Noise is simply categorised as unwanted sound. In order to assess the impact of the surrounding environment, such as roads/motorways, factories, airports, etc, on people, noise assessment can be carried out. These assessments will typically involve the monitoring of sound over a set time period using a sound level meter with an A-weighted filter.

The A weighting is used to simulate the response of the human ear with respect to the various audible frequencies, and is defined in EN 61672-1:2013 [1] and BS 8233:2014 [2].

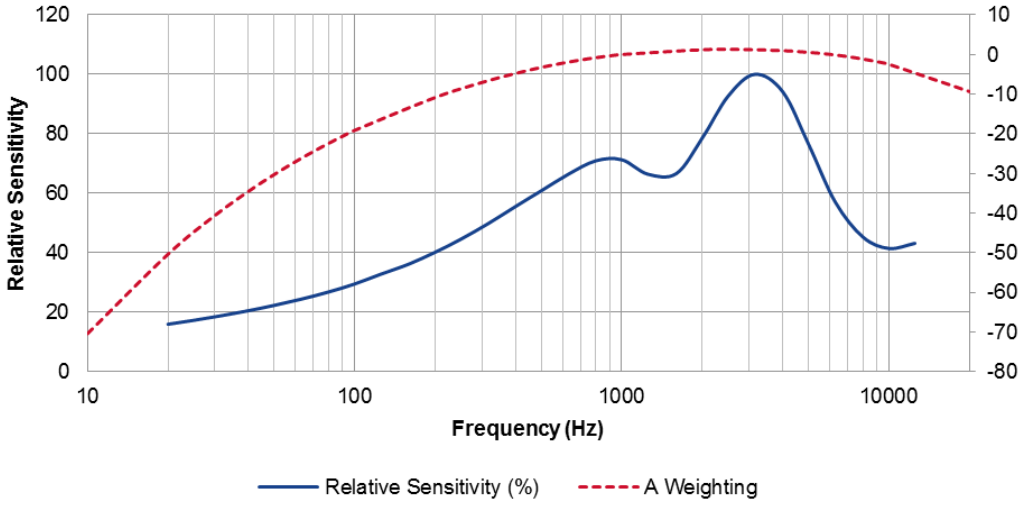

Figure 1 - Figure 8 8 - A-weighting adaptation and human hearing sensitivity

In addition, octave band sound pressure levels can also be measured to provide more information relating to the specifics of the noise at the location, and enable glazing, and other façade elements to be more appropriately selected.

Requirements can be determined through either weighted values (dBA and Rw) or by octave bands, with the latter offering a more accurate assessment of the likely internal noise levels.

DETERMINING REQUIREMENTS BY WEIGHTED PERFORMANCE

It would be expected to be the responsibility of an acoustician to provide a weighted performance value to meet the requirements for an internal noise level against a noise incident on the façade. Typically, all elements within a façade would be expected to meet the minimum requirements, and glazing and vents are often considered the weakest element.

As an example, a noise level at the façade of 64 dBA needs to be reduced to a 35 dBA internal noise level. Therefore, all elements would be expected to provide, at minimum, an Rw of 29 dB.

This assessment doesn't consider the performance at different frequencies or internal conditions, and so, as per BS 8233:2014, this would be considered to be a rough estimation. 5 dBA is stated as the likely level by which the internal noise level is underestimated by this method, and a recommendation is in place, that if within 5 dBA of the target noise level, a more complex assessment is carried out.

DETERMINING REQUIREMENTS BY OCTAVE BAND PERFORMANCE

As above, a more complex method involves estimating the internal noise level based on the whole façade construction. Façade elements have acoustic performance measured in different ways, and for glass and glazing, this is discussed in document **Acoustics 3A**.

Some elements, including wall constructions, often have standard values based on construction, which can be used when assessing whole façade performance. For glass and glazing, performance is typically provided for both octave band and weighted performance.

In order to determine the requirements for each element, the requirements for the façade must also be determined. The façade performance will be a combination of each element, typically, walls, windows and trickle vents. Roofs and floors can also be included when required and applicable.

ATTENUATION OF WHOLE FAÇADE

An estimation of the acoustic performance of a façade against outdoor sound can be determined by assessing in accordance with EN 12354-3:2000 [3] and BS 8233:2014 [2]. This allows façade elements and interactions to be considered with regards to areas and interfaces.

