agents and Carcinogens Regulations can be used. There are many other substances with OELVs available in the code that are relevant to IAQ. However, the OELVs concern occupational exposures where people are explicitly working with the substance so applying a 10% (OELV) value for non-occupational IAQ purposes would be appropriate.

Other standards for pollutants such as those regulated under S.I. Air Quality Standards Regulations (S.I. 180 of 2011) or in the updated WHO annual Air Quality Guidance are useful when assessing IAQ or investigating IAQ complaints.

Air sampling and analysis reports should conform to accepted best practice – see H.S.A guidance on Occupational Hygiene report writing.

IAQ investigations can present challenges. For example, it is not possible to draw any health-related conclusions about an odour merely by perceiving it. Even if a human perceives a smell as being, very strong it can still be lower than the analytical detection limit for that specific substance.

A comprehensive procedure for the investigation of the indoor working environment is available in a Report by the German Social Accident Insurance entitled "Indoor workplaces – Recommended procedure for the investigation of working environment".

SECTION 4

4.0 Ventilation

Ventilation is a critical method of removing contaminants from buildings, and is essential to ensuring good indoor air quality as well as thermal comfort. Ventilation refers to the movement of outdoor air into a building and the circulation of that air within the building (or room) while removing stale air to improve the air quality.

Buildings can be ventilated in three different ways:

- they can be naturally ventilated with outside air
- they can be fully closed, with no user controlled openings, and ventilated mechanically, or
- they can use a combination of the two approaches.

Natural ventilation uses the natural driving forces of wind (wind effect) and temperature differences within the building (the stack effect or hot air rising) to drive airflow through the building on a daily or even hourly basis. The outside environment influences natural ventilation performance.

Mechanical ventilation uses fans, ducts and control systems to drive the ventilation process, and is generally independent of the outside environment in typical weather conditions.

The quantity of ventilation required depends on a number of factors, including the fresh air required for the number of people expected to be in the space, what they will be doing, how they are expected to dress, the types of local heat sources such as lighting, small appliances and computers, any sources of pollutants in the space, such as copiers, and sources of humidity such as catering equipment.

It is important to ensure air intakes are not sited in contaminated areas or near where contaminated discharged air is exhausted. Likewise, ensure discharge exhaust air is kept away from doors, windows and other air inlets.

There is no ‘one size fits all’ when it comes to ventilation. It is critical that competent advice is sought prior to modifying or installing a ventilation system.

A detailed description of ventilation types and components are described in Table 5 below.

Table 5

Ventilation Systems and Components

Type of Ventilation or component	Description	Considerations
Natural Ventilation	**Natural Ventilation** is the way that outside air is brought into a building via passive flow, without using fans or other mechanical means. This includes airflow through openings in the building such as • partial or complete window opening, • partial or complete external door openings, • roof turrets • Trickle vents e.g. Small slot/opening in a window or building envelope component, that allows small amounts of ventilation (trickle ventilation) through a window and/or door when it is closed • Other vents • Unplanned openings i.e. **infiltration**, the process by which outdoor air flows into the building through openings, joints and cracks in walls, floors and ceilings, and around windows and doors.	Natural ventilation usually relies on individual behaviour to open windows and vents, which can present issues with winter thermal comfort, uncontrolled energy use, noise, pollution intrusion and security. Automatic controls are especially useful as they can feature smart technology able to recognise weather patterns, fire alarms thus opening or closing windows or vents as necessary. Where there are issues with outside air, consideration must be given to air filtration or air cleaning systems.
Mechanical ventilation	**Mechanical ventilation** employs mechanical or powered means such as fans to transfer air into and/or out of an area. In smaller indoor spaces, these may be in the room e.g. outdoor-vented fans intermittently remove air from toilets or kitchens. Larger buildings may employ a network of inlet grilles, ducts and fans (air distribution equipment) to bring outside air into rooms and/or	Consideration must be given to the source of outside air. Depending on the source of outside air, it may need to be filtered or cleaned before it enters the building.

