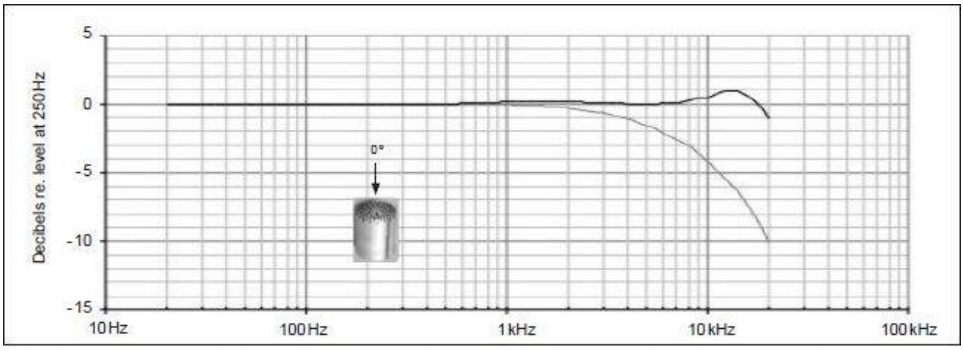
iDB® and iVIBE® Microphone Orientation

Sound or noise measurements are generally undertaken using a free-field microphone which is designed to measure the sound pressure in the sound field whilst compensating for its presence in the sound field. In effect, the microphone measures the sound pressure as it existed before the microphone was introduced in the sound field, in other words *free-field* conditions. A free-field microphone is suitable for use in open spaces.

There are other types of measurement microphone, namely *pressure-field*, and *random-incidence*. These microphones behave similarly at lower frequencies but differently at higher frequencies above a few kHz.

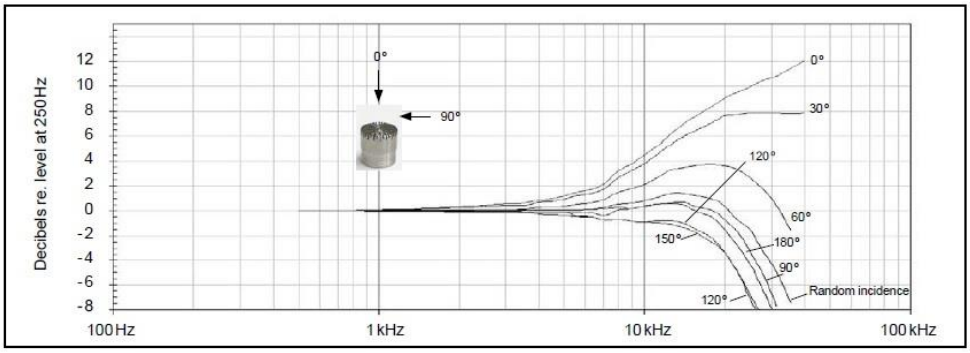


Typical frequency response of a Class 1 free-field microphone.
Upper curve shows free-field response for 0°, lower curve shows pressure-field response.

A pressure-field microphone is designed to measure the sound pressure in front of its diaphragm. It is suitable for use in an enclosure, or cavity, which is small when compared with the sound's wavelength, and where the sound has the same magnitude and phase at any position in the field. Pressure-field microphone applications include testing the pressure exerted on walls, on airplane wings, or inside structures such as tubes, housings, or cavities.

Random-incidence or diffuse-field microphones respond uniformly to sounds arriving simultaneously from all angles. However, for most microphones, the pressure and random-incidence responses are similar, so pressure-field microphones are often used for random-incidence measurements too.

Note that, when used as a free-field microphone, angle of incidence correction factors must to be applied to pressure-field and random incidence microphones.



Typical pressure microphone free-field corrections for different angles of incidence

The relevant international standard for sound level meters is IEC 61672. This defines Class 1 and Class 2 performance levels when a free-field microphone is pointed towards the sound source at a 0° angle of incidence. The standard also recognizes that microphones are directional and it gives acceptance limits (Table 2) for deviations from the performance design goal due to the microphone's directional response.

Freq. kHz	Class 1	Class 2
0.25 to 1	1.5 dB	3.0 dB
>1 to 2	2.0 dB	4.0 dB
>2 to 4	4.0 dB	7.0 dB
> 4 to 8	7.0 dB	12.0 dB
> 8 to 12.5	10.0 dB	

extract from EN 61672-1 Table 2 showing maximum absolute values of deviation from design goal for directional response at 90 degree angle of incidence

For sound level measurements performed in accordance with IEC 61672-1, the sound level meter is supposed to be pointed towards the source (0° incidence).

