# Conveyor Equipment Manufacturers Association (CEMA)

## Technical Report 2007-01

# Noise Considerations for Conveyor System Design and Application

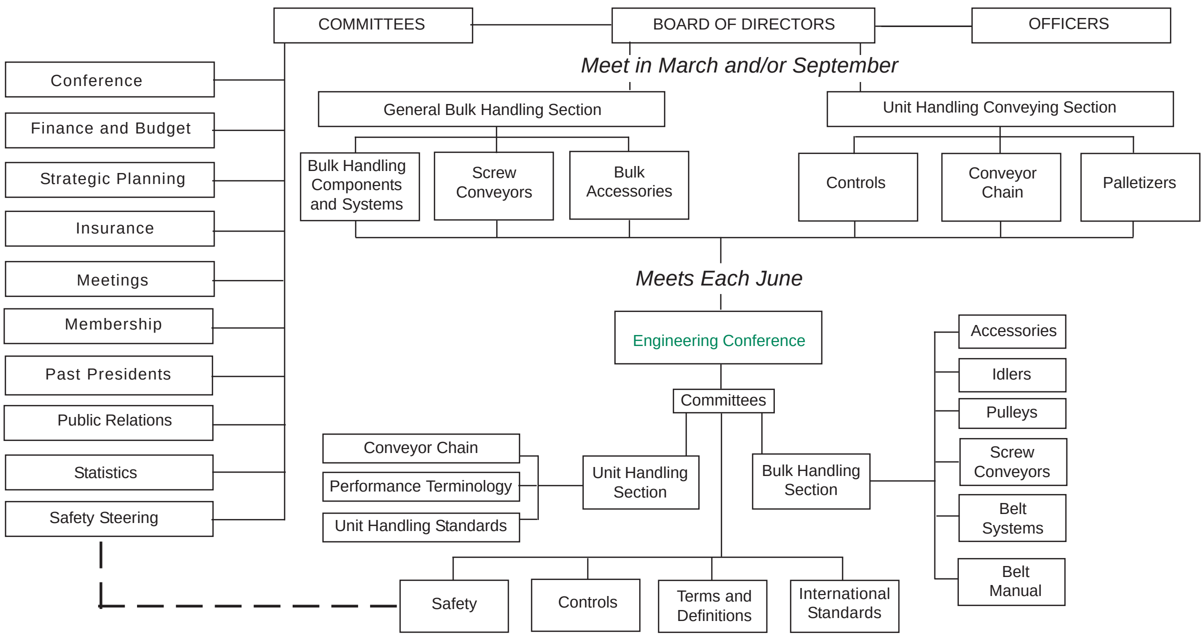
**Provided**
**as a service**
**to**
**the**
**Conveying Industry**
**by**
**the**
**CEMA Engineering Conference**

CEMA®

## October, 2007

**Cosmetic Update**
**to same document issued**
**May, 2003**

## CEMA ORGANIZATIONAL CHART




For Information on Company Membership
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### SAFETY NOTICE

The Conveyor Equipment Manufacturers Association has developed Industry Standard Safety Labels for use on the conveying equipment of its member companies.

The purpose of the labels is to identify common and uncommon hazards, conditions, and unsafe practices which can injure, or cause the death of, the unwary or inattentive person who is working at or around conveying equipment.

The labels are available for sale to member companies and non-member companies.

A full description of the labels, their purpose, and guidelines on where to place the labels on typical equipment, has been published in CEMA's *Safety Label Brochure* No. 201. The Brochure is available for purchase by members and non-members of the Association. Safety Labels and Safety Label Placement Guidelines, originally published in the Brochure, are also available free on the CEMA Web Site at http://www.cemanet.org/CEMA_Safety_Pg.htm

PLEASE NOTE: Should any of the safety labels supplied by the equipment manufacturer become unreadable for any reason, the equipment USER is then responsible for replacement and location of these safety labels.

Replacement labels and placement guidelines can be obtained by contacting your equipment supplier or CEMA.

Table of Contents



### *Purpose*

Noise Considerations for the Design, Specification, and Installation of Roller Conveyor Systems havebeen developed by the member companies of the Conveyor Equipment Manufactures Association(CEMA) to offer guidance to those considering noise in the design, specification, and installation ofconveyor systems.

### *Disclaimer*

These considerations are advisory only. They have been promulgated by the member companies ofCEMA with the sole intent of offering information for the design, specification, and installation ofconveyor systems.

CEMA makes no warranties (express, implied or statutory) in connection with these considerations.

### *Acknowledgment*

The members of the CEMA Sound Committee thank the Conveyor Product Section of Material HandlingIndustry for allowing us to use their document "Noise Considerations for the Design, Specification, andInstallation of Roller Conveyor Systems" (published 1997) as a starter document for this project.

## Introduction

Noise can be defined as unwanted sound. Noise has an adverse impact on people and theirperformance in the workplace. As such, it is good business practice to minimize exposure to noise.However, in an industrial setting, there are generally many sources of noise. Each noise sourcecontributes to the total level of noise which a person may be exposed. However, reduction in noisefrom one or more of these sources may not significantly reduce the level of noise. Therefore, thetotal work environment (including the building structure and all sources of noise must be consideredas an integrated system when addressing noise reduction. Focusing on only one component of thatsystem (e.g., the material handling system) may not yield the level of noise reduction desired.

These guidelines have been developed by the Engineering section of The Conveyor EquipmentManufacturers Association (CEMA) to address noise reduction issues related to the design andinstallation of conveyor systems. As such, it addresses the impact of only one noise source (thematerial handling system) and its impact on the total work environment. However, many of theguidelines discussed are also more generally applicable to other noise sources (e.g., productionequipment). These should help you develop specifications for the design and installation ofconveyor systems that will help meet hearing safety standards for the total work environment.

