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Quiet that compressor

Excessively loud air-compressor systems are often a source of plant noise. Solve facility noise issues by considering the source, path and receiver — then reap the benefit of improved communications.

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The general intent of noise mitigation is to neutralize its objectionable characteristics by modifying tonal, temporal and loud noise into a continuous broadband noise at a lower sound level. Identifying the types of noise generation and paths of travel leads to uncomplicated, feasible, economical ways to attenuate and isolate both airborne- and structure-borne sound.

Excessively loud air compressor systems in the plant or operations area are associated with hearing protection, difficult workplace communications, fatigue and annoyance. Central plant or building services noise can intrude into conference rooms, offices and laboratory spaces, resulting in speech interference or annoyance.

The complaints and their sources make it apparent that noise is more complicated than mere loudness. Sound quality, or tonal and temporal noise characteristics, affects perception and annoyance. But you can solve facility noise issues by considering the source, the path and the receiver.

Source

Determine where the noise originates and how it radiates. The source may be machine rotation, reciprocating vibration or impact contact. Turbulence and gas escaping a nozzle or other opening also produces noise. If it's unclear which of several potential noise sources is at fault (Figure 1), turn off each one sequentially until the true source is obvious.

[Editor's Note: To view Figures 1, 2 and 4 in this article, simply click on the Download Now button at the bottom of this article.]

Then characterize the noise as tonal (low-, mid- or high-frequency) or as broadband (sound distributed evenly over the audible spectrum). Figure 2 illustrates different noise spectra. The blue spectrum is a whine, peaking at 1,000 Hz. The red spectrum, heavily unbalanced on the low frequency side, would be perceived as rumbly. The purple spectrum has a tonal characteristic with sound level in the 500 Hz band that is much louder than the side bands. The green spectrum is a relatively balanced or flat spectrum, relative to the noise criteria lines. Of the four shown, this would be least objectionable.

Next, determine how the noise differs from the continuous background sound in the area. Identify tonal components, such as buzz, hum, hiss or rumble by subjective listening or by measurement. Also, identify temporal or time-varying nature, such as on and off.

Path

Determine whether the sound travels through the air, the floor and walls, or both. Determine whether the airborne- or structure-borne path is stronger, or whether noise travels over both paths. This requires either careful listening or sound and vibration measurements along the suspected route. Sometimes structure-borne sound can be detected by putting an ear against wall surfaces and comparing that noise with the general room noise. As noted above, turning suspect sources on and off may confirm the offender. Along the path, consider conditions that affect airborne sound:

- Amplification of airborne sound by reflection.
- Attenuation of airborne noise by absorption.
- Reduction by transmission through solid partitions and other barriers.

Look for holes in what may appear to be solid walls. Look for gaps in mortar between bricks or masonry units. Drywall partitions might not be caulked at floor and penetrations. Find holes and penetrations for ducts, piping and conduit. Look for partitions that terminate at a suspended ceiling. Locate and evaluate vertical shafts and pipe chases. Determine whether a discontinuity could be introduced into a structure-borne path to either isolate or break the vibration path or damp vibrating surfaces (ringing or free vibration).

Potential solutions might include adding absorptive surfaces to reduce reflective or reverberant noise buildup along the path. Improve partition barriers by increasing their mass and stiffness while closing gaps, penetrations and other holes. Often a combination of measures at the source and along the path mitigate noise disturbance most effectively.

Absorption, though, is often misapplied. It helps to reduce reverberant and reflective sound, particularly near the source and along the path, but it may be of little benefit in the room where the noise is objectionable. The reason is that absorptive materials reduce the sound level of everything in the room. If the intrusive noise is 3 dB louder than the background before absorption is added, it will probably remain about 3 dB above the background afterward.

Receiver

Noise is perceived relative to other environmental sounds. If the ambient level is quiet, relatively modest noise can be annoying. If the background is loud but broadband, tonal or temporal components of noise can still be perceptible and annoying. Evaluate the severity, perceptibility and annoyance of the noise by comparing the noise (with equipment operating) to the background sound at the receiver location (with equipment off).

