FLUID POWER
Design Data Sheet

Revised Sheet 24 - Womack Design Data File

INFORMATION ON SOUND POWER AND SOUND PRESSURE

The Nature of Sound

Airborne sound (including noise) is a variation in PSI air pressure in the audible range, and sound pressure can be measured by its force against the diaphragm of a microphone. Sound waves, unlike light waves, are longitudinal vibrations of air molecules moving back and forth in the direction of the traveling wave. Energy from a sound generator sets sound waves in motion, and they travel approximately 1100 feet per second in air.

As sound waves radiate outward from their source, their intensity diminishes as the square of the distance traveled, starting with a first measuring point at least 2 or 3 times the largest dimension of the noise source. On small components such as pumps, this first measuring point is taken as 3 feet or 1 meter from the center of the pump.

The wide range of sound intensity and sound pressure in the audible range complicates the problem of rating noise strength. The human ear can hear, without damage and without discomfort, sound pressures 10,000 times greater than the weakest sound it can detect.

Because of this extremely wide range, noise measuring instruments are usually calibrated in decibels (dB) instead of in PSI. The dB scale is logarithmic, which compresses the upper end of the scale and allows ratings to be given in not more than 3 digits (120 dB, etc).

An important fact to remember about decibels is that they are merely ratios, and only become absolute values of power or pressure when referred to a fixed base. In acoustics, the sound pressure which is barely audible is 3 × 10 PSI, and this has been assigned a value of 0 dB. It takes a calculated value of 10.042 dB of acoustic power (from a pump, for example) to produce a pressure level of 0 dB at a distance of 3 feet from the pump. The reference, or base, level for acoustic power is taken as 1×10^{-12} watts.

A person can comfortably tolerate sound pressure levels up to 80 dB. Between 80 and 90 dB he might show some intolerance to the noise, but above 90 dB the average person can tolerate it only for short periods.

Threshold of sound	0 dB	Noisy factory	90 dB
Average hearing threshold (whisper)	16 dB	Heavy city traffic	100 dB
Very quiet office	40 dB	Rock band	120 dB
Residential kitchen	55 dB	Pain threshold	140 dB
Normal conversation	60 dB	Bad weather siren	140 dB
Very noisy office	70 dB	Structural Ear Damage	140 dB
Loud radio	78 dB	Jet Engine	160 dB
Walsh-Healey limit for 8-hour exposure (85 dB future)			90 dB

Definition of the Decibel

On the decibel scale used for expressing the total amount of acoustic power radiated from a noise source, the dB level is defined as 10 times the logarithm (to the base 10) of the ratio between the sound level and 0 dB (1×10^{-12} watts). However, since sound pressure at any radius from the source is proportional to the square root of the sound power producing it, the decibel scale for expressing the sound pressure is defined as 20 times the logarithm of the ratio between the measured sound pressure and 0 dB, because to square a number its logarithm must be doubled. The accepted reference level for 0 dB on the pressure scale is 3×10^{-9} PSI. (0.0002 microbar).

Acoustic Power Radiation

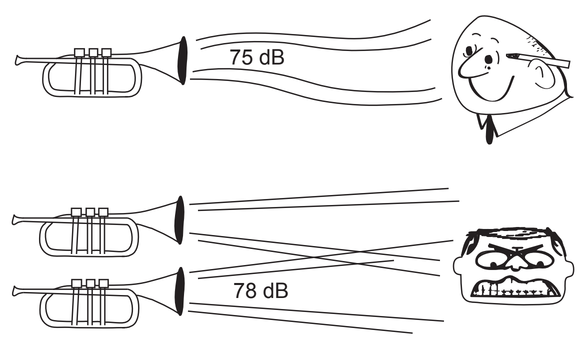


Figure 1. *Doubling the sound power at its source increases its level by 3 dB, and increases the sound pressure level at all distances by the same 3 dB.*

If acoustic power at the source is increased, the chart below gives examples of how to calculate the increase on the dB power scale. The first example shows that if the sound power is doubled, the radiated dB level increases by approximately 3 dB.

If one pump is rated at 85 dB and another identical pump is added, the sound power increases to 88 dB. If a third pump is added, the power level becomes 89.77 dB, etc.

Increasing the sound power, for example by 5 dB, also increases the sound pressure by 5 dB at all distances.

Power Increase	Examples of Calculations of Sound Power dB Increase at the Source
2 Times	Increase = 10 × log 2 = 10 × 0.301 = 3.01 dB
3 Times	Increase = 10 × log 3 = 10 × 0.477 = 4.77 dB
4 Times	Increase = 10 × log 4 = 10 × 0.602 = 6.02 dB
1,000 Times	Increase = 10 log 1,000 = 10 × 3.0 = 30 dB

Sound power at the source cannot be measured; it can be calculated by making a dB pressure measurement at any distance, then using the formula: dB (power) = dB (pressure reading) + 20 × logarithm of distance in feet + 0.5 dB. At 3 feet: dB (power)= dB (pressure) + (20 × 0.477) + 0.5 dB.

"A" Weighted Sound Pressure Levels ...

Figure 2. Whether a sound is objectionably loud depends on its frequency as well as on its intensity. Higher frequency sounds are less tolerable and do more damage to the ear than do sounds of the same intensity at lower frequencies.