## Fundamentals of Sound

The vibrating motion of displaced molecules in an elastic medium creates sound. This medium canbe air, wood, steel, or other materials. This vibration produces waves, which radiate in all directions,much like ripples on a pond. As these waves travel through air, a small pressure change, above andbelow atmospheric pressure, is created. Our ear is able to sense this change, enabling us to hear.This change in pressure is known as sound pressure level. The sound pressure level is the measure ofsound most commonly referred to when discussing industrial noise control. It is easily measuredusing simple hand-held devices. People are able to hear sound pressure levels between about $3x10^{-9}$ psi and $3x10^{-2}$ psi. Higher sound pressure levels are painful and dangerous even for very shortdurations. Therefore, the useful hearing range is about seven orders of magnitude in terms of soundpressure levels. Since sound intensity and sound power are proportional to sound pressure squared,the useful hearing range spans 14 orders of magnitude in terms of intensity or power. To describethis huge range of levels with manageable numbers, the logarithmic decibel scale is used. Each orderof magnitude represents one Bel or 10 decibels (dB). Therefore, the useful hearing range starts atabout 0 dB and extends to about 140 dB.

Frequency is defined to be the rate at which molecules vibrate. A given noise source contains manydifferent component frequencies. The sound pressure level may vary for different frequencies asshown in Figure 1 on the next page.

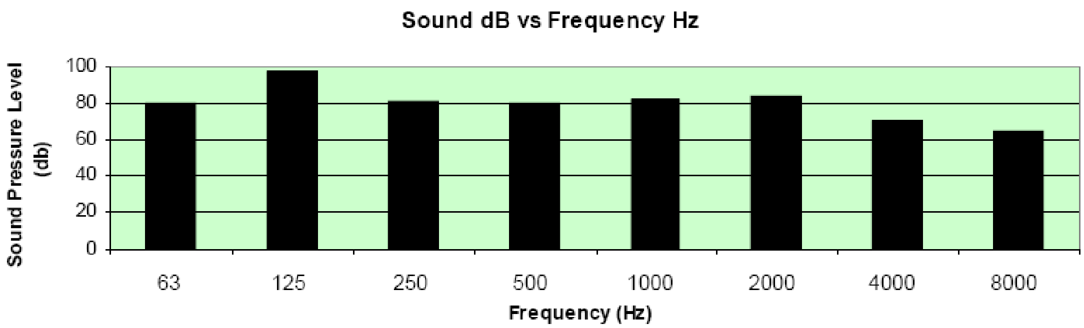



**Figure 1: Sound Pressure Level Versus Frequency**

The human ear is able to perceive a relatively narrow frequency range, from 30 to 17,000 Hz. Whenmeasuring sound pressure level, it is convenient to express sound pressure level as a single numberrather than as a function of frequency. The A-scale on common sound level meters uses a weightingscheme, which closely follows the frequency response of the human ear. This enables soundpressure level to be expressed as a single measure denoted as dBA. The A-scale plays a prominentrole in noise control.

Our subjective sense of loudness is not directly proportional to the actual sound energy or powerinvolved. For example, a 3 dB increase represents a doubling of actual energy, but it is justnoticeable. A 5 dB increase represents a tripling of actual energy, but is perceived as being onlyclearly louder. A 10 dB increase represents 10 times as much energy, but it sounds only twice asloud. Table 1 is useful in understanding this point.

| Change in Energy Level | Change in Sound Level | Change in Subjective Loudness |
|---|---|---|
| 26% | 1 dB | Insignificant |
| Doubling | 3 dB | Just Perceptible |
| Tripling | 5 dB | Clearly noticeable |
| 10 Times | 10 dB | Twice as loud (or half as loud) |
| 100 Times | 20 dB | Much louder (or quieter) |

**Table 1: Change in sound loudness**

Sound power measures the flow rate of acoustical energy from a sound source and is independent of any point in space or time. A sound source radiates power, which results in sound pressure. Sound power is the cause and sound pressure is the effect or what we hear. Sound power and sound pressure are frequently confused. This is partly because they are both measured in decibels. The logarithmic decibel scale is also used to measure sound power because the range of values overwhich sound power (measured in watts) typically varies is extremely wide. However, sound power is analogous to the power rating of a light bulb. Experience indicates that a 100 watt light bulb is brighter (light intensity or illumination) than a 25 watt bulb at any given distance. Similarly, the sound pressure level created by a sound source of 100 watts (140 dB) is greater than that created by a 25 watts source at any given distance. Sound pressure level is a function of distance. Sound poweris independent of distance. Table 2 shows some common sound sources and the approximate soundpower generated by those sources.

| Common Sound Source | Noise/Sound Power Level (dB) | Effect |
|---|---|---|
| Boom Cars | 145 | |
| Jet Engines (near) | 140 | |
| Shotgun Firing | | |
| Jet Takeoff (100-200 ft.) | 130 | |
| Rock Concerts (varies) | 110–140 | Threshold of pain begins around 125 dB |
| Oxygen Torch | 121 | |
| Discotheque/Boom Box | 120 | Threshold of sensation begins around 120 dB |
| Thunderclap (near) | | |
| Stereos (over 100 watts) | 110–125 | |
| Symphony Orchestra | | |
| Power Saw (chainsaw) | 110 | |
| Pneumatic Drill/Jackhammer | | Regular exposure to sound over 100 dB of more than one minute risks permanent hearing loss. |
| Snowmobile | 105 | |
| Jet Flyover (1000 ft.) | 103 | |
| Electric Furnace Area | 100 | No more than 15 minutes of unprotected exposure recommended for sounds between 90–100 dB. |
| Garbage Truck/Cement Mixer | | |
| Farm Tractor | 98 | |
| Newspaper Press | 97 | |
| Subway, Motorcycle (25 ft.) | 88 | Very annoying |
| Lawnmower, Food Blender | 85–90 | 85 dB is the level at which hearing damage (8 hrs.) begins |
| Recreational Vehicles, TV | 70–90 | |
| Diesel Truck (40 mph, 50 ft.) | 84 | |
| Average City Traffic | 80 | Annoying; interferes with conversation; constant exposure may cause damage |
| Garbage Disposal | | |
| Washing Machine | 78 | |
| Dishwasher | 75 | |
| Vacuum Cleaner, Hair Dryer | 70 | Intrusive; interferes with telephone conversation |
| Normal Conversation | 50–65 | |
| Quiet Office | 50–60 | Comfortable hearing levels are under 60 dB. |
| Refrigerator Humming | 40 | |
| Whisper | 30 | Very quiet |
| Broadcasting Studio | 30 | |
| Rustling Leaves | 20 | Just audible |
| Normal Breathing | 10 | |
| | | The threshold of normal hearing starts at about 1000 to 4000kHz. |

