HOARE LEA

Former Stag Brewery.
London.
Reselton Properties Limited. .

SUSTAINABILITY
BB101 (2018) ASSESSMENT
OVERHEATING RISK ASSESSMENT
REVISION 03 – 18 AUGUST 2022

Audit sheet.

Rev.	Date	Description of change / purpose of issue	Prepared	Reviewed	Authorised
01	28/07/2022	For issue.	E. Jolly	A. Cane	T. Brown
02	18/08/2022	Updated following discussions with design team.	E. Jolly	T. Brown	G. Jones
03	18/08/2022	Updated following comments from Gerald Eve	E. Jolly	T. Brown	G. Jones

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Contents.

Executive summary.

This report provides a summary of the BB101 (2018) assessment undertaken to support the application for planning permission (ref: 22/0902/FUL) submitted on 11th March 2022 for the erection of a three-storey building to provide a new secondary school with sixth form; sports pitch with floodlighting, external MUGA and play space; and associated external works including landscaping, car and cycle parking, new access routes and other associated works. This assessment seeks to respond to the adopted London Plan (2021) policy SI4 – Mitigating heat risk.

A dedicated thermal model has been built in accordance with the information issued by the architect, Squire & Partners, and used to assess the proposed building against the overheating risk during occupied hours. The results discussed in the main body of this report respond to the 2018 criteria.

The analysis has been carried out in accordance with the respective standards and all the assumptions listed in this report and related appendices.

It should be noted that whilst industry guidance has been followed, results in practice are likely to be dependent on factors which are highly user dependent, such as occupancy levels, internal heat gains from equipment and user behaviour such as operation of windows.

BB101 (2018)
The results demonstrate that not all assessed rooms meet the requirements of Criterion 1 and therefore do not demonstrate compliance against BB101 using current weather data.

Future weather years
Future weather scenarios have also been tested up to 2080 to assess the risk of overheating under possible warmer weather conditions brought about by climate change. The assessed zones are shown to not meet the BB101 comfort criteria for the 2020, 2050 and 2080 weather years.

Comfort expectation
In accordance with BB101, the assessed areas have been assessed against a 'normal' level of comfort expectation. Pupils with complex health needs and medical conditions may experience a lower threshold for discomfort and an assessment of individual needs should be undertaken if it is known that the school will cater for such pupils.

Table 1: Summary of results including future weather years.

Scenario	BB101 Crit 1 (Hrs ΔT ≥1°C)	BB101 Crit 2 (Max. daily degree hrs)	BB101 Crit 3 (Max ΔT)	Overall BB101 compliance
Current climate (2020)	15% (9/60)	15% (9/60)	15% (9/60)	15% (9/60)
Future climate (2050)	17% (10/60)	13% (8/60)	20% (12/60)	17% (10/60)
Future climate (2080)	10% (6/60)	0% (0/60)	3% (2/60)	10% (6/60)

Conclusion and next steps.
The analysis has been undertaken at the equivalent design stage of RIBA Stage 2, to support the planning application of the school. Therefore, a number of assumptions have been made to complete the modelling as the level of detail is not currently available.

Furthermore, the design parameters used within this analysis and detailed within this report have been aligned with the Part L and daylight analysis in an attempt to balance thermal comfort, occupant wellbeing and resultant carbon emissions.

It is recommended that further analysis is carried out during detailed design once more detail can be determined. The mitigation strategy will follow the cooling hierarchy, i.e. seek passive measures in the first instance before considering active cooling in occupied spaces, and will need to be balanced between the energy strategy and daylighting analysis.

The following measures are advised, as a minimum, to be considered as part of the ongoing development of the mitigation strategy:

- Use of internal shading (e.g. blinds) – It would need to be confirmed that these would be installed prior to handover.
- Review of window openings – Where viable in regard to safety and security, increase the resultant free area. This can be achieved via bottom hung windows with an increased restriction, introduction of ventilation louvres.
- Glazing g-value – A lower g-value will reduce the level of solar gains coming into the occupied spaced. However, this can decrease positive solar gains in winter months resulting in an increase of carbon emissions.
- Increased external shading – The introduction of increased overhands, fins, etc. would reduce solar gains in the summer.
- Review of internal gains – The internal gains are currently assumed to be industry standard levels for the room use type. However, parameters such as number of occupants, room use profiles, heat loss from lighting and equipment can be improved upon but cannot be confirmed at this stage of design.

All measures listed above are considered as passive measures. Should a passive approach continue to demonstrate risk of overheating, non-passive measures such as cooling can be considered as a last resort.

1. Introduction.

1.1 Background.

This report provides a summary of the BB101 (2018) assessment undertaken for the proposed School that will be developed as part of the Former Stag Brewery masterplan in London. A thermal model has been built in accordance with the information issued by the architect, Squire & Partners. Figure 1 shows the 3D model created within the assessment software, based on the proposed geometry.

It should be noted that whilst industry guidance has been followed, results in practice are likely to be dependent on factors which are highly user dependent, such as occupancy levels, internal gains from equipment and user behaviour such as operation of windows.

1.2 Scope of work.

Hoare Lea has been appointed to undertake an assessment to assess the risk of overheating for the teaching areas for the proposed development. This has been carried out in accordance with BB101 (2018) - Ventilation of School Buildings. A dedicated thermal model has been used to assess the proposed building against the standard criteria.

Site description

Application 22/0902/FULL submitted on 11th March 2022 seeks planning permission for the erection of a three-storey building to provide a new secondary school with sixth form; sports pitch with floodlighting, external MUGA and play space; and associated external works including landscaping, car and cycle parking, new access routes and other associated works

London Plan (2021) Policy SI4 – Managing heat risk

This assessment seeks to respond to the adopted London Plan (2021) policy SI4 – Mitigating heat risk:

Development proposals should minimise adverse impacts on the urban heat island through design, layout, orientation, materials and the incorporation of green infrastructure.

Major development proposals should demonstrate through an energy strategy how they will reduce the potential for internal overheating and reliance on air conditioning systems in accordance with the following cooling hierarchy:

1. *Reduce the amount of heat entering a building through orientation, shading, high albedo materials, fenestration, insulation and the provision of green infrastructure*
2. *Minimise internal heat generation through energy efficient design*
3. *Manage the heat within the building through exposed internal thermal mass and high ceilings*
4. *Provide passive ventilation*
5. *Provide mechanical ventilation*
6. *Provide active cooling systems.*

BB101 Comfort Criteria

BB101: 2018 version Comfort Criteria for classroom and teaching spaces has been used. BB101 thermal comfort requirements broadly follow the criteria defined by CIBSE TM52. This approach considers human adaption to changing environmental conditions, instead of a fixed temperature limit the maximum acceptable temperature is based upon a running mean of previous weather. Therefore, the limiting comfort temperature is dependent upon the building location and the time of year. However, unlike TM52 which requires at least 2 of 3 overheating criteria to be achieved, BB101 requires Criterion 1 to be met, with the other two criteria reported for information. The three criteria are defined as follows:

Criterion 1: Total hours of exceedance (H_e)

For schools, the number of hours (H_e) that ΔT is greater than or equal to one degree (K) during the period 1st May – 30th September (ignoring school holidays) for the defined hours (09:00-16:00 with lunch break at 12:00-13:00 Monday to Friday) shall not exceed 40 hours.

