



TECHNICAL GUIDE

BUILDING
BULLETIN 101
UPDATE



*Impending changes for ventilation in schools,
based upon the consultation that took place
between June and September 2016.*

IMPENDING CHANGES FOR VENTILATION IN SCHOOLS

The Department for Education (DfE) is currently in the process of updating the Building Bulletin 101 (BB101)¹, which is being produced to fall in line with Education Funding Agency (EFA) Guideline Standards² – in particular its ‘Facilities Output Specification’ (FOS).

The proposed new name will be ‘BB101 – Guidelines for ventilation, thermal comfort and indoor air quality in schools’ - it draws inspiration from the last 10 years of school design as well as other regulatory guides, such as the Priority School Building Programme (PSBP)³, the CIBSE Technical Memorandum (TM52:2013) *The limits of thermal comfort: avoiding overheating in European buildings*⁴, and Part L of the Building Regulations⁵, to deliver a greater emphasis on energy efficiency and indoor comfort.

BB101 Consultation⁶

The consultation closed on 6th September 2016. Although it may be subject to change, architects, builders, contractors and the decision makers in education need to be prepared for the direction the DfE wishes to go with regards to ventilation in schools. There are two key changes based on the draft BB101 proposal:

- ▶ Indoor air quality: carbon dioxide (CO₂) levels
- ▶ Thermal comfort

The current BB101 2006 guide outlines ventilation requirements which set levels for different strategies that can be adopted; **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 stack effect 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.

1 <https://www.gov.uk/government/publications/building-bulletin-101-ventilation-for-school-buildings>

2 <https://www.gov.uk/government/publications/psbp-baseline-designs>

3 <https://www.gov.uk/government/publications/psbp-overview>

4 <http://www.cibse.org/Knowledge/knowledge-items/detail?id=a0q2000000817f5AAC>

5 <https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l>

6 <https://consult.education.gov.uk/capital/bb101-school-design-iaq-comfort-and-ventilation/> (PDF)

INDOOR AIR QUALITY



CO₂

Studies^{1 2 3} have suggested that the perfect CO₂ conditions for an average classroom would be 1200 parts per million (ppm) of CO₂ 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 CO₂ control in the new consultation attempts to achieve better performance for optimised learning conditions.

BB101 2006 regulations used the same rates whether the ventilation was natural, mechanical or hybrid to ensure that CO₂ 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 proposed BB101 attempts to find a better operational and commercial balance between the two very different ventilation strategies:

- ▶ **Naturally ventilated teaching**
 - Average daily ventilation rate of 5 l/s/p.
 - Concentration of CO₂ less than 1500 ppm.
- ▶ **Mechanically ventilated teaching**
 - Need to achieve a daily average CO₂ concentration of less than 1000 ppm.
 - Typically achieved by supplying around 8–9 l/s/p of fresh air.

In an environment where energy is also on the top of everyone's agenda, and effective public spending is of paramount importance, lower CO₂ targets for forced mechanical ventilation in the consultation and control of thermal comfort clearly indicate a need for a demand controlled strategy, with a mechanical or hybrid ventilation solution.

1 <https://www.salford.ac.uk/cleverclassrooms/1503-Salford-Uni-Report-DIGITAL.pdf>
2 <https://www.bartlett.ucl.ac.uk/iede/documents/cognitiveperformance-1.pdf>
3 <http://www.sciencedirect.com/science/article/pii/S0360132311002617>

THERMAL COMFORT

Overheating

Demonstrating that the classroom would not suffer from overheating is relatively easy to do under 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, generated concerns and has led to an emphasis on thermal comfort in the revised BB101 guide.

Current BB101 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 2016 outlines tighter methods to demonstrate that teaching and learning spaces will not suffer from overheating. In order to demonstrate compliance they should comply with the recommendations of CIBSE TM 52 and the DSY weather data.

The three criteria from CIBSE TM 52 are:

- ▶ 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.

- ▶ 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.

- ▶ Upper Limit Temperature (T_{upp}):

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

Two of the three criteria must be met in order for a teaching space to satisfy the regulations. 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.



How to achieve the changes

Implementing mechanical and hybrid solutions

To achieve the new proposed BB101 guidelines, control of comfort condition and CO₂ levels is of paramount importance. Implementing a **demand-controlled ventilation¹ 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.

CO₂, 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	Current BB101			Proposed changes	
CO ₂	Max. 8 l/s/p	Ave. 5 l/s/p	Min. 3 l/s/p	Natural <ul style="list-style-type: none"> Average ventilation rate 5 l/s/p Concentration <1500 ppm 	Mechanical <ul style="list-style-type: none"> Average daily CO₂ concentration <1000 ppm
Thermal comfort <i>(two of three to be met)</i>	<ul style="list-style-type: none"> <120 hours of air temp >28 °C Average internal to external temperature difference <5 °C Internal temperature always <32 °C 			<ul style="list-style-type: none"> Number of hours (H_d) that DT is greater than or equal to one degree (K) during the period 1 May to 30 September for the defined hours <40 hours Weighted exceedance (W_d) ≤6 in any one day Maximum value of indoor operative temperature - value of DT <4K 	

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

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Summary of change: EFA Business Engagement Assessment

Benefits

The proposed BB101 guidelines have been piloted within the PSBP by the EFA. A Business Engagement Assessment¹ has been compiled by EFA Lead Assessor Richard Daniels. Demonstrable benefits were seen in improved learning environment in terms of thermal comfort and CO₂ levels, reduced energy consumption and potential for lower capital costs.

A summary of the quantifiable costs and benefits considered in the calculation of the BEA² has been provided. In summary:

- ▶ An estimated decrease in school building costs of £8.76/m² 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.

1 <https://consult.education.gov.uk/capital/bb101-school-design-iaq-comfort-and-ventilation/> (PDF)

2 <https://consult.education.gov.uk/capital/bb101-school-design-iaq-comfort-and-ventilation/> (Excel)

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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 Assessment

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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.	<p>ISO 7730 and EN 15251 are implicit in EPBD, Building Regulations Part L National Calculation Method and Workplace Regulations - Temperature requirements.</p> <p>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.</p> <p>Benefit due to improved guidance leading to reduced thermal stress and improved thermal comfort in summer and winter.</p>
Section 3.7.1 and Table 3.9	<p>Criteria for cold drafts</p> <p>Section 3.7.1 and Table 3.9 give the criteria to avoid cold draughts.</p>	No criteria given for prevention of cold drafts	<p>BB101 guidance brought into line with CIBSE good practice and ISO 7730.</p> <p>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.</p>	<p>No cost increase over standards in ISO 7730 and in EN 15251 and in temperature requirements of the Workplace Regulations.</p> <p>Benefit due to improved guidance leading to reduced thermal stress and improved thermal comfort in summer and winter.</p>
Sections 3.11 and 3.12	Criteria to prevent summertime overheating	<p>Hours of exceedance over a summertime fixed temperature threshold.</p> <p>“There should be no more than 120 hours when the air temperature in the classroom rises above 28°C”.</p>	<p>Move to adaptive thermal comfort calculation in line with standard in CIBSE TM 52 and EN 15251 calculation procedure.</p> <p>“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”.</p> <p>Category III building adopted as minimum standard for new schools.</p>	<p>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.</p> <p>Benefit due to improved guidance leading to reduced thermal stress and improved thermal comfort in summer and winter.</p>

Adapted from EFA Business Engagement Assessment



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, integrating mechanical ventilation as required. The perfect balance between comfort and energy consumption.



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

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