Using sound level meters in general and the Nor 110 with mode 14 in particular

General

Sound level meters are normally calibrated in dB units based on a typical microphone sensitivity for ½" microphones of around 50 mV/Pa (50 millivolts per Pascal).

Many sound level meters will measure vibration if the microphone can be replaced with an accelerometer using a suitable mechanical adaptor like the B&K JJ 2615 which terminates in a microdot connector or a Norsonic 1447 adaptor that has a BNC connector. Switch off the meter and carefully remove the microphone capsule from the preamplifier, do not remove the microphone protection grid under any circumstances. Then connect the input adaptor in place of the microphone.

When measuring acceleration, the convention is not to use dB levels, but 'g' or ms^{-2} (metres per second squared). Accelerometers come in a variety of sizes and sensitivities, so it is necessary to calibrate [or normalise] the meter.

Nor 110 analysers fitted with option 14 include hand-arm weighting networks and whole body filters according to the British & International Standards. The Nor 110 is also able to analyse down to 1 Hz, a feature not found in many sound level meters. If a Nor 1505 IPC accelerometer set is used, this plugs directly into the 7-pin preamplifier socket of the Nor 110 instead of the normal microphone preamplifier. If you are using charge amplifiers, then the Nor 110 BNC line input socket may be used.

These notes may also be read in conjunction with other meters as the general principles apply and once calibrated we can read the acceleration levels from the dB to vibration chart supplied at the rear of this brochure.

Calibration

It is usual to calibrate a sound level meter with a calibrator or key in the sensitivity given in the microphone calibration chart.

Microphone calibration values are in mV/Pa and/or dB re 1V .... for example 50 mV/Pa = -26.0 dB re 1V.
A calculator will quickly convert from one to the other – for example 20 log (50/1000) = -26 dB.

Accelerometers are similar, except the sensitivity is given in mV/g or mV/ms^{-2} ** . So if the value, for example was 50mV/g then the sensitivity would have been the same as the microphone ... i.e. –26 dB re 1V.

Similarly if the level given in the calibration certificate is $5mV/ms^{-2}$ then the sensitivity would be 20 log (5/1000) = -46 dB and this would be the value to be keyed into the Nor 110 or similar meter.

The Nor 110 with mode 14 enables the use of both dB and engineering units - toggle the F4 key to switch between absolute units and dB levels – see also the table at the back of this document, which lists the different suffixes.

Using the Nor 110 select MODE 8 CALIBRATION, then select the SENS = position and key in the accelerometer sensitivity using the formulae: xdB = 20log(s/1000) where s = mV/g or mV/ms^{-2}.

When you enter the dB level the sensitivity in mV will be displayed next to it - so you can check your sums.

Alternatively if you have a calibrator giving say $10ms^{-2}$ then apply the calibrator and select the Nor 110 AUTO - CALIBRATION position. Key in the dB level given in the chart at the back of this document - for example 10 ms^{-2} or 10g = 114 dB.

If you are not using a Nor 110 meter, then modify the above instruction to suit your particular instrument.

> NOTE - some calibrators state the calibration level in PEAK values not RMS. Sound level meters measure RMS, so subtract 3 dB (i.e. 111 dB in the example given). This correction is valid for sinusoidal signals.

Once a Nor 110 or similar meter have been calibrated for use with an accelerometer using one of the above procedures then read the vibration values from our Conversion Chart - for example 100 dB = 2 ms^{-2} or 'g' and 40 dB = 0.002 units

Some meter sensitivities are not adjustable; they are set for the specific microphone delivered. The simplest solution here is to apply a vibration calibrator like the B&K 4294 with the meter set to Linear. If the dB level for 10 ms^{-2} is say 103dB then draw a new point of the Conversion Chart at 10 = 103 dB. Now 20 dB is a factor of 10 to 1 so we can also plot another point at 1 = 83 dB. Join the points up and extend the graph parallel to the existing curve. Use the new 'curve' to read vibration values directly from your meter.

** Converting Charge to Voltage sensitivity is discussed in some detail at the end of this document.

Measurement

Using a Nor 110, measurements may be made in the LEVEL , FREQUENCY or TIME MODE.

Acceleration

Read the values directly with the Nor-110 Mode 14 or use the graph at the end of this document to read off the acceleration for any measured dB value. Precise values may de calculated using the formula Engineering units = antilog (dB/20) x 0.00002

Velocity and Displacement

Using the Nor 110 real time filtering down to 1Hz you can establish the vibration v frequency characteristic. Knowing the acceleration at a given frequency, you can read the velocity and displacement from the vibration nomogram at the end of this document. Alternatively divide the acceleration value by 2λf to get velocity and divide the velocity by 2λf to get displacement. For the spreadsheet wise, velocity [2λf] is –6 dB per octave slope applied to the acceleration graph and displacement [2λf] x [2λf] is a -12 dB per octave slope.

