TECHNICAL GUIDE

BUILDING BULLETIN 101 UPDATE

Changes for ventilation in schools

VES

Better air for the built environment

CHANGES FOR VENTILATION IN SCHOOLS

The Education & Skills Funding Agency (EFSA) has updated the Building Bulletin 101 (BB101)[1], which now falls in line with the past 12 years of new standards and guidelines.

The new BB101 has drawn inspiration from other regulatory guides such as, the Priority School Building Programme (PSBP)[2], the Output Specification (OS)[3], the CIBSE Technical Memorandum (TM52:2013). The limits of thermal comfort: avoiding overheating in European buildings[4], and Part L of the Building Regulations[5], to deliver a greater emphasis on energy efficiency and indoor comfort.

BB101 (2018)

The revised version was published on 23rd August 2018. There are two key changes within the BB101 (2018) document:

- Indoor air quality: carbon dioxide (CO_2) levels
- Thermal comfort

The previous BB101 (2006) outlines ventilation requirements and set levels for the different ventilation strategies; natural, mechanical and hybrid. UK schools have traditionally been ventilated either by natural means or by fixed speed mechanical ventilation, which has not always optimised the learning environment or the energy consumption throughout the school day.

Natural ventilation *should* be able to effectively ventilate a school without the use of energy. However, the use of stack effects and/or wind speed to deliver sufficient air is uncontrollable and can cause draughts. Mechanical-only solutions do not utilise natural ventilation in ideal conditions, during which time significant energy could be saved. The update to BB101 aims to provide better guidelines to bridge the gap between controllability and energy consumption.

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1 https://www.gov.uk/government/publications/building-bulletin-101-ventilation-for-school-buildings
2 https://www.gov.uk/government/publications/psbp-overview
3 https://www.gov.uk/guidance/output-specification-2017
4 http://www.cibse.org/Knowledge/knowledge-items/detail?id=a0q20000008I7f5AAC
5 https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l

INDOOR AIR QUALITY

CO_2

Studies[678] have suggested that the perfect CO_2 conditions for an average classroom would be 1200 parts per million (ppm) of CO_2 in a room. This level is not consistently achievable through natural ventilation and as such BB101 has set a limit of 2000 ppm. Coupled with the risks of drifting from ideal temperature and humidity conditions, a drive toward better CO_2 control in the BB101 (2018) update attempts to achieve better performance for optimised learning conditions.

Previously, BB101 (2006) regulations used the same rates whether the ventilation was natural, mechanical or hybrid to ensure that CO_2 levels never exceeded 1500 ppm:

- Maximum litres per second per person of fresh air that needed to be supplied to a teaching space at any occupied time was 8 l/s/p.
- A daily average of 5 l/s/p.
- And never dropped below 3 l/s/p.

The revised BB101 (2018) attempts to find a better operational and commercial balance between the two very different ventilation strategies:

- Naturally ventilated teaching

  - Daily average concentration of CO_2 of less than 1500 ppm, during the occupied period.[9]
  - The maximum concentration should also not exceed 2000 ppm for more than 20 consecutive minutes each day.[9]

- Mechanically ventilated general teaching spaces

  - Where mechanical ventilation is used, or when hybrid systems are operating in mechanical mode, sufficient outdoor air should be provided to achieve a daily average concentration of CO_2 of less than 1000 ppm.[9]
  - The maximum concentration should also not exceed 1500 ppm for more than 20 consecutive minutes each day.[9]

In an environment where energy is also on the top of everyone's agenda, and effective public spending is of paramount importance. The lower CO_2 targets for forced mechanical ventilation in BB101 (2018) and control of thermal comfort, clearly indicate a need for a demand controlled strategy using a mechanical or hybrid ventilation solution.

6 https://www.salford.ac.uk/cleverclassrooms/1503-Salford-Uni-Report-DIGITAL.pdf
7 https://www.bartlett.ucl.ac.uk/iede/documents/cognitiveperformance-1.pdf
8 https://www.sciencedirect.com/science/article.pii/S0360132311002617
9 When the number of room occupants is equal to, or less than the design occupancy

THERMAL COMFORT

Overheating

Demonstrating that the classroom would not suffer from overheating is relatively easy to do under the previous BB101 (2006). CIBSE TRY (Test Reference Year) weather data, instead of the much hotter DSY (Design Summer Year) weather data could be used for the simulation. The generated concerns and has led to an emphasis on thermal comfort in the revised BB101 (2018) guide.