**Table 2: Sound power level of common sounds**

The relationship between sound power and sound pressure level for a point source in a free field isgiven by the following equation:

$$\mathbf{L_p = L_w - 20 \log_{10}(r) - 11}$$

where $\mathbf{L_p}$ = sound pressure level (dB)
$\mathbf{L_w}$ = sound power (dB)
$\mathbf{r}$ = distance from sound source (meters)

For a point source on a hard surface outdoors with no other reflecting surfaces nearby, sound wavesradiate in a hemisphere above the surface rather than a sphere. The total sound power is the same, but the hemisphere has only half the surface area of a sphere. Therefore, the sound intensity is doubled at any given distance, and the sound level is 3 dB higher. This factor is referred to as directivity, and a flat surface has a directivity (Q) of 2 in the following equation

$$\mathbf{L_p = L_w + 10 \log Q - 20 \log_{10}(r) - 11}$$

This equation is frequently used in acoustics. As an illustration, consider a lawn mower in the middle of alarge concrete parking lot with no other reflective surfaces nearby. For purposes of the illustration, we will assume that the lawn mower radiates noise uniformly in all directions. If the lawn mower produces asound power level of 110 dBA, what is the sound pressure level at 5 meters?

$$\mathbf{L_p = 110 + 10 \log 2 - 20 \log_{10} (5) - 11}$$
$$\mathbf{L_p = 88\ dBA}$$

As reported earlier, sound pressure level can be easily measured using a sound level meter. However, sound power is not easily measured. Therefore, another useful equation expresses sound pressure level as a function of the distance from the noise source. Let $\mathbf{L_{p,1}}$ and $\mathbf{L_{p,2}}$ be the sound pressure levels at a distance **r1** and **r2** respectively, from the noise source. The resulting relationship between these sound pressure levels is:

$$\mathbf{L_{p,2} = L_{p,1} - 20 \log_{10} (r_2/r_1)}$$

Therefore, if the sound pressure level is 90 dB at 5 meters from the source, what is the sound pressure level at 10 meters from the source?

$$\mathbf{L_{p,2} = 90 - 20 \log_{10} (10/5)}$$
$$\mathbf{L_{p,2} = 84\ dB}$$

This illustrates an often quoted rule of thumb that states that the sound pressure level decreases by 6dB when the distance from the noise source is doubled.

The preceding equations are useful for sound sources located outdoors without building, fences, or other similar reflective surfaces in the vicinity. However, when a source is located indoors, the walls and roof contain the sound energy. These surfaces reflect sound back into the space, and can cause the overall level to increase quite significantly. This is called reverberant build-up of sound energy. In a real production facility with many sources distributed throughout the space, the sound level may drop off by several dB as you move a short distance away from a source. However, the sound levels may then remain fairly constant as you move farther away because reverberant noise energy becomes more significant than noise radiated directly from a source. Therefore, it is important to include absorptive wall and ceiling treatments in any facility where significant noise is generated to control reverberant noise.

When there are multiple sound sources, $\mathbf{L_{p,i}}$, the resultant sound pressure level, $\mathbf{L_{p,t,}}$ at a given distance can not be determined algebraically. Since the sound pressure level is measured using a logarithmic scale, the following equation is used to determine the combined effect.

$$\mathbf{L_{p,t,} = 10 \log \left( \sum_{i=1}^{n} 10^{L_{p,t,}/10} \right) dB}$$

***Example: What is the total sound pressure level due to the following individual sources?***

| | | | |
|---|---|---|---|
| Conveyor A at 76.0 dBA | $10^{7.6}$ | = | 39.8EE6 |
| Conveyor B at 75.0 dBA | $10^{7.5}$ | = | 31.6EE6 |
| Conveyor C at 68.0 dBA | $10^{6.8}$ | = | 6.3EE6 |
| Conveyor D at 72.0 dBA | $10^{7.2}$ | = | 15.8EE6 |

| | | | |
|---|---|---|---|
| Conveyor E at 75.5 dBA | $10^{7.55}$ | = | 35.5EE6 |
| Ambient Noise at 75.0 dBA | $10^{75}$ | = | 31.6EE6 |
| | Total | = | 160.7EE6 |

$$L_{(total)} = 10 \log 160.7EE6 \quad = \quad 82.1 \text{ dBA}$$

This equation yields two useful rules of thumb. When two equal sound sources are combined, the resulting sound pressure level will be only 3dB higher. If two different sound sources are combined and the difference between the two levels being added is 10 dB, the combined sound pressure level will only be 0.5 dB higher than the higher of the two sources. The additive effect of noise is illustrated in Table 3 and the graph in Figure 2.