	another set of fans, ducts and grilles to extract the stale air. If a mechanical ventilation system only recirculates air and has no outdoor air supply, the area is likely to be poorly ventilated. Air conditioning is not mechanical ventilation.	Where present, mechanical ventilation systems must be maintained in good working order e.g. as part of a plant maintenance system, and operate in such a way that employees are not exposed to draughts which cause discomfort. Mechanical ventilation systems must also be cleaned regularly to avoid contamination. These arrangements must be documented and records kept. Where wet cooling systems exist e.g. cooling tower, arrangements must be in place to control *Legionella spp*. See Legionella control in water cooling towers
Supply ventilation	**Supply ventilation** works by pressurising the building, forcing external air inside via a fan. Air will then escape via cracks in the building, doors and windows, or purpose-built ducts and vents.	Depending on the source of outside air, it may need to be filtered or cleaned before it enters the building For the system to provide adequate outside air, it is essential that these external grilles are kept free from blockages. Incoming air can be located in diffusers in the ceiling, on the wall or on the floor.

		If not correctly installed, they can also cause excessive moisture in colder temperatures.
Exhaust ventilation	**Exhaust ventilation** systems operate by depressurising the building, reducing the inside air pressure so it is below outdoor air pressure. The stale air is sucked out via the exhaust mechanism and through a ducting system outside. It's then replaced by fresh air from a different source, usually another air vent.	They are most commonly found within the toilets, kitchens, or utility room to ensure a build-up of steam and humidity does not become too prevalent. It is most effective to position them in localised spaces near to where steam builds up, although larger rooms may require additional systems. Extract grilles or exhausts must be positioned to prevent extracted air re-entering the building.
Spot Ventilation	**Spot Ventilation** involves having local exhaust fans, the same as those used in the bathrooms or kitchens. It removes the moisture and inside air pollution at its source, and as a result, it improves the usefulness of the ventilation system.	
Supply and extract ventilation	**Supply and extract ventilation** has one series of ducts and inlet grilles delivering outside air into a space, while another set of ducts extracts stale air from the space and exhausts it to the outside..	*There are a number of different systems that use this method.* The grilles that deliver the incoming air can be located in diffusers in the ceiling, on the wall or on the floor.

		For the system to provide adequate outside air, it is essential that these grilles are kept free from blockages. Depending on the source of outside air, it may need to be filtered or cleaned before it enters the building
Balanced Ventilation	**Balanced Ventilation** Designs can be implemented that neither pressurise nor depressurise the building. They supply and extract the same level of air by positioning at least two fans and two duct systems in the most effective positions around the room.	
Smoke ventilation	**Smoke ventilation** helps in the removal of thick, condensed smoke in event of a fire.	It is outside the scope of this COP.
Mixed Mode Ventilation	**Mixed Mode Ventilation** is a hybrid approach. The requirement for sufficient fresh air in enclosed places of work is achieved through a combination of natural and mechanical ventilation. Mechanical ventilation may rely on natural ventilation to maximise fresh air. Mechanical ventilation may be the primary means of delivering outside air into the room year-round. Openable (manual or automatic) windows provide the additional benefit of allowing more outside air in to help cooling during the summer or to purge the room, for example from a smell caused by a spillage.	Recirculation of untreated air should be avoided
Heating, ventilation and air conditioning systems (HVAC)	**Heating, ventilation and air conditioning systems (HVAC)** are a combination of both mechanical ventilation and air conditioning. Air conditioning heats or cools the air or controls humidity and just recirculates the air.	Recirculation of untreated air should be avoided. Air conditioning alone does not provide fresh air or ventilation.

Mechanical ventilation with heat recovery (MVHR)	**Mechanical ventilation with heat recovery (MVHR)** is a controlled way of ventilation to minimize waste energy using a heat exchanger. It transfers heat from the warm exhaust air to the cold supply air. In this way, the cost of heating ventilated incoming air is reduced. If the air temperature inside the building is colder than the outside air, the exhaust air receives the heat from warmer fresh air and cools it down, reducing the cooling price.	There are requirements for airtightness of the buildings where MVHR systems are used. Mechanical ventilation with heat recovery (MVHR), heat recovery ventilation (HRV) or Comfort ventilation are all names for the same thing
Air Circulation -	**Air Circulation** - The ventilation system is not only about introducing fresh clean air into a space. The pattern of circulation of air / airflow direction within the space is equally important.	If airflow paths and circulation is not good, the air is not well mixed and there can be zones inside a room with a higher concentration of contaminants. This can happen if intake and extract grills are too close together at roof level. In high ceiling rooms, where intake and extract are both at high levels at opposites sides of the room, stratification can occur resulting in very clean air at high levels (above breathing zones). Avoid airflow directed onto individuals or across groups of individuals.
Directional airflow	**Directional airflow** is a protective ventilation concept where air movement flows in a clean-to-less-clean direction. The creation of directional airflow can be accomplished within a particular space or between two adjacent spaces.	Directional airflows must be evaluated carefully. Testing of the directional airflow effectiveness can be accomplished using