Vibration Dose - according to BS 6841 (ISO 2631)

Having carried out weighted vibration measurement using the Nor 110 with option 14 it is then necessary if you require Vibration Dose values to take into account the duration of the vibration and the number of events during the period of interest i.e. the working day etc.

According to the standard the vibration dose may be calculated according to the formulae

$$eVDV = [\ (1.4 \times a)^4 \times b\ ]^{1/4}$$

where eVDV is the estimated vibration dose value
a is the rms value in ms-2
b is the duration in seconds

The correction value of 1.4 given in the formulae in BS 6841 has been determined empirically from typical vibration environments having low crest factors and this procedure will under-estimate the true vibration dose value when the crest factor exceeds about 6.0.

The Nor 110 may be used to estimate the crest factor i.e. PEAK - LEQ, but where there is any doubt the idealised formulae should be used

$$VDV = \left(\int_0^T a^4(t)dt \right)^{1/4}$$

where

VDV is the vibration dose value in $m\text{-}s^{-1.75}$

a(t) is the frequency weighted acceleration

T is the total period of the day in seconds during which vibration may occur

Choosing an Accelerometer

The choice of accelerometer depends upon the application and we offer a fairly wide range – see our website.

For general Hand-Arm vibration measurements we recommend the B&K 2537 Hand-Arm Vibration Meter, but there are occasions when customers prefer to hire a Nor 110 for this and other purposes. Under these circumstances we still recommend you order the B&K 4505 accelerometer but also include a GA 85W2 Mounting kit for fixing the 4505 accelerometer to a hand tool etc for measurements in all three planes. Also included in the kit is a B&K DB 3585 mount with fixing ties + a B&K JJ 2615 adaptor to converter sound level meter preamplifiers inputs to take accelerometer cable

Absolute Units

The Nor 110 option 14 enables measurements in absolute units.

A sound level meter doesn't actually measure dBs, it measures the sound pressure in Pascal. For example a 50mV/Pa microphone has a sensitivity of –26 dB re 1V, which in turn means that a sound pressure of 94 dB corresponds to 1 Pascal.

Hence for a setting of -26 dB re 1V the instrument will report a level of exactly 1 unit when exposed to a sound pressure of 94 dB and 2 units when exposed to 100 dB.

If we replace the microphone with an accelerometer of 50 mV/ms^{-2} then it too would have a sensitivity of –26 dB re 1V, which in turn means an acceleration level of 94 dB corresponds to 1 unit and 100 dB = 2 units, except in this case the units are ms^{-2} or 'g' and not Pascals.

By the same token if we connected a velocity or any other transducer with a sensitivity of 50mV/unit, then when the meter reads 94 dB i.e. 1 unit , the speed would be 1m/s in the case of the velocity transducer.

For historical and convenience reasons the sound level meter displays dBs not Pascals. The absolute units option 14 in the Nor 110 converts the dB scaling back to linear units. If we are using a microphone, then these are Pascals and in the case of accelerometers these are ms^{-2} or imperial units.

Because the dB scale covers a wide range of units then the absolute values displayed can also cover a wide range. Norsonic use notations rather than a full mathematical representation. For example 2.01 x 10^{-3} is displayed a 2.01 m. The following table details the notations used.

XX.X denotes level in decibels
XX.XT denotes level in tera units = x 10^{12}
XX.XG denotes level in giga units = x 10^{9}
XX.XM denotes level in mega units = x 10^{6}
XX.Xk denotes level in kilo units = x 10^{3}
XX.X_ denotes level in units = x 10^{0}
XX.Xm denotes level in milli units = x 10^{-3}
XX.Xu denotes level in micro units = x 10^{-6}
XX.Xn denotes level in nano units = x 10^{-9}
XX.Xp denotes level in pico units = x 10^{-12}
XX.Xf denotes level in femto units = x 10^{-15}

Some people are more comfortable using dB values and prefer to use the Conversion Chart.

** Notes on converting Charge and Voltage sensitivities

The charge sensitivity of an accelerometer is independent of the cable length. The voltage sensitivity on the other hand is for the accelerometer when used with its standard length of cable.

To take into account different cable lengths or to convert from charge sensitivity to voltage sensitivity, divide the charge sensitivity by the total capacitance of the accelerometer and the cable, for example :-

a 1pC/ms^{-2} and 9.8pC/g accelerometer with a capacitance of 900pF and a 1.2m cable (100pF)

would give 1 pC / (900+100) pF = 1 mV/ms^{-2}

or 9.8 pC / (900+100) pF = 9.8 mV/g

note 1 g = 9.807 ms^{-2} or conversely 10 ms^{-2} = 1.02 g.