| Additive Effect of Two Sources, Each Equidistant from an Observer | |
|---|---|
| Δ = dBA Difference | Added dBA to Higher of Two Sources |
| 0 | 3.0 |
| 1 | 2.5 |
| 2 | 2.1 |
| 3 | 1.8 |
| 4 | 1.5 |
| 5 | 1.2 |
| 6 | 1.0 |
| 7 | .8 |
| 8 | .7 |
| 9 | .6 |
| 10, 11 | .4 |
| 12 | .3 |

**Table 3: Addition of sound sources**

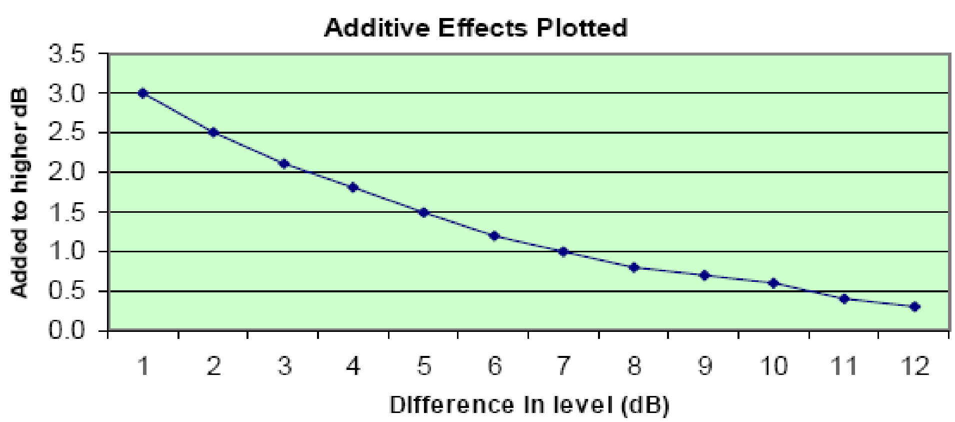
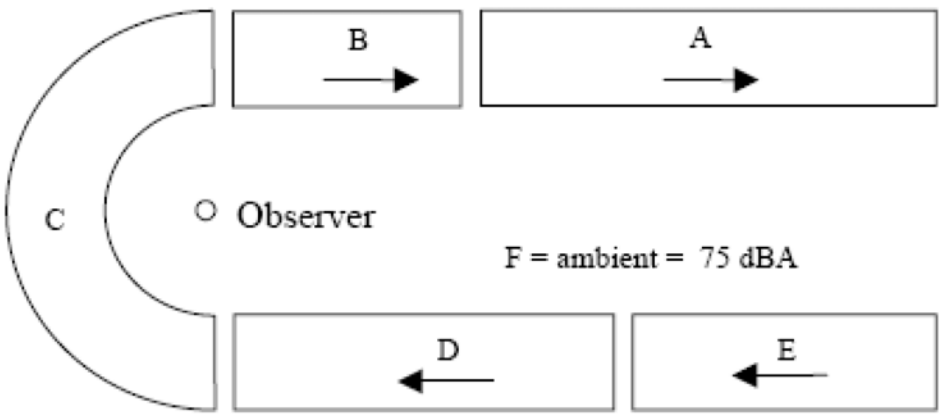


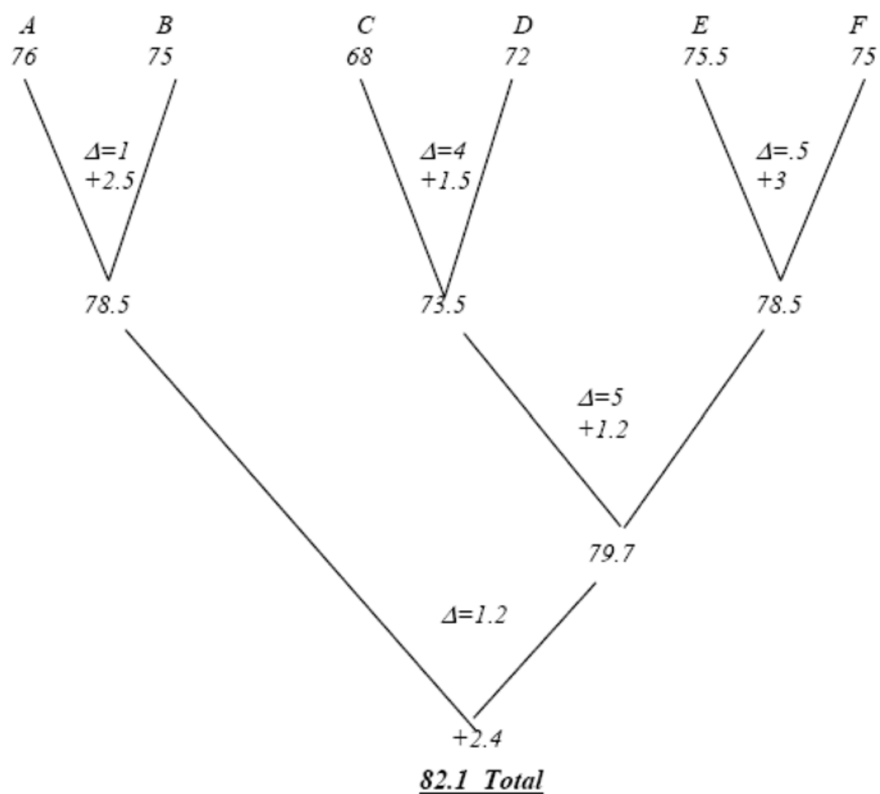

**Figure 2: Addition of sound sources**

Example:




All noise sources are approximately equidistant from the observer. Individual equipment readings are obtained from manufacturer or direct observation in a "quiet room" (Ambient level less than 50dBA).

