

Reoccupation of buildings following the COVID-19 outbreak

Construction and Building Services Division Institution of Mechanical Engineers

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DISCLAIMER

The Board of the Construction and Building Services Division have drawn together a group of members from across the Institution of Mechanical Engineers (IMechE) to form a COVID-19 taskforce to discuss engineering issues around combating the coronavirus outbreak in the built environment and the re-opening of buildings after a long lockdown.

Key issues for engineers will be the way in which building services and their use are modified to reduce the surface and airborne spread of the virus, as well as ensuring that building services systems and equipment can be restarted safely and comply with relevant codes of practice and legal requirements. The document which follows discusses these issues and references other sources that are of value in guiding professionals to make those assessments in their individual situations. We welcome any feedback on its content, and indeed any omissions, via ge@imeche.org.

INTRODUCTION

The CBSD – Construction and Building Services Division (CBSD) – is a member-led industry sector Division of the Institution of Mechanical Engineers, which covers the interests of members involved in the Construction industry and works for the benefit of the public and society at large.

With regard to the outbreak of COVID-19, the CBSD has formed a special task force as a Technical Advisory Committee (TAC) which reports to the CBSD Board. The TAC members have developed guidance to support the safe, secure and healthy return to normality.

The TAC has also formed liaisons with other organisations to share and discuss options and solutions in an effort to make positive progress as quickly as possible. This liaison is ongoing.

The UK has been and still is in 'lockdown' mode due to the COVID-19 outbreak. This lockdown is causing a great deal of stress and concern and is preventing people from going about their everyday business. It is also costing a great deal of resources and doing much harm to the UK and other economies. There is an urgent need to end the lockdown and this will require the application of measures into buildings which will reduce the risks from COVID-19 and allow earliest reoccupation. These measures are referred to as Infection Control Engineering.

Members have asked for information on the relevant procedures to take in order to restart mechanical, electrical and public health systems when buildings and their engineering systems are reoccupied after the enforced shutdown imposed by the government during the COVID-19 outbreak. They also require guidance on the types of measures and technologies which will reduce risk of COVID-19 infections and the concerns that a 'second wave' of COVID-19 might break out if we simply 'go back to normal'.

PURPOSE

The proposed guidance contains information to support IMechE members – and others – to understand the issues which must be addressed before buildings can be reoccupied once the COVID-19 pandemic is over. This includes restoration of existing systems to safe, working order and the installation of any equipment which will reduce the risks of COVID-19 if an infected person were to enter the building, noting that there would also be a requirement for effective management of such a situation.

DEFINITIONS

Infection control engineer

An infection control engineer is a mechanical engineer who is qualified and has experience in ventilation and other measures for safe and healthy premises.

Air borne infection

Any situation where harmful particulates, pathogens, droplets or gases could be transmitted for all or part of their journey through the air and cause health issues.

SCOPE

There is a great deal of information focused on Healthcare facilities being published by the UK government and its agencies including the NHS and Public Health England (PHE) concerning the COVID-19 outbreak (see references below). There is no specific information published by these bodies which is directed at the potential measures to reduce the risk of COVID-19 transmissions using engineering

applications after reoccupation of buildings which will have been locked down for long periods – predicted to be in excess of 12 weeks.

Such long term closures are rare. Due to the COVID-19 outbreak many buildings will have been forcibly shut down or mothballed and for a range of reasons remain closed for an extended period.

Depending on the level of attention taken to attending the building during the shutdown period, it will be necessary to clean, repair/maintain, check and possibly recommission all of the engineering systems serving the building. Failure to undertake this in a systematic way could result in health and wellbeing problems for returning occupants. Leaving systems idle for such a long period allows time for harmful agents to build up and an attempt to restart by simply switching back on could lead to “sick building syndrome” issues.

This guidance will highlight the approach to take and will direct members to relevant information such as codes of practice and standards published by the HSE, MCHLG (Building Regulations), CIBSE, ASHRAE and other relevant sources including BESA, a commercial organisation that produces the SFG schedules, and BSRIA, who publish guides on maintenance and best practice building operations. The intent is not to repeat the data from these sources but direct members to use them appropriately. According to reports from government, there is a concern that COVID-19 will be around for some time and could easily be carried into buildings by infected people. Professor Chris Whitty, physician and epidemiologist who is Chief Medical Officer for England, has expressed the view that the lockdown could last 18 months, by which time the virus would have been driven out of the UK.

