GE Energy

Acoustic Terms, Definitions and General Information

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Foreword

The following document has been prepared for use during discussions and negotiation of common questions and issues regarding noise in Power Plant sales and applications. Expected readers include internal GE Sales and Engineering organizations not involved with the subject of noise on a regular basis.

Our intent is to present brief, easily understood definitions, explanations and examples of common terms and subjects, which may be encountered during communication with GE Customers and Partners.

Section I – Common Terms and Definitions is a compilation of terms which are commonly used in the Acoustic Design discipline, and a brief definition of each.

Section II – General Information presents basic definitions and terminology, as well as a brief discussion on the subject of noise contribution, reflection and reverberation, which are frequently subjects our Customers and Partners are not familiar with.

We hope that you find this document informative and helpful during discussions on the subject of Power Plant related noise.

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Section I – Terms and Definitions

Acoustic enclosure — A structure built around a machine to reduce noise.

Acoustic lagging — Materials applied externally to the surface of pipes and ducts to reduce noise penetration.

Acoustics — (1) The science of sound. (2) Of a room: those factors, which determine its character with respect to the quality of the received sound.

Airborne sound — Sound or noise radiated directly from a source, such as a loudspeaker or machine, into the surrounding air.

Ambient noise — Total noise level in a specified environment.

Attenuation — Term used to indicate reduction of noise or vibration, by whatever method necessary, usually expressed in decibels.

Audible frequency range — The range of the sound frequencies normally heard by the human ear. The audible range spans from 20 Hz to 20,000 Hz, but for most engineering investigations only frequencies between about 40 Hz and 11,000 Hz are considered.

Average Room Absorption Coefficient (α) — Total room absorption in Sabins or metric Sabins, divided by total room surface area in consistent units of square feet or square meters.

A-weighting — A frequency weighting that relates to the response of the human ear.

Background noise level — Prevailing noise level in a specified environment measured in the absence of the noise being studied.

Broad band noise — Spectrum consisting of a large number of frequency components, none of which is individually dominant.

Continuous equivalent noise level, L_{Aeq} — The steady noise level (usually in dBA) which, over the period of time under consideration, contains the same amount of sound energy as the time varying noise.

C-weighting — A frequency weighting closest to the linear or unweighted value.

dB (A) — The A-weighted sound pressure level.

Decibel (dB) — (1) Degree of loudness. (2) A unit for expressing the relative intensity of sounds on a scale from zero for the average least perceptible sound to about 130 for the average pain level.

Diffraction — The process whereby an acoustic wave is disturbed and its energy redistributed in space as a result of an obstacle in its path.

Direct sound — Sound that reaches a given location by direct, straight-line propagation from the sound source.

Directivity Index (DI) — The difference between sound pressure level in any direction in the acoustic far field and the average sound pressure level in that field.

F (fast) time weighting — (1) Averaging time used in sound level meters. (2) Fast setting has a time constant of 125 milliseconds and provides a fast reacting display response allowing the user to follow and measure not too rapidly fluctuating sound.

Far field — (1) Part of the sound field where the sound wave is spreading spherically. (2) Sound decays at 6 dB for a doubling of the distance from the sound source.

Field measurements — Measurements carried out on site.

Filter — A device that transmits signals within a certain band of frequencies but attenuates all others.

Free field conditions — An environment where there is no reflective surfaces.

Frequency — Repetition rate of a cycle, the number of cycles per second.

Impulse noise — A transient signal of short duration.

Insertion Loss (IL) —The reduction of noise level at a given location due to placement of a noise control device in the sound path between the sound source and that location. Usually rated in octave bands or 1/3-octave bands.

Intermittent noise — Noise that is not continuous.

L_{Amax} — The maximum A-weighted sound pressure level occurring in a specified time period.

L_{peak} — The maximum deviation of a signal from its mean value within a specified time interval.

L_1 — Sound pressure level that is exceeded one % of the time.

L_{10} — Sound pressure level that is exceeded 10% of the time.