Where sports halls are used for exam purposes, the duration for this activity shall be taken as weekdays 09:00-16:00 from 1st May – 8th July with a lunch break of 12:00-13:00. The criterion should be calculated for this period with the number of hours reduced from 40 to 18 hours.

Criterion 2: Daily weighted exceedance (W_e)

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

Where $W_e = \Sigma h_e \times wf = (h_{e0} \times 0) + (h_{e1} \times 1) + (h_{e2} \times 2) + (h_{e3} \times 3)$

- wf = 0 if ΔT<0, otherwise wf = ΔT
- h_{ey} = time in hours where wf=y.

Criterion 3: Upper limit temperature (T_{upp})

To set an absolute maximum value for the indoor operative temperature the value of ΔT shall not exceed 4°C.

Weather data

This assessment methodology prescribes the use of the appropriate CIBSE Design Summer Year 1 2020, 50th percentile weather file for the location. The most appropriate weather file for the location of the Former Stag Brewery by proximity to the site is London Heathrow and has been used throughout this analysis.

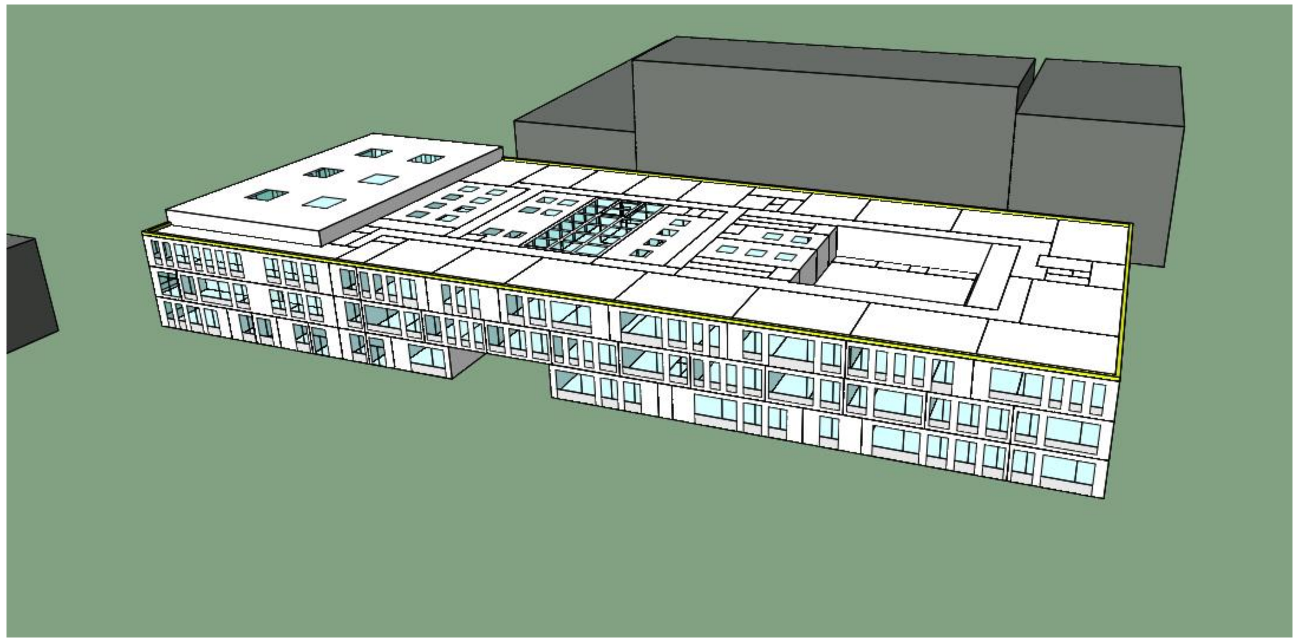

Figure 1: 3D model used within IES VE for analysis.

2. Geometry modelling and inputs.

2.1 Geometry modelling.

The geometry has been built based on drawings which have been issued by Squires & Partners. Additional information on the geometry and thermal properties are reported in Appendix B.

2.2 Internal gains.

Internal gains have been set to reflect the possible occupancy pattern and load during normal operation.

All the internal loads are based on a range of assumptions concerning occupancy density, profiles and internal gains. Actual conditions will in practice be reliant on factors which are highly user dependent. Results are therefore only an estimate of potential conditions.

Further details on the assumed loads, variation profiles and usage schedules are reported in Appendix B.

Internal blinds

Internal blinds are not included in this assessment.

2.3 Ventilation strategy

This section outlines the ventilation strategy.

Infiltration

A background infiltration rate has been included throughout the blocks to reflect an air permeability of 5 m^3/m^2 per hour @ 50 Pa m^3/m^2. The assumed value is 0.20 ac/h for each zone in accordance with the conversion tables in CIBSE Guide A.

Natural Ventilation

Additional natural ventilation is provided via openable windows. These are modelled as bottom-hung in accordance with the current design proposals, with a restricted opening of 100mm-200mm as outline in Appendix H.

Ground floor doors are also assumed to be openable for temperature regulation and are modelled with a maximum opening angle of 25°.

The windows and ground floor doors have been assumed open if:

- The room is occupied
- Internal dry bulb temperature exceeds 20°C and it is warmer inside than outside. This approach avoids bringing heat into the classrooms during particularly warm weather.

Mechanical Ventilation

Room-level mechanical ventilation with heat recovery (MVHR) units have been modelled to provide the required fresh air to all teaching and staff areas in accordance with the proposed mechanical services design. Further details about the proposed airflow rate have been reported in Appendix B.

Table 2 lists the different modelling parameters for ventilation strategy.

Table 2: Ventilation strategy.

Ventilation strategy			
	Airflow	Additional ventilation	Additional information
Local MVHR	12 l/s per person	Openable windows	Operating during occupied hours
Natural Ventilation	Determined by opening	-	Perimeter small group rooms
Infiltration		Infiltration of 0.20 ACH	