First, evaluate or categorize the continuous background or ambient conditions at the receiver in terms of loudness and spectrum (preferably without the offending or disturbance noise). Listen to the background noise and describe it subjectively as loud or quiet, and with descriptive adjectives, such as roar, whine, buzz, hum, rumble or whistle.

Take note of how far you can be from a person speaking in a normal conversational voice and still understand most of what is said. If you can conduct measurements, the A-weighted levels from a simple hand-held meter provide a start. With a two-band meter, compare A- and C-weighted measurements to evaluate the noise spectrum. If the difference between A and C levels is 10 dB or more, you probably have an unbalanced spectrum with a lot of low-frequency rumble. Using a spectrum analyzer to determine octave band levels makes tonality much easier to identify.

Next, repeat the process with the intrusive noise present looking for the difference in overall levels, both A- and C-weighted, or in octave bands if you have a spectrum analyzer. Alternately, listen and make a subjective judgment of the intruding sound and how it changes the character of the noise in the receiver room. You get a good sense of how much and what kind of mitigation is called for by determining how much the sound changes and whether low, middle or high frequencies are the most changed.

Evaluating the source, path(s) and receiver as described above is the easiest way to develop a scheme to mediate the noise. Implementing noise mitigation at the source and along the path reduces or alters the noise volume and its tonal and temporal characteristics.

Compressor noise

Compressors are pumps for air, refrigerants or other gases. They generate noise in various ways. Continuous flow noise is typical of scroll, centrifugal and turbine compressors. Pulsation is typical of reciprocal, screw and rotary compressors. In other words, like pumps, compressors can be divided into centrifugal and positive displacement classifications. The mechanisms of noise generation and attenuation are different for each class.

Most compressor noise can be found at the inlet, at the discharge and radiated from the compressor casing. So-called “waste air” ports represent secondary discharge sources and, therefore, are the first places to apply noise reduction. Connected piping can transmit noise, so consider reducing the sound within the lines and damping pipe wall vibration for attenuation along the path.

Air leaks generate noise, so apply some proper maintenance. You can quiet nozzle discharge by using a low-noise nozzle that diffuses the air stream.

Compressors generate noise, but so do motors and other drivers. If subjective listening or measurement reveals the motor to be a strong contributor to noise, treat it as a secondary source. Place a temporary housing or cover over the compressor while leaving the motor exposed. If the motor is noticeably loud, or if sound measurement is within 6 dB of the uncovered compressor-motor assembly, consider installing a motor mute. If the difference is greater than 6 dB, the motor can be left untreated.

Easy fixes

Several simple techniques can attenuate noise at the compressor. Install a muffler or silencer on the inlet (Figure 3). Device selection must consider its effect on compressor operation, available space and noise characteristics.

Treat high-frequency inlet noise with a simple absorptive muffler. These have a straight perforated pipe through a housing stuffed with fibrous media. You might have used a similar “glass-pack” muffler on your car to achieve that muscle car sound.

The absorptive muffler has a low-pressure drop and can be used at an open inlet unit with a filter or in-line if low-pressure air is being piped from a remote source. Some combination filter-silencer products may be available from filter manufacturers.

