Instrumentation today

1. Instrumentation and its Uses

A sound level meter is an instrument designed to respond to sound and to give objective, reproducible measurements of sound pressure level.

The microphone converts the sound signal into an equivalent electrical signal. The electrical signal produced by the microphone is very small, typically:

20 dB	3 µV
40 dB	30 µV
60 dB	300 µV
80 dB	3 mV
100 dB	30 mV
120 dB	300 mV
140 dB	3 V

The microphone signal is amplified before the signal can be processed. Several types of processing may be performed on the signal. The signal may pass through a weighting network. These weighting networks sensitivities vary with frequency in the same way as the human ear, thus simulating the equal loudness contours. This has resulted in three internationally standardised characteristics termed the “A”, “B”, and “C” weightings.

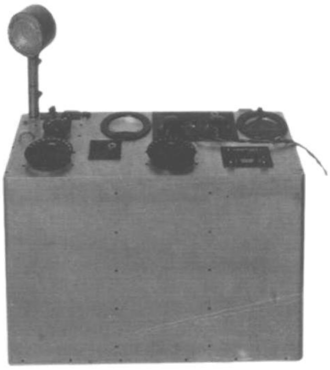
The “A” weighting network weights a signal in a manner which approximates to an inverted equal loudness contour at low L_P’s, the “B” network corresponds to a contour at medium L_P’s and the “C” network to an equal loudness contour at high L_P’s. Nowadays the “A” weighting is almost exclusively used.

Most sound level meters also have a linear LIN network. This does not weight the signal and enables the signal to pass through unmodified. After the signal has been weighted the resultant signal is amplified and the Root Mean Square (rms) value determined in an rms detector. The rms is a special kind of mathematical average value. It is used because its value is directly related to the amount of energy in the sound being measured. The last part of a Sound Level Meter is the display either analogue or digital.

Integrating, Averaging Sound Level Meters

Taking instantaneous sound pressure measurements has its limitations in that in most cases noise does fluctuate quite considerably. To overcome this problem, it is important to obtain an average over a period of time ($L_{eq,T}$). This either requires a lot of hard work (many measurements and calculations) or an integrating sound level meter, such as the Castle SONUS (GA216i).

2. A Brief History of Sound Level Meters



- The first Sound Level Meter (1930's)
- **IEC 123: 1961** Electroacoustics
    - Recommendations for Sound Level Meters
- **BS 3489: 1962** Sound Level Meters
    - (Industrial Grade)
- **BS 4197: 1967** Sound Level Meters
    - (Precision Grade)
- **BS EN 60651:1994** (IEC 651: 1979)
    - Sound Level Meters
- Still based on analogue displays
- Was originally BS 5969: 1981Now replaced by IEC61672:2002

3. IEC 61672:2002

IEC 61673 is the current standard governing how sound level meters should perform. It is split into 3 parts; Part one details the requirements for a sound meter to be classified under the standard, part 2 covers pattern evaluation to allow independent organisations to verify that a type of sound meter is ok to be classified to the standard and part 3 covers verification of individual instruments to ensure that they are still within the specifications. The classification system is simplified from IEC651 into Class 2 and Class 1 (class 1 being the higher specification)

4. Accuracy of Sound Level Meters in IEC61672:2002

The accuracy of a sound meter is dependent upon the frequency and level of sound being measured, but as a guide, the linearity can be checked by inputting 2 signals, no more than 10dB apart. The resulting level should be within this range.

Readings	Class 1	Class 2
Inside primary indicator range,1 to 10 dB	± 0.6 dB	± 0.8 dB

5. Time Weightings: Slow (S), Fast (F), Impulse (I), Peak (P)

Most sounds that need to be measured fluctuate in level. To measure the sound properly we want to be able to measure these variations as accurately as possible. However, if the sound level fluctuates too rapidly, analogue displays change so rapidly it is difficult to get a meaningful reading. For this reason, two detector response characteristics are standardised. These are known as Fast(F) and Slow(S).

If the sound to be measured consists of isolated impulses or contains a high proportion of impact noise, then the normal “F” or ”S” time responses are not sufficiently short to give a measurement which is representative of the subjective human response. For such measurements the Impulse (I) response is used. This gives a better perception and measurement of impulsive noise.