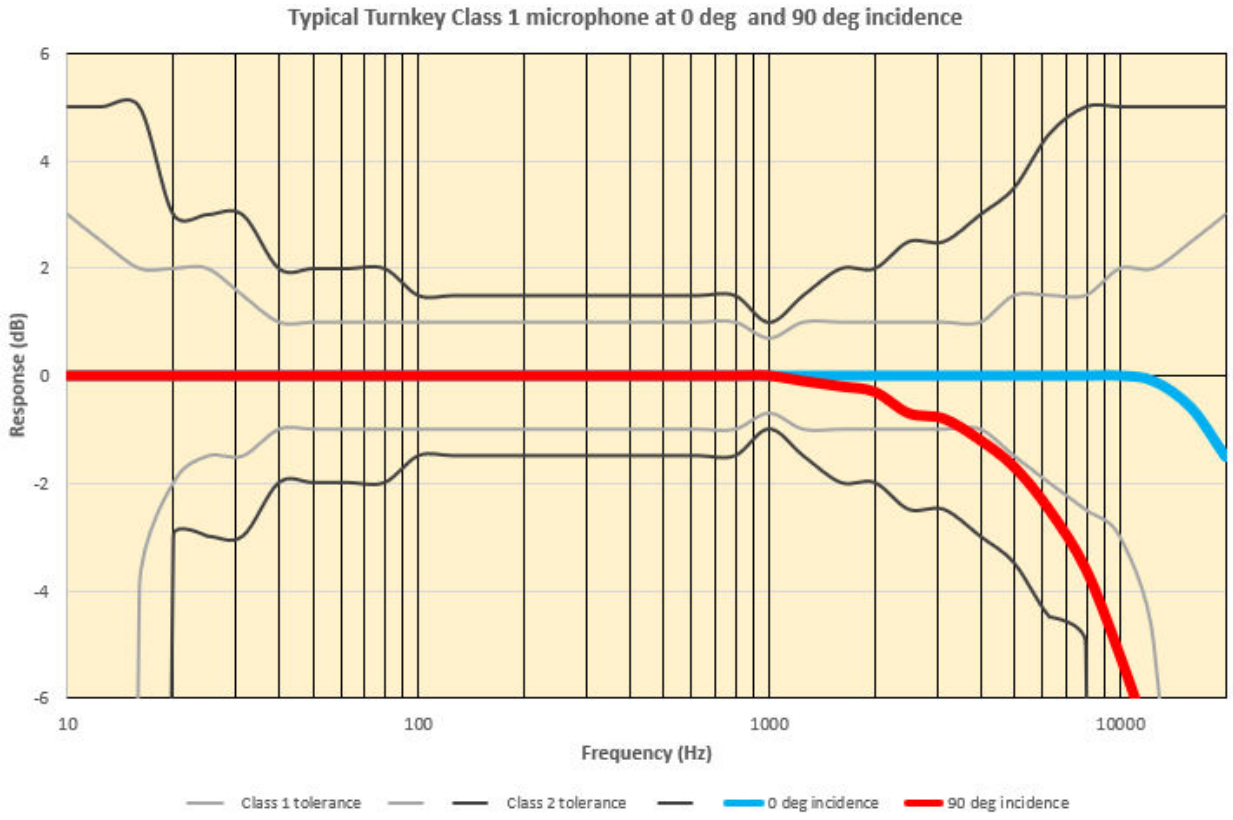
Clearly, when an operator is present (but not in the sound field), the microphone can be pointed at the sound source in accordance with international standard.

However, this is not the case for unattended monitoring when multiple sources are measured with a random angle of incidence with respect to the microphone. Noise generated by construction sites, factories, ground transportation, leisure activities, etc., could come from all directions, although, in the main, horizontally.



It follows that if the microphone is mounted vertically (either pointing up or down) all horizontally located sound sources will have a 90 degree angle of incidence to the microphone. Importantly, the angle of incidence remains the same regardless of horizontal location of the sound source.

To assess the impact of mounting the microphone vertically consider the following chart which shows a typical Turnkey Class 1 microphone response when mounted at 0 degree and 90 degree angles of incidence to the sound source.