Previous BB101 (2006) criteria:

These standards apply outside the heating season and are for the occupied period of 09:00 to 15:30, Monday to Friday, from 1st May to 30th September.

- There should be no more than 120 hours when the air temperature in the classroom rises above 28°C.
- The average internal to external temperature difference should not exceed 5°C (i.e. the internal air temperature should be no more than 5°C above the external air temperature on average).
- The internal air temperature when the space is occupied should not exceed 32°C.

In order to show that the proposed school would not suffer from overheating, two of these three criteria needed to be met. BB101 (2018) outlines tighter methods to demonstrate that teaching and learning spaces will not suffer from overheating. In order to demonstrate compliance, BB101 (2018) refers to the recommendations of the CIBSE TM 52 and the use of DSY weather guide.

The three criteria from CIBSE TM 52 are:

- Criterion 1 - Hours of Exceedance (H_e):

For schools, the number of hours (H_e) that DT is greater than or equal to one degree (*K*) during the period 1st May to 30th September for the defined hours shall not be more than 40 hours.

- Criterion 2 - Daily Weighted Exceedance (W_e):

To allow for the severity of overheating, the weighted exceedance (W_e) shall be less than or equal to 6 in any one day.

- Criterion 3 - Upper Limit Temperature (T_{upp}):

To set an absolute maximum value for the indoor operative temperature, the value of DT shall not exceed 4K.

In order to show that the proposed school design will not suffer from overheating, Criterion 1 must be met. The following two criteria are primarily used to show short-term discomfort and should be reported for information only. If a model of the school indicates that it would not meet either / both Criterion 2 or Criterion 3, steps should be taken to mitigate the risk of overheat.

This drive towards greater thermal focus during initial design of the school ensures that any teaching spaces will be more comfortable for learners and more robust against possible future temperature increases due to climate change.

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How to achieve the changes

Implementing mechanical and hybrid solutions

To achieve the new proposed BB101 guidelines, control of comfort condition and CO_2 levels is of paramount importance. Implementing a **demand-controlled ventilation[10] strategy** adds intelligence, reacting automatically to real-time conditions within a room.

The new changes to BB101 can be achieved through adopting an intelligent demand-control strategy.

CO_2, temperature and humidity sensors constantly monitor **indoor air quality**, automatically introducing a fresh flow of air into the room when required and extracting the stale air, to meet the most effective learning conditions outlined within the new guidelines. A combined hybrid approach can utilise the natural ventilation conditions where possible, with the automatic integration of mechanical ventilation when key set points are exceeded, providing a perfect balance between comfort and energy consumption.

A combination of mechanical and natural ventilation will ensure air quality and thermal comfort can be efficiently achieved, whilst maximising energy efficiency opportunities.

New changes to the **thermal comfort** guidelines in BB101 seek to provide direction on how to prevent overheating. The fluctuations in thermal comfort due to radiant and air temperatures both inside and outside of the classroom can only be effectively managed by using an intelligent ventilation system. Adopting a demand-control ventilation strategy, combining mechanical and natural ventilation, will ensure air quality and comfort conditions can be controlled in the most energy efficient manner, whilst becoming considerably more efficient via effective heat recovery.

Issue	Previous requirements			BB101 (2018) changes	Effects on classroom design
Indoor air quality	Max. 8 l/s/p 8 l/s/p	Ave. 5 l/s/p 5 l/s/p	Min. 3 l/s/p	• Average CO_2 during occupied day <1500 ppm • Average CO_2 during occupied day <1000 ppm	• Increased focus on IAQ, which requires early analysis at design stages • Increased focus on IAQ, requires relevant sensors to demand control ventilation levels.
	<1500 ppm average not exceeding 5000 ppm during teaching day.			CO_2 can't be greater than: Natural - 2000ppm // Mechanical - 1500ppm. For 20 consecutive minutes or more during occupied day.	
Thermal comfort	• < 120 hours above 28°C • Avg. internal vs. external temp. no more than 5°C • Max 32°C			• Criterion 1: Number of hours (H_e) that #T is greater than or equal to one degree (K) during the period 1st May to 30th September for the defined hours <40 hours • Criterion 2: Weighted exceedance (W_e) $\leq$6 in any one day. • Criterion 3: Maximum value of indoor operative temperature - value of #T <4 K	More stringent overheat criteria requiring more detailed thermal comfort modelling of the classroom at design stages.

