

# Measuring Room Reverberation Time with the Classroom Reverb Survey Kit



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# Contents of Classroom Reverb Survey Kit

(Connevans part no. 85CRSK1)

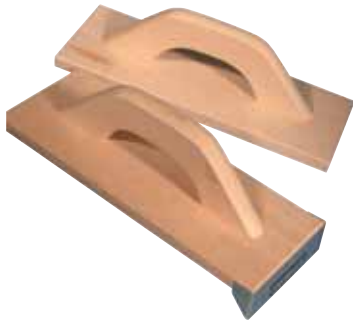
Carry case



Blue AC Meter  
with 4 x AAA batteries



Pair of wooden  
clapper boards



Ear defenders  
(Part no. 13EP6100)



Cleaning wipes  
(Part no. MRONTTIS)



Personal ear plugs  
(Part no. 13EP6400)



Ultrasonic/laser measure (*optional*)  
(Part no. 85B20)



## Contents

- 1 Introduction
  - 2 Using the wooden clapper boards to produce a sound impulse (bang)
  - 3 Hints on operating the blue AC meter
  - 4 Method for reverberation time (RT-60) measurement
  - 5 Switching off the AC meter
  - 6 Setting the “PH” auto off time
  - 7 Using the blue AC meter as a sound level meter (SLM)
  - 8 How to interpret the results
  - 9 Other AC meter settings
  - 10 Explanatory Notes
  - 11 Reference information
  - 12 Optional accessories
  - 13 AC Meter – Additional Information
    - How to fit the batteries
    - Automatic microphone calibration
    - Maintenance
    - Processor reset function
    - What the analogue SLM display looks like
- Appendix 1 Correction factor
- Appendix 2 Table of reverberation times extracted from Buildings Bulletin 93

# Classroom Reverb Survey kit for measuring reverberation time

## 1. Introduction

Using the Classroom Reverb Survey Kit, you can quickly and easily obtain a measurement to indicate whether the room clearly does or does not meet the requirements of BB93 or whether a full evaluation with more accurate equipment is required in order to be certain.

The Classroom Reverb Survey kit is sufficiently affordable that an education authority would be able to have a number of these kits generally available.

A Room Acoustics Measurement Package would be required to give accurate measurements for borderline cases, either as a central resource or by hire.

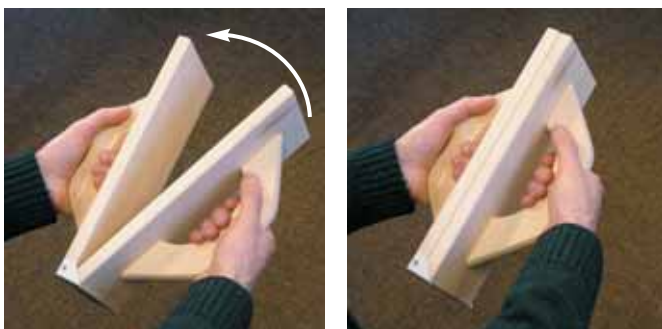
Survey kit method: The clappers are used to make a loud, short bang and the blue AC meter gives a reverberation time reading which can be noted down. This is done several times around the room and finally the figures are averaged and adjusted in conjunction with the correction factors which are included in this instruction booklet.

The measured result from the Classroom Reverb Survey Kit must be adjusted to convert it to the required BB93 value. Accuracy of the result is limited by the test method. Inherent accuracy is better at longer reverberation times, but the method can be difficult to use for reverberation times approaching 1 second. Accuracy is improved significantly by correcting the measured result as a function of room volume. Uncorrected accuracy should be taken as  $\pm 20\%$  but corrected accuracy is likely to be better than  $\pm 10\%$  (tbc). If the dimensions of the room are not known, it is still worth estimating the room volume and applying the correction factor.

## 2. Using the wooden clapper boards to produce a sound impulse (bang)



1. **WARNING** – Always use ear protection – never use the clapper boards without everyone in the room using ear protection.
2. Hold the clapper with the metal bracket (clapper 1) by the handle in your weaker (non-writing) hand.
3. Hold the other clapper (2) similarly in the other hand.
4. Place one end of clapper 2 into the metal bracket on clapper 1 so that the end edge of the wood touches against both the wood of clapper 1 and the metal bracket.
5. Whilst gently keeping the lower ends pressing together, slap the clappers together. You will need to use as much force as necessary to trigger the measurement on the blue AC meter .
6. It is important to keep the lower parts touching during this manoeuvre so that only one impulse (bang) is produced. If you release pressure on the lower end a double impulse may be produced which could invalidate the measurement.
7. When using the clappers, hold them quite flat pointing towards the the blue AC meter so that the sound wave travelling past will trigger it.