Although the perceived loudness of a short duration sound is lower than that of steady continuous sound, the risk of damage to hearing is not necessarily reduced. For this reason the Peak Level may be measured independent of sound duration.

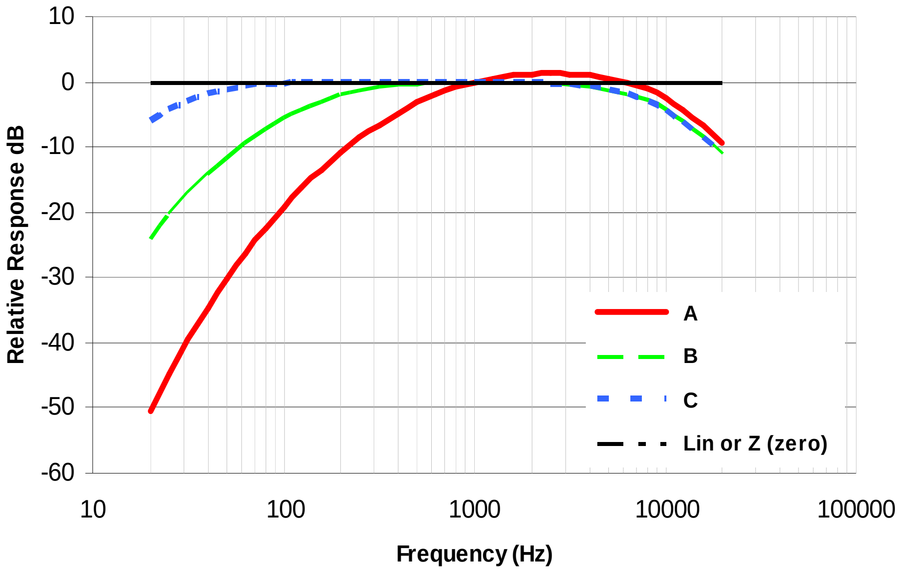
The four responses in *increasing speed order* are S, F, I, and P.

- **Slow** T = 1 second, equal rise and fall time
- **Fast** T = 125 ms, equal rise and fall time, rms
- **Impulse** T = 35 ms for a rising signal, T = 1.5 s for a falling signal
- **Peak** 100 µs pulse produces a deflection of no more than 2 dB down than would be produced by a 10 ms pulse of equal peak amplitude.

Peak is usually used with a maximum hold feature to enable the transient pulse to be captured for display. Note that “S”, “F”, and “I” will give the same reading for a steady state signal.

If the signal is not steady state the “I” response will be higher than “S” or “F” which will always be the same. Peak is an entirely different type of measurement and does not give an rms measurement.

6. Frequency Response, A, B, C, Lin



The figure shows “A” and LIN frequency weighting. These are the two main weightings used, although occasionally “B” and “C” weighting are used.

7. Dynamic Range and Crest Factor

Dynamic range is the maximum measurable L_P minus the minimum L_P measurable for each of the instrument ranges.

Crest Factor (CF) is the ratio of PEAK to RMS: **CF = Peak / rms**

8. Calibrators

Most International and British Standards call for the calibration of the sound level meter to be checked before (and after) each series of measurements. This is normally done with a portable calibrator. These fall into two main categories, the pressure calibrator known as a piston phone and the more common electro-acoustic calibrator.

Most electro-acoustic calibrators produce a fixed sound level at a single frequency, typically 94 dB @ 1 kHz. A piston-phone produces an oscillating change in air pressure in a fixed volume cavity. Portable calibrators are used for field work. The sound level meter should be recalibrated, traceable to a national standard annually by the manufacturer.