$L_{10(1\ hr)}$ — Sound pressure level that is exceed 10% of the time in a period of 1 hour.

L_{90} — Level of noise that is exceeded 90% of the time.

L_{Aeq} — A steady noise level (weighted) which over a period of time has the same sound energy as the time varying noise.

Micro Pascal — One millionth of a Pascal.

Near field — (1) Area that surrounds the noise source. (2) Sound does not decay at 6 dB for a doubling of the distance from the sound source.

Noise — Unwanted sound.

Noise limit — A maximum value imposed on a noise level.

Noise Reduction (NR) — The difference in sound pressure level between any two points along the path of sound propagation.

Octave — The range between two frequencies whose ratio is 2:1.

Pascal — A unit of measure equal to 1 N/m^2

Peak — The maximum deviation of a signal from its mean value within a specified time interval.

Perceived noise level — The sound pressure level assessed by observers.

Pico watt — One-trillionth (10^{-12}) part of a watt.

Pure tone — A sound for which the waveform is a sine wave at a single frequency.

Reflection — Redirection of sound waves.

Refraction — Change in direction of sound waves caused by changes in the sound wave velocity.

Residual noise — Ambient noise remaining when specific noise is suppressed.

Reverberant sound/reverberation — The sound in an enclosed space, which results from, repeated reflections at the boundaries.

S (slow) time weighting — (1) Averaging times used in sound level meters. (2) Time constant of one [1] second that gives a slower response which helps average out the display fluctuations.

Sabin — Unit of acoustic sound absorption, equivalent to the absorption by one square meter of perfect absorber.

Silencer — A device used for reducing noise within air and gas flow systems.

Sound — Pressure fluctuations in air within the audible range.

Sound absorption — (1) The process by which sound energy is converted into heat, leading to the reduction in sound pressure level. (2) The sensation perceived by the sense of hearing.

Sound Absorption Coefficient (α) — The dimensionless ratio of sound energy absorbed by a given surface to that incident upon the surface.

Sound insulating material — Material designed and used as partitions in order to minimize the transmission of sound.

Sound insulation — The reduction or attenuation of sound by a solid partition between source and receiver. This may include a building wall, floor, barrier wall or acoustic enclosure.

Sound intensity — The sound flowing per unit area, in a given direction, measured over an area perpendicular to the direction of flow; units are W/m^2.

Sound level — A frequency-weighted sound pressure level, i.e., A-weighted value.

Sound level meter — Device used to measure sound pressure levels.

Sound power — The sound energy radiated per unit time by a sound source, measured in Watts (W).

Sound Power Level, L_w (PWL) — Sound power measured on a decibel scale.

Sound pressure — The fluctuations in air, measured in Pascals (PA).

Sound Pressure Level, L_p (SPL) — Sound pressure measured on a decibel scale.

Sound transmission — The transfer of sound energy through a barrier from one medium to another.

Sound Transmission Class (STC) — A single number decibel rating of the transmission loss properties of a partition.

Spectrum — A quantity expressed as a function of frequency, such as sound pressure versus frequency.

Structure borne noise — Generation and propagation of time-dependent motions and forces in solid materials, which result in unwanted, radiated sound.

Threshold of hearing — The lowest level of sound that can be heard by the human ear.

Transient — Sounds, which are audible for a limited period of time.

Transmission loss — Measure of the airborne sound insulating properties, in a particular frequency band, of a material.

Unweighted sound pressure level — A sound pressure level that has not been frequency weighted.

Vibration isolation — Reduction of force or displacement transmitted by a vibratory source.

Watt (W) — The unit of power when 1 joule is expanded in one second.

White noise — A random broadband noise that contains equal power per unit bandwidth.

Section II – General Information

A. What is Sound?

Any pressure variation that the eardrum can detect.