### 3. Hints on operating the blue AC meter

1. Like everything, although it's easy once you know how, using the blue AC meter is not intuitive and may be initially frustrating if you do not follow the instructions as given.
2. If you get into difficulty with the blue AC meter menu system, the easiest way of starting again is to let the meter switch itself off. Just put it down for a few minutes until the screen goes blank or follow section 5.
3. The instruction “press and release” means do not hold the key down for more than half a second or so.
4. The instruction “press and hold” means hold the key down until the display shows what is described in the instruction but then release the key immediately afterwards.
5. If you hold the key down for more than about 2 seconds after the described display mode is shown, the meter mode will change to something else and you will have to go round again.
6. Pressing and releasing the “Sel” key performs different functions, depending which part of the menu system you are in but eventually it will always take you back to the “CD” or “SOURCE” menu from where you can start again.



### 4. Method for reverberation time (RT-60) measurement

1. To switch on the blue AC meter: press and release the “Sel” key.
2. If the meter automatically switched itself off the last time it was used then it will start up in the mode that it was last in.
3. If the display shows “CD” or “SOURCE x”, then carry on to step 4. If the display is already in Sound Level Meter (SLM) mode as described below in step 4 then jump to step 5.
4. Hold the “Sel” key until the display mode changes to the Sound Level Meter (SLM) then release (either analogue bars or digital –depending on mode setting). You can recognise the analogue SLM mode by the line of numbers across the centre of the display (marked 45 to 95dB) and by talking to the meter and looking for two relatively slowly moving bar graphs underneath. The digital mode is obvious because the display shows XX.XdB.
5. Press and release the “F1” key twice to show “RT-60” in the display.
6. Hold the “F1” key until the display shows “RELEA KEY” then release. The meter is now in reverberation time (RT-60) mode. This mode is distinguished from the analogue SLM mode by the fast jumping bars below the line of numbers when a sound is made.
7. Place the AC meter in front of you where you can read the display, ideally at seated head height and preferably not with the meter microphone lying next to a flat surface (see picture).
8. Put on or insert ear protection – never use the clapper boards without everyone in the room using ear protection.  
**Note: BB93 recommends that only one person should be in the room when taking valid measurements.**
9. Move to a distance at least 1 metre away from the AC meter (typically between 1.5 to 2 metres) so that the AC microphone is pointing away from you and the clappers face the meter.
10. Create a single impulse (bang) using the clappers.
11. Observe the display





12. Providing the 'bang' is loud enough, the meter will show an RT-60 reading e.g. "**RT 420mS**". Make a record of this reading.  
*Note that if the RT-60 time exceeds 980msec/0.98 second (default, unless the AC meter has been programmed to measure a longer RT-60 time as mentioned in section 9) then the RT-60 time is displayed blank and the display reverts quickly to the measurement mode of fast moving bars.*  
 The RT-60 reading is displayed for about 4 seconds before the meter is automatically reset for another measurement.
13. If the bang is not loud enough to trigger the meter, the display will just show bouncing bars and you will have to use more force with the clappers and/or make sure that the clappers are roughly in line with the meter (i.e. not sideways on). In some (particularly large, reverberant) rooms it may be necessary to point the clappers towards the front of the AC meter at a shorter distance, although this may reduce accuracy of readings. This is a limitation of the fixed trigger threshold broadband impulse measurement method.
14. Repeat the measurement a few times in each of a number of locations around the room, noting the reading each time. The reading will vary each time due to statistical changes in impulse strength, measurement resolution and the position in the room. Typically the readings will vary by about  $\pm 40$  msec. This is why it is important to take a number of measurements in each location and around the room. If any result is very different from others then discard it as it is probably erroneous.
15. Calculate the average of all the similar readings to find the reverb time for the room.
16. In combination with the clapper impulse generator, the AC typically reads slightly low compared with the results from an accurate measurement system as explained in the notes of section 10, so adjust the averaged reading obtained according to the room size correction table in Appendix 1.
17. Unadjusted accuracy of the averaged RT-60 result should be taken as  $\pm 20\%$ . Adjusted accuracy should be taken as  $\pm 10\%$ , but may well be better than this.