	This can be done passively, through intentional placement of supply and exhaust heating, ventilation, and air conditioning (HVAC) grilles, or by the intentional creation of pressure differentials between adjacent spaces through specification of offset exhaust and supply airflow rates. Creation of the directional airflow can also be done actively, through the use of fans exhausting through open windows, strategic placement of ductwork attached to portable HEPA filtration units, or dedicated exhaust systems (installed or portable) that generate a desired airflow by exhausting air out of windows, doorways, or through temporary ducts.	visual tracer techniques that use "smoke tubes" or handheld "fog generators." Other tools, such electronic monitors or visual aids to monitor pressure differences can be used when directional airflow is established between two adjacent spaces. To reduce the potential for directing airflow from infectious towards non-infectious space occupants, it is important that the "clean" and "less-clean" space determinations be established using infection control risk assessment considerations. Where Sanitary facilities and workrooms have an intervening ventilated space, the space should be air intake with exhausts located in the cubicle area. .
Fans	**Fans** alone are not ventilation systems. Ceiling mounted, desk and portable fans do not provide fresh air and can mask poor ventilation issues.	Fans can be difficult to keep clean, and could increase the duration of suspended particles by creating air currents in confined spaces. Such fans merely recirculate air in a room if there is no source of fresh air. Therefore, a fresh air supply, should be provided when using a fan.

		When used, fans should be directed to exhaust directly to the exterior environment (e.g. open window), to minimise potential spread of contaminants. Fans should ideally only be used where there is a single occupant in a room.
Filters	**Filters** in ventilation systems have a variety of functions: • keep the ventilation system clean in order to protect the mechanics of the ventilation system • collect and filter external pollutants • collect and filter internal pollutants. In order for your ventilation system to work correctly and effectively, maintaining good indoor air quality and energy efficiency, the correct filters must be used as per the manufacturer's specifications and air filters should be properly sized and within the recommended service life	It is important that the filters are changed regularly and are checked more frequently. If the premises is located near a busy road or other source of pollution, it may be necessary to change the filters more often. Consideration should be given to installing the most efficient filter for the system (HEPA, MERV 13 to 16; ISO 16890 ePM1 rating 60-90%) (not all systems will be able to cope with a HEPA filter without significantly diminishing design airflow/fresh air amount). This will be determined by the ventilation system manufacturer's specifications.

Ventilation arrangements or planned changes to ventilation need to also consider, in addition to health and safety regulations, the regulatory requirements under building and food legislation along with other consequences such as comfort, cost, energy use, noise and security. These considerations can all be documented in the risk assessment.

A combination of natural ventilation, mechanical ventilation and air conditioning can work very well. Natural ventilation can be used when it is feasible or desirable, thereby reducing the energy costs of the mechanical ventilation and air conditioning. The HVAC system can be used when and where it is necessary.

Further resources on ventilation can be found in Section 5.

4.1 Carbon Dioxide Monitors

CO_2 measurements form the basis of building ventilation standards in many countries. Indoor measurements and comparisons with outdoor air concentrations (approximately 400-480 ppm) are often used as an indicator of ventilation indoors. Carbon Dioxide (CO_2) monitors can be useful way of checking for poorly ventilated areas where people work. People exhale CO_2 so if there is a build-up of CO_2 in an area it can indicate that ventilation needs improving.

CO_2 monitors can assist with initial risk assessment of workplace areas that are usually occupied and poorly ventilated. Monitoring is also likely to be beneficial in raising a person's awareness of ventilation requirements and is used to inform individual behaviour in improving ventilation.

The amount of CO_2 in the air is measured in parts per million (ppm). A consistent CO_2 value below 1000ppm is likely to indicate that an indoor space is adequately ventilated. CO_2 levels consistently higher than 1500ppm in an occupied room indicate poor ventilation and action should be taken well before this upper threshold level is reached.