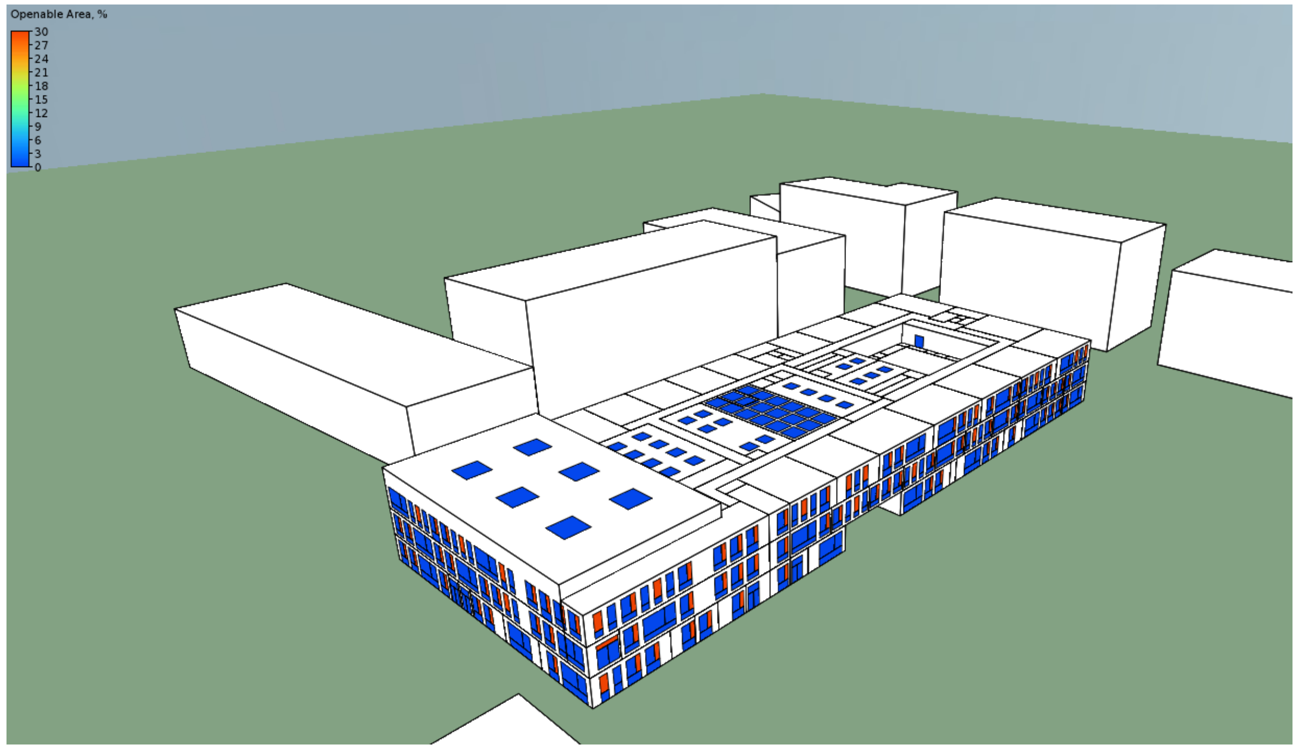

Figure 2: Window opening allocation.

3. Results.

A sample of occupied rooms were assessed against BB101(2018) for risk of overheating. All the analyses have been carried out in accordance with the relative standards and all the assumptions listed in this report and related appendices. Further information regards the assessment methods are reported in Appendix A.

Comfort expectation
The teaching and learning spaces have been assessed against the Category II comfort expectation. As outlined in BB101 this is appropriate for spaces with a normal level of activity such as teaching, study, exams, admin and staff areas.

It should be noted that pupils with complex health needs (e.g. non-ambulant pupils or those with medical conditions) may have a lower adaptive comfort threshold and an assessment of the individual needs should be undertaken if such pupils are expected to use the space.

3.1 Current weather.

BB101:2018
The thermal model has been used to assess the building against the BB101:2018 overheating criteria. In accordance with BB101:2018, the relevant weather file for this analysis is the DSY1 2020 scenario.

The results tabulated in Table 3 demonstrate that a proportion of the assessed rooms meet the requirements of Criterion 1 and therefore do not demonstrate compliance against BB101 using current weather data when assessed in accordance with the parameters set out in this report.

3.2 Future weather scenarios.

Future weather scenarios have also been tested up to 2080 to assess the risk of overheating under possible warmer weather conditions brought about by climate change.

A summary of results are shown in Table 3. Please refer to Appendix D for the full tabular results.

As shown in Table 3, overall compliance with BB101 is not achieved for future (2050 and 2080) weather scenarios. The 2050 and 2080 weather scenarios demonstrate a higher risk of short-term discomfort, as represented by the Criterion 2 (daily weighted exceedance) and Criterion 3 (maximum exceedance) metrics as anticipated due to warmer future weather conditions.

Table 3: Summary of results including future weather years.

Scenario	BB101 Crit 1 (Hrs ΔT ≥1°C)	BB101 Crit 2 (Max. daily degree hrs)	BB101 Crit 3 (Max ΔT)	Overall BB101 compliance
Current climate (2020)	15% (9/60)	15% (9/60)	15% (9/60)	15% (9/60)
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Future climate (2080)	10% (6/60)	0% (0/60)	3% (2/60)	10% (6/60)

4. Conclusion.

This report provides a summary of the overheating risk assessment undertaken for the proposed school being developed as part of the Former Stag Brewery masterplan.

A dedicated thermal model has been built in accordance with the information issued by the architect, Squire and Partners, and used to assess the proposed building against the overheating risk during occupied hours. The results discussed in the main body of this report respond to the 2018 criteria.

The analysis has been carried out in accordance with the respective standards and all the assumptions listed in this report and related appendices.

It should be noted that whilst industry guidance has been followed, results in practice are likely to be dependent on factors which are highly user dependent, such as occupancy levels, internal heat gains from equipment and user behaviour such as operation of windows.

The assessment has been undertaken using approved IES software which is an approved AM11 software.

4.1 Summary of results

The results demonstrate that all assessed rooms do not meet the requirements of Criterion 1 and therefore do not demonstrate compliance against BB101 using current weather data.

Future weather years

Future weather scenarios have also been tested up to 2080 to assess the risk of overheating under possible warmer weather conditions brought about by climate change. The assessed zones are shown to not meet the BB101 comfort criteria for the 2020, 2050 and 2080 weather years.

Comfort expectation

In accordance with BB101, the assessed areas have been assessed against a 'normal' level of comfort expectation. Pupils with complex health needs and medical conditions may experience a lower threshold for discomfort and an assessment of individual needs should be undertaken if it is known that the school will cater for such pupils.

Next steps.

The analysis has been undertaken at the equivalent design stage of RIBA Stage 2, to support the planning application of the school. Therefore, a number of assumptions have been made to complete the modelling as the level of detail is not currently available.

Furthermore, the design parameters used within this analysis and detailed within this report have been aligned with the Part L and daylight analysis in an attempt to balance thermal comfort, occupant wellbeing and resultant carbon emissions.

It is recommended that further analysis is carried out during detailed design once more detail can be determined. The mitigation strategy will follow the cooling hierarchy, i.e. seek passive measures in the first instance before considering active cooling in occupied spaces, and will need to be balanced between the energy strategy and daylighting analysis.

The following measures are advised, as a minimum, to be considered as part of the ongoing development of the mitigation strategy:

- Use of internal shading (e.g. blinds) – It would need to be confirmed that these would be installed prior to handover.
- Review of window openings – Where viable in regard to safety and security, increase the resultant free area. This can be achieved via bottom hung windows with an increased restriction, introduction of ventilation louvres.
- Glazing g-value – A lower g-value will reduce the level of solar gains coming into the occupied spaced. However, this can decrease positive solar gains in winter months resulting in an increase of carbon emissions.
- Increased external shading – The introduction of increased overhands, fins, etc. would reduce solar gains in the summer.
- Review of internal gains – The internal gains are currently assumed to be industry standard levels for the room use type. However, parameters such as number of occupants, room use profiles, heat loss from lighting and equipment can be improved upon but cannot be confirmed at this stage of design.