**Quick Summary:**

<b>Short Sel</b>	(to switch on)
Display may show	"CD" or "SOURCE x", or SLM mode
If display shows	"CD" or "SOURCE x" then
<b>Long Sel</b>	from "CD" or "SOURCE x" to SLM mode
Otherwise:	from SLM mode
<b>Short F1</b>	(D-LOGGING mode)
<b>Short F1</b>	(RT-60 mode)
<b>Long F1</b>	(RT-60 start)

Use clapper boards to generate impulse

## 5. Switching off the blue AC meter

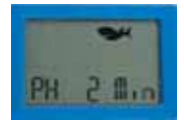
1. By default, the AC meter will automatically switch itself off after 30 seconds or 3 minutes (depending on current operating mode) since last key press or after the “PH” time set, if longer.
2. To switch off manually follow this procedure:
3. Cancel RT-60 mode and return to SLM mode by pressing and releasing the “Sel” key
4. From SLM mode, press and hold the “Sel” key until the display shows “CD”
5. Press and release the “Sel” key so that the display shows “SOURCE x”
6. Press and hold the “F3” key until the display shows “PWR OFF”
7. Release the “F3” key



*Quick Summary:* **Short Sel, Long Sel, Short Sel, Long F3, release**

## 6. Setting the “PH” auto off time

1. Switch the blue AC meter on (press and release the “Sel” key)
2. Press and hold the “Sel” key for 5 to 7 seconds until the display shows “SETUP AC” then release
3. Press the “R” or “L” keys either side of the “Sel” key as necessary until “PH” shows the required auto switch off time e.g. “PH 2 Min”
4. Press and release the “Sel” key to exit setup mode.



## 7. Using the AC meter as a sound level meter (SLM)

1. The AC meter is also an IEC-651 Type 2 sound level meter (when calibrated with an acoustic calibrator). The measurement range is 41dB SPL to 115dB SPL with A or C weighting.
2. A calibrated IEC-651 Type 2 SLM gives an accuracy over the normal acoustic frequency range and standard range of room temperature of  $\pm 1$ dB.
3. To switch on: press and release the “Sel” key
4. If the meter automatically switched itself off the last time it was used then it will start up in the mode that it was last in.
5. If the display shows “CD” or “SOURCE x”, then carry on to step 6. If the display is already in Sound Level Meter (SLM) mode as described below in step 6 then jump to step 7.
6. Hold the “Sel” key until the display mode changes to the SLM then release (either analogue bars or digital –depending on mode setting). You can recognise the analogue SLM mode by the line of numbers across the centre of the display (marked 45 to 95dB) and by talking to the meter and looking for two relatively slowly moving bar graphs underneath. The digital mode is obvious because the display shows XX.XdB.
7. The analogue mode display shows two scales. The top one is a fast response time (125 msec) and the lower one is a longer term average (1 sec), with the peak values held for the “PH” time. Resolution in analogue mode is 2dB. Press “Sel” to reset the peak indicators.
8. The resolution in digital mode is 0.1dB (but that doesn’t mean the accuracy is 0.1dB).
9. To change the SLM display mode, go to the “SETUP AC” display, as described in section 6.



10. Press and release the “F1” key to select A or C frequency weighting.
11. Press and release the “F3” key to select analogue or digital display.
12. Press and release the “Sel” key to return to SLM mode.

*Quick Summary:*    **Short Sel**                      (to switch on)  
    If display shows            “CD” or “SOURCE x” then  
    **Long Sel**                      from “CD” or “SOURCE x” to SLM mode

## 8. How to interpret the results

1. Refer to Table 1.5 of Section 1 of Building Bulletin 93 (see section 11 and appendix 2) to find the maximum RT-60mf time permitted for the room being measured.
2. Compare the averaged and corrected AC survey kit measurement result with the published maximum in BB93.
3. If the AC survey kit result is more than 90% of the published maximum then the room needs to be re-measured with an accurate reverberation time measurement system (also available from Connevens) but the probability is that it will need acoustic treatment to comply with the requirements of BB93.
4. If the AC survey kit result is less than 90% of the published maximum then it is safe to assume that the room meets the requirements of BB93, especially as RT-60 reduces when more people are in a room due to additional sound absorption.

