UNIVERSAL SILENCER

noise control and air filtration solutions

Universal Silencer's
Exhaust Stack Recommendations

It is common for the industry to refer to noise in terms of frequency, while the science of noise control engineering is more a function of the wavelength of noise. Low frequency noise is characterized by long wavelengths that are difficult to attenuate by conventional noise control techniques. The high gas turbine exhaust temperatures exacerbate the problem (wavelength increases as the speed of sound increases, which increases with temperature). Additionally, these techniques create an energy loss (pressure drop) that results in loss capacity (power output). The task is then to provide the required DIL while creating the minimum pressure drop possible.

Reducing low frequency noise with long wavelengths requires a great deal of effort. Some of the key parameters that must be analyzed in the design phase are gap velocities, stack exit velocity, acoustic pack density, flow resistivity of the material, baffle thickness and length. All of these parameters must be set while maintaining pressure drop at the lowest value possible. Many of these parameters are interdependent and/or contradicting.

Some of the design parameters set for this application are listed below.

- Flow resistivity defined to provide maximum attenuation of the low frequency, long wavelength noise.
- Gap velocity set low enough that the effect of flow is minimized.
- Stack exit velocity set to prevent self-generated noise from influencing the overall sound environment.
- Baffle thickness set to provide significant low frequency, long wavelength noise attenuation.
- The silencer should have a double wall construction design that will maximize transmission loss of the system.

Flow Resistivity:

Turbine exhaust noise is typically dominated by low to mid frequency noise (31.5 to 1 kHz) with corresponding wavelengths of approximately 57 feet to 1.5 feet. Flow resistivity is one of the most important material acoustic properties. The designer must chose a material property that has a low enough flow resistance to allow sound to penetrate into the acoustic material but have a high enough flow resistance where sound is dissipated before it can exit the acoustic material.

Flow resistivity is affected by many variables. Temperature and pack densities are the two most significant parameters that effect flow resistivity for turbine exhaust systems. Much like a SPL

(Sound Pressure Level) value having limited meaning without a distance specified; flow resistivity should have the gas temperature value defined when values of flow resistivity values are specified. Compression of acoustic material also has a significant impact on the final value of flow resistance. Compressing of acoustic material can be a tool to achieve a desired acoustic performance or be a constraint if not accounted for properly in the design and manufacturing phase.

As mentioned above turbine exhaust noise is typically dominated by low- to mid-frequency noise that has long wavelengths. Attenuation of this type of noise generally requires higher flow resistivity material than a noise field dominated by higher frequency/shorter wavelength noise. It is typical to specify materials with flow resistivity values between 20,000 to 40,000-mks rayls/m at ambient temperature when stringent low frequency noise attenuation is required.

There have been many instances where two sets of parallel baffles in series have been used to obtain the needed silencer insertion loss. Typically, we will design the baffles closest to the turbine to attenuate the low frequency noise and the second set of baffles to attenuate the high frequency noise. It is common practice for Universal Silencer to design the low frequency baffles thick and long with a high flow resistivity material. The high frequency baffles are thinner, shorter, and have acoustic material with an ambient temperature rated flow resistivity of approximately 20,000-mks rayls/m.

Pack Retention:

Acoustic material will migrate into the air-stream if not properly protected by some type of pack retention. A typical method of pack retention is to wrap the acoustic material with fiberglass cloth. There are two concerns with this.

1 The fiberglass cloth has an extremely high flow resistance with inhibits the noise reduction ability of the acoustic material (particularly in the middle frequencies where the most noise attenuation is needed).

2 Turbine high exhausts flow rate causes the fiberglass cloth to rub against the perforated facing resulting in deterioration of the protective fiberglass material. The acoustic material migrates into the flow stream without the protective material in place compromising the performance of the silencer.

Universal Silencer's design guidelines were changed years ago to replace the protective fiberglass cloth with multiple layers of stainless steel wire mesh. Stainless steel wire mesh has the advantage of high temperature strength and corrosion protection. The mesh pattern of the liner was selected to provide the maximum protection of the acoustic material ensuring long life and being acoustical transparent in practical terms

Gap Velocity:

Gap velocity effects acoustic performance in several ways. The net effect of the change in acoustic performance is that when sound is traveling in the direction of airflow you gain high frequency performance but lose low frequency performance. The situation is reversed when sound is traveling opposite airflow. The lower the gap velocity, the less effect on acoustics. However, lower gap velocities generally result in larger more expensive silencers. In critical noise environments Universal Silencer will limit the gap velocities to below 0.9 Mach which is approximately 9,000 fpm at 900 degrees Fahrenheit. The lower velocities also help promote acoustic pack retention, and reduce the possibility of flow generated noise.

Exit Velocity:

Silencer exit velocity is typically not an issue with most gas turbine applications. However, care must be taken to prevent flow-generated noise when the baffles end right at the silencer discharge. If the gap velocity guideline criteria described above is maintained; then flow-generated noise should not contribute to the overall sound field noise level.

Baffle Thickness:

As stated before low frequency noise is characterized by long wavelengths. There really is no set standard as what the correct baffle thickness should be. Some literature states the baffle thickness should be 1/8 the wavelength of the noise while others state the baffle thickness should be 1/10 the wavelength of the offending noise. Usually cost restriction and physical constraints prevent either of the above criteria from being met if the offending noise is in the 31.5 and 63 Hz octave bands.

Universal Silencer attempts to design exhaust systems that have a flat noise spectrum (i.e. each A-weighted octave band has approximately the same amplitude). We will do this by a choice of baffle thickness, choice of acoustic material, and separating the silencer into two silencers if necessary.

Transmission Loss:

Noise passing through the silencer walls can set the upper level of the sound field at a turbine installation. Care must be taken to increase the transmission loss of the silencer wall as well as all associated ductwork. The most effective means to increase shell transmission loss is to have a double wall construction separated by some distance. The space between the walls is typically filled with an absorptive material. The inner wall and outer wall should have different material thickness ensuring different coincidence frequencies.