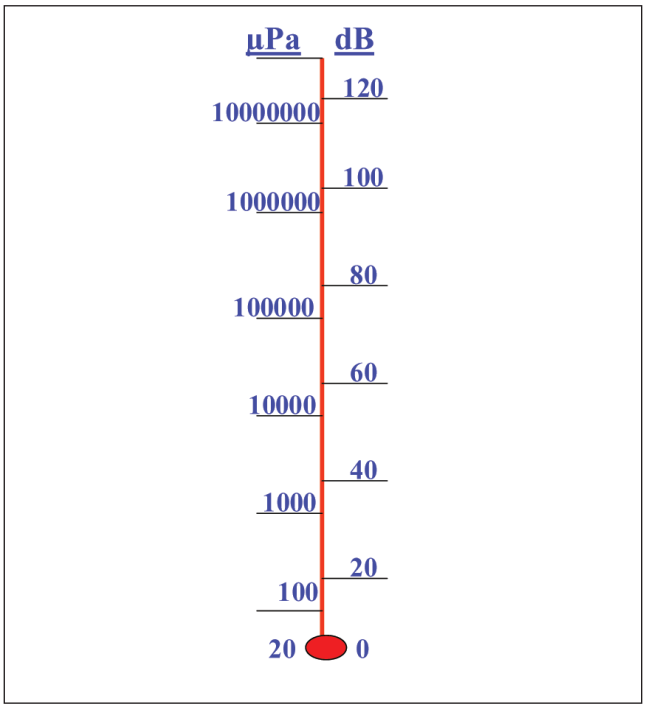
B. Terminology

Decibel – dB

- Threshold of hearing – 20 m Pa
- Threshold of pain – 200,000,000 m Pa
- Ear does not respond linearly to sound level
- Logarithmic scale replicates the human ear better

Weighting – dB (Lin) & dB(A)

- Hearing sensitivity varies at different frequencies
- "A" Weighting simulates the frequency response of the Human Ear