## 9. Other AC meter settings

The maximum RT-60 time measurement is 980msec (0.98 sec) with 20msec resolution.

Note, however, when measuring long RT-60 times it can be difficult to get enough energy into a large room from the supplied clappers for a satisfactory measurement, so an alternative impulse device such as a balloon or starting pistol may be needed.

For larger rooms with longer reverberation times we recommend using a more capable measurement system such as our Room Acoustics Measurement kit (Pt.no. 85CRAMK1) – please contact customer services or visit [www.Connevens.co.uk](http://www.Connevens.co.uk) if you would like further information.

## 10. Explanatory Notes

The blue AC meter performs a reverberation time measurement over a broad frequency range therefore the frequency spectrum of both the impulse (bang) device and the reverberation time frequency spectrum of the room will affect the measured result.

For this reason the accuracy of the measurement is limited to survey use. Accurate measurements must be undertaken with a more capable measurement system that uses a different measurement method.

BB93 requires the reverberation time to be measured at frequencies of 500Hz, 1kHz and 2kHz and an average taken.

Typical rooms have longer reverberation times at low frequencies than at high frequencies therefore if a broadband impulse based measurement system is used the impulse device should provide less energy at low frequencies to counteract this typical room characteristic. [Note however, that accurate measurements on more capable systems should include low frequency characterisation of reverb times since long low frequency reverb times can cause masking of speech in a room that otherwise meets the basic requirements of BB93.]

The supplied clappers produce more energy in the frequency range of 500Hz upwards and, in our opinion, offer a reasonable compromise between portability, accuracy, ease of use and use of

consumables for testing typical teaching and study spaces. Bursting balloons and starting pistols will produce more low frequency energy so the typical broadband RT-60 result will be higher in a room with longer low frequency reverberation time when using these impulse sources.

It is not possible to change the trigger sensitivity of the AC meter; it is 40dB above the background noise or 77dB SPL, whichever is greater.

According to the requirements of BB93, the room should be occupied by only the one person doing the measurement.

If a soundfield or similar system is installed then the system should be switched on (with the microphone live) whilst the room is being tested. Ideally, the sound impulse source should be at a similar distance from the microphone as would be the human user but, given the limited accuracy of this measurement method, such detail is not warranted.

## 11. Reference information

The relevant reverberation time (RT-60mf) limits for teaching and other spaces in schools may be found in Table 1.5 of Section 1 of Building Bulletin 93, downloadable from

[www.teachernet.gov.uk/docbank/index.cfm?id=5649](http://www.teachernet.gov.uk/docbank/index.cfm?id=5649)  
or [www.connevans.com/acoustics](http://www.connevans.com/acoustics)

A Microsoft Excel file is available from <http://www.connevans.com/acoustics> that may be used to estimate the likely effect of room surface treatment required to bring the RT-60mf time within the recommendations of BB93. Room dimensions and other constructional data are required to use this file.

## 12. Optional accessories

Ultrasonic/laser measure (20m max)	Connevans part number	85B20
30 metre long tape measure	Connevans part number	85TAPE30
Reusable ear plugs	Connevans part number	13EP6400
Cleaning wipes (pack/50)	Connevans part number	MRONTTIS
Acoustic calibrator	Connevans part number	40SCR511E
Bag of round balloons	Call in at the local toy shop!	

## 13. AC Meter – Additional Information

### How to fit the batteries

To open the cover at the back of the AC meter use a small screwdriver. Do not try to open it with your fingernails because they may break.

Insert the screwdriver into the edge of one of the two curved cutouts (see pic 1).

Push the screwdriver down and lever up that end of the cover.

Repeat the procedure with the second slot then the cover can be lifted out.

Remove or fit 4 x AAA batteries as required, observing the correct polarity (see pic 2).



To close the cover again, place the cover over the battery compartment (slots pointing to the right side) with the tabs on the left side fitting into the corresponding slots. Then push the cover gently down on both slots (see pic 3).

*Note: It is only fair to point out that the batteries are likely to spring out of the meter as soon as the cover is opened and the new batteries will also need to be held in place while you put the cover back on.*

Batteries last about 50 hours.

Dispose of used batteries according to local Council regulations.