CO_2 monitors should:

- Be CE marked.
- Be based on non-dispersive infrared (NDIR) technology (The most appropriate portable devices to use in the workplace are non-dispersive infrared (NDIR) CO_2 monitors.) *'Equivalent CO_2' sensors or monitors that estimate concentrations based on measurements of other indoor pollutants are not recommended.*
- Have a measurement range up to at least 2,000 ppm.
- Be used in accordance with the manufacturer's instructions. (It is important to follow the manufacturer's instructions to understand how to use your monitor correctly).
- Be calibrated - It is important to follow the manufacturer's instructions to understand how to calibrate the monitor.

Like any other indoor air pollutant, some precautions need to be observed when making and interpreting measurements of indoor CO_2 concentrations.

Some of the key points in relation to measuring CO_2 concentrations indoors are provided below:

- Human exhaled breath contains high concentrations of CO_2 (approximately 40,000 ppm) and CO_2 measurements should therefore be made at least 0.5 metres away from people e.g., not placed on an employee's desk for example.
- Similarly, as outdoor air contains approximately 400 - 480 ppm of CO_2, indoor measurements should not be made near windows or ventilation grilles. If practical, CO_2 monitors should be placed in the centre of the room at head height (1.5 m). Keep them away from windows, doors, air supply openings and heaters
- Try out several locations to find the most representative position for the monitor in the space. In larger spaces, more than one sampling location will usually be required.
- Single or 'snapshot' readings can be misleading. Measurements should be made over a minimum of 1 hour, to allow the readings to reach a steady state and to collect a representative sample of data. Short term/spot measurements are unreliable and should not be used to interpret ventilation performance.
- Take several measurements throughout the day, when the room is occupied, to represent changes in activities, the number of people using it and ventilation rates.
- As weather changes you may need to repeat monitoring due to differences in ventilation, for example from opening windows and doors. Measurements taken over several days or weeks can enable occupants to become familiar with the impact of activities, occupancy levels and outdoor weather conditions on ventilation. Such detailed investigations could be used to inform a strategy for improved ventilation.
- Record CO_2 readings, number of occupants and the type of ventilation being used at the time.
- It is recommended to check the CO_2 readings (i.e. the sensor response) weekly by measuring the CO_2 concentration outdoors, where recorded values should be approximately between 400 and 480 ppm.
- Portable CO_2 monitors capable of working from both battery and mains electricity can facilitate measurements in a wider range of locations and allow the user to periodically check the response of the sensor in outdoor fresh air.
- If the ventilation is controlled by the occupant (for example opening windows in naturally ventilated rooms), CO_2 sensors may provide a useful visual or audible alert to occupants to warn against poor ventilation. They could be used as "traffic-light style" indicators of indoor air quality. REHVA recommend setting CO_2 sensors to 'warn' as concentrations rise between 800 pm and 1000 ppm and to 'alarm' when concentrations approach and exceed 1000 ppm.

CO_2 monitors will only be effective in certain workspaces. They are less effective / of limited use in work areas:

- used by few people e.g. areas with not many people in them or large offices with one or two occupants).
- such as in large workspaces i.e. large, open spaces with higher ceilings such as production halls or warehouses, where you cannot be sure the air is fully mixed and CO_2 monitors may be less representative.
- where there are other CO_2 sources other than people, such as fuel combustion (fires and stoves), cooking, baking, brewing or dispensing carbonated drinks.

- that rely on air cleaning units, which remove contaminants (such as SARs-CoV-2) from the air but do not remove CO_2.

4.2 Air cleaning and filtration units /Other Equipment and Systems

Local air cleaning or air purification systems removes certain pollutants from the indoor air. Local air cleaning is not a substitute for good ventilation. It may be beneficial in reducing risks in some spaces, particularly where it is not possible to increase ventilation using natural or mechanical means as set out above. Priority should be given to any areas identified as poorly ventilated for improvement in other ways before using an air-cleaning device.
These devices are usually stand-alone and can be deployed in any space or installed in a manner similar to a local air conditioning unit. While these devices can increase the airflow, their effectiveness will depend on the volume of the room/area and the flow rate through the device and location. Two smaller devices at different locations may be more effective than one large device.