Conveyor A ------------76.0 dBA
Conveyor B ------------75.0 dBA
Conveyor C ------------68.0 dBA
Conveyor D ------------72.0 dBA
Conveyor E ------------75.5 dBA
Ambient Noise F ------75.0 dBA



## *Sound Measurement*

The primary instrument used to measure sound pressure level in the field is the sound level meter(see Figure 3). The A scale and “slow” response should be used to integrate different soundfrequencies into a single composite measure (dBA). For reliable and accurate sound level measurements, background noise should be reduced to a minimum. Measurements taken when the difference in level between total noise and background noise is 3 dB or less should be avoided. In addition, sound can bounce or reflect from some surfaces. Severe measurement errors can and often do occur in industrial environments where reflective surfaces are present. This is especially true when these reflective surfaces are in close proximity to a noise source (e.g., a hard masonry wall close to a conveyor).

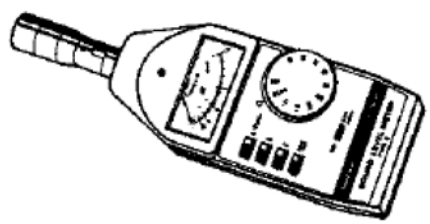


**Figure 3: Typical sound level meter**

The sound pressure level surrounding a source of noise will be a function of many factors. Therefore, the most realistic portrait of the noise a human operator will be exposed to can be obtained from a noise contour map. A noise contour map provides a visual image of the sound field over an area as shown in Figure 4.

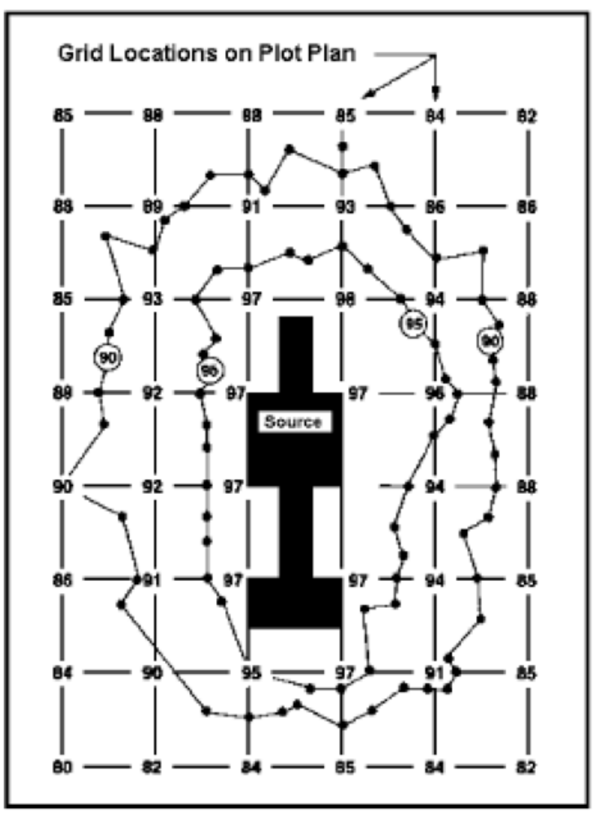



**Figure 4: Noise contour map**

A noise contour map can be easily developed using the following 3-step process.

1. Using the A-scale and “slow” response settings on a sound level meter, walk around the sound source, maintaining a constant reading (e.g., 80dBA). Record your path until it closes on itself, forming a loop, or until the path exits the area to be surveyed.

2. Trace the path followed on a plant layout or area map. This can most easily be done by a second person following the surveyor.

3. Repeat the process for as many contours as desired or needed.

## *Noise Regulations*

The Occupational Safety and Health Administration (OSHA) limitS the noise to which employees are exposed during the normal course of their employment. In order to fully understand OSHA's regulations, the complete text of 29 CFR 1910.95 should be carefully studied. Following is a brief summary of the key requirements of the July 1, 1998 revision of this regulation. Always check the most current revision of this federal regulation as well as any state or local regulations that may apply to your particular application.

OSHA regulations become applicable when an operator's exposure exceeds a time-weighted average level of 85 dBA for an eight-hour period. Noise levels which exceed 85 dBA are of no significance to OSHA unless they occur in a location where operators are exposed to them. OSHA is concerned only with operator exposure to high noise levels - not with noise levels per se.

Where workers are exposed to a daily noise level of 85 dBA or more, employers are required to initiate a hearing conservation program. Hearing protectors must be made available, and signs must be posted warning of potential hearing damage. CEMA has a caution label designed to be placed onequipment to notify workers of hazardous noise levels (see Figure 5). More information concerning the purchase of these and other safety labels may be obtained at http://cemanet.org/safety/index.html. Employees must be given audiograms on a regular basis to detect possible progressive hearing loss. Fairly elaborate record keeping is also required.


**Figure 5: CEMA hearing protection label**

When an operator's exposure exceeds a time-weighted average level of 90 dBA for an eight-hour period, the use of hearing protectors becomes mandatory. Feasible engineering or administrative controls must also be implemented.

Engineering controls usually consist of process modifications, silencers, machine or operator enclosures, or the addition of acoustical absorption to the area. An acceptable alternate is administrative control in which the daily cumulative exposure to noise is limited by moving workers out of noisy areas in a systematic rotation. For any period spent in areas where the noise levels are below 80 dBA, operator exposure is considered to be zero.

Once noise contours have been defined, the risk to human operators can be established. The permissible levels of noise exposure specified by the U.S. Department of Labor in the Occupational Safety and Health Act are time-weighted average exposures. OSHA regulations become applicable when an operator's exposure exceeds a time-weighted average level of 85 dBA for an 8-hour period. The permissible levels of exposure to occupational noise permitted by OSHA are shown in Table 4.

