# Acoustic Challenges In Gas Turbine Plants and Novel Attenuation Methods

by

Vince Gambino

October 18, 2012

aercoustics
engineering limited

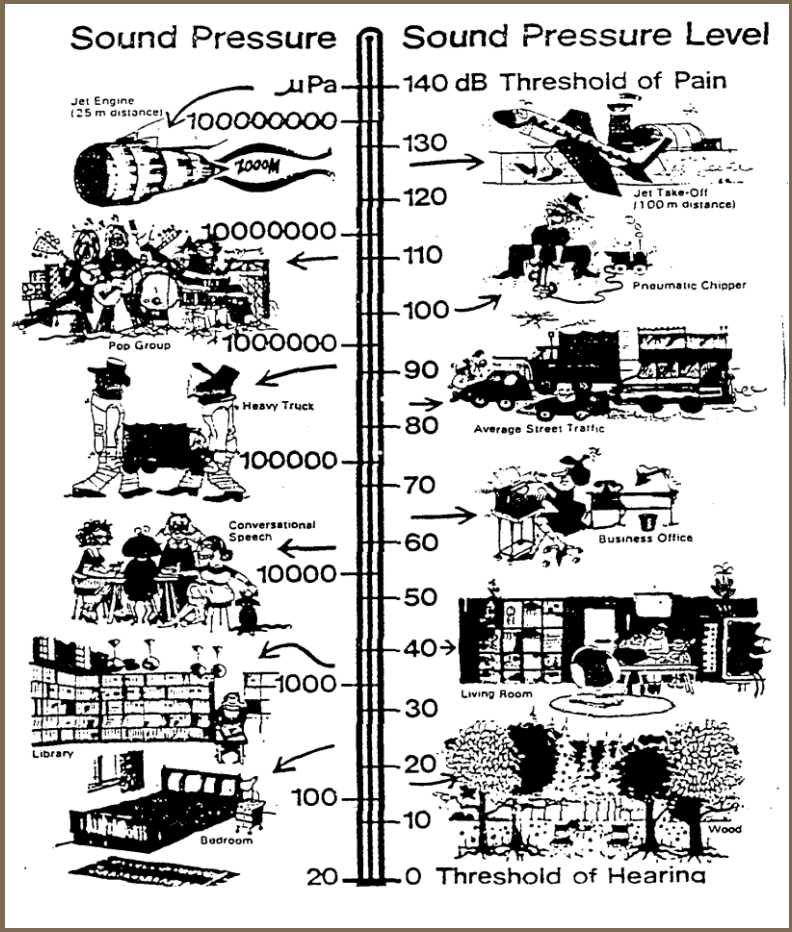
Acoustics
Noise
Vibration