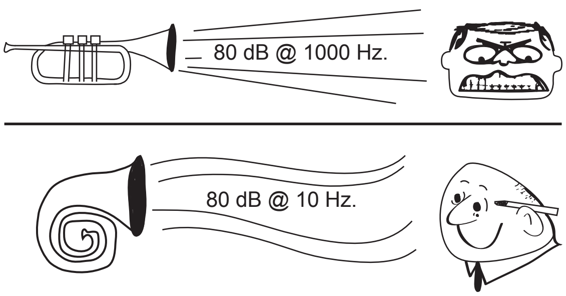
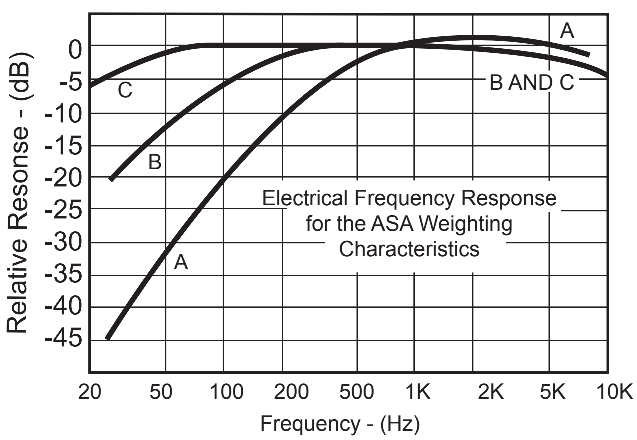


Figure 2. *"Noise" intolerance depends on frequency as well as on intensity of the sound source.*

The permissible noise exposure levels stated in the Walsh-Healey Act are in the "A" weighted frequency response network, and marked "dBA".

Noise level meters have a selector switch for setting their sensitivity over the audible range either to the "A", "B", or "C" weighted response characteristics. When set on the "A" scale, filters in the electronic circuit of the meter give it about the same response as the human ear over the audible range, and meter readings are specified in "dBA". This scale is always used when measuring sound pressure imposed on an operator because it totalizes the full range of frequencies which cause discomfort and ear damage. The "B" and "C" weighted scales on the meter also have filters which give the frequency response curves shown on the graph. They are used mainly for scientific measurements when tracing the source of noise.



Frequency sensitivity of the dB "A" curve is designed

Noise Level at the Operator's Position ...

Figure 3. The objective, of course, in making noise measurements is to be sure the sound pressure level on the operator's ears does not exceed an acceptable level. A hydraulic pump rated at 120 dB may or may not be too noisy, depending on its distance from the operator.

The chart under Figure 3 gives examples of how to calculate decrease in dB pressure level as the sound source is moved further from the operator, based on a reference position located 3 feet from the source. The first example shows that if the separation distance is doubled (as referred back to the 3-foot reference point), the sound pressure level is reduced by approximately 6 dB from its original level, etc.

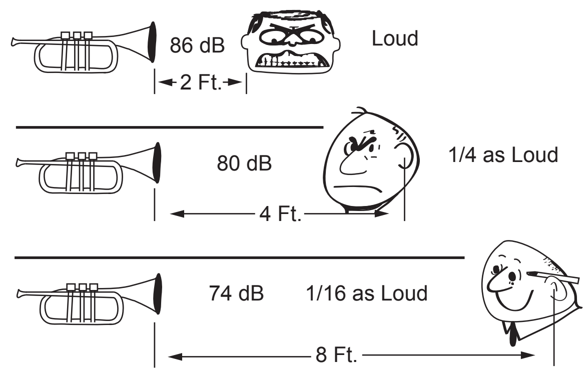


Figure 3. *Sound pressure on the listener's ears decreases as the square of the distance from the source.*

If the dB power rating of a pump is known, the dB pressure level at any distance can be calculated with this formula: dB (pressure) = dB (power) - 20 log distance in feet - 0.5 dB.

Acoustics Measurements Summary

Sound is measured with an instrument which includes a microphone, an electronic amplifier with filters, and a voltmeter having a scale graduated logarithmically and marked in decibels (dB). However, a sound meter cannot measure the acoustic power being radiated from a sound source. Instruments can only measure the air pressure produced at varying distances from the source by the energy of the sound waves. From pressure measurements, the acoustic power at the source can be determined mathematically.

If it were possible to have 5 identical pumps set up so they were always equidistant from a sound meter, and if the meter reading with one pump running was 70 dB at a distance of 3 feet from the meter, these meter readings might be expected at other distances and other running conditions:

No. of Pumps Running	Distance From Center of Pumps			
	3 Feet	6 Feet	12 Feet	24 Feet
1 Pump	70 dB	64 dB	58 dB	52 dB
2 Pumps	73 dB	67 dB	61 dB	55 dB
3 Pumps	74.8 dB	68.8 dB	62.8 dB	56.8 dB
4 Pumps	76 dB	70 dB	64 dB	58 dB
5 pumps	77 dB	71 dB	65 dB	59 dB

Note from this chart that dB power levels Increase by 3 dB each time the radiated sound power doubles, but the sound pressure read on a meter decreases by 6 dB each time the distance from the 3-foot reference position doubles. Sound pressure decreases faster with distance than it does by decreased sound power because sound pressure is considered to be proportional to the square root of the radiated sound power.

In a later issue we will summarize points on the original system design to obtain a quieter hydraulic system.

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