However, there are many who fear that such a long lockdown is not sustainable and would be extremely costly. There are signs that the public are already struggling due to the lockdown restrictions. For these reasons there is a desire to end the lockdown and open buildings sooner rather than later. This would necessitate the installation of equipment and systems which would reduce the risk of spreading the virus should an infected person enter, so that a safe early opening could be realised.

CURRENT SITUATION

The UK has had a total ‘lockdown’ imposed by government as part of the strategy to overcome the COVID-19 outbreak. The majority of the population have been asked to ‘stay at home’ until the lockdown is lifted.

As a result, the majority of buildings have been closed through a managed process, although in many cases the lockdown was immediate and premises were just evacuated and locked.

During the shutdown, most buildings will have been able to be remotely monitored using BMS and security systems. There is limited reason or need to visit except to make occasional checks and ideally undertake 'caretaking' maintenance duties, for example to make sure there are no leaks or damage which need attention.

REOCCUPATION

Prior to reoccupation it is essential that buildings are safe and that all engineering systems are operating correctly and in compliance with Building Regulations and health and safety requirements. For this to happen, every building must be cleaned of any potential health risk including COVID-19 and have its engineering systems checked and restarted. This must be achieved by undertaking restart procedures for each system.

Further to a review by IMechE members of the maintenance schedules for some commercial spaces that they had already operated in, the following list of services detailed in the 'Reoccupation' section could be expanded to fall in line with the *"BESA SFG-30 Maintenance & Task Schedules: Mothballing & Recommissioning of Buildings"*.....

- Building Fabric Elements
- Building Management System (BMS)/Controls
- Catering Services
- Chilled Water Systems
- Compressed Air Systems
- DX Cooling Plant
- Electrical Systems
- Emergency Lighting
- Fire Alarm Systems
- Gas Supply
- Heating Systems
- Lighting and Lighting Systems
- Motors, Generators, UPS and Battery Systems
- Oil Supply
- Pipework (All Systems)
- Refrigerant Gases
- Security Monitoring and Access Systems

- Swimming Pools
- Transformers and Substations
- Ventilation Plant
- Water Hygiene Services
- Water Services - Fire Protection and Environmental Supply Systems

The following more detailed sections describe the types of issues which must be addressed:

Water

Unless drained, water systems, will have water lying in pipes, which will be static. This will very likely promote bacterial growth within the system and Pseudomonas. As well as the potential threat to health, Pseudomonas does remove the passive layer of the copper pipework and results in the copper 'rotting', initially through pin holing and then more widespread failure. This will take months to initially reveal itself. Each water system should be cleaned (sterilised) using chlorination or other method and flushed in accordance with LG8 and pre commissioning cleans.

All shower heads will benefit from being sterilised and cleaned and potentially flushed without the shower head in operation (to prevent Ozone/misting) but making sure hoses do not come into contact with the shower tray drain. Flexible hoses should be sterilised. Outside taps and hoses should be flushed down the drain, minimising close contact.

Follow guidance issued by the ESCMID Study Group for Legionella Infections - ESGLI - in their 'Guidance for managing Legionella in building water systems during the COVID-19 pandemic'.

Air systems

Ductwork will have had stagnant air for a long period and dust and dirt will have collected. Before starting any fans, systems require to be cleaned. It is likely to be sensible to operate systems with a new set of filters which are then replaced after a short period, for example one week.

There are some concerns that COVID-19 droplets may enter ductwork and be contained in colony-forming units within ducted systems. For this reason, extra care must be taken to ensure contaminated air is not distributed around the building. Cleaning ducts, and making sure they are not contaminated, will assist in meeting cleanliness standards – but refer to CIBSE guide M re: maintenance of engineering installations.

Cooling systems

Refrigerants may have leaked and each system must be checked for pressure. Where leaks have occurred, the system must be refilled using an approved refrigerant. If the system contained R22 or any other banned substance, a suitable 'drop in' refrigerant must be used. Refer to current ASHRAE guidance.

