12/01: Controlling Noise on the Plant Floor

Toning down steam ejectors

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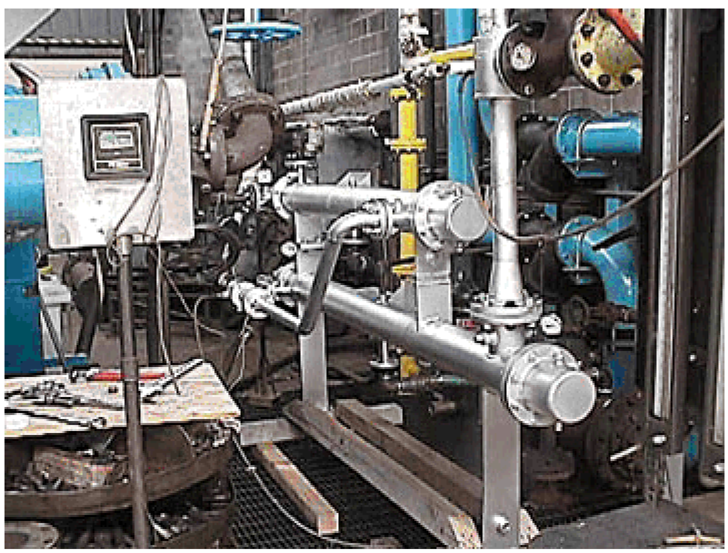
The current U.S. Occupational Safety and Health Administration (OSHA) regulations are clear: Ambient sound level in manufacturing plants must be kept at or below 85 decibels (dBA) at one meter from the equipment generating the sound. However, the strategies for implementing these regulations are not as clear.

In certain applications, steam jet ejectors can create a high level of noise. Predicting this noise level can be complicated, but it is easier if you know some steam ejector basics.

The noise level generated by an ejector is not constant. Its highest level is at startup when suction pressure is closest to atmosphere. At its designed operating pressure, an ejector typically generates its lowest sound levels.

Sound emanates from an ejector at two sources — through its wall and at its discharge.

The source of sound
A steam jet ejector works by combining high-pressure motive steam with low-pressure suction gases, discharging to an intermediate pressure. The motive steam leaves the ejector nozzle at a high velocity and entrains the suction vapors. The combined mixture increases in pressure until it is discharged from the ejector.



For this two-stage vacuum system under performance testing, where the noise limit was 85 dBA at 3 ft. from the equipment, the noise at 3 ft. was measured at 82 dBA, and no acoustic insulation was required. The noise is low because of the after-condenser.

The first source of noise comes from the high steam velocity inside the ejector, emanating through its wall. The ejector body contains this sound, and increasing material thickness will dampen the noise.

Small ejectors fabricated from bar stock and plate produce a relatively low noise level through the wall of the ejector, usually between 60 dBA and 85 dBA. Larger ejectors fabricated from plate will have a higher noise level through the wall because they typically are made from a thinner material.

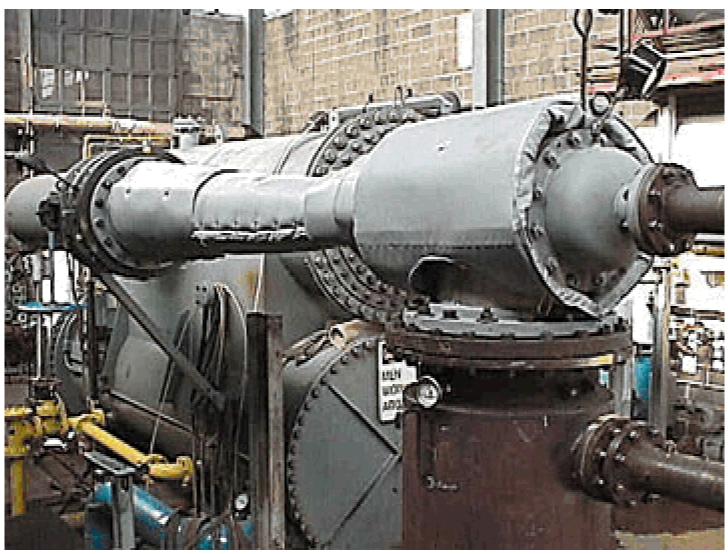
The second, more common source of noise is related to the vapor's discharging from the ejector through the discharge connection. This is where the noise level tends to be highest. Typical sound levels at the discharge would be 110 dBA for a Z stage discharging to atmosphere and 120 dBA for a primer, or hogger, discharging to atmosphere.

Permissable Noise Exposures
According to OSHA (Standard 1910.95, "Occupational Noise Exposure"), protection against the effects of noise exposure must be provided when the sound levels, measured on the A scale of a standard sound level meter at slow response, exceed the following levels:

90 dBA for a duration of 8 hours per day
92 dBA for a duration of 6 hours per day
95 dBA for a duration of 4 hours per day
97 dBA for a duration of 3 hours per day
100 dBA for a duration of 2 hours per day
102 dBA for a duration of 11/2 hours per day
105 dBA for a duration of 1 hour per day
110 dBA for a duration of 1/2 hour per day
115 dBA for a duration of 1/4 hour or less per day

Employees subjected to sound exceeding these limits must use "feasible administrative or engineering controls," says OSHA. In addition, the employer must administer a continuing hearing conservation program whenever employee noise exposures equal or exceed an 8-hour time-weighted average sound level of 85 dBA measured on the A scale. When daily noise exposure consists of two or more periods of noise exposure of different levels, OSHA states that companies must consider their combined effects instead of the individual effect of each. *CP* Staff

Measuring the sound
The Heat Exchange Institute's (HEI) "Code for the Measurement of Sound from Steam Jet Ejectors" provides detailed and complex recommendations for the measurement of airborne sound pressure levels and the calculation of sound power levels and noise power emission levels. The sound measurement code is based on many years of research and development by HEI Steam Jet Ejector Section members.



This 16-in. multi-nozzle thermocompressor uses a prefabricated insulating jacket that is removed in the field for maintenance. It is being tested for both process performance and noise level.

The code strongly recommends that tests be performed with the ejector's operating at design conditions. Background sound level, when the ejector is not in operation, also should be measured for comparison. In fact, as the code points out, acoustical treatment of related valves, piping, strainers and other auxiliaries might reduce perceived problems with ejector noise.

Reducing noise
The two sources of ejector noise must be treated independently. Sound propagated through the body of an ejector can be dampened with acoustic or, in some cases, thermal insulation. Insulation of the body of an ejector is accomplished by:
• Wrapping insulation around the unit. A typical insulation uses low-density open-weave fiberglass, with a flexible barrier and aluminum facing. The insulation is applied from rolls, and thickness is added until the desired noise reduction is reached. The final thickness is generally 1 inch (in.) or 1.5 in.
• Alternatively, by designing an acoustic jacket to serve as an integral part of the ejector. The jacket typically will encase the entire unit and should be filled with a sound-insulating material such as mineral wool or sand.

Several options exist for addressing sound emanating at the discharge of an ejector, including:
• Designing the discharge directly into a receiver, usually a vacuum condenser. Thermocompressors, for example, often discharge into shell-and-tube heat exchangers; standard ejector systems can be designed to discharge into inter- or after-condensers. Each arrangement typically results in efficient sound reduction.
• Installing a separate silencer at the discharge of an ejector. This is standard operating procedure for hogging or priming ejectors, and can achieve up to a 30-dBA reduction in noise level.

Silencers are characterized as absorptive (packed) or reactive (chamber), or a combination of the two.

Absorptive silencers are filled with either fiberglass or stainless steel packing. The use of stainless steel increases capital costs but results in longer life and better temperature resistance for the equipment. Absorptive silencers work best at the upper end of the octave band frequencies.

Reactive silencers are designed with a number of consecutive chambers that reduce the velocity of the entering gas or vapor. This results in a higher-pressure drop than that created by an absorptive silencer. This drop must be taken into consideration at the design phase of the project because ejector systems using reactive silencers characteristically will require higher motive steam usage.

A typical ejectors is tested with a silencer for pressure drop and noise reduction.

Conclusion
How the ejector and surrounding equipment are supported plays a major role in exactly how much noise is generated and how much is piped away. Loose supports, long lengths of unsupported piping, faulty flanged connections and other problems can add to the noise-generating potential of equipment.

As a practical "fix," ejector discharge always should be directed away from operational areas, and preferably directed upward.

Ejectors often are thought of as fairly noisy in operation. When background noise is discounted and appropriate attenuating measures are taken, ejectors often turn out to be acceptable members of a well-balanced plant in conformance with OSHA regulations.

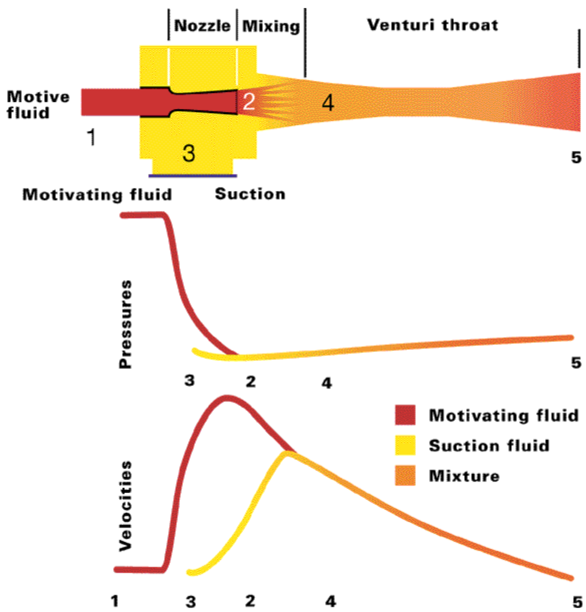
Steam Jet Ejectors: an Overview

Steam jet ejectors offer a reliable and economical means for producing vacuum. The primary advantages of the steam jet ejector are its low initial cost, lack of moving parts and simplicity of operation.

Steam jet ejector operation

A conventional steam ejector has four basic parts: a steam chest, a nozzle(s), a mixing chamber and a diffuser. The diagram illustrates basic ejector operation.

A high-pressure motivating fluid enters at 1 and expands through the converging-diverging nozzle to 2; suction fluid enters at 3 and mixes with the motivating fluid in the mixing chamber (4); both fluids then are recompressed through the diffuser to 5.



Ejector construction

The simplicity of the ejector design permits fabrication from any workable or weldable material, including cast iron, carbon steel, stainless steel, Monel, Teflon, Hastelloy, Ni-Resist, Haveg, graphite-lined and rubber-lined carbon steel, titanium and fiberglass-reinforced plastic.

Single-stage ejectors are used to create vacuum ranging from atmosphere to 3 inches (in.) Hg absolute. Higher vacuum, ranging from 3 in. Hg absolute to 3 microns Hg absolute, can be achieved through multiple staging. Multiple-staged systems often include surface- or direct-contact-type condensers. Intercondensers reduce motive steam requirements and, under certain conditions, permit recovery of product condensate.

Multiple-staged systems are custom-engineered for optimum performance and minimum utility consumption. They are designed to handle a variety of process gases, including air, water, hydrochloric acid, butane, sulfur dioxide, ethylene glycol and many other organic and inorganic vapors. Where conditions warrant, corrosion-resistant materials of construction are used.

Although most ejectors are steam motivated, other fluids can be used. For example, to maintain the purity of a product, a process-compatible fluid can serve as the motive fluid.