C. Sound Pressure vs. Sound Power

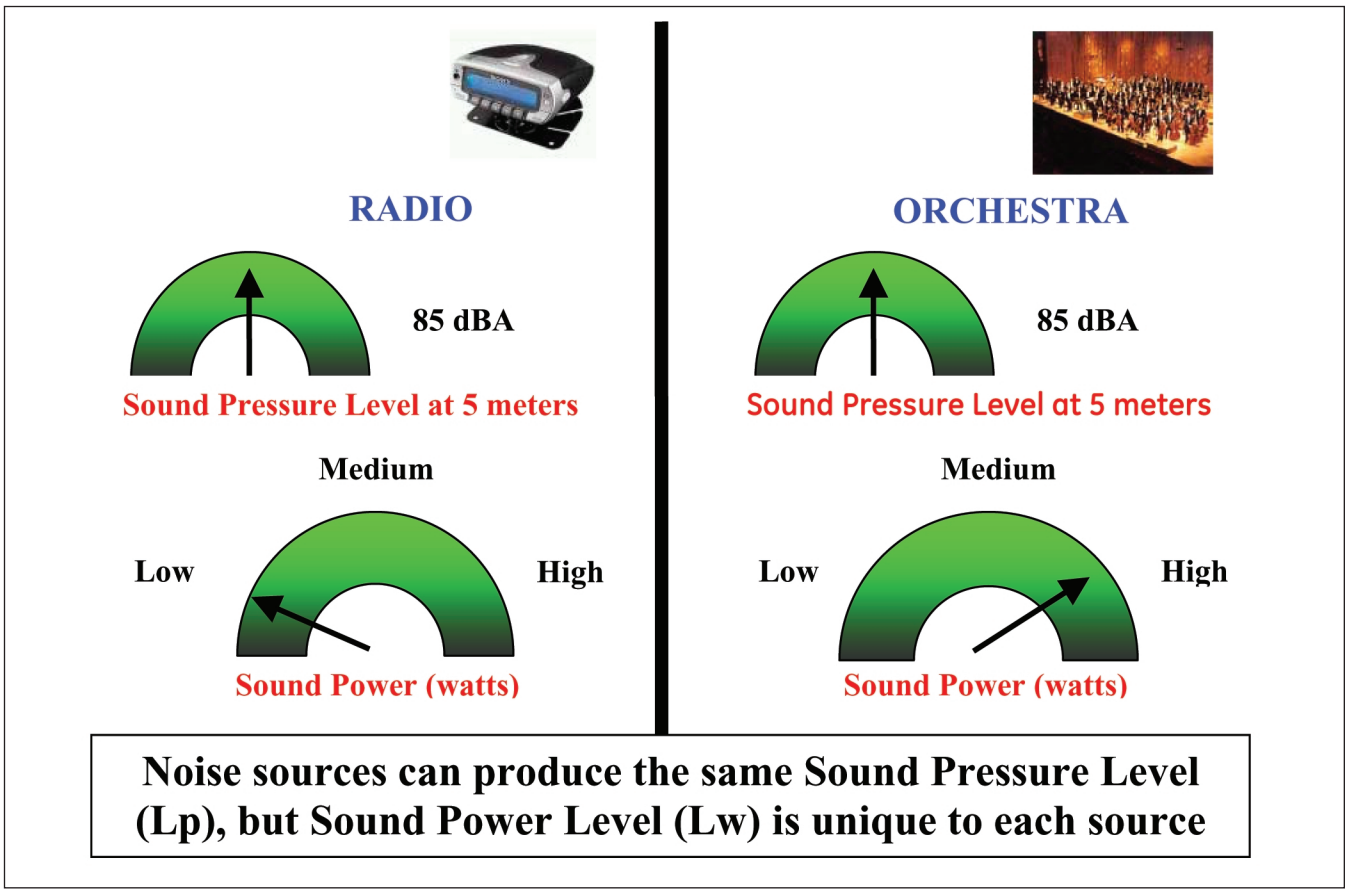


Figure 1. Sound Pressure vs. Sound Power

D. Comparative Noise Sound Pressure Levels

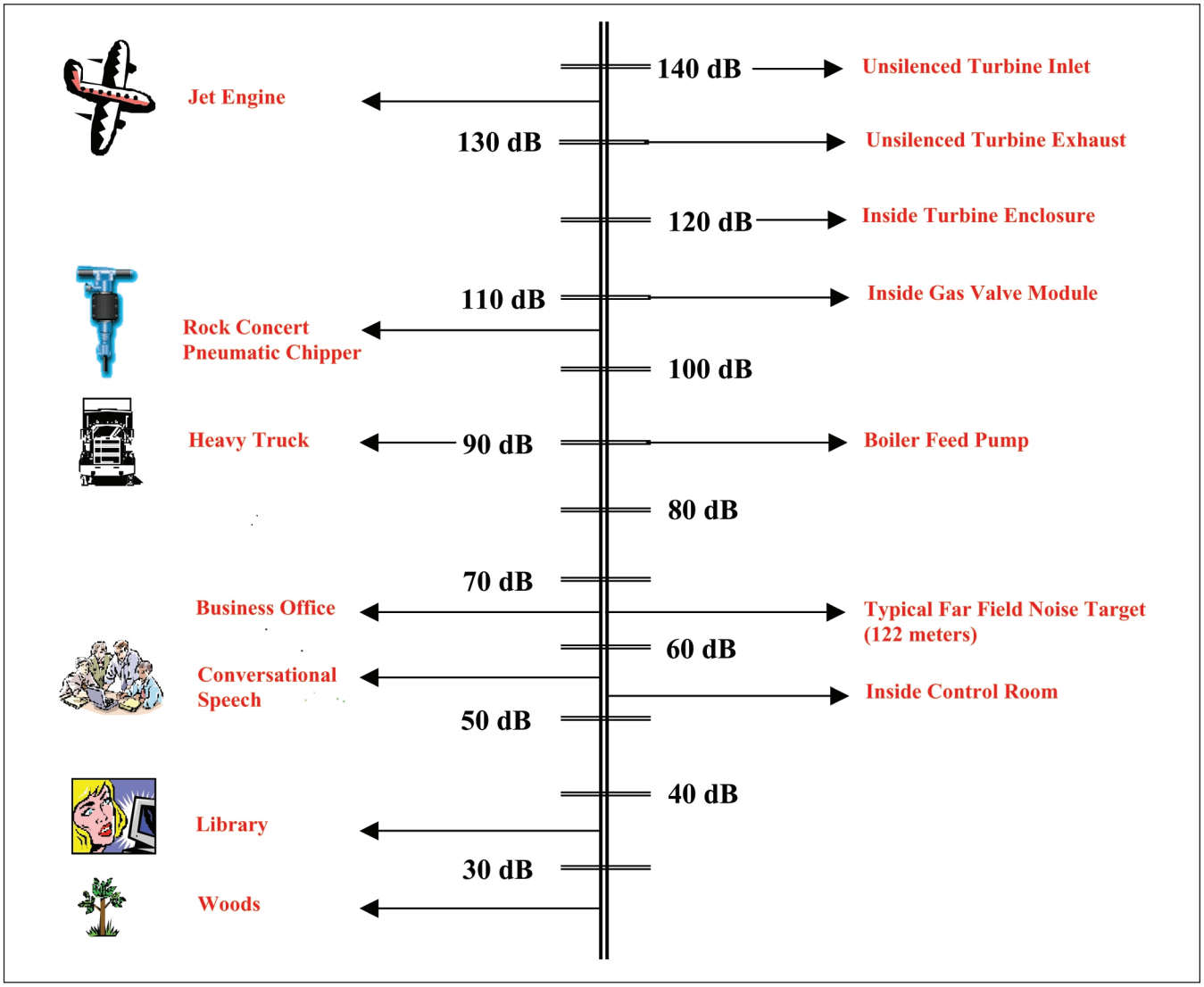


Figure 2. Comparative Noise Sound Pressure Levels

E. Power Plant Noise Levels

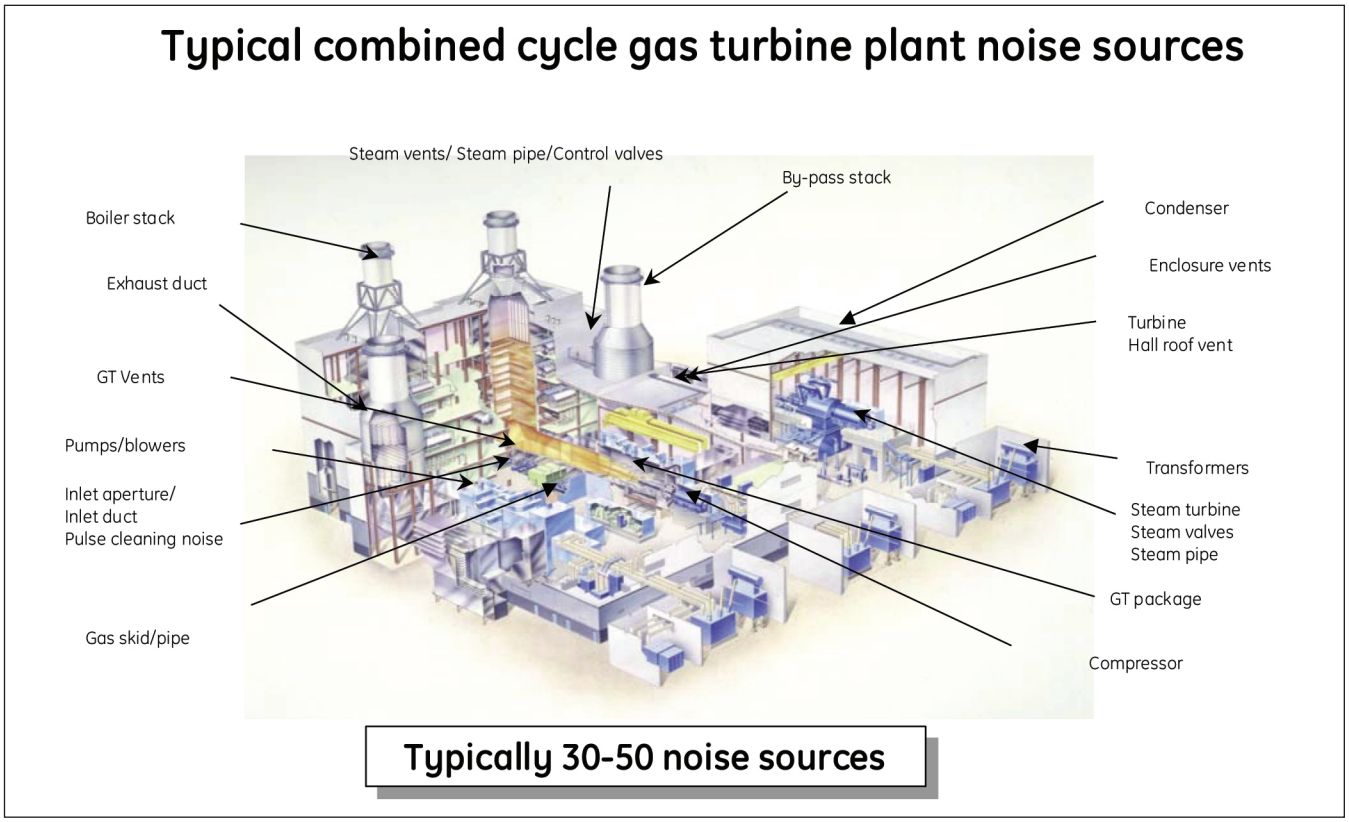


Figure 3. Power Plant Noise Levels

F. Noise Contribution, Reverberation and Reflection

The noise level at any location within a plant is the combined effect of noise radiated by all sources. Therefore, the noise from each individual source must be less than the overall plant requirement.

In addition, the containment of the sound energy within a building results in a reverberant buildup of noise. The noise reflected from the interior building walls and other surfaces causes an increase in the noise level.

For example: In order for the entire plant to satisfy a noise guarantee of 85 dBA Maximum it is necessary for each piece of equipment, including all of GE scope of supply equipment as well as the equipment supplied by others, to radiate less than 85 dBA.

As an example, if the vacuum pump is located 2 meters from the combustion turbine and radiates 80 dBA at 1 meter and the combustion turbine radiates 80 dBA at 1 meter, the resulting sound level is 83 dBA at a location 1 meter from both pieces of equipment (80 dBA + 80 dBA = 83 dBA). In addition, there will be noise from other equipment within the area. A 1 dBA allowance is included to account for the contribution from this other equipment. A 1 dBA allowance is also included to account for the reverberant buildup effect of noise within the building. Therefore, all equipment must be designed to a level of 80 dBA or less in order for sound levels within the building to meet the client's requirement of 85 dBA at all locations. To minimize the impact of achieving these stringent noise requirements, no design margin should be included in these design values. The