10 https://en.wikipedia.org/wiki/Demand_controlled_ventilation

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Summary of change: Education Fund Agency (EFA) Business Engagement Assessment

Benefits

The proposed BB101 guidelines have been piloted within the Priority School Building Programme (PSBP) by the EFA. A Business Engagement Assessment[11], based on the BB101 (2016) consultation document, has been compiled by EFA Lead Assessor, Richard Daniels (see appendix for further information). The consultation version of BB101 (2016), includes virtually the same guidelines as the current BB101 (2018). Demonstrable benefits were seen in improved learning environment in terms of thermal comfort and CO_2 levels, reduced energy consumption and potential for lower capital costs.

A summary of the quantifiable costs and benefits considered in the calculation of the Basic Earnings Assessment has been provided. In summary:

- An estimated decrease in school building costs of £8.76/m^2 of gross floor area is attributable to the lower cost of simpler methods of room based classroom ventilation.
- The cost of maintenance of room based systems is between £150 and £300 per annum depending on the complexity of the systems. Choice of systems with a lower maintenance cost leads to a significant cost saving for schools.
- Savings accrue in energy running costs for new and refurbishment projects due to the use of demand controlled ventilation.
- An estimated 20% reduction in gas consumption for school heating in all new schools and a 50% reduction in gas consumption in refurbished schools.
- Reduction in the cost of ventilation of school science labs due to the adoption of simpler ventilation systems with intermittent purge ventilation during experiments is available for laboratories with semi-mobile ducted fume cupboards.
- Improved indoor air quality has been shown to benefit pupil performance. The benefits from improved educational performance cannot be easily quantified.

11 https://consult.education.gov.uk/capital/bb101-school-design-iaq-comfort-and-ventilation/

Appendix:

Changes vs proposed cost benefits

Section	Topic	Current BB101	Proposed Changes	Impact Assessment
Section 2.4 and Sections 3.1 to 3.5	Indoor air quality Ventilation rates of teaching spaces	Standards for new buildings in terms of carbon dioxide concentration and for existing buildings in terms of litres per second per person. Minimum ventilation rates in l/s/person make no allowance for demand control of ventilation and lead to high heat losses due to ventilation when spaces are partially occupied.	Same standard as BB101 but allows for reduction in ventilation rates due to demand control in new build and refurbishment as standard now in concentration of carbon dioxide rather than l/s/person. In line with EN 15251 and Energy Performance of Building Directive standards for carbon dioxide concentrations in classrooms.	The average overall cost of newer hybrid ventilation systems is estimated at between £47.24 per square metre of gross floor area. These newer systems have been introduced in PSBP schools. The cost of these systems is on average £8.76 per square metre of gross floor area cheaper than the systems that were previously used to meet comfort standards estimated to be at least £56/m^2.
Section 2.5	Indoor air quality Ventilation rates for science labs	5 air changes per hour required in all science labs.	Minimum exhaust rates of 4 l/s/square metre of floor area in chemistry labs. Slight reduction in ventilation rates by using l/s/m^2 rate equivalent to 5ach for 2.7m high spaces as most spaces now 3 to 3.2m high. Using l/s/m^2 as ASHRAE 62-1 method is more logical than ach.	Cost reduction for school laboratory ventilation systems, as higher rates only needed as slightly lower rate specified. Vent at higher rates for purging room can have higher noise level meaning classroom ventilation units can be used in science labs.
Section 2.5	Ventilation for other practical spaces	N/A	Minimum exhaust rate of 2.5 l/s/m^2 in all other practical spaces as per Art spaces in ASHRAE 62-1.	No cost impact as equivalent to ventilation rate of 5l/s/person for 24 people required by Workplace Regulations.
Sections 3.1 to 3.5	Air quality Guidelines on reduction of external air pollution	Reference to: AD F National Air Quality Strategy DETR, 2000 CIBSE TM 21 Minimising Pollution at Air Intakes, 1999 Guideline figures for all major pollutants were considered, e.g., NO_2, Formaldehyde, PM10 except for PM2.5.	Update of guidelines by reference to World Health Organisation (WHO) Indoor Air Quality Guidelines (2010). Levels for external pollution from PM2.5 included for first time based on 2008/50/EC Guideline values. PM2.5 external levels are closely correlated with NO_2 levels so no cost increase.	No cost increase as where PM2.5 external levels are high NO_2 levels are also high and guidance already exists in AD F, e.g., AD F contains guideline values for NO_2. Impact assessment of the health benefits considered during revision of AD F and European Council Directive. Health benefits due to better application of 2008/50/EC levels to schools due to improved guidance leading to better IAQ in schools in polluted areas.