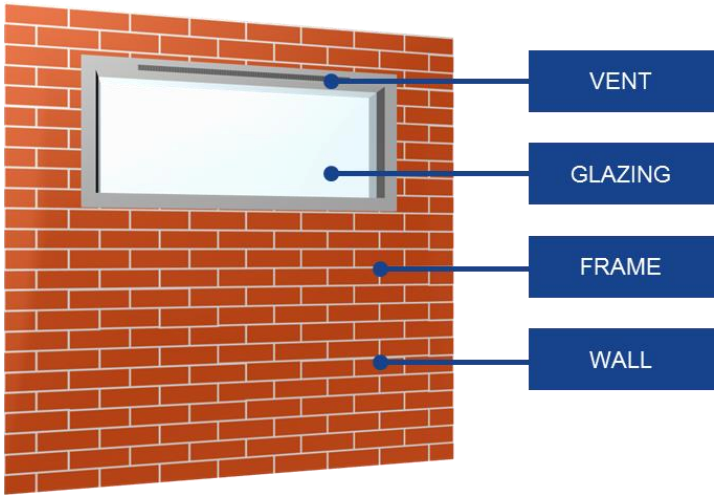

Figure 2 - Facade elements

INFLUENCES OF GLAZING ON OVERALL PERFORMANCE

In order to demonstrate the influence of the glazing, the following example calculation, based on EN 12354-3:2000 and BS 8233:2014 is shown. Taking the weighted noise level from previous, and looking instead at the octave band values, the noise, measured over a period of 18 hours, corrected at the 2 metres from the façade, is as below;

Table 1 - Octave band noise levels at facade

Noise Level (dB)	Octave Band Frequency (Hz)						Noise Level (dBA)
	125	250	500	1000	2000	4000	
2 m from Façade, $L_{1,2m}$	61	62	63	58	56	53	64
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1	
A-Weighted	44.9	53.4	59.8	58	57.2	54	

The room under consideration has a volume of 40 m^2, with a 10 m^2 façade, of which 2 m^2 is glazing and the remainder is double brick wall. A trickle vent is also included. The room must achieve an internal noise level of 35 dB(A) over the duration of the measurement period. Performance for the various elements is as follows;

Table 2 - Facade element example performance

Element	Octave Band Frequency (Hz)						Noise Level (dBA)
	125	250	500	1000	2000	4000	
Trickle Vent	37	36	35	36	34	32	37
Double Brick Wall	44	45	46	52	55	58	50
Glazing 4(16)4, uPVC Frame	25	18	26	38	42	37	32

Based on this information, and with consideration to the factors present within the standards, the following internal noise levels can be calculated;

Table 3 - Resultant frequency based internal noise levels

Noise Level (dB)	Octave Band Frequency (Hz)						Noise Level (dBA)
	125	250	500	1000	2000	4000	
2 m from Façade, $L_{1,2m}$	61	62	63	58	56	53	64
Internal, L_2	34	41	36	27	26	25	37

From the above, the internal noise level (L_2) is 37 dBA, and so above the required. In order to improve on this consideration should be given to areas where the façade, specifically the glazing in this case, underperforms. As can be seen on the following chart, at lower frequencies, the dip in glazing performance corresponds to the frequencies where noise levels are higher.