All measures listed above are considered as passive measures. Should a passive approach continue to demonstrate risk of overheating, non-passive measures such as cooling can be considered as a last resort.

Appendix A – Overheating overview.

What is Overheating?

Overheating within a space implies that occupants feel uncomfortably hot and that discomfort is caused by the indoor temperature of a space. The risk of overheating happens in a building either through poor design, bad management and/or inadequate services and results in an internal environment too warm for comfort. CIBSE state that most people begin to feel 'warm' at 25°C and 'hot' at 28°C. Contributing factors can include gains from occupancy, lighting, solar and electrical appliances.

Thermal comfort is subjective and complex. Essentially, thermal comfort is when an occupant is content with the ambient thermal conditions within the building. Thermal comfort can be shown on various scale through comfort research. The ASHRAE scale and the Bedford scale (not shown here) use numerical values to represent the comfort levels of occupants.

In contrast with Building Regulations Part L calculations, dynamic thermal modelling allows more complex assessments under a range of assumptions. This method allows for a more detailed approach which can include, amongst others, occupancy patterns, the use of blinds to control solar gain into a space and the operation of windows for natural ventilation.

BB101 and CIBSE TM52.

CIBSE TM52 is now a standard industry wide methodology for assessing overheating risk for use on all commercial projects. The guidance builds upon overheating criteria outlined in the following CIBSE documentation which has formed the basis of overheating assessments previously.

Overheating risk is based on the operative temperature which takes account of both ambient air temperature and the mean radiant temperature of materials. This gives a 'realistic feeling of temperature' that not only accounts for air temperature around a person in a space, but also recognises perceived comfort of hot or cold surfaces around the person.

BB101 is a recognised standard to investigate the overheating risk for teaching and learning spaces in schools. The BB101 and CIBSE TM52 requirements are described briefly below.

BB101 Overheating criteria.

The criteria for acceptable ventilation rates and conditions within education buildings are set out in Building Bulletin BB101. This assessment methodology has been used to test the teaching and learning spaces against the overheating risk.

The BB101 document has prescriptive ventilation rates (per occupant) for both natural and mechanically ventilated areas that are considered sufficient to maintain concentrations of CO_2 levels below the threshold limits. These rates will be provided as a minimum. However, it is generally accepted that these ventilation levels are not sufficient to remove internal heat gains and provide acceptable levels of temperature regulation within the occupied spaces. Therefore, this study has concentrated on demonstrating compliance with thermal comfort criteria with acceptable CO_2 control then being achieved by default.

The summertime overheating criteria as stated in BB101 is as follows:

Criterion 1: Total hours of exceedance (H_e)
For schools, the number of hours (H_e) that ΔT is greater than or equal to one degree (K) during the period 1st May – 30th September (ignoring school holidays) for the defined hours (09:00-16:00 with lunch break at 12:00-13:00 Monday to Friday) shall not exceed 40 hours.

Where sports halls are used for exam purposes, the duration for this activity shall be taken as weekdays 09:00-16:00 from 1st May – 8th July with a lunch break of 12:00-13:00. The criterion should be calculated for this period with the number of hours reduced from 40 to 18 hours.

Criterion 2: Daily weighted exceedance (W_e)
To allow for the severity of overheating, the weighed exceedance (W_e) shall be less than or equal to 6 in any one day.

Where $W_e = \Sigma h_e \times wf = (h_{e0} \times 0) + (h_{e1} \times 1) + (h_{e2} \times 2) + (h_{e3} \times 3)$

- wf = 0 if $\Delta T<0$, otherwise wf = ΔT
- h_{ey} = time in hours where wf=y.

Criterion 3: Upper limit temperature (T_{upp})
To set an absolute maximum value for the indoor operative temperature the value of ΔT shall not exceed 4°K.

Unlike TM52 which requires at least 2 of 3 overheating criteria to be achieved, BB101 requires Criterion 1 to be met, with the other two criteria reported for information.

The test period is 1st May - 30th September, Monday - Friday, 9am – 4pm as per the requirements of BB101.

BB101 prescribe the use of the DSY weather file to perform the overheating calculation.

CIBSE TM52.

CIBSE TM52 was released in 2013 and proposes broader definitions of comfort and describes alternative methods for assessing overheating risk in buildings. The guidance is intended primarily for naturally ventilated/free running buildings (i.e. have occupant operable windows as the predominant means of ventilation and no mechanical cooling).

Research has shown that comfortable room temperatures vary with the external air temperature. CIBSE TM52 follows the 'adaptive thermal comfort model' which works on the basis that in free running buildings (i.e. not mechanically ventilated or cooled), people will accept higher internal temperatures during parts of the year that are also hot outside.

To assess adaptive thermal comfort, three criteria are provided:

7. Hours of Exceedance
8. Daily Weighted Exceedance
9. Upper Limit Temperature

Criterion 1 – Hours of Exceedance (H_e)
The number of hours that the operative temperature (the temperature in the room) exceeds the threshold temperature (Tmax) by 1°C should be no more than 3% of occupied hours between 1 May and 30 September.

Tmax is a function of the running mean of external temperature (Trm), as follows: Tmax = 0.33 Trm + 21.8.

The intent of the criterion is to allow the internal temperature that's deemed to be comfortable (i.e. the threshold temperature, Tmax) to rise according to the external temperature, to account for people's willingness to accept higher internal temperatures during periods of high external temperature.

Criterion 2 –Daily Weighted Exceedance (W_e)
Criterion 2 deals with the severity of overheating, which can be as important as its frequency, the level of which is a function of both temperature rise and its duration. This criterion sets a daily limit for acceptability.

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

Where:

$W_e = \Sigma he \times wf = (h_{e0} \times 0) + (h_{e1} \times 1) + (h_{e2} \times 2) + (h_{e3} \times 3)$

the weighting factor wf = 0 if $\Delta T \leq 0$, otherwise wf = ΔT, and h_{ey}= time in hours when wf = y

Criterion 3. Upper Limit Temperature (T_{upp})
To set an absolute maximum value for the indoor operative temperature, the value of ΔT shall not exceed 4°C, i.e. the temperature in the room shall not be more than 4°C warmer than the adaptive target temperature for comfort.

Software used.

Dynamic Thermal Modelling simulates building physics interactions and predicts internal temperature of a building based on detailed hourly parameters, such as weather profiles, internal gains, solar gain, ventilation and other factors which define the thermal environment.

The assessment has been carried out using IES Virtual Environment v.2021.2.0.0 software. The software package is capable of undertaking fully dynamic thermal analysis and has been selected and applied in accordance with CIBSE AM11.

Appendix B – Technical parameters.

The following section details the inputs used to complete the BB101 assessments. These parameters have been set by BB101 2018 guidance and input from the design team.

Weather files.