Therefore, it is important that if considering this as an option the device should be of a suitable specification for the relevant area. Their introduction and use in the workplace should be done as part of an overall assessment of the existing ventilation systems in place to show that their use is necessary. There are also drawbacks in using these devices and these impacts need to be risk assessed before using them. In addition, operators need to be trained to use them correctly. They should not be placed beside windows or barriers.

The most suitable types to use with particulate contaminants are those with high efficiency particulate air (HEPA) filter.

When comparing devices, check that the performance ratings are comparable e.g. do they specify a decay rate e.g. cleaning room after occupancy or a rate for continuous occupancy of the space. Where noise is a potential issue, running the device at less than full power can reduce noise. However, additional devices may then be required.

UVGI (ultraviolet germicidal irradiation) is the use of ultraviolet (UV) energy to kill viral, bacterial, and fungal organisms. UVGI fixtures produce UV-C energy, which has shorter wavelengths than more penetrating UV-A and UV-B rays and pose less risk to human health. They are typically installed near a room ceiling (upper-room UVGI) or inside the HVAC system of a building. Fixtures must be installed to prevent direct UV exposures to people in the room. The airflow rate is crucial for in-duct UVGI as if the airflow is too fast past the device, the air will not be disinfected. The specification and installation of these systems is a specialist job.

Other devices such as ozone generating devices and air disinfection devices may present additional physical or chemical related hazards in the workplace and their use should be fully justified by an appropriate risk assessment. They tend to be best suited to more specialist and settings applications e.g. healthcare sterilisation and require competent advice from qualified personnel prior to their installation. It is not recommended to use these devices in occupied spaces. Contamination builds up when they are not in use.

Where any of these systems have been introduced, emergency plans must be reviewed and updated if required. In addition, a documented cleaning, servicing and maintenance regime is required e.g., filter change. All these activities must be risk assessed and training carried out.

4.3 Other IAQ Considerations

Ventilation or filtration to improve IAQ cannot be looked at in isolation. A holistic, multifaceted approach is required. There are other legislative, economic and environmental aspects to consider.

4.3.1 Designing out IAQ issues

A well-designed building begins with consideration of building orientation and intelligent facade design to minimize heating and cooling loads. The location of the building also plays a role in the choice of ventilation e.g. building near motorway usually requires air cleaning. Choice of construction materials (low VOC emissions) and arrangements for natural ventilation (e.g. openable windows), mechanical ventilation (e.g. location of intakes), air filtration, good air circulation e.g. high ceilings, relative location of intake and extracts in room are far more cost effective if implemented at the design stage. Computer modelling can be useful for complex designs or specialist facilities.

Designing out is part of initial building design but can also be incorporated into retrofit and refurbishment projects.

All the fixture and fittings that are present in the workplace can play a role in IAQ. The paint on the walls, the flooring, the furniture and many other items could be sources of chemicals known as Volatile Organic Compounds (VOCs). These are released from plastics, adhesives and sealants. Wood composite products can have formaldehyde and VOCs emissions. Water based paints can have added biocides.

When painting, the room should be ventilated and left to dry and off gas. The Safety Data Sheets must be consulted and a risk assessment completed. The risk assessment should take account of the risk to the painter and the room occupants.

Look out for labels such as “low VOC” or “no added formaldehyde” on products. Check if the products have been independently tested to back up these claims. The use of no-emission, or as low as possible emission equipment and products helps improve indoor air quality

Regular cleaning can help improve IAQ when it is done right. Sweeping and dusting can re-suspend dirt and dust. Vacuuming can reduce this when suitable filters are installed to prevent release back into the air.

Environmentally friendly cleaning products are often purchased due to their perceived health benefits. People assume “no risk” as they are environmentally friendly products. However, labelling can be confusing.-“Natural ingredients” can still cause allergic contact dermatitis as well as respiratory

irritation. The form of the cleaner also plays a role e.g. a cream cleaner probably releases less airborne contaminants than a spray.

The Safety Data Sheet for cleaning chemicals must be consulted and a risk assessment completed. Ideally cleaning products must have an adequate cleaning performance and be both environmentally friendly and healthy for the user.

4.3.2 Energy efficiency and IAQ

EU directives on the energy performance of buildings and energy efficiency (Directive 2010/31/EU, 2012/27/EU, (EU) 2018/844) specifically reference the issue of a healthy indoor climate including indoor air quality.

Energy performance upgrades of existing buildings should contribute to achieving a healthy indoor environment.