Electrical systems

Whole-building electrical testing must be carried out. As a starting point, and where a controlled shutdown has taken place, all isolators are switched off, a visual inspection is first carried out, and with an initial suitably qualified Electrical Technician visually witnessing at the plant and who is in radio contact with the technician at each distribution board whilst the breakers are activated one at a time in sequence, thereby reducing the start-up load and giving the opportunity to witness any unusual occurrences. Any sign of malfunction should be investigated and walk-round plant tours undertaken each hour for the first four hours.

Heating

Gas-fired boiler plant and piped hot water heating systems must be inspected and tested, ensuring all flues have been drained properly. All Carbon Monoxide detectors should be tested first.

BMS and Controls

The BMS and/or controls systems must be checked for correct operation. Undertake checks to confirm start-up and stop functions for each system. Undertake operational control checks for each system by adjusting temperature settings and observing correct control operational sequences.

Check each safety feature including emergency stop. Frost protection will have to be undertaken by adjusting the control settings upward in order to observe functions and reset afterwards.

Ensure a full checklist and record of all settings are left for ongoing operation. It is noted that most building systems undergo 'fine tuning' over a period in order to overcome the idiosyncrasies of each particular building and its HVAC systems and it is important that these are left as found in order to maintain the building as required by its occupants. These settings will have been reached after many adjustments by the operational team. If an attempt to return to the original settings is made – i.e. a 'reset to original settings' approach – it could negate the important works carried out by operational staff over many years. It is important that the reoccupation process is carried out in collaboration with the building's FM team.

A record of each setting should identify where, and why, settings such as these are being kept, so that a future visit by a maintenance operative does not attempt to reset for the reasons mentioned above.

Fire Safety systems

Each fire safety system should be checked in accordance with the regular routine checks.

Firefighting equipment

Check all handheld appliances such as fire extinguishers and, where necessary, have units serviced or replaced by the incumbent contractor.

ADDITIONAL REQUIREMENTS TO MEET COVID-19 RISKS

There is a growing desire to end the lockdown and 'open up' the UK again for business, leisure, education and travel. Many parties are concerned about a range of issues including business and employment decline, the economy and GDP, social care, mental health, domestic life, etc.

However this can only be done safely and in a controlled manner. Opening too soon, and without any precautions, risks a second wave of COVID-19 and a return to lockdown which would be highly damaging and costly.

There are options which could improve safety and reduce COVID-19 risks within buildings and around premises:

- Effective ventilation can dilute the amount of COVID-19 droplets and aerosols in the air and can remove COVID-19 droplets and aerosols if more fresh air is used
- UVGI air sterilisers can 'kill' viruses
- HEPA air filters can remove particulate matter, including droplets which may contain virus
- Humidity levels between 40% and 60% can reduce many health risks including COVID-19 (reference Dr Stephanie Taylor, Harvard).

These and other measures should be identified by an engineer (usually a mechanical engineer experienced in ventilation) who will need to establish the appropriate, practical and cost effective solutions for each application.

For example, the following may be worth considering:

Modify ventilation system to achieve higher fresh air flows – less, or NO recirculation – in order to promote higher dilution levels. It is noted that this may challenge energy saving measures, but whilst COVID-19 is an issue, the priority should be health and wellbeing by means of using more fresh air. If these modifications turn out to be long term (which depends on factors such as vaccines, etc.) then energy recovery equipment should be installed, such as heat pumps, heat pipes, run around coils. At this time, thermal wheels are considered an issue due to possible carry-over and advice should be sought from a manufacturer.

Inside rooms, upper room (ceiling void) UVGI (Ultra Violet Germicidal Irradiation) units – which are air sterilisers – should be installed. Units which are typically 600 x 600 can be installed into a standard ceiling grid. Each unit draws in air and passes it across UV lamps, which are hidden from direct view inside the unit box, and effectively 'kill' viruses by breaking their DNA.

A single unit could achieve acceptable risk reduction in a classroom or other small room. For larger spaces, several units would be needed.