As expected higher frequencies are affected most, with a loss in response of -12 dB at 20 kHz for 90º incidence. The 90º response falls outside the Class 1 tolerance for frequencies above 4 kHz.

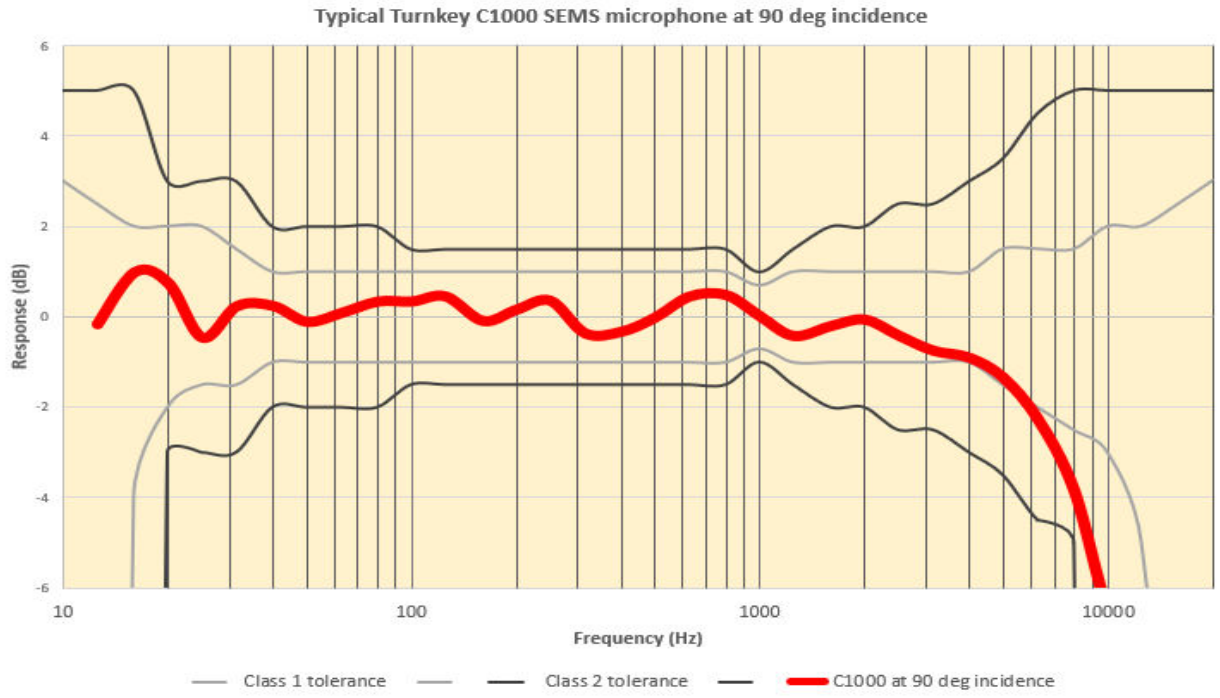
However, It is clear that although no longer meeting the requirements of IEC 61672 Class 1, the Turnkey Class 1 microphone, when mounted at 90 degrees to the sound source, still meets the performance requirements of Class 2.

IEC 61672 Class 2 performance is adequate for long term noise monitoring of construction sites and most long term environmental surveys.

The next chart shows the 90º incidence performance of the Turnkey C1000 MEMS microphone which employs a rugged MEMS (MicroElectroMechanicalSystem) sensing element which has a linear response to 130 dB SPL, extended low frequency response down to 6 Hz (-3 dB), dynamic range of 99 dB, and typically 31 dBA of self-noise.

The C1000 uses an acoustic sensor fabricated on semiconductor production lines from silicon wafers using highly automated processes. This assures excellent reproducibility between microphones, for example the sensitivity tolerance between C1000's is better than ±1 dB and the temperature coefficient is less than 0.005 dB/ºC.

The frequency response of the C1000 microphone is not as flat but is still good enough to maintain Class 2 performance at 90 degree incidence



We conclude that, for unattended noise monitoring, placing the microphone vertically is the best compromise when the sound sources are not localized but spread over a wide horizontal area.

Note, in principle, a pressure-field microphone could be used to give Class 1 performance at 90º incidence but such a microphone would not meet Class 1 or Class 2 performance at 0º incidence unless significant correction factors were applied.

For more information please visit:

www.iVIBE.UK

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