- **BS EN 60942: 2003**
  - Electro-acoustics - Sound Level Meters (Sound Calibrators) 2nd Edition
    - Class O, 1 and 2 Accuracy levels
    - Class 1 ± 0.3 dB, Class 2 ± 0.5 dB
    - Originally BS 7189: 1989 (IEC 942: 1988)

9. Advanced Function Standards

- **BS EN 60804: 2001**
  - Integrating, Averaging Sound Level Meters.
    - How $L_{eq,T}$ is calculated
    - Tolerance of calculations
    - Accuracy of measurements
    - Testing conformity
- Was originally BS 6698: 1986

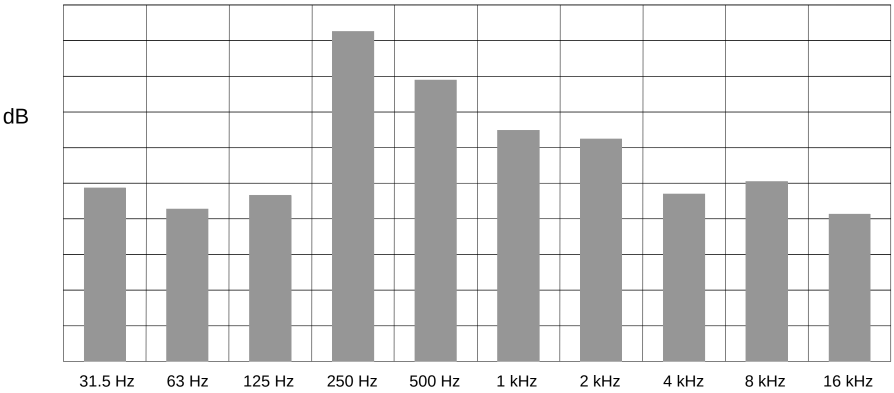
10. Dosemeters

To efficiently measure the exposure to noise of any individual, you must measure the actual noise that the person is receiving at the ear, to do this a dosemeter could be used, such as the Castle GA257. This type of instrument has a microphone that can be located near the ear and by measuring the sound levels can display the dose% that the individual has received. The GA257 can also estimate dosages for extended time periods based upon the measurements taken.

- **BS EN 61252: 2002**
  - Personal Sound Exposure Meters
    - Accuracy and Tolerance
    - Reference to IEC 651 Type 2
    - Calculation of Pa^2h
    - Testing Conformity
    - Was originally BS 6402: 1994

11. Octave Band Measuring

An octave band sound level meter measures sound levels over many different frequencies at the same time, called an octave band. Typical octave bands would range from 31.5 Hz to 16 kHz.



12. Hearing Protection Data

The other task you are likely to want to undertake as part of a noise at work survey is to look at hearing protection, whether to assess existing hearing protection already in use, or to establish what kinds of hearing protection might be suitable for a given job. There are 3 ways to do this and the measurements you take will be determined by what you decide to do.

- SNR – Single Number Rating method
- HML – High, Medium and Low (Frequency) method

- Octave Band – Using Octave Band attenuation data

The Single Number Rating method is an appealing one to use as it looks simple on the face of it. You should, however be very wary of this approach as it does not take any account of the frequency of sound an employee is exposed to and this can make a huge difference to your results. Hearing protection works much better at high frequency than low and this is why some of this variation should be accounted for. To use the SNR method, the Rating number for the protector is subtracted from the ‘C’ weighted Leq, so you have to measure that separately anyway! You then add 4dB if you want to follow the HSE guidance as this is designed to adjust the result for problems of fitting, wear and tear and the varying shapes of human ears

- ‘C’ weighted Sound Pressure or Leq required
- 4dB ‘real world’ correction at the end

The HML method is a great way of taking into account the performance variation over different frequencies and requires the ‘C’ weighted Leq as well as the ‘A’ weighted Leq and uses the difference between this and the ‘C’ weighted level (a bigger difference means more low frequency sound!). There is a formula for working out the protection level in the booklet from the HSE “Controlling Noise at Work L108” which can be downloaded from the HSE website. There is also a calculator on that site at this link http://www.hse.gov.uk/noise/calculator.htm which will do the job for you!