### Automatic microphone calibration

The built in AC microphone may be calibrated using a 'Microphone Calibrator' which reproduces a 1 kHz tone of 94 dB SPL.

Switch the AC meter on (press and release the "Sel" key)

Press and hold the "Sel" key for 5 to 7 seconds until the display shows "SETUP AC" then release

Hold the AC microphone into the acoustic port of the calibrator

Press the 'Sel' button for 2 sec to activate the 'Auto Calibration' function. If there is no 'Microphone Calibrator' applied the AC display will show the version number of the software and the calibration value will not be changed.

Press and release the "Sel" key to exit setup mode.

### Maintenance

Do not expose the AC to heat, sun, or water.

To clean the AC use a damp cloth. Do not use alcohol or any other cleaning substances.

The display should be cleaned only with soft fabric.

The AC does not require any special maintenance.

In case of difficulty refer to Connevens customer services.

## Processor reset function

If your blue AC meter does not react in any way, despite batteries being inserted, it most likely that the device is NOT broken but has crashed like any common computer does. In this case the AC processor must be reset.

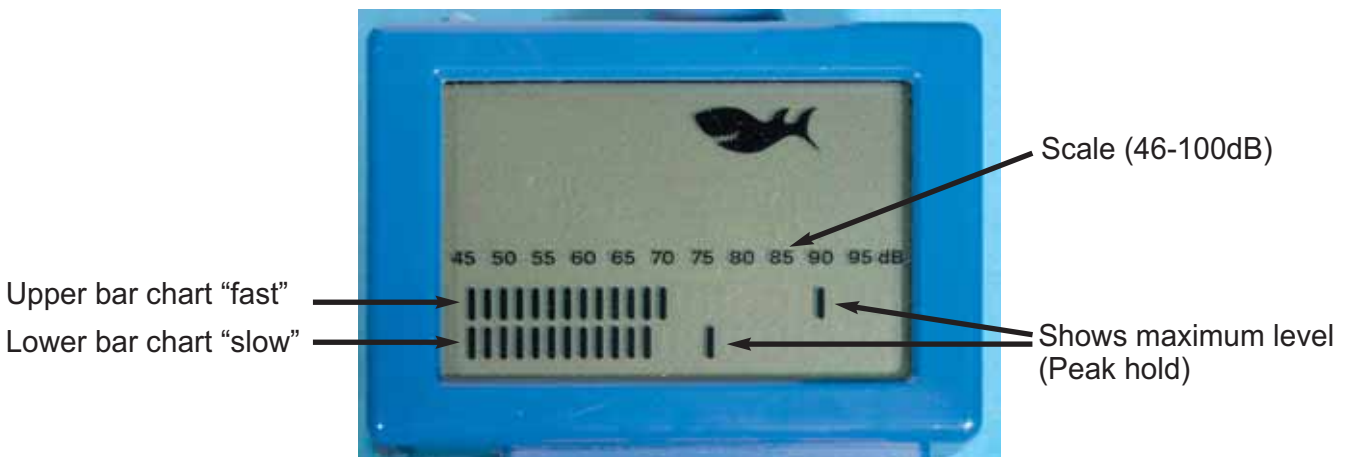
### To reset the AC processor:

Turn the AC meter over so that the COM socket shows downward and the display faces the table. Open the cover and take out the batteries as described at the beginning of this section.

Directly above the cross-head screw on the green circuit board you will see two small silver contacts.

Shortcircuit these contacts with the screwdriver. Replace the batteries in the case and close the cover. Now the AC should function again.

## What the analogue SLM display looks like:



## Appendix 1: Correction factor V0.2 December 2005

Note that the correction below only applies to the AC meter reading with the SLM weighting set to "C" (default) when using the supplied clapper impulse device to convert to the RT-60mf (500Hz-2kHz average) required by BB93. Accuracy after correction may currently be assumed to be  $\pm 10\%$  or as shown below, based on a statistical analysis of our current database. If the means to measure the room volume is not available, accuracy may still be improved by correcting the measured value as a function of value rather than as a function of volume.

### Room volume correction

Use this correction method if you have room volume measurements or a reasonable estimate of volume available

$$\text{RT60mf (corrected)} = R \cdot (1.23 - V/1421) \quad \{\text{valid for } 50 < V < 330 \text{ cubic metres}\}$$

where R is the averaged RT-60 reading from the AC meter and V is the room volume in cubic meters

$2\sigma$  accuracy = 9.4% for n = 15 (i.e. 95.4% of results would be expected to be within 9.4% of the true value based on a sample of 15 room measurements)

The following table may be used if you do not have a calculator available but the result will not be as accurate.