The portion of time an operator is projected to spend working in a given sound field can be estimated and the level of exposure calculated. For these calculations to be valid, the sound field must be defined based upon reasonable operating expectations. The amount of noise in the work environment depends upon more than the level of noise generated by the conveyor itself. It also depends upon the speed at which the conveyor is operated, the nature and type of the unit load carrier used, the presence of other noise sources near the operating area, the architectural design of the building housing the system, and other considerations.

| Sound level dBA slow response | Duration per day, hours |
|---|---|
| 90 | 8 |
| 92 | 6 |
| 95 | 4 |
| 97 | 3 |
| 100 | 2 |
| 102 | 1 1/2 |
| 105 | 1 |
| 110 | 1/2 |
| 115 | 1/4 or less |

Footnote(1) When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: C(1)/T(1) + C(2)/T(2)C(n)/T(n) exceeds unity, then, the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level, and Tn indicates the total time

**Table 4: Permissible Levels of Exposure to Occupational Noise.**

*Ref. OSHA 1910.95(b)(2), Table G-16*

Ideally, the design specification should specify the operating environment in which the conveyor system must function. No one can accurately predict what the overall sound levels in a facility will be until after the system is up and operating in the intended configuration. However, there are several options for reducing the noise associated with these systems. These are discussed in the next section.

## Noise Control Options

There are several options to be considered when seeking to reduce workplace noise. These include:

1. Do not make the noise.
2. Modify or substitute processes and components that generate less noise.
3. Use vibration isolation or damping.
4. Absorb acoustic energy.
5. Shield or enclose the noise source or the receiver.
6. Combine or integrate solutions.

Noise can be controlled at the source, anywhere along its transmission path, or at the receiver. The primary goal should always be to reduce noise at its source. Often the most effective noise reduction approaches involve simple design changes to reduce the noise generated. A second approach involves modifying or substituting processes and components to reduce noise. For example, belts can be substituted for gears or free-fall conveying processes can be avoided. Cushioning impact points or substituting plastics for metal parts can be effective ways to isolate vibration or dampen sound. The use of acoustical materials to absorb sound within housings, enclosures, and buildings is another option frequently used. Alternatively, the noise source can be partially or fully enclosed. Properly done this can be very effective. However, if done incorrectly, it can be a complete failure or it may even amplify the noise from a source. Frequently, effective noise control requires a combination of these solution approaches.

There are many different types of conveyors frequently used in commerce and industry. The diversity of conveyor operating environments, conveyor designs, and installation options makes it impossible to specify a general solution to noise control problems. Noise control must be apartnership between the conveyor supplier and the end user. There are many different facets to the noise control problem. The conveyor supplier can address some of these issues like conveyor designand installation. However, other issues like the operation environment and maintenance of unit load carriers are controlled by the end user. Working together in a partnership, noise control options canbe identified and analyzed based upon user requirements. The following sections address the major concerns that must be addressed by this partnership.

## Conveyor Design and Installation Issues

There are potentially many different approaches to noise control, which can be developed. Different conveyor suppliers offer a range of conveyor designs. Different designs offer different challenges when it comes to noise control. What may be a noise control issue for one supplier may not be an issue for another supplier. Each conveyor design provides unique challenges and opportunities. For example, roller tube ringing is a common source of noise in conveyor systems. One cost-effective approach to this problem utilizes lined or covered tubes. However, some line shaft conveyor suppliers have found that the drive belt on these designs has a damping effect on this ringing sound and have found it unnecessary to use lined tubes. In addition, the type of unit load being conveyed may dampen this ringing. Therefore, to specify that lined or covered tubes be used may not provide a cost-effective solution in all applications.

Recognizing that different conveyor designs offer different noise control opportunities, what problems commonly occur? A typical powered roller conveyor system consists of three majorcomponents as shown in Figure 6. These are the structural framework, the drive mechanism, and the conveyor rollers. In a complex conveyor system, there are typically a limited number of structural frameworks and drive mechanisms. However, there are hundreds or thousands of conveyor rollers in use. These rotating rollers can frequently be the major source of noise in many conveyor systems.

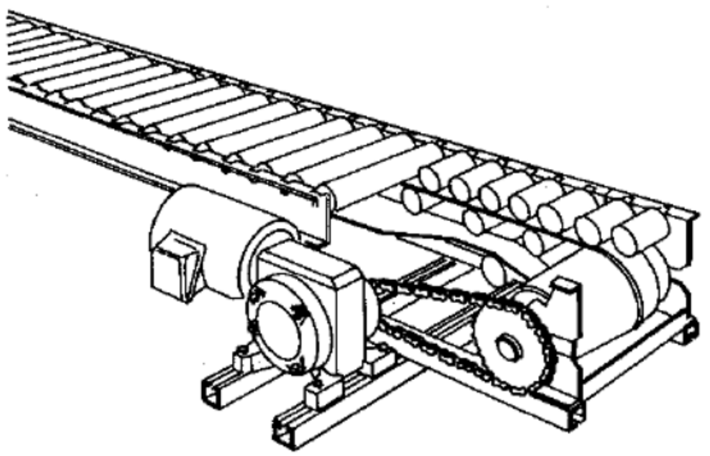


**Figure 6: Example of a powered roller conveyor**

## *Rollers*

Conveyor rollers can be a major source of the noise produced by high-speed conveyor systems. Most conveyor rollers are hollow metal tubes that resonate as conveyed materials move over them. In many high-speed roller conveyor systems, there is a constant "ringing" sound emanating from the roller tubes. This ringing can be reduced by using a plastic tube material or by covering or lining the tube with a sound absorbing material or vibration damping material.

With roller conveyors, the noise level is also a function of speed; as speed increases, the noise level increases. A 50% increase in speed can cause a 3 to 5 dB increase in noise level. At double the original speed, the level is 6 to 7 dB higher. At very high speeds the noise increases stop or level off, i.e., the noise versus speed curve flattens out, and slight reductions in noise levels have been observed at even higher speeds. This implies that the noise versus speed curve is convex and has a peak.