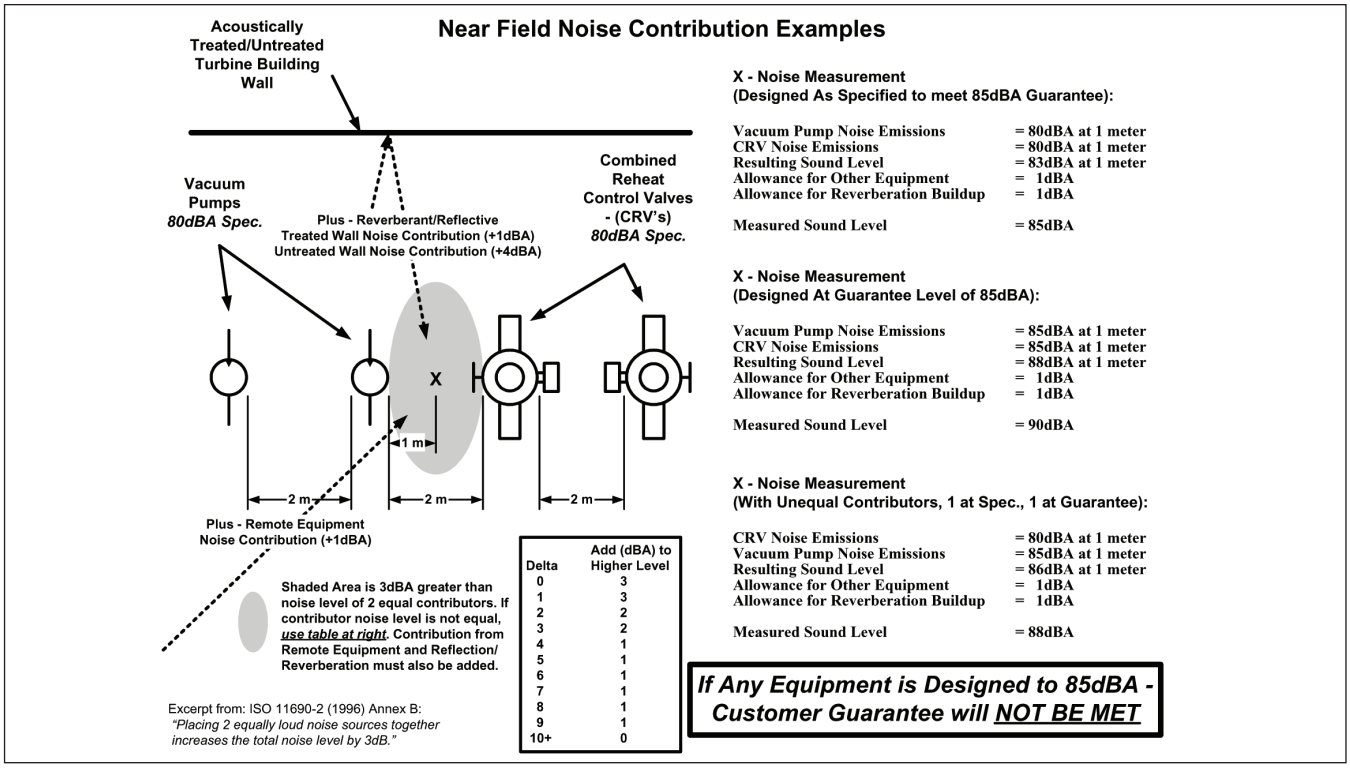


Figure 4. Near-Field Noise Contribution Examples

values specified are anticipated to achieve the required sound levels with no additional design margin. The GE-supplied equipment will be designed to the same stringent sound level requirements as the equipment supplied by others.

- Vacuum Pump Noise Emissions = 80 dBA at 1 meter
- Combustion Turbine Noise Emissions = 80 dBA at 1 meter
- Resulting Sound Level = 83 dBA at 1 meter
- Allowance for Other Neighboring Equipment = 1 dBA
- Allowance for Reverberation Buildup = 1 dBA
- Actual Sound Level Measured = 85 dBA

Section III — Applicable Reference Documents and Standards

GEK-110392, “Standard Noise Assessment Procedure.”

GER-4221, “Power Generation Equipment and Other Factors Concerning the Protection of Power Plant Employees Against Noise in European Union Countries.”

GER-4239, “Power Plant Near Field Noise Considerations.”

ANSI/ASME PTC 36-1985, “Measurement of Industrial Sound.”

ANSI B133.8-1977, “Gas Turbine Installation Sound Emissions.”

ISO 3746, “Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane.”

ISO 6190, “Acoustics — Measurement of sound pressure levels of gas turbine installations for evaluating environmental noise — Survey method.”

ANSI S1.1-1994, “American National Standard Acoustical Terminology.”

ISO 10494-1993, “Gas turbine and gas turbine sets — Measurement of emitted airborne noise — Engineering/survey method.”