A UVGI ceiling unit would be very useful in a lift because it would draw air through and keep the viral load in the lift air down. Although full lift occupancy would still not be advisable, lifts could carry 4 to 6, depending on capacity. This would be greatly preferable to the one-person-only recommendation currently necessary to meet social distancing rules, although non-contact rules would still apply.

A ceiling jet type of UVGI unit would be useful above places such as supermarket cashier tills, where they would direct cleaned air down onto the cashier and push back any air from customers. The unit creates a 'clean zone' of air which could protect the cashier.

The use of floor-mounted 'mobile' UV units can be beneficial where there are no suitable ceilings and may be the lowest-cost option in many cases, because they can easily be wheeled into position and plugged into a standard electrical socket.

As an alternative – or in addition – HEPA filter units can be installed to provide clean air. But because they filter out the COVID-19 and other pathogens, they must be treated carefully and be considered as a biohazard, with suitable procedures followed for filter changes, etc.

For large buildings with central AHU ventilation plant, the use of in-duct UV or filter upgrades to HEPA – or even both – can be considered and should be developed as a solution by an engineer.

Maintaining humidity between 40% and 60% RH minimises the risk of COVID-19 transmission, because viruses are less active in this range. Install humidification into ducted systems to control RH in this range, as reported by Dr Stephanie Taylor from research undertaken at Harvard University Medical Center. See references below for research papers.

Building confidence amongst occupants

As part of the reoccupation process, an Infection Control Engineer must produce a list of additional works needed for the building to open early. Once these works are completed and the checks and maintenance cleaning works listed above are

completed, the building can be reoccupied with some confidence that the COVID-19 risk is reduced.

APPROVAL PROCEDURES

The restart process should be fully documented and signed off by a competent person.

Each stage of the works must be carried out by a competent, approved person and, once all works are completed, the building should be signed off by a competent Chartered Engineer.

MANAGEMENT MEASURES TO REDUCE RISK

Engineered infection control measures must be complemented by good management of COVID-19 risks, which will require occupants to behave and observe guidelines such as social distancing and PPE, including mask wearing etc.

EXAMPLE OF SCHOOLS

As an example of management measures and applied for schools, ensure children and staff are tested in time to get results before first day back

All children and staff should be told to arrive wearing virus-catching masks and gloves and bring a polythene bag to put used masks in

On arrival, ensure all children are wearing blue surgical masks under their face covering, or issue one if not.

Spray the fingertips of their gloves with sanitizer, or follow the school's hand hygiene routine

Children should be instructed on sanitising their own work area

On being seated in class in SD layout, children can remove masks and gloves, as can the teacher.

Children should be instructed on the mechanisms of infection, possibly using extracts of these visualisations and simulations or those specially prepared

https://drive.google.com/file/d/1IKptICQVt_ABHU-nmP7zo7KGgMRKw8fN/view?usp=sharing

<https://www.mscsoftware.com/work-from-home/stay-safe>

Whilst the children are in class, the janitor should ventilate corridors by creating a through draft

If standing, the teacher should stand back 4m from children when speaking and should wear a mask when looking over children's shoulders or walking between desks.

At break, the children should put on their masks and gloves again to enter corridors, etc.

Children and staff should be warned not to follow directly behind those in front in corridors and to use separations greater than 2m.

Teachers should ventilate classrooms by creating through draft for 5 mins prior to the next class.

Similar management procedures should be developed for other building types and situations.

OTHER SOURCES AND REFERENCES

The following sources contain useful guidance. It is noted that, as COVID-19 is a new and emerging disease, there is still a great deal of research ongoing and guidance is being developed and updated regularly.

Professor Catherine Noakes CEng, FIMechE, FIHEEM, Professor of Environmental Engineering for Buildings and Deputy Director Leeds Institute for Fluid Dynamics, School of Civil Engineering, University of Leeds, is a member of SAGE and has been advising government on the types of issues raised here. Catherine has provided the following reports which are useful in gaining an understanding of the issues concerned. Dr Noakes was awarded the annual CBSD prize for her work.

