providing innovative noise and emission control solutions
Who is Noise Solutions?

A proven industry leader providing engineered turnkey noise analysis and suppression with GUARANTEED results.

Based out of:

- Head Office: Calgary, Canada
- US Office: Denver, USA

1-877-NO-NOISE
www.noisesolutions.com

A proven industry leader providing engineered turnkey noise analysis and suppression with GUARANTEED results.

APEGGA Permit to Practice P08789
Some of our Clients
“I’ve been wanting to say “thanks” for the excellent work your Noise Solution’s Team did in reducing the sound levels throughout the Shuttle Crawler Transporters… I had the opportunity to experience first-hand the reduced noise levels due to your new Mufflers & Acoustical Ventilation Systems … Plus what a huge difference the Jacking Equalization & Leveling “Hydraulic Silencers” modifications made! The difference in the control room alone is very impressive!”

Quote by Perry L. Becker
Chief, Shuttle Ground Structural Systems Branch
Mechanical Division, Engineering Directorate
NASA Kennedy Space Centre
“From my perspective as a “NASA customer” I’d like to say it’s been a real pleasure working with Noise Solutions Teams since 2000. Noise Solutions has a strong customer focus – that isn’t quite as common as it should be in the business world today!”

Quote by Perry L. Becker
Chief, Shuttle Ground Structural Systems Branch
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Understanding Sound and Noise
Understanding Sound and Noise
Sound:
Pressure variations that occur strongly & rapidly enough for the ear to detect:
• 20 to 20,000 cycles per second (Hertz).
• $3 \times 10^{-9}$ psi pressure change or greater.

Noise:
Unwanted or annoying sound.
Sound:
Pressure variations that occur strongly & rapidly enough for the ear to detect:
• 20 to 20,000 cycles per second (Hertz).

Noise:
Unwanted or annoying sound.
Sound...

...travels in waves and radiates in all directions vertically & horizontally.
Sound

**Wavelength:**
Distance a sound wave travels to complete one full cycle.

**Amplitude:**
Strength or loudness of the sound.
Period:
The time it takes for one wavelength to pass.

Frequency (Hertz):
The number of changes per second (cycles per second).
Calculating Wavelength

Average speed in air: 1100 feet per second
Environmental factors influence transmission
  (Wind, humidity, temperature)

\[ L = \frac{C}{F} \]
Calculating Wavelength

\[ L = \frac{C}{F} \]

- Speed (feet per second)
- Frequency (Hz)
31.5 Hz

Low Frequency

8000 Hz

34.9 Feet

\[
\frac{1100 \text{ ft/s}}{8000 \text{ Hz}} = 34.69 \text{ inches}
\]

1.65 Inches

High Frequency
Sound with only one frequency – like a note on a musical instrument.

Broadband Noise ➔ When sound is made up of several frequencies.
Tonal Noise

A spike of high energy at a specific frequency.
10 dB or greater difference relative to adjacent frequencies.
Creates an annoying, audible noise.
A dimensionless number that represents relative sound, based on what the human ear can hear.

**Linear Decibel Scale (dB):**

- A scale that takes more of the low frequency sound into account.
- An A-weighted Scale (dBA)
  - The dB scale modified to account for the way humans hear different frequencies.

**C-weighted Scale (dBC):**

- A scale that takes more of the low frequency sound into account.
A dimensionless number that represents relative sound, based on what the human ear can hear.

**Theoretical Limit of Hearing**

- Quiet Neighborhood: $3 \times 10^{-9}$
- Whisper: $3 \times 10^{-8}$
- Conversation: $3 \times 10^{-7}$
- Busy Office: $3 \times 10^{-6}$
- Traffic: $3 \times 10^{-5}$
- Heavy Truck: $3 \times 10^{-4}$
- Loud Music: $3 \times 10^{-3}$
- Car Horn: $3 \times 10^{-2}$
- Rock Concert: $3 \times 10^{-1}$
- Artillery: $3 \times 10^0$
- Turbo Prop: $3 \times 10^1$
- Jet Takeoff: $3 \times 10^2$

**A-weighted Scale (dBA)**

The dB scale modified to account for the way humans hear different frequencies.

**C-weighted Scale (dBC)**

A scale that takes more of the low frequency sound into account.
To the human ear, sound intensity doubles every 10 dB.

- 50 dB is twice as loud as 40 dB.
- 80 dB is 16 times louder than 40 dB.
Sound Power
The acoustic energy radiating from a sound source. It is a function of the area of the transmitting source.

Sound Pressure
The change in air pressure above and below the average air pressure. It is what we perceive as sound and what the noise meter reads in decibels.
Sound Power
The acoustic energy radiating from a sound source. It is a function of the area of the transmitting source.