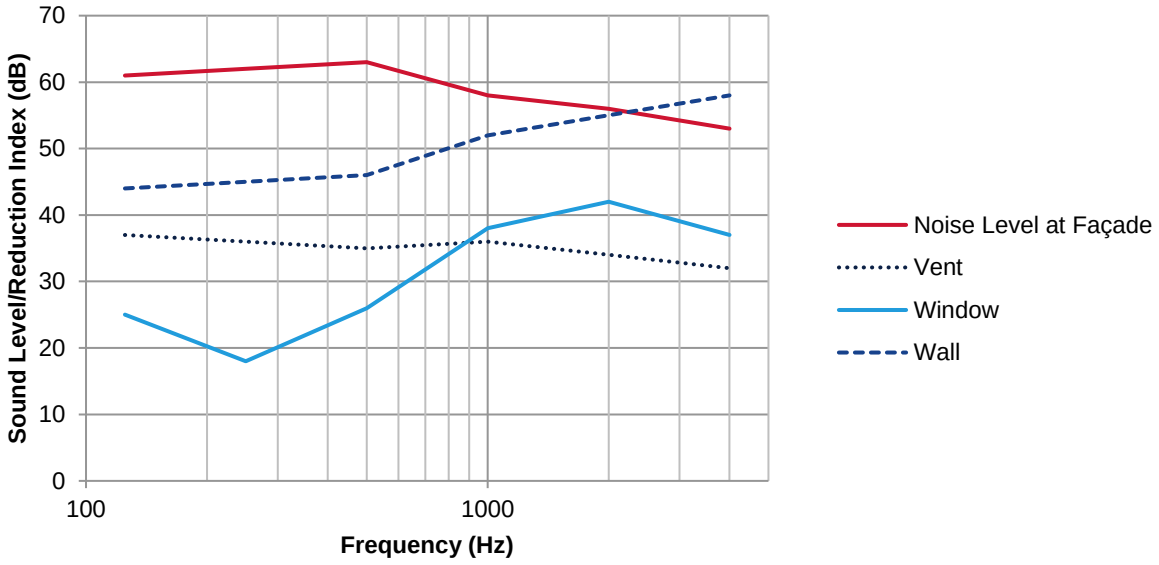

Figure 3 - Facade noise and element noise reduction

An alternative glass specification requirement can be generated, based on other elements remaining the same.

Table 4 - Alternative specification noise reduction

Noise Level (dB)	Octave Band Frequency (Hz)						Noise Level (dBA)
	125	250	500	1000	2000	4000	
2 m from Façade, $L_{1,2m}$	61	62	63	58	56	53	64
Requirement	32	37	38	35	36	38	---
10(24)14.8A	33	37	44	45	44	54	---
Internal, L_2	15	23	29	26	27	27	34

The use of thicker glazing will offer improved attenuation at lower frequencies, and an acoustic interlayer within a laminate, will improve performance at mid to high frequencies. This is discussed in more detail in **Acoustics 3B**. As above, this provides an internal noise level below the 35 dBA required.

NOISE LIMITATIONS

The noise levels within various buildings, for various activities and times of day, are defined by BS 8233:2014 [2]. For example, dwellings have the following requirements:

Table 5 - BS 8233:2014 noise limitations

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living Room	35 dB $L_{aeq,16hour}$	---
Dining	Dining Room/Area	40 dB $L_{aeq,16hour}$	---
Sleeping	Bedroom	35 dB $L_{aeq,16hour}$	30 dB $L_{aeq,16hour}$

Other requirements apply for buildings with other uses, and are defined within BS 8233:2014.

For partitions within offices, some guidance is provided within BS 5234-1:1992 [4], including minimum sound insulation performance levels for various locations.

GLAZING SELECTION

When selecting glazing based on acoustic performance, there are two main criteria to consider, weighted values and octave centre band values. Testing of acoustic performance in accordance with ISO 10140-2:2010 [5], previously ISO 140-3:1995 [6], will produce third octave band centre frequency values, from which octave band centre frequency values can be calculated, as well as weighted values, Rw, Rw,C and Rw,Ctr, in accordance with ISO 717-1:2013 [7].

REFERENCES

[1] European Committee for Standardization, *EN 61672-1:2013 - Electroacoustics. Sound level meters. Specifications,* CEN, 2013.

[2] British Standard Institute, *BS 8233:2014 - Guidance on sound insulation and noise reduction for buildings,* BSI, 2014.

[3] European Committee for Standardization, *EN 12354-3:2000 - Building acoustics. Estimation of acoustic performance in buildings from the performance of elements. Airborne sound insulation against outdoor sound,* CEN, 2000.

[4] British Standards Institute, *BS 5234-1:1992 - Partitions (including matching linings). Code of practice for design and installation,* BSI, 1992.

[5] International Organization for Standardization, *ISO 10140-2:2010 - Acoustics - Laboratory measurement of sound insulation of building elements - Part 2: Measurement of airborne sound insulation,* ISO, 2010.

[6] International Organisation for Standardization, *ISO 140-3:1995 - Acoustics - Measurement of sound insulation in buildings and of building elements - Part 3: Laboratory measurements of airborne sound insulation of building elements,* ISO, 1995.

[7] International Organization for Standardization, *ISO 717-1:2013 - Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation,* ISO, 2013.