How can airborne transmission of COVID-19 indoors be minimised?
<https://www.sciencedirect.com/science/article/pii/S0160412020317876>

And

<https://www.gov.uk/government/publications/evidence-of-environmental-dispersion-of-covid-19-for-different-mechanisms-14-april-2020>

<https://www.gov.uk/government/publications/environmental-influence-on-transmission-of-covid-19-28-april-2020>

<https://www.gov.uk/government/publications/emg-transmission-and-control-of-sars-cov-2-on-public-transport-18-may-2020>

<https://www.gov.uk/government/publications/emg-summary-of-disinfection-technologies-for-microbial-control-18-may-2020>

From IMechE CBSD Coronavirus Information note – Ventilation Measures
26th March 2020 Issue 1

This information relates to current direction for the technical aspects of Heating, ventilation and Air Conditioning during the current pandemic. This information is to support IMechE members and a wider audience to better understand the appropriate standards that normally apply, resources available and to provide guidance for those being treated.

There is a great deal of information being published by the UK government and its agencies including the NHS and Public Health England (PHE). See document COVID-

19: Guidance for infection prevention and control in healthcare settings

<https://www.nhs.uk/conditions/coronavirus-covid-19/>.

Specific advice on infection prevention and control can be found at:

<https://www.gov.uk/government/publications/wuhan-novel-coronavirus-infection-prevention-and-control>.

Much of this advice could be useful to members globally, though each country may provide local advice or instruction, which should be reviewed in conjunction with this note.

The COVID-19 virus is a new flu like virus and has no current vaccine to protect from it.

- The majority of people who catch this virus (c. 80%) can overcome it within a period of circa two weeks of self-isolation at home
- A further circa 15% can potentially remain at home but have more acute symptoms and are required to seek support
- Approximately 5% of those who catch the virus will require hospital treatment and potentially intensive care treatment and about 0.5% will die from the virus

There is various established guidance on HVAC that is, and remains, relevant, including:

Health Building Note 04-01: Supplement 1 – Isolation facilities for infectious patients in acute settings Updated 2013: <https://hberm.com/wp-content/uploads/2015/10/HBN-04-01-Supplement-1-Isolation-facilities-for-infectious-patients-in-acute-settings-20131.pdf>

REHVA which is the Association representing all European professional engineering societies has published specific guidance which can be reached on website [https://www.rehva.eu/fileadmin/user_upload/REHVA covid guidance document 2020-03-17 final.pdf](https://www.rehva.eu/fileadmin/user_upload/REHVA_covid_guidance_document_2020-03-17_final.pdf)

This is supported by a bibliography on [https://www.rehva.eu/fileadmin/user_upload/REHVA COVID-19 guidance document Bibliography.pdf](https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_Bibliography.pdf)

Updates can be found at: https://www.rehva.eu/activities/covid-19-guidance?no_cache=1

Healthcare teams requiring guidance should refer to HTM 03 - Health Technical Memorandum (HTM) 03-01: Specialised ventilation for healthcare premises Part A and B and CIBSE Guide B for technical guidance on system design and installation. Also useful is the NHS guidance on isolation rooms - **Health Building Note 04-01: Supplement 1 – Isolation facilities for infectious patients in acute settings** Updated 2013: <https://hberm.com/wp-content/uploads/2015/10/HBN-04-01->

[Supplement-1-Isolation-facilities-for-infectious-patients-in-acute-settings-20131.pdf](#)

Engineers should follow these documents as the current guidance and apply to the facility concerned, bearing in mind that prompt action may be necessary due to the numbers of affected patients.

The IMechE and CIBSE have members who collaboratively support both institutions. The CIBSE Healthcare group are currently providing technical input to NHS, with their new version of HTM 03 which will be published shortly and will be developing technical CPD programmes to assist members apply it once available.

CIBSE has published guidance at [www.cibse.org/Coronavirus-\(COVID-19\)](http://www.cibse.org/Coronavirus-(COVID-19))

ASHRAE has published guidance at www.ashrae.org/covid19

UK Government strategy for return to work and reoccupation at:
<https://www.gov.uk/government/publications/our-plan-to-rebuild-the-uk-governments-covid-19-recovery-strategy>

HSE has published the following: www.hse.gov.uk/news/working-safely-during-coronavirus-outbreak.htm