Room volume m <sup>3</sup>	50-100	100-200	200-300	300-400
Correction %	+15	+10	+5	0

### RT60 value correction

Use this correction method if you do not have room volume measurements available

$$\text{RT60mf (corrected)} = R \cdot (1.262 - R/4.21) \quad \{\text{valid for } 0.3 < R < 1 \text{ second}\}$$

where R is the averaged RT-60 reading from the AC meter

$2\sigma$  accuracy = 10.4% for n = 15 (i.e. 95.4% of results would be expected to be within 10.4% of the true value based on a sample of 15 room measurements)

*Please check <http://www.connevens.com/acoustics/ACsurvey> from time to time as these correction figures and formula will change as more statistical data becomes available.*

## Appendix 2: Table of reverberation times extracted from Buildings Bulletin 93

**Table 1.5:** Performance standards for reverberation in teaching and study spaces – mid-frequency reverberation time,  $T_{mf}$ , in finished but unoccupied and unfurnished rooms

\* Part E of Schedule 1 to the Building Regulations 2000 (as amended by SI 2002/2871) applies to teaching and learning spaces and is not intended to cover administration and ancillary spaces (see under Scope in the Introduction). For these areas the performance standards are for guidance only.

### NOTES ON TABLE 1.5

**1** Common materials often absorb most sound at high frequencies. Therefore reverberation times will tend to be longer at low frequencies than at high frequencies. In rooms used primarily for speech, the reverberation times in the 125 Hz and 250 Hz octave bands may gradually increase with decreasing frequency to values not more than 30% above  $T_{mf}$ .

**2** For very large halls and auditoria, and for halls designed primarily for unamplified music rather than speech, designing solely in terms of reverberation time may not be appropriate and specialist advice should be sought. In large rooms used primarily for music, it may be appropriate for the reverberation times in the 125 Hz and 250 Hz octave bands to gradually increase with decreasing frequency to values up to 50% above  $T_{mf}$ . For more guidance see Section 5.

**3** Assembly halls, multi-purpose halls, lecture rooms and music performance/recital rooms may be considered as unfurnished when they contain permanent fixed seating. Where retractable (bleacher) seating is fitted, the performance standards apply to the space with the seating retracted.

Type of room	$T_{mf}^1$ (seconds)
Nursery school playrooms	<0.6
Nursery school quiet rooms	<0.6
Primary school: classrooms, class bases, general teaching areas, small group rooms	<0.6
Secondary school: classrooms, general teaching areas, seminar rooms, tutorial rooms, language laboratories	<0.8
Open-plan	
Teaching areas	<0.8
Resource areas	<1.0
Music	
Music classroom	<1.0
Small practice/group room	<0.8
Ensemble room	0.6 - 1.2
Performance/recital room <sup>3</sup>	1.0 - 1.5
Recording studio	0.6 - 1.2
Control room for recording	<0.5
Lecture rooms <sup>3</sup>	
Small (fewer than 50 people)	<0.8
Large (more than 50 people)	<1.0
Classrooms designed specifically for use by hearing impaired students (including speech therapy rooms)	<0.4
Study room (individual study, withdrawal, remedial work, teacher preparation)	<0.8
Libraries	<1.0
Science laboratories	<0.8
Drama studios	<1.0
Design and Technology	
• Resistant materials, CAD/CAM areas	<0.8
• Electronics/control, textiles, food, graphics, design/resource areas	<0.8
Art rooms	<0.8
Assembly halls, multi-purpose halls (drama, PE, audio/visual presentations, assembly, occasional music) <sup>2,3</sup>	0.8 - 1.2
Audio-visual, video conference rooms	<0.8
Atria, circulation spaces used by students	<1.5
Indoor sports hall	<1.5
Gymnasium	<1.5
Dance studio	<1.2
Swimming pool	<2.0
Interviewing/counselling rooms, medical rooms	<0.8
Dining rooms	<1.0
Ancillary spaces	
Kitchens*	<1.5
Offices*, staff rooms*	<1.0
Corridors, stairwells	See Section 1.1.6
Coats and changing areas*	<1.5
Toilets*	<1.5