# Re-opening UoS Buildings after the Covid-19 Building Closures – Ventilation Systems

Contained within this paper is information and guidelines on how to control the risks of airborne diseases, such as Covid-19. These guidelines have been followed and undertaken by SEF Engineering Teams. All the available guidance from the authorities in ventilation, such as CIBSE, and the Government have been understood, rigorously applied and implemented. They are listed below:

- Before putting any mechanical ventilation system into operation, a pre-operation check of the plant is carried out.
- This has included (whether the normal scheduled maintenance plan was due or not) replacement of filters; cleaning air handling units and supply fans; setting systems to 100% fresh air (where applicable) and a physically checking that any dampers are in the correct position and functional.
- Flushing of the system by running on full fresh air, wherever possible, for a suitable duration prior to re-occupation of buildings/spaces.
- If the building benefits from a Building Management System (BMS) it has been set to run ventilation systems to a 24/7 working pattern to ensure constant cycling of air within the spaces.
- During the period of building closure, and wherever possible, fan speeds and temperature settings were reduced.
- Pre-ventilation of spaces has been carried out wherever possible by opening all of the available windows.
- Signs have been placed in ventilated spaces informing occupants not to close windows or turn off ventilation systems if they are cold.

Running ventilation on full fresh air settings will mean that spaces are potentially colder than occupants would normally find comfortable. We therefore advise that occupants wear suitable clothing to stay warm and not to close windows or alter the settings for the ventilation during this period.

During the colder winter months, SEF are in discussions with suppliers of specialist ventilation equipment to provide a warm environment with safe air quality, to ensure that rooms can be used as intended.

# Ventilation Systems air change calculations

As part of the ventilation requirements, the design process is based on the minimum supply flows to individual zones as well as the outdoor air requirements. In this process, the designer takes into account maximum occupancy in a room or zone and the ventilation is at its minimum supply or discharge airflow rates. SEF maintenance engineers have checked and validated all mechanical ventilation systems and they are operating as per their design requirements. If they were not operating at 100%, remedial work has already been undertaken to rectify these issues.

This, coupled with ramping up the mechanical ventilation systems to operate at 100% capacity therefore provides a very positive level of air flow per person, compared to times before Covid-19 was a concern.

# Determining the specification and design of a ventilation system for a building or room

When specifying a ventilation system, one of the most important considerations is the number of air changes per hour (also known as air change rate) needed to sufficiently ventilate the room. It is equally crucial to take into account the volume of outside air (fresh supply air) that the room requires. This can be calculated based on the number of people typically living or working in the space. These requirements can depend on a number of factors but the nature of the rooms' usage is a key place to start.

According to Ashrae, the American National Standards Institute, who are the ventilation authority in the USA and globally respected in their own right, the calculation for air changes is as follows, which is the same as is used in the UK and throughout the rest of the world "Air changes per hour (ACPH) is a measurement of air volume that is added to (or removed from) a room divided by the total volume of the room. Put simply, it measures how many times the air in the room is replaced. Higher ACPH values mean better ventilation." The formula is as follows:

ACPH = $Q$ / $Vol$

Whereby:

- $Q$ = Volumetric flow rate of fresh air from outside in cubic metres per hour ($m^3/h$)
- $Vol$ = Space volume $L \times W \times H$ in cubic metres ($m^3$)

SEF have calculated the minimum air change rates for many buildings across campus, but in reality, for reasons outlined in the 2nd section of this paper, the calculations will be significantly higher. These figures below are conservative and represent the figure for the least well ventilated room in the building. Where rooms have A/C present, this has not been used to affect ACH, as the benefit of A/C is to alter temperature, not to exchange air.

Mechanical refers to mechanical ventilation and Natural refers to windows. For the mechanical readings, no windows were open and for the natural readings, only one window was open. If there is more than one window, the reading below can be multiplied by the number of windows. In the case of JMS, as the room is high up, with all 4 windows open, the ACH would have been 117.7. The results in the table below are from actual calibrated measurements:

| Building | Type of ventilation, mechanical or natural | Air changes per hour |
|---|---|---|
| Shawcross | Mechanical | 14.43 |
| Silverstone | Mechanical | 6.34 |
| Chichester 1 | Mechanical | 14.56 |
| Chichester 2 | Mechanical | 12.9 |
| Medical Teaching School | Mechanical | 7.6 |
| Hastings | Natural | 6.2 |
| Arundel | Natural | 8.9 |
| Arts A | Natural | 9.4 |
| Chichester 3 | Natural | 7.8 |
| Essex House | Natural | 6.6 |
| ACCA | Natural | 6.69 |
| Accelerator Building | Mechanical | 11.12 |
| Arts B | Mechanical | 5.5 |
| Arts C | Natural | 5.33 |
| Asa Briggs A1- A2 | Mechanical | 5.08 |
| Ashdown House | Natural | 9.6 |
| Bramber | Mechanical | 6.93 |
| BSM Research | Mechanical | 5.2 |
| Clinical Imaging Sciences Centre (CISC) | Mechanical | 11.52 |
| CRPC | Mechanical | 20.02 |
| Education in Cancer (Shore-C) | Mechanical | 5.74 |
| Falmer House | Natural | 6.2 |
| Falmer Sports Complex | Mechanical | 9.67 |
| Freeman Building | Mechanical | 20.03 |
| Friston | Natural | 12.47 |
| Fulton | Natural | 19.05 |
| Genome Centre | Mechanical | 12.34 |
| Innovation Centre | Natural | 11.71 |
| John Clifford West | Natural | 6.5 |
| John Maynard Smith | Natural | 29.43 |
| Jubilee Building | Mechanical | 66.66 |
| Library | Natural | 6.29 |
| Meeting House | Natural | 5.67 |
| Pevensey 1 | Mechanical | 10.53 |
| Pevensey 2 | Natural | 33.66 |
| Pevensey 3 | Natural | 8.57 |

| | | |
|---|---|---|
| Research Centre (TFMRC) | Natural | 7.2 |
| Richmond | Mechanical | 6.3 |
| Sport Centre | Natural | 18 |
| Sussex House | Natural | 11.52 |
| Trafford Centre | Natural | 6.3 |

The table shown is a representation of all buildings across the campus which vary in age, design and function and all ventilation systems, from entirely natural to a combination of mechanical and natural ventilation have been represented. All buildings have been surveyed and the ventilation systems within have been serviced and checked to working as per their original design, apart from the exception of JMS, where the ventilation has been removed; a project has started looking into replacing this ventilation with something more effective for the space and usage of this wing of the building.

The buildings in the table are a mixture of mechanical and natural ventilation to provide a clear picture of how both perform. Wind speeds on the days when ACH were calculated (Thursday 10th September, Tuesday 22nd September and Wednesday 23rd September) was slight, ranging from 1.5-2.5 metres per second outside. The air flow speed inside, at the time of testing, was between 0.15- 0.40 and this level of air flow speed is hardly perceptible.
In the areas where I recorded the air changes with just mechanical ventilation in effect, with open windows as well as the mechanical ventilation working, the air exchange rates would dramatically increase, see Table 5.
All buildings had ventilation systems that worked as they should, even older systems. This is likely to be because minimum air exchange rates tended to be higher pre 1989 when new legislation came out. Post 1989, the guidance is based on a minimum ACH, whereas prior 1989, the guidance was to standard figure plus smoking was commonplace in buildings and this required much higher ACHs ( of circa 30 changes per hour) than they do nowadays.

After surveying every room with the buildings detailed in the table above only 1 room provides insufficient ventilation in these times where COVID-19 is an issue. That room is the Silverstone Audio Recording Studio. This is a single person space, formed by a room within a room, retrospectively installed. The School were made aware of this restriction at the time of survey. It presents no operational or educational constraints. This space has no mechanical or natural ventilation installed.