## *Roller Bearings*

Factors which influence noise generated from bearings include; the smoothness of the raceway (ground or unground), the level of precision of the ball (roundness and variation in diameter), ball separators (cages) and types of lubricant. In general, noise levels decrease as the quality of the bearing increases.

There are typically three types of bearings used in conveyor rollers. Stamped commercial grade cageless bearings utilize hardened unground steel balls and raceways with a full compliment of balls. These are the most economical bearings used in conveyor rollers. The next step up in quality is the stamped commercial grade “semi-precision” bearing. These bearings have hardened unground steel balls and raceways but utilize a stamped sheet metal cage to separate the balls. The highest quality bearings used in conveyor rollers are ABEC-1 precision bearings. They utilize hardened and ground balls and raceways with a caged ball complement. In most clean area applications, ABEC-1 precision bearings also offer longer life and lower maintenance and operating costs compared to traditional bearings.

Noise reductions can be significant when ABEC-1 precision bearings are used versus stamped commercial grade cageless bearings. At lower speeds the individual balls in a cageless bearing will “fall” in the raceway causing a readily identifiable “pinging or tinkling” sound. At higher speeds the balls are held against the raceway by centrifugal force and this sound is not present. ABEC-1 bearings have a caged ball compliment which eliminates any noise from the balls regardless of speed.

Table 5 shows the difference in noise levels at varying speeds between commercial grade cageless bearings and ABEC-1 precision bearings. This data is to be used as a guideline only – results will vary greatly depending on bearings, method of securing roller shafts in frames, frame material and design, and method used to drive the rollers.

| Speed (FPM) | Range of sound level difference (dB) |
|---|---|
| 120 | 7 - 17 |
| 180 | 8.5 - 19 |
| 240 | 9.3 - 20 |

**Table 5: Sound level of commercial vs. precision bearings**

Note: Above range of values were determined from sound measurements on various types of conveyors at a distance of 3 feet from the rollers. Sound levels are A scale, slow response.

## *Roller Shafts*

Shaft clatter can be another significant contributor to noise from conveyor rollers. While the manufactured roller is reasonably round, there will be some ovality and some imbalance. These issues are accentuated at high speeds. As speed increases, rollers begin to bounce in the frame creating noise. Several techniques are available to prevent shaft noise. Threaded shafts with either male threads or tapped holes are popular in Europe. Metal clips to secure shaft ends are also available. Alternatively, plastic, rubber or polymers can be used as inserts into a frame or adapters over a metal shaft to prevent metal to metal clatter.

### *Frames*

Conveyor frames are generally fabricated of formed or structural steel. These frames transmit the noise generated by the rotating components they support and the noise generated by the goods being conveyed. Isolation devices like damping pads, non-metallic hangers, vibration absorbers, etc., help by absorbing vibration energy at each support joint. Also, for installations where conveyors are located on mezzanines, isolation pads could prevent vibration energy from being transmitted to the floor and being re-radiated on both sides of the mezzanine. If the mezzanine is open flooring, the grating should rest on resilient rubber or dense foam strips to prevent rattling.

### *Drives*

The drive mechanism typically includes an electric motor and gearbox, and various bearings, belts, chains, sprockets, etc. The electric motors generally operate quietly if properly maintained. Invariable frequency AC drives, if the motor is operated at very slow speeds, the motor can whine. Although it may not add much to the overall sound level, the presence of the high pitched tone is very annoying.

The gearbox connected to the motor can produce noise as torque is increased or speed reduced. Higher precision gearboxes effectively reduce noise. Also, high quality bearings should be used throughout the drive system. Vee belts or Polyvee belts and gearbelts produce less noise than chain drives in many applications. Where chains, of any type, are used, the chain guides should be of a smooth plastic to reduce noise. Proper lubrication is also important. Finally, all powertrain hardware should be securely attached to rigid support structures to avoid vibration. Sound boxes lined with acoustically absorptive materials can be used to further isolate the drive from nearby operators.

### *Pneumatic Devices*

Consideration should be given to the use of silencers on the exhaust ports of pneumatic devices. Air leaks should be eliminated to avoid unnecessary noise.

### *Conveyor Belts*

Belt conveyors use wide flat belts to move product rather than rollers. This type of conveyor presents it's own unique set of variables that affect the noise generated. The bottom surface of the belt is generally more important than the top because it contacts either the slider bed or the roller bed that supports it. Belt on slider bed is typically quieter than belt on rollers. The weave of the belt has an effect on both the level and frequency content of the noise generated. Likewise, the impression pattern on the top surface and the material affect the level and frequency content of the noise.

Belt driven live roller conveyors use narrow belts (relative to the roller width) to provide driving force to the carrying rollers. The narrow belt is snubbed against the bottom side of the roller and friction causes driving force. Both sides of the belt are critical to the noise generation.

Belt construction influences noise generation; the weave and covering are major factors.

Air travelling with the belt is trapped as the belt engages a roller or snub. Longitudinal ribs in the belt provide an escape route for this air and minimize the noise.

The quality and orientation of the belt lacing and joints in the belt can affect the noise as it passes over the rollers, sliders, end rollers, snubs and drive pulley. Mechanical lacing installed on a bias angle is quieter than lacing installed at a right angle. Some belts can be vulcanized endless; this eliminates the lacing noise; however, ease of replacing the belt should be considered before choosing endless construction.