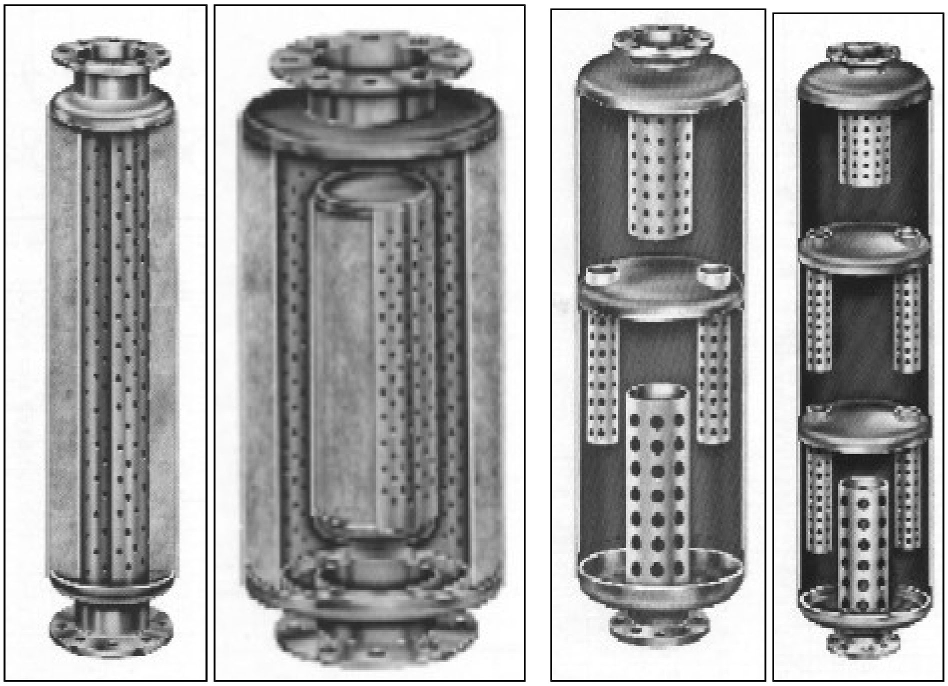

Figure 3 Use absorptive mufflers (left two) for high-frequency noise. Consider expansion chamber or reactive mufflers (right two) for low frequencies.

Low-frequency inlet noise can be treated with an expansion chamber muffler, but at the expense of much greater pressure drop. The expansion chamber, or reactive muffler, is a housing with two or more empty chambers connected by short segments of perforated tube, similar in design to the standard auto muffler.

Centrifugal compressor discharge and inlet noise may be treated similarly, but positive displacement compressors require pulsation control. In either case, an inline silencer and a pulsation damper (similar to a two-chamber reactive muffler) can be installed in the discharge piping.

The waste-air port usually discharges directly to atmosphere and the nozzle effect can produce high-frequency noise. A simple, inexpensive air diffuser can be installed in the port to reduce the shear between fast-moving gas and the slower ambient air.

Motor noise varies with motor type. TEFC motors are more likely to radiate noise from the ventilation inlet than drip-proof or other motors. Inexpensive motor mutes installed over the end of the motor attenuate the internal fan noise. These are little more than sheet metal cans with an interior acoustical liner attached with simple screw brackets.

If temperature rise won't be a problem, noise radiating from the compressor casing or body can be contained with a noise barrier jacket. The jacket can be fabricated from mass-loaded vinyl or a noise barrier septum in a quilted blanket (Figure 4). The jacket needs close-fitting openings for pipes and conduit connections.

If a noise jacket is inappropriate, an enclosure, sometimes called a doghouse, can be fabricated to fit over the compressor. It should be made of a solid material, such as sheet metal or plywood, and lined with acoustically absorptive material. Access doors should be fitted with gaskets to achieve an airtight enclosure, but the doghouse for smaller compressors should be able to be lifted off.

The entire compressor or compressor-motor assembly should be enclosed if possible. Penetrations should be close-fitting to limit noise escape. Gasketed openings are preferred, and pipe and conduit can be caulked with a permanently resilient sealant.

It's possible for the housing to vibrate and radiate noise, so curved surfaces are more desirable than flat surfaces because their stiffer arc is less likely to vibrate.

Pay attention to piping
Treat noise within the piping at the compressor discharge. Pipe-borne vibration, which causes radiated noise along the path, should be stopped with flexible couplings between the compressor and the piping.

A neoprene sphere spool piece is preferred for pressures to 100 psi or 125 psi, and a temperature below 150°F, but a braided metal spool piece may be required for high temperature or pressure. The braided flexible coupling's greater stiffness makes it less effective as a vibration isolator.

Radiated pipe noise can be an issue if compressed gas or air lines are routed in or near acoustically sensitive spaces, such as offices, conference or laboratory spaces rooms. Install vibration isolator hangers or mounts on piping suspended from or mounted on building elements. Support the entire line this way.

If this is inappropriate, inadequate or uneconomical, the segments of pipe close to sensitive spaces can be lagged or enclosed to contain noise. Lagging is a noise barrier jacket wrapped around external insulation on the pipe. The purpose of the insulation is to prevent contact between the pipe and solid surfaces. Common lagging jacket materials include mass-loaded-elastomers, sheet lead, lead-aluminum laminates, and similar relatively high-mass materials.