The Design Summer Year (DSY) weather file has been created specifically for use within thermal comfort simulations. The procedure used to produce the DSY dataset is to analyse the weather data for the region during the period April to September over 23 years, the year with the third warmest period is then taken as the DSY weather file. The DSY can therefore be considered to be a warmer than average year, roughly equivalent to a "five-year event".

The most appropriate weather file for the location of the School by proximity to the site is London (Heathrow) and has been used throughout this analysis.

Building Fabric.

– The table below summarises the building fabric specification used in the thermal comfort modelling.

Exposed Floor U-value (W/m²K)	0.20
Spandrel panel U-value (W/m²K)	0.22
External Wall U-value (W/m²K)	0.20
Roof U-value (W/m²K)	0.20
Glazing U-value (W/m²K)	1.60
Glazing g-value	40%
Rooflight U-value* (W/m²K)	2.30 (g value: 55%)
Air Permeability (m³/h.m²) @ 50Pa	5.00

*Assessed in the vertical plane.

Internal heat gains.

Table 4 is a summary of the room heat gains applied to the thermal model. Heat gains and occupancy have been based upon a combination of BB101 guidance and the assumed FF&E. For the purpose of this assessment occupancy has been modelled in accordance with the proposed occupancy schedule.

Miscellaneous heat gain from equipment is taken to be 5W/m² in classrooms (based upon IT provision for 6 pupils). All pupils are assed to use tablet device during class, with the teacher using a data projector with speakers. Room includes one wireless access point. Internal lighting gain is assumed to be 7.2W/m² as recommended within BB101 guidance.

Table 4: Summary of room heat gains – occupied zones.

Area	Max Occupancy	Lighting (W/m²)	Equipment (W/m²)	Ventilation
Teaching spaces	20	7.2	5	12 l/s/person
Small group rooms	3	7.2	5	12 l/s/person
Main Hall	48	7.2	5	2.5 ach
Offices / admin	4.5 m²/person	7.2	15	12 l/s/person
Group rooms	3	7.2	5	12 l/s/person
Circulation	Transient	7.2	0	None
WCs, showers & hygiene rooms	Transient	7.2	0	Extract: 10 ach
Stores	Transient	7.2	0	10 ach (cleaners & medical)
Food preparation	5	7.2	25	12 l/s/person

Table 5: Occupancy gains as per BB101 2018 guidance.

Gain	Maximum sensible Gain (W/person)	Maximum Latent Gain (W/person)
Occupancy	70	55

Window openings.

Table 6: Opening data.

Window Type	Free Area (%)	Opening Profile
Large - openable panes	Side hung – 100 mm. 11% Gross Orifice area	T_{in}>20°C during occupied hours and T_{in}>T_{out}
Medium – openable panes	Side hung – 100 mm. 10% Gross Orifice area	
Small - openable panes	Side hung – 100 mm. 15% Gross Orifice area	

Appendix C – Design standards.

The BB101 document sets out regulations, standards and guidance on ventilation, thermal comfort and indoor air quality for school buildings. The most recent and applicable document revision was released in August 2018.

Regulatory framework.

Ventilation, thermal comfort and indoor air quality is covered applies to schools and the requirements are outlined in the following documents:

Building regulations Part F
Part F includes the requirements for providing adequate ventilation. The requirement is such that:

"there shall be adequate means of ventilation provide for people in the building"

For guidance on schools, Part F refers to BB 101. Part F does not make references to reducing risk of summertime overheating.

Building regulations Part L 2013
Part L (discussed in the next section) includes the Criterion 3 solar gain check, which requires that all occupied spaces meet a set solar gain target, which is defined by an equivalent notional building.

Criterion 3 is not considered as a pre-requisite to overheating risk as it does not include for the impact of heat gains from activities within a space such as heat gains from occupants and equipment. The proposed ventilation strategy is also not considered as part of the Criterion 3 check.

Building regulations Part C
Part C includes requirements for ensuring exposure to contaminants and moisture is minimised. Part C is not considered further in this analysis.

Department for education.

Performance standards for teaching and learning spaces
The Department for Education (DfE) sets the following performance standards for teaching and learning spaces which must be met for BB101 compliance:

1. When mechanical ventilation is used, outdoor air should be provided to ensure an average daily concentration of CO_2 of less than 1000 ppm during the occupied period is met
   a. The maximum concentration should not exceed 1500 ppm for more than 20 consecutive minutes each day when occupied
2. Where natural ventilation is used, sufficient outdoor air should be provided to ensure average daily concentration of CO_2 of less than 1500ppm during the occupied period is met.
   a. The maximum concentration should not exceed 2000 ppm for more than 20 consecutive minutes each day when occupied
   b. The system should be designed to achieve a CO_2 level for the majority of time less than
      i. 1200 ppm for a new building for the majority of occupied time during the year
      ii. 1750 ppm for a refurbished building for the majority of occupied time during the year

Minimum ventilation rates for spaces.

BB101 provides comprehensive guidance on natural, mechanical and hybrid ventilation strategies for schools.

This section provides a brief summary of the ventilation rates required for various space uses. This section should not be considered as a full review of BB101 and the reader is referred to the BB101 guidance document.

Table 7 below provides a summary of minimum ventilation rates that are required for various spaces.

Table 7: Minimum ventilation rates for school spaces (Source: BB101).

Room type	Ventilation type and rate
Office accommodation	– Ventilation in accordance with Part F – 10 l/s/person.
Print rooms	– Extract rate of 20 l/s per machine, exhausted outside the building. – If located in a separate room, it must be ventilated at the rate of 10 l/s/person when occupied as an office. – Cooling required to larger reprographics machinery.
Sanitary accommodation and washrooms	– 6 l/s per shower head/bath – 6 l/s per WC/urinal – Sanitary washrooms and accommodation where there is occupancy sor controls – 4 l/s/appliance.
Cleaners store	– Extract ventilation
Food and beverage preparation areas	– Intermittent air extract rate of 15 l/s when food is being prepared.
Specialist rooms	– Local exhaust ventilation is often required to deal with a specific process, heat source or pollutant source. – Laboratories over 70m^2 4 l/s/m^2 – Laboratories 37-70m^2 11.42 – (0.106 x area) l/s/m^2 – Laboratories less than 37m^2 7.5 l/s/m^2 – Chemistry store room 2 air changes per hour, 24 hours a day – Art classroom – 2.5 l/s/m^2 – Metal/wood/workshop – 2.5 l/s/m^2
Atria, circulation space and corridors	– Corridors should be ventilated via opening windows or vents.

Minimum ventilation rate for special educational needs and special schools can be found in Table 5.6 of BB101.

Thermal comfort.

The thermal comfort criteria for schools is based on the adaptive thermal comfort standards for free running buildings outside the heating season.

Performance standards for the avoidance of overheating

BB101 proposes the use of the adaptive method for assessing overheating risk. The adaptive comfort criteria applies to free running buildings. Examples include those without mechanical cooling and with means for occupants to locally alter conditions. Examples include an increase the ventilation rate by means of opening windows and by local room controls. Most schools are free running outside the heating season.

The adaptive comfort principle, as outlined in CIBSE TM52 was released in 2013.