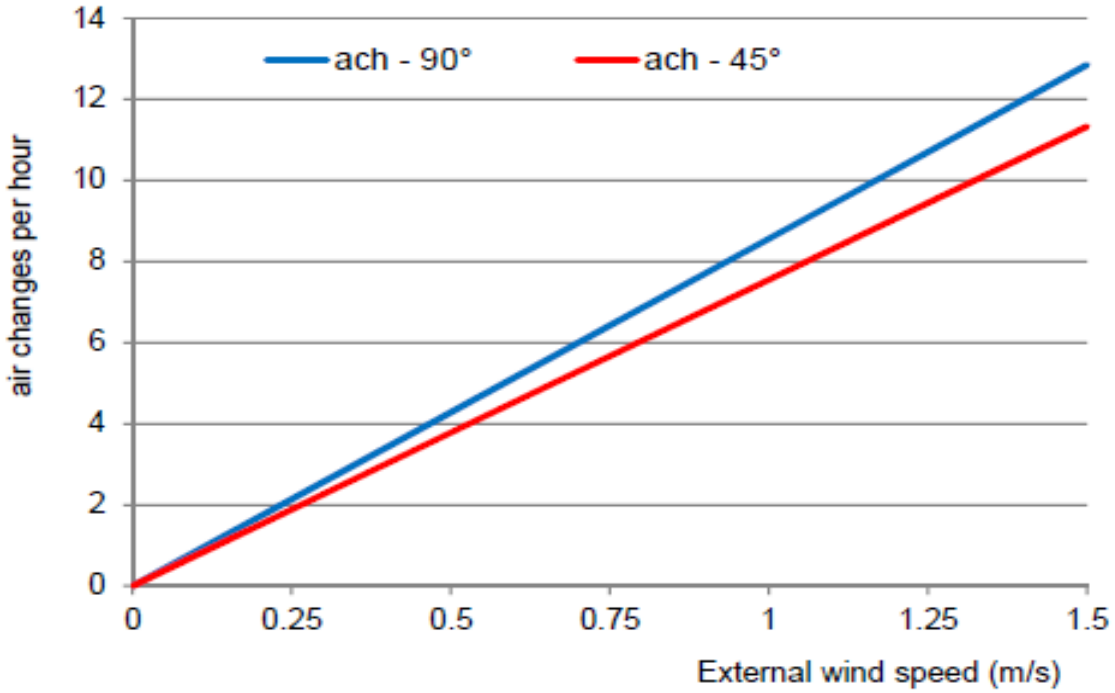
# Natural ventilation

The formulae in CIBSE Guide A can be used to estimate the natural airflow rates for simple building layouts, as seen in the following table:

| | Wind @ 90° | Wind @ 45° | Stack effect |
|---|---|---|---|
| Airflow rate ($m^3/s$) | 1.61 | 1.42 | 0.84 |
| Air changes per hour (ach) | 12.8 | 11.3 | 6.7 |
| l/s/person | 107 | 94 | 56 |

**Table 5 Natural ventilation air flow rates using formula in CIBSE Guide A**

The table below (Table 5) taken directly from CIBSE Guide A, shows how wind speed, hitting a building at either 45 or 90 degrees, creates sufficient air changes. The wind speed required is actually very low, a speed of just 1 metre per second will provide around 8 air changes per hour in a room. Average wind speed in the UK is 8.4 knots or 4.32 m/s, so this is a clear indicator of the potential for natural ventilation.




This demonstrates how effective natural ventilation via open windows is. CIBSE have made assumptions for the calculations, for instance "a coefficient of discharge (Cd) of 0.61 is adopted based on cl 4.6.1 of CIBSE Guide A to take into account the pressure drop through a sharp edged opening, such as a window. The resulting air flow rates are shown in Table 5."

In office buildings it is generally necessary to calculate air changes for one typical interior zone, and in the case of this campus, we have chosen the rooms with the lowest ventilation rates. No other calculations are required, even if the building has 1,000 zones.

# Ventilation Systems with only re-circulation available

This includes air conditioning systems, with ceiling cassettes and ducted units.

The risks are as above with potential build-up of dust, debris and bacteria.

How we control risk:

- During this period, we will not operate ventilation systems with only re-circulation where there is no fresh air input.
- However in spaces with windows that open, the continued use of these systems remains viable.
- SEF and the University carry out risk assessments on the re-occupation of building spaces to determine if additional control measures are required to mitigate any intolerable risks identified.
- Overnight we'll set systems to run on higher heat settings for an hour to support effective operation in the long-term.
- SEF place signs in ventilated spaces informing occupants to keep windows open during use and not to turn off ventilation systems if they are cold.

# Building Management System (BMS)

A BMS is a computer-based control system installed in buildings that control and monitor the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems.

How we control risk:

- Daily operational checks of the BMS are completed to ensure that there are no faults on the system.
- If faults are detected these are attended to promptly using our in-house teams or specialist contractor support network.
- Set operation to a 24/7 working pattern to ensure constant cycling of air within the spaces and with reduced fan speeds and temperatures out of occupied times.

# Other Mechanical Systems

There will be other mechanical systems within the workspace and the risks are varied and many.

How we control risk:

- Checks and testing are carried out on any gas detection systems.
- Checks on gas boilers and water heaters for correct operation along with auxiliary equipment are carried out.
- Checks are carried out on the operation of chiller plant and auxiliary equipment.
- Checks are carried out on F-Gas systems and that the logbook is up to date for all equipment.

- Checks are carried out on all gas Certification to ensure that it is up to date.
- Checks are carried out on the operation of all air conditioning equipment.
- Checks are carried out on the operation of compressed air systems.

***In this unprecedented time, it is vital that all ventilation defects or issues are reported as soon as possible to the Service Centre, via email to service.centre@sef.fm or by phone to 01273 877 777. The SEF Maintenance Team can then repair or replace as soon as possible.***

# Reference

HSE ACoP - Workplace (Health, Safety and Welfare) Regulations 1992 – Reg. 6 Ventilation

HSE Guidance - Air conditioning and ventilation during the coronavirus outbreak – 2020

CIBSE COVID-19 Ventilation Guidance – v.2 May 2020

Natural ventilation in non-domestic buildings, CIBSE Applications Manual AM10 - 2005