It is a really good idea if using either of these methods to have a sound meter that can measure the ‘A’ weighted and the ‘C’ weighted Leq sound levels at the same time. You will also find that the decent ones will have software available to do the HML calculations for you! The Castle SONUS meters are perfect for this –

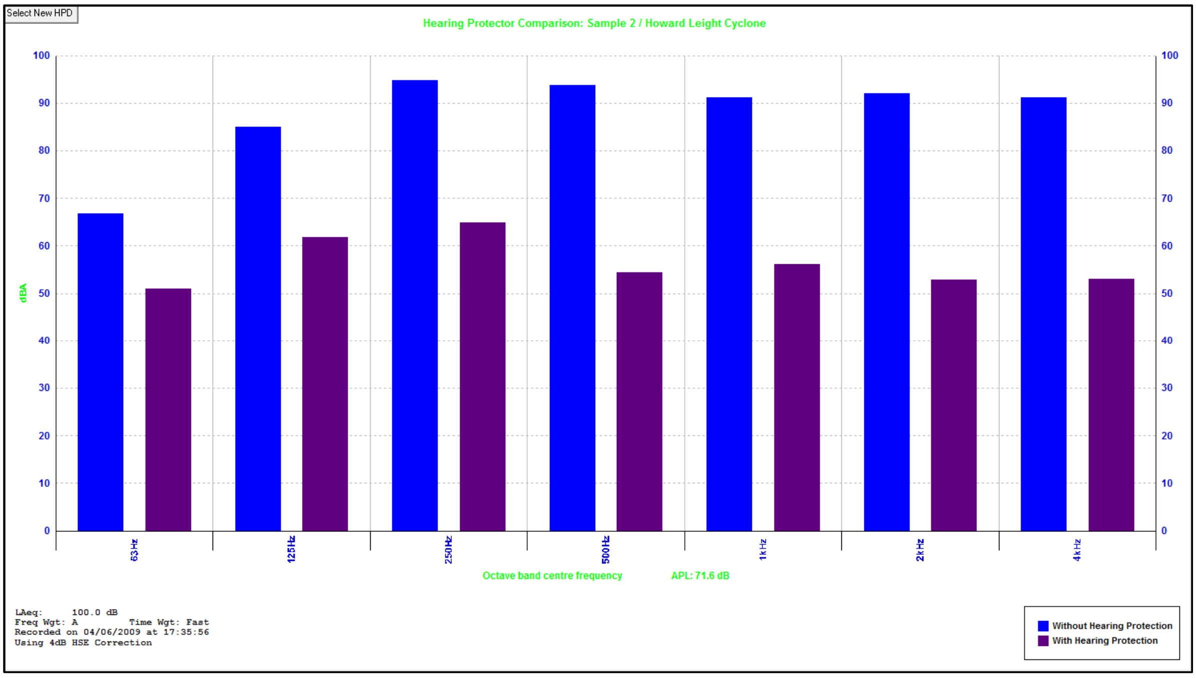
http://www.castlesafetyshop.com/noise-meters/industrial-noise-meter-kits/nk001-logging-sound-meter-system.html.

- ‘A’ weighted Sound Pressure or Leq
- ‘C’ weighted Sound Pressure or Leq
- Use formula, HSE calculator or sound meter software
- 4dB ‘real world’ correction

Using the Octave Band Method requires use of a sound meter that can measure in octave bands. Using this method is certainly the most accurate method of calculating the effect of using a particular ear defender in a given environment. You will need to measure the ‘A’ Weighted Leq in octave bands, which will give you 8 or more levels at different frequencies. Your chosen hearing protection will have a table of data with it, stating how much it will reduce the sound level at each frequency. From here, it’s simply plugging that into the HSE calculator http://www.hse.gov.uk/noise/calculator.htm, or using your sound meter software to come up with the answer. The Castle GA141 series meters do everything you need for octave band hearing protection. The picture below shows how this looks in dBdata PC software for the sound meters.

http://www.castlesafetyshop.com/noise-meters/industrial-noise-meter-kits/safety-advisor-sound-meter-kit.html.

- ‘A’ weighted Leq or Sound Pressure in Octave Bands
- HSE Calculator or Sound meter Software
- 4dB ‘real world’ correction



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LAeq:      100.0 dB
Freq Wgt: A          Time Wgt: Fast
Recorded on 04/06/2009 at 17:35:56
Using 4dB HSE Correction
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What you will get at the end of the process with each of these is a single number representing the residual sound level at the ear after the hearing protection. This number should certainly be lower than the Limit value in the regulations of 87dB and should ideally be between 70 and 75dB.