Alternately, the pipes, whether they're on hangers or trapeze racks, can be enclosed in gypsum board or plywood furring, chases or soffits. The furring should have acoustical liner on the inside to reduce reverberant noise within the enclosure. Frame the furring independently of the pipes and supports to prevent transmitting pipe or support vibration to the enclosures.

Compressed air noise at end-user locations may contain contributions from the compressor, which is transmitted by piping, and from nozzles or escaping gas at the user point. Treat the compressor noise upstream, as described above. Diffusers and low-noise nozzles are simple, inexpensive devices for reducing noise at open port and blow-off stations.

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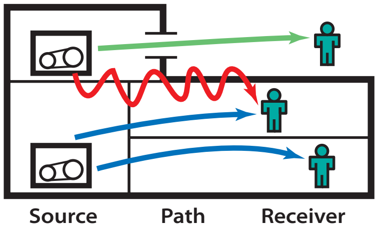
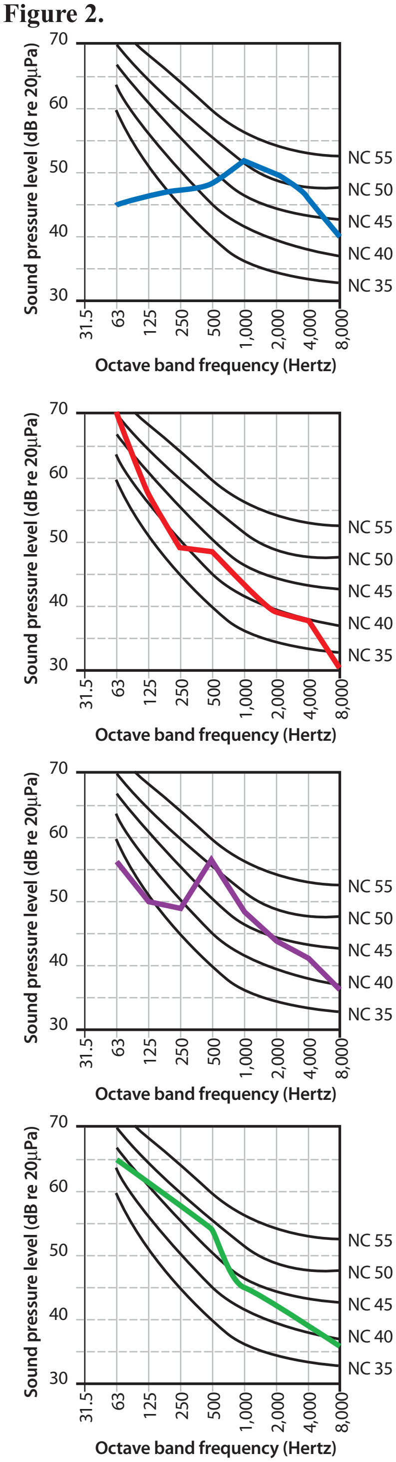
Figure 1.



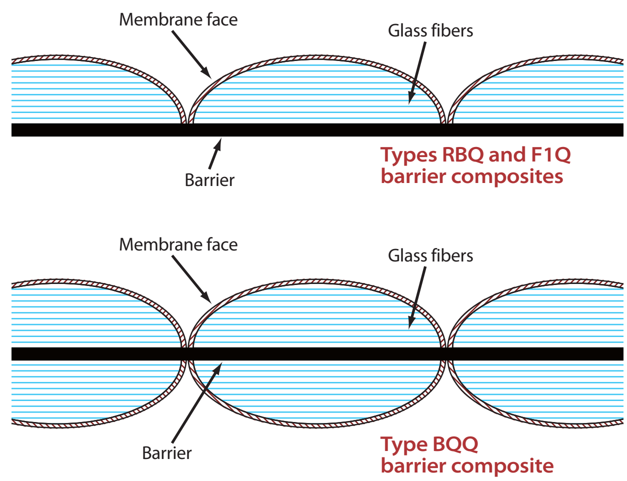
Solving a noise problem requires addressing the source, path and receiver.

Figure 2.



Spectrum noise charts depict whine (blue), rumbly (red), tonal (purple) and flat (green).

Figure 4.



Mass-loaded quilt can be used to jacket noisy compressors, if thermal considerations allow it.