## *Operating Environment and Other End-User Considerations*

The environment in which the conveyor systems must operate can have a major impact on the amount of noise generated. Significant noise control can be obtained by controlling the reflected noise that accumulates in enclosed interior environments. This phenomenon, called reverberation, occurs when there is a lack of absorbing surfaces. The walls, floor and ceiling in industrial plants are typically acoustically hard and significant reverberation buildup is common. Acoustical bats or baffles can be suspended in rows or in "egg crate" type ceiling arrangements to absorb noise. However, little reduction is usually achieved within 10 feet of the source. In many factory areas, the noise sources are distributed over the entire floor area. As such, moving 10 feet from a noise source simply puts you in the noise field of another noise source. Nevertheless, since the noise a person is exposed to consists of direct noise and reflected noise, distributing extra absorption in the plant will reduce the reflected noise of distant sources and lower the overall noise level. Reductions of 5 to 7dB can be achieved.

*The noise reduction achieved is a function of the ratio of the amount of absorption "after", to the amount of absorption "before". Sound absorption is measured in sabines. A sabine is the term used to express 100 percent sound absorption per square foot of surface. The amount of sabines is simply the sound absorption coefficient multiplied by each square foot of surface. All sound absorption must be added for* ***A before****, and all sound absorption must be added for* ***A after****.* The relationship is plotted in Figure 7.

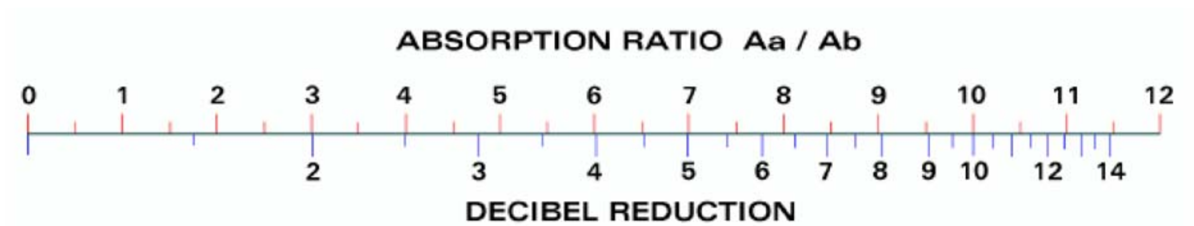



**Figure 7: Reduction in Reflected Sound Level**
**Noise reduction in dB = 10 log10 (A after/A before)**

From the figure we see that a doubling of the absorption gives a 3 dB reduction in the reflected noise level. Approximately three to five times the "before" absorption level is required to achieve 5 to 7dB reductions.

There are several features in the building's design, which are best incorporated in the design and construction phases that can reduce the noise level in the plant. Some buildings include a thermal insulation on the inside of the side-walls; often it is a rigid, closed-cell foam sheathing. This material has practically no acoustic absorption capacity. A fiberglass material, with a protective and moisture-proof barrier, can be used which will have the necessary thermal properties plus acoustic absorption. Metal roof decks usually include a fiberglass thermal insulation.

If the underside of the metal deck is perforated, such that the noise can reach the fiberglass, then considerable absorption can be achieved. Also, spray-on cellulose materials are available to add absorption to existing structures; these materials also add thermal insulation. Having an absorptive roof deck and side-walls can give a 3 to 4 dB reduction in the noise level.

The unit load being conveyed can also impact noise levels. Unit load carriers (pallets, tote bins, etc.) should be adequately maintained to reduce noise and damage to rollers. The material used to construct the unit load carrier (wood, plastic, metal, etc.) can further contribute to the problem. Be sure to use materials that tend to dampen any noise generated by conveyance of the unit load. If this is not possible, soft but durable strips of cushioning material could be added to the bottom of the unit load carriers. Also, loose parts being conveyed can generate noise as they vibrate or bounce around. These can be packed so as to minimize movement.

Factories also include other equipment besides conveyors that can cause noise. Large roof or wall mounted ventilation fans, heaters, and air compressors also can cause considerable noise. Care should be taken by the end user to select equipment that meets certain noise criteria. Remember, two pieces of equipment that each separately give a level of 83 dB, both under the OSHA 85 dB criterion level, will result in a level of 86 dB, which is over the OSHA criterion level.

When considering noise control, what's most important is the level of noise people will be exposed to during the performance of their jobs. The areas where people are expected to spend the majority of their work time need to be defined and sound pressure levels measured or estimated in these locations. If possible, jobs located in noisy areas may be redesigned to structure work differently and thus remove the operator from these areas. Noise reduction and the resulting quiet operation environment, will have a significant impact on employee performance, system throughput, and environment conformity.

## *Summary*

It is a good business practice to minimize operator exposure to noise. The total work environment and all sources of noise must be considered as an integrated system when addressing noise reduction. In addition to the conveyor itself, the building, the unit load carrier, the structure of work, other noise sources (e.g., production equipment), and reverberation must be considered. System design and installation specifications should focus on operator exposure to noise. Working together, the conveyor supplier and the end user can identify cost effective solutions to noise management.

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Note: Much of this information was copied from a document published by Material Handling Industry Association in 1997. We used that document as a reference source with the permission of Tom Carbott, Managing Executive Conveyor Products, MHIA.

Additional text andillustrations were donated by Matthew Kluesener, a sound and vibrations consultant in Cincinnati, Ohio, Mathews Conveyor Danville, Kentucky, and The Buschman Company, Cincinnati, Ohio.

Document History: This document was begun in 1998 by the CEMA Sound under the Chairmanship of Mr.John Martin of The Buschman Company.CEMA Sound Committee. It went through several revisions and was finally published by the CEMA Sound Committee in 2002 under the Chairmanship of Mr. Boyce Bonham of Hytrol Conveyor Company.

CEMA wishes to thank the many member companies who provided contributors to this document. Please submit any change requests or suggestions for improvements to CEMA Headquarters, attn: Phil Hannigan, CEMA Executive Secretary.

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