The adaptive thermal comfort methodology is based on comparisons of the predicted air temperatures with a maximum acceptable room temperature calculated from the 'mean' outdoor temperature.

Overheating in spaces has previously been quantified by the number of occupied hours annually that the internal temperature exceeds a maximum temperature irrespective of external temperature. CIBSE TM52 uses adaptive comfort approach where the overheating threshold is not fixed but dynamic. Research has shown that comfortable room temperatures vary with the external air temperature and occupants are generally more accepting of warmer room temperatures if the weather is also warm outside.

Adaptive comfort criteria.

Three criteria for identifying risk of overheating have been developed and are detailed below. The first criterion (total hours of exceedance) defines a minimum requirement for the overheating risk assessment whereas the 2nd and 3rd criteria should be reported for information only. All three criteria are defined in terms of ΔT which is the difference between the actual operative temperature in the room at a time (T_{op}) and the limiting maximum acceptable temperature (T_{max}).

Criterion 1: Total hours of exceedance (H_e)

For schools, the number of hours (H_e) that ΔT is greater than or equal to one degree (K) during the period 1st May – 30th September (ignoring school holidays) for the defined hours (09:00-16:00 with lunch break at 12:00-13:00 Monday to Friday) shall not exceed 40 hours.

Where sports halls are used for exam purposes, the duration for this activity shall be taken as weekdays 09:00-16:00 from 1st May – 8th July with a lunch break of 12:00-13:00. The criterion should be calculated for this period with the number of hours reduced from 40 to 18 hours.

Criterion 2: Daily weighted exceedance (W_e)

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

Where $W_e = \Sigma h_e \times wf = (h_{e0} \times 0) + (h_{e1} \times 1) + (h_{e2} \times 2) + (h_{e3} \times 3)$

- $wf = 0$ if $\Delta T<0$, otherwise $wf = \Delta T$
- h_{ey} = time in hours where wf=y.

Criterion 3: Upper limit temperature (T_{upp})

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

Simulation parameters

To ensure consistency is achieved across the criteria and methodology, a number of assumptions must be applied to the assessed areas. The required parameters are detailed below:

Table 8: Simulation parameters to be assumed (Source: BB101).

Parameter	Value
Weather file	CIBSE Design Summer Year (DSY) 1 (50th percentile) 2020 weather file
Occupied hours	09:00 – 16:00, Monday to Friday Occupied throughout the summer period
External ambient CO_2 concentration	400 ppm
Occupancy gains	70 W sible heat gain, 55 W latent heat gain
Lighting gains	7.2 W/m^2
Equipment gains	Typical classroom – 10 W/m^2 (dependant on room type) Dedicated ICT rooms and practical room – 25 W/m^2
Ventilation rate	Maximum average air speed through a vent < 0.8 m/s Ventilation rates as per Table 7.

BB101 guidance performance standards for avoidance of overheating

To manage overheating effectively, it is important to allow for / consider the following for design and operation of the building:

- To allow relaxation of formal dress in hot conditions, encouraging individuals to adapt to conditions.
- Where disability exists, local cooling may be most appropriate to achieve comfortable conditions.
- Ventilation for warmer weather should be provided by using cross flow natural ventilation or ventilation systems with equivalent ventilation effectiveness and night cooling
  - Cross ventilation typically requires small ventilation openings compared to single side ventilation
- Mechanical ventilation should not be the sole method for mitigating overheating, natural ventilation should be provided.
- As a rule of thumb, openable windows for summertime ventilation should be sized so that the effective area is 35% of the floor area.
- Controls should be provided for the teacher to override the mechanical ventilation in each room
- Internal blinds should not interfere with ventilation
- Design should allow for air movement to be increase during summer through opening windows or vents, switching on fans or increasing rate of mechanical ventilation. Ceiling fans can be used in higher spaces where they cannot be reached.

Air quality and carbon emission concentration.

In addition to the general ventilation requirements of Section 6 of Approved Document Part F, the following performance standards for teaching and learning spaces which ensure compliance which ensure compliance with Regulation 6 of the Workplace Regulations on Ventilation. These standards must be followed if a school building is to comply with BB101 (2018).

Mechanical Ventilation

1. Sufficient outdoor air should be provided to achieve a daily average concentration of carbon dioxide (CO_2) of less than 1000 ppm during the occupied period.
2. The maximum concentration should not exceed 1500 ppm for more than 20 consecutive minutes each day during occupation.

Natural ventilation

1. Sufficient outdoor air should be provided to achieve a daily average concentration of CO_2 of less than 1500ppm during occupied hours.
2. The maximum concentration should not exceed 2000 ppm for more than 20 consecutive minutes each day during occupation.
3. The system should be designed to achieve a CO_2 level for the majority of the time of less than 1200 ppm for the majority of the occupied time.

Appendix D – Tabular results.

DSY1 2020.

ID	Room Name	BB101 Crit. 1 (Hrs ΔT ≥1°C) Max: 40	Crit 2 & 3 - For information only (Max. Daily Degree Hrs) Max: 6	(Max ΔT) Max: 4	Overall BB101 Compliance
1	00-Graphics	4	15	5	MET
2	00-Head Office	242	26	5	-
3	00-Int Rm	0	0	0	MET
4	00-General Office	206	31	7	-
5	00-Office-premises	0	2	1	MET
6	00-Kitchen	757	39	5	-
7	00-Seminar 02	673	49	8	-
8	00-DT SWR	215	14	3	-
9	00-Drama	89	11	3	-
10	00-Conference	446	69	15	-
11	00-Large GRP RM	26	21	6	MET
12	00-SEN CO	26	23	6	MET
13	00-Hygene Rm	103	15	4	-
14	00-Music Practice 01	763	133	18	-
15	00-Music Practice 05	763	93	13	-
16	00-Music Practice 02	763	134	18	-
17	00-Music Practice 03	763	130	18	-
18	00-Music Practice 04	763	98	14	-
19	00-Resistant MAT 1	62	21	5	-
20	00-Textiles	74	21	5	-
21	00-Head PA	23	23	6	MET
22	00-Reception	37	13	4	MET
23	00-Sick Rm	98	17	4	-
24	00-Art SWR	712	50	8	-
25	00-ART 2	7	8	3	MET
26	00-ART 3D	3	6	2	MET
27	00-ART 1 - SMALL	8	19	4	MET
28	00-Server	0	0	0	MET
29	00-Reprographics	6	4	1	MET
30	00-IT Tech	0	0	0	MET
31	00-Small GRP Rm 01	6	5	2	MET
32	00-Small GRP Rm 02	9	7	2	MET
33	00-Small GRP Rm 03	4	4	1	MET
34	00-Office 01	22	10	3	MET
35	00-Office 02	20	10	3	MET
36	00-Seminar 01	715	57	9	-
37	00-Office/ MTG	8	5	2	MET
38	00-ICT RICH 1	0	0	0	MET
39	00-ICT RICH 2	0	0	0	MET
40	00-Small GRP RM	2	3	1	MET
41	00-MI Room	7	6	2	MET
42	00-Music 2	109	25	5	-
43	00-Music 1	66	43	9	-
44	00-Resistant MAT 2	78	27	6	-