Adapted from EFA Business Engagement Assesment

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Section	Topic	Current BB101	Proposed Changes	Impact Assessment
Sections 3.6 to 3.10	Thermal comfort criteria for heating and ventilation system design		BB101 guidance brought into line with CIBSE good practice and ISO 7730 thermal comfort standards.	ISO 7730 and EN 15251 are implicit in EPBD, Building Regulations Part L National Calculation Method and Workplace Regulations - Temperature requirements. No cost increase over regulatory standards: implicit in EPBD, Part L NCM energy calculations and in temperature requirements of the Workplace Regulations. Detailed standards contained in ISO 7730 and in EN 15251. Benefit due to improved guidance leading to reduced thermal stress and improved thermal comfort in summer and winter.
Section 3.7.1 and Table 3.9	Criteria for cold drafts Section 3.7.1 and Table 3.9 give the criteria to avoid cold draughts.	No criteria given for prevention of cold drafts	BB101 guidance brought into line with CIBSE good practice and ISO 7730. Lack of criteria on cold drafts led to inadequate single sided window design that was not used in cold weather due to comfort problems and to excessive drafts from mechanical ventilation systems.	No cost increase over standards in ISO 7730 and in EN 15251 and in temperature requirements of the Workplace Regulations. Benefit due to improved guidance leading to reduced thermal stress and improved thermal comfort in summer and winter.
Sections 3.11 and 3.12	Criteria to prevent summertime overheating	Hours of exceedance over a summertime fixed temperature threshold. "There should be no more than 120 hours when the air temperature in the classroom rises above 28°C".	Move to adaptive thermal comfort calculation in line with standard in CIBSE TM 52 and EN 15251 calculation procedure. "During the period 1st May to 30th September for the defined hours, the number of hours when the actual operative temperature exceeds the maximum temperature allowable by EN 15251 for the Category of building by more than 1°C should not be more than 40 hours". Category III building adopted as minimum standard for new schools.	Change in design by omission of suspended ceilings and use of thermal mass together with boost ventilation in summertime represents a very small increase in cost over designs to meet former BB101 thermal comfort standards that were inadequate and led to widespread overheating, cold drafts and other thermal comfort problems in schools. Benefit due to improved guidance leading to reduced thermal stress and improved thermal comfort in summer and winter.

Adapted from EFA Business Engagement Assesment

VES offers ventilation and heat recovery solutions to comply with the current BB101, BB102 and BB93 guidelines. The ErP ready products below are ideal for school classrooms.

EVC

With a range of low profile heat recovery units designed to fit into shallow ceiling voids, Ecovent Counterflow from VES is an ideal choice for classroom heat recovery ventilation.

EVC-A

With the same benefits as the EVC, the EVC-A offers a very low profile heat recovery solution. The spigot arrangement of the Ecovent Counterflow has been changed from side-by-side to top and bottom while still achieving airflow and acoustic requirements.

EVH

A hybrid ventilation approach utilising natural ventilation where possible, intergrating mechanical ventilation as required. The perfect balance between comfort and energy consumption.

ErP READY 1253/2014

We also offer a wide range of products and solutions for all areas of schools.

To discuss your school ventilation needs call us on 0800 31 66 000 or email sales@ves.co.uk.

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Better air for the built environment

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