Sound Pressure
The change in air pressure above and below the average air pressure. It is what we perceive as sound and what the noise meter reads in decibels.
When 2 or more sound sources are combined, the overall dB value is increased.

<table>
<thead>
<tr>
<th>When two dB values differ by</th>
<th>Add the following dB to the higher value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>2 or 3</td>
<td>2</td>
</tr>
<tr>
<td>4 to 8</td>
<td>1</td>
</tr>
<tr>
<td>9 or more</td>
<td>0</td>
</tr>
</tbody>
</table>
Decibel Addition

When two dB values differ by | Add the following dB to the higher value
---|---
0 or 1 | 3
2 or 3 | 2
4 to 8 | 1
9 or more | 0

80 dB + 83 dB = 83 dB
Decibel Addition

<table>
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</tr>
<tr>
<td>9 or more</td>
<td>0</td>
</tr>
</tbody>
</table>

Add the following dB to the higher value:

- 83 dB
- 83 dB
- 86 dB
- 83 dB
- 86 dB
- 83 dB
- 88 dB
- 83 dB
- 83 dB

Result: 90 dB
Decibel Addition

When two dB values differ by | Add the following dB to the higher value
---|---
0 or 1 | 3
2 or 3 | 2
4 to 8 | 1
9 or more | 0

- 83 dB
- 83 dB
- 83 dB
- 83 dB
- 83 dB

83 dB
86 dB
88 dB
Environmental effects on Noise

Reflection, Transmission and Absorption  Diffraction  Refraction

Wind, temperature and humidity affect how noise travels and its intensity.
Environmental effects on Noise

Reflection, Transmission and Absorption

When a sound wave strikes an object, part of it is reflected, part is absorbed within the object and part is transmitted through to become a sound wave again on the other side.
Sound is transmitted by molecules exciting adjacent molecules, both in front and at the sides. Sound therefore diffracts or wraps around barriers. Barriers may not be effective tools for oilfield noise control because residents typically live outside the sound shadow.
Refraction occurs when sound enters a different medium (e.g. different temperature and density of air) at an angle. The differing air densities will cause the sound wave to bend. This is what’s called an inversion and creates an amplification in the sound level at ground level.
Measuring and Analyzing Sound and Noise
Measuring and Analyzing

Sound and Noise
Collecting Noise

Data

Specialized acoustic equipment allows technicians to collect detailed onsite noise data. This instrument uses pressure transducers (microphones) to measure sound pressure and convert it to decibels and frequency.
Methods of Analysis
Two main methods of acoustic data analysis

1. Comprehensive Surveys
   • Actual measured reading at a specified distance or receptor point.

2. Noise Impact Assessments (NIAs)
   • Predicts levels at a specified distance or receptor point, from source data.
Comprehensive Survey

• Continuous recording of ALL noise sources at specified distance or receptor;
• Modeling accurately predicts noise level at receptor(s);
• Used to determine compliance with local regulations;
• Source order ranking of sound pressure at receptors presented;
  - Cumulative of ALL noise sources in the area, not isolated to one facility;
• Noise control recommendations;
  - Provides ordered process for effective and efficient noise suppression.
Field-based Noise Impact Assessment

Noise levels modeled using actual data collected in the field. Used for existing facilities.

Theoretical Noise Impact Assessment

Noise levels modeled using published manufacturer’s data and an in-house database. Used for proposed facilities.

Hybrid Model

Noise levels modeled using a combination of actual and theoretical data. Often used when adding to an existing facility.
Noise Impact Assessment

Source Order Ranked Sound Pressure Levels

- Noise at a specified distance or receptor point.
- Derived from sound propagation modeling.
- Shows noise contribution from each noise source to the specified receptor point.
- Also shows cumulative effect of all combined sources.
- Sound pressure levels below $3 \times 10^{-9}$ psi (theoretical hearing limit) are shown as a negative.
- Octave band sound pressure levels are available for noise control design.

<table>
<thead>
<tr>
<th>Source</th>
<th>Source Sound Level</th>
<th>Source Sound Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Sound Level Contribution (dB)</td>
<td>Source Sound Level Contribution (dBC)</td>
<td></td>
</tr>
<tr>
<td>G3406 Engine Exhaust</td>
<td>42.3</td>
<td>38.1</td>
</tr>
<tr>
<td>G3406 North Open Doors</td>
<td>38.5</td>
<td>35.8</td>
</tr>
<tr>
<td>G3406 Cooler Inlet</td>
<td>41.6</td>
<td>35.5</td>
</tr>
<tr>
<td>G3406 Cooler Plenum</td>
<td>39</td>
<td>33.8</td>
</tr>
<tr>
<td>G3406 South Open Doors</td>
<td>36.4</td>
<td>33.6</td>
</tr>
<tr>
<td>G3406 Cooler Outlet</td>
<td>45.2</td>
<td>32.5</td>
</tr>
<tr>
<td>G3406 Building</td>
<td>36.9</td>
<td>31.3</td>
</tr>
<tr>
<td>G3406 Engine Exhaust Silencer Shell</td>
<td>36.2</td>
<td>30.8</td>
</tr>
<tr>
<td>Yourown Open Doors</td>
<td>31.1</td>
<td>29</td>
</tr>
<tr>
<td>G3406 Exhaust Piping / Building Opening</td>
<td>31.1</td>
<td>27.9</td>
</tr>
<tr>
<td>G3406 Open Windows</td>
<td>29.8</td>
<td>27.9</td>
</tr>
<tr>
<td>G3406 Engine Air Inlet</td>
<td>29.3</td>
<td>27.1</td>
</tr>
<tr>
<td>G3406 Cooler - Ground Opening</td>
<td>38.4</td>
<td>26.6</td>
</tr>
<tr>
<td>G3406 Wall Vent</td>
<td>27.4</td>
<td>26.1</td>
</tr>
<tr>
<td>Yourown Cooler Inlet</td>
<td>31.1</td>
<td>24.7</td>
</tr>
<tr>
<td>G3406 Building Skid</td>
<td>27.1</td>
<td>24.4</td>
</tr>
<tr>
<td>Yourown Building</td>
<td>30.1</td>
<td>24.3</td>
</tr>
<tr>
<td>G3406 Ridge Vent</td>
<td>27.3</td>
<td>24.1</td>
</tr>
<tr>
<td>Yourown Building - Ground Opening</td>
<td>31.1</td>
<td>24</td>
</tr>
<tr>
<td>Yourown Cooler Outlet</td>
<td>24.8</td>
<td>21.1</td>
</tr>
<tr>
<td>Yourown Wall Vent</td>
<td>18.4</td>
<td>16.8</td>
</tr>
<tr>
<td>Yourown Engine Exhaust Silencer Shell</td>
<td>27</td>
<td>16.1</td>
</tr>
<tr>
<td>Yourown Engine Exhaust</td>
<td>37.5</td>
<td>13.1</td>
</tr>
<tr>
<td>Existing Facility Sum</td>
<td>50.6</td>
<td>44.5</td>
</tr>
</tbody>
</table>
## Noise Impact Assessment

### Engineered Noise Control

<table>
<thead>
<tr>
<th>Step</th>
<th>Noise Control Measure</th>
<th>Residence 713 metres Northwest Predicted Sound Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Facility on (dBC)</td>
</tr>
<tr>
<td>1</td>
<td>Replace the existing engine exhaust silencer on the Caterpillar G3406 engine with a Noise Solutions Zeron® Model Silencer.</td>
<td>49.8</td>
</tr>
<tr>
<td>2</td>
<td>Install a Noise Solutions acoustically treated ventilation system on the Caterpillar G3406 compressor building. The acoustically treated ventilation system must provide adequate cooling air volumes to permit operations with building doors and other untreated ventilation openings closed.</td>
<td>49.1</td>
</tr>
<tr>
<td>3</td>
<td>Install a Noise Solutions Box ‘T’ Model cooler inlet silencer on the Caterpillar G3406 unit.</td>
<td>48.2</td>
</tr>
<tr>
<td>4</td>
<td>Install a Noise Solutions ‘L’ Style cooler outlet silencer on the Caterpillar 3406 unit. In addition, acoustically enclose or lag the exposed surfaces of the cooler plenum and cover the cooler ground void and skid.</td>
<td>44</td>
</tr>
<tr>
<td>5</td>
<td>Install a Noise Solutions Combustion Air Inlet Silencer on the combustion Air Inlet of the Caterpillar G3406 engine.</td>
<td>43.9</td>
</tr>
</tbody>
</table>

¹ dBA: Decibels Sound Pressure Level
² dBC: Decibels Sound Power Level
Noise Impact Assessment
Benefits of a Proactive Approach

- Target a noise level below local regulations.
  - Human hearing technically commences at 0 dBA.
  - 20 dBA typical for noticeable sound.
  - Allow a safety margin to accommodate future regulatory changes.
- Maintain focus on production optimization and business growth.
- Increases potential for landowner support for development plans.
- Provides improved working environment.
Noise Suppression Blueprint®

Critical steps for a GUARANTEED noise level.

1. Analyze Noise Issue
   Pinpoint the exact steps needed to reach regulatory compliance

2. Engineer & Design
   Design practical solutions targeted to your specific needs

3. Manufacturing
   Ensure on-time delivery and consistent quality

4. Installation
   Guarantee fast, professional installation with minimal facility downtime