ID	Room Name	BB101 Crit. 1 (Hrs ΔT ≥1°C) Max: 40	Crit 2 & 3 - For information only (Max. Daily Degree Hrs) Max: 6	(Max ΔT) Max: 4	Overall BB101 Compliance
45	00-Staff Rm	756	66	9	-
46	00-SEN Resource	21	20	6	MET
47	00-Group Practice	763	93	13	-
48	01-Humanities 5	18	21	6	MET
49	01-Humanities 4	21	37	7	MET
50	01-English SWR	50	48	10	-
51	01-Office / Meeting 02	33	14	4	MET
52	01-ICT / Business 2	0	0	0	MET
53	01-ICT / Business 1	0	0	0	MET
54	01-Maths 6	99	34	8	-
55	01-Maths 7	169	37	9	-
56	01-Maths 8	285	40	9	-
57	01-Humanities 1	92	40	9	-
58	01-Humanities 2	164	54	11	-
59	01-Maths SWR	264	50	11	-
60	01-Office / Meeting 04	1	3	1	MET
61	01-Office	149	19	4	-
62	01-Office / Meeting 06	204	24	5	-
63	01-Office	149	19	4	-
64	01-Void Above Activity Studio	297	58	10	-
65	02-MFL 5	15	19	5	MET
66	02-6th Form Social	704	126	16	-
67	02-ICT / Business 5	0	0	0	MET
68	02-Seminar	700	79	12	-
69	02-Office	26	15	5	MET
70	01-Activity Studio	20	13	4	MET
71	01-English 1	17	25	6	MET
72	01-English 2	207	30	7	-
73	01-English 3	54	25	6	-
74	01-English 4	78	26	7	-
75	01-English 5	78	30	7	-
76	01-English 6	19	19	5	MET
77	01-English 7	32	19	5	MET
78	01-English 8	89	22	6	-
79	01-Learning Resources Centre	0	0	0	MET
80	01-Void Over Dance Studio	71	11	3	-
81	01-Maths 1	316	37	8	-
82	01-Maths 2	103	28	7	-
83	01-Maths 3	67	29	8	-
84	01-Maths 4	101	34	8	-
85	01-Maths 5	159	36	9	-
86	01-Humanities 3	46	33	7	-
87	01-Humanities SWR	758	68	10	-
88	01-Office	149	19	4	-
89	01-Office / Meeting 03	12	11	3	MET
90	01-Office / Meeting 05	0	2	1	MET
91	01-Office / Meeting 01	2	3	2	MET
92	02-6th Form Study	50	30	7	-

ID	Room Name	BB101 Crit. 1 (Hrs ΔT ≥1°C) Max: 40	Crit 2 & 3 - For information only (Max. Daily Degree Hrs) Max: 6	(Max ΔT) Max: 4	Overall BB101 Compliance
93	02-MFL 1	89	35	8	-
94	02-MFL 2	90	35	8	-
95	02-MFL 3	156	37	9	-
96	02-MFL 4	342	43	9	-
97	02-MFL SWR	762	83	12	-
98	02-ICT / Business 4	0	0	0	MET
99	02-ICT / Business 3	0	0	0	MET
100	02-Science SWR	652	60	10	-
101	02-Office / Meeting	23	16	4	MET

DSY1 2050.

ID	Room Name	BB101 Crit. 1 (Hrs ΔT ≥1°C) Max: 40	Crit 2 & 3 - For information only (Max. Daily Degree Hrs) Max: 6	(Max ΔT) Max: 4	Overall BB101 Compliance
1	00-Graphics	65	21	6	-
2	00-Head Office	134	17	5	-
3	00-Int Rm	0	0	0	MET
4	00-General Office	190	25	6	-
5	00-Office-premises	4	2	1	MET
6	00-Kitchen	113	11	3	-
7	00-Seminar 02	533	38	9	-
8	00-DT SWR	34	6	2	MET
9	00-Drama	60	9	3	-
10	00-Conference	505	62	13	-
11	00-Large GRP RM	149	26	7	-
12	00-SEN CO	153	28	7	-
13	00-Hygene Rm	62	12	4	-
14	00-Music Practice 01	702	94	19	-
15	00-Music Practice 05	673	68	13	-
16	00-Music Practice 02	698	95	19	-
17	00-Music Practice 03	699	93	18	-
18	00-Music Practice 04	679	73	14	-
19	00-Resistant MAT 1	228	28	6	-
20	00-Textiles	233	29	7	-
21	00-Head PA	93	22	6	-
22	00-Reception	54	13	4	-
23	00-Sick Rm	76	14	4	-
24	00-Art SWR	513	37	8	-
25	00-ART 2	54	13	4	-
26	00-ART 3D	39	13	4	MET
27	00-ART 1 - SMALL	102	25	5	-
28	00-Server	0	0	0	MET
29	00-Reprographics	7	4	2	MET
30	00-IT Tech	0	0	0	MET
31	00-Small GRP Rm 01	12	7	3	MET
32	00-Small GRP Rm 02	19	8	3	MET
33	00-Small GRP Rm 03	10	5	2	MET
34	00-Office 01	10	6	3	MET
35	00-Office 02	15	8	3	MET
36	00-Seminar 01	552	40	9	-
37	00-Office/ MTG	6	4	2	MET
38	00-ICT RICH 1	0	0	0	MET
39	00-ICT RICH 2	0	0	0	MET
40	00-Small GRP RM	11	7	3	MET
41	00-MI Room	23	8	3	MET
42	00-Music 2	263	32	6	-
43	00-Music 1	290	45	8	-
44	00-Resistant MAT 2	263	33	7	-
45	00-Staff Rm	521	38	8	-
46	00-SEN Resource	140	24	7	-
47	00-Group Practice	650	66	14	-
48	01-Humanities 5	128	26	7	-
49	01-Humanities 4	163	35	7	-
50	01-English SWR	244	44	9	-
51	01-Office / Meeting 02	102	20	5	-
52	01-ICT / Business 2	0	0	0	MET
53	01-ICT / Business 1	0	0	0	MET
54	01-Maths 6	288	41	9	-
55	01-Maths 7	363	45	10	-
56	01-Maths 8	436	48	10	-
57	01-Humanities 1	292	42	9	-
58	01-Humanities 2	389	56	10	-
59	01-Maths SWR	437	53	10	-
60	01-Office / Meeting 04	15	8	3	MET
61	01-Office	149	19	5	-
62	01-Office / Meeting 06	166	21	6	-
63	01-Office	149	19	5	-
64	01-Void Above Activity Studio	443	62	12	-
65	02-MFL 5	113	26	6	-
66	02-6th Form Social	698	111	18	-
67	02-ICT / Business 5	0	0	0	MET
68	02-Seminar	642	67	13	-
69	02-Office	151	25	6	-
70	01-Activity Studio	93	20	5	-
71	01-English 1	108	26	7	-
72	01-English 2	259	31	7	-
73	01-English 3	166	27	7	-
74	01-English 4	191	30	7	-
75	01-English 5	172	29	7	-
76	01-English 6	110	25	6	-
77	01-English 7	158	27	7	-
78	01-English 8	221	30	7	-
79	01-Learning Resources Centre	0	0	0	MET

ID	Room Name	BB101 Crit. 1 (Hrs ΔT ≥1°C) Max: 40	Crit 2 & 3 - For information only (Max. Daily Degree Hrs) Max: 6	(Max ΔT) Max: 4	Overall BB101 Compliance
80	01-Void Over Dance Studio	50	9	3	-
81	01-Maths 1	382	35	8	-
82	01-Maths 2	236	29	7	-
83	01-Maths 3	237	33	8	-
84	01-Maths 4	282	37	8	-
85	01-Maths 5	348	42	9	-
86	01-Humanities 3	235	37	7	-
87	01-Humanities SWR	639	53	11	-
88	01-Office	149	19	5	-
89	01-Office / Meeting 03	71	19	5	-
90	01-Office / Meeting 05	4	2	1	MET
91	01-Office / Meeting 01	23	9	3	MET
92	02-6th Form Study	206	36	8	-
93	02-MFL 1	243	38	8	-
94	02-MFL 2	242	38	8	-
95	02-MFL 3	291	39	9	-
96	02-MFL 4	400	45	9	-
97	02-MFL SWR	682	65	12	-
98	02-ICT / Business 4	0	0	0	MET
99	02-ICT / Business 3	0	0	0	MET
100	02-Science SWR	590	57	11	-
101	02-Office / Meeting	103	21	5	-

DSY1 2080.

ID	Room Name	BB101 Crit. 1 (Hrs ΔT ≥1°C) Max: 40	Crit 2 & 3 - For information only (Max. Daily Degree Hrs) Max: 6	(Max ΔT) Max: 4	Overall BB101 Compliance
1	00-Graphics	5	20	6	MET
2	00-Head Office	502	69	9	-
3	00-Int Rm	242	59	7	-
4	00-General Office	276	43	9	-
5	00-Office-premises	304	53	7	-
6	00-Kitchen	455	134	15	-
7	00-Seminar 02	763	189	21	-
8	00-DT SWR	461	83	10	-
9	00-Drama	254	66	8	-
10	00-Conference	569	117	24	-
11	00-Large GRP RM	65	39	9	-
12	00-SEN CO	85	47	10	-
13	00-Hygene Rm	428	63	9	-
14	00-Music Practice 01	763	231	28	-
15	00-Music Practice 05	755	155	19	-
16	00-Music Practice 02	763	234	28	-
17	00-Music Practice 03	763	225	27	-
18	00-Music Practice 04	760	165	20	-
19	00-Resistant MAT 1	97	31	7	-
20	00-Textiles	130	37	8	-
21	00-Head PA	80	52	11	-
22	00-Reception	346	52	7	-
23	00-Sick Rm	393	62	8	-
24	00-Art SWR	383	78	10	-
25	00-ART 2	11	12	3	MET
26	00-ART 3D	2	10	3	MET
27	00-ART 1 - SMALL	3	21	4	MET
28	00-Server	244	58	7	-
29	00-Reprographics	351	63	7	-
30	00-IT Tech	238	50	6	-
31	00-Small GRP Rm 01	340	56	7	-
32	00-Small GRP Rm 02	382	59	7	-
33	00-Small GRP Rm 03	315	50	6	-
34	00-Office 01	659	106	12	-
35	00-Office 02	632	98	11	-
36	00-Seminar 01	763	208	23	-
37	00-Office/ MTG	356	68	8	-
38	00-ICT RICH 1	176	46	10	-
39	00-ICT RICH 2	245	69	10	-
40	00-Small GRP RM	225	38	6	-
41	00-MI Room	278	44	6	-
42	00-Music 2	171	33	6	-
43	00-Music 1	49	46	9	-
44	00-Resistant MAT 2	65	35	8	-
45	00-Staff Rm	681	107	13	-
46	00-SEN Resource	102	47	10	-
47	00-Group Practice	735	173	21	-

ID	Room Name	BB101 Crit. 1	Crit 2 & 3 - For information only		Overall BB101 Compliance
		(Hrs ΔT ≥1°C)	(Max. Daily Degree Hrs)	(Max ΔT)	
		Max: 40	Max: 6	Max: 4	
48	01-Humanities 5	20	23	6	MET
49	01-Humanities 4	9	39	8	MET
50	01-English SWR	56	52	10	-
51	01-Office / Meeting 02	341	65	9	-
52	01-ICT / Business 2	245	131	15	-
53	01-ICT / Business 1	245	131	15	-
54	01-Maths 6	103	46	10	-
55	01-Maths 7	137	49	11	-
56	01-Maths 8	192	49	11	-
57	01-Humanities 1	74	46	10	-
58	01-Humanities 2	93	56	11	-
59	01-Maths SWR	228	57	12	-
60	01-Office / Meeting 04	188	30	4	-
61	01-Office	396	69	9	-
62	01-Office / Meeting 06	369	62	8	-
63	01-Office	396	69	9	-
64	01-Void Above Activity Studio	568	142	18	-
65	02-MFL 5	9	20	5	MET
66	02-6th Form Social	516	164	19	-
67	02-ICT / Business 5	245	163	19	-
68	02-Seminar	758	209	24	-
69	02-Office	255	40	7	-
70	01-Activity Studio	405	105	12	-
71	01-English 1	33	39	9	MET
72	01-English 2	224	48	10	-
73	01-English 3	112	43	9	-
74	01-English 4	127	41	9	-
75	01-English 5	131	44	9	-
76	01-English 6	23	24	6	MET
77	01-English 7	59	25	6	-
78	01-English 8	113	25	6	-
79	01-Learning Resources Centre	245	115	13	-
80	01-Void Over Dance Studio	348	70	9	-
81	01-Maths 1	286	67	14	-
82	01-Maths 2	177	62	13	-
83	01-Maths 3	114	54	12	-
84	01-Maths 4	127	53	12	-
85	01-Maths 5	153	53	12	-
86	01-Humanities 3	69	36	7	-
87	01-Humanities SWR	634	119	14	-
88	01-Office	396	69	9	-
89	01-Office / Meeting 03	206	28	5	-
90	01-Office / Meeting 05	433	105	12	-
91	01-Office / Meeting 01	205	34	4	-
92	02-6th Form Study	99	40	9	-
93	02-MFL 1	118	44	10	-
94	02-MFL 2	110	44	10	-
95	02-MFL 3	152	44	10	-

ID	Room Name	BB101 Crit. 1	Crit 2 & 3 - For information only		Overall BB101 Compliance
		(Hrs ΔT ≥1°C)	(Max. Daily Degree Hrs)	(Max ΔT)	
		Max: 40	Max: 6	Max: 4	
96	02-MFL 4	233	48	10	-
97	02-MFL SWR	575	109	13	-
98	02-ICT / Business 4	131	57	11	-
99	02-ICT / Business 3	163	61	12	-
100	02-Science SWR	519	120	15	-
101	02-Office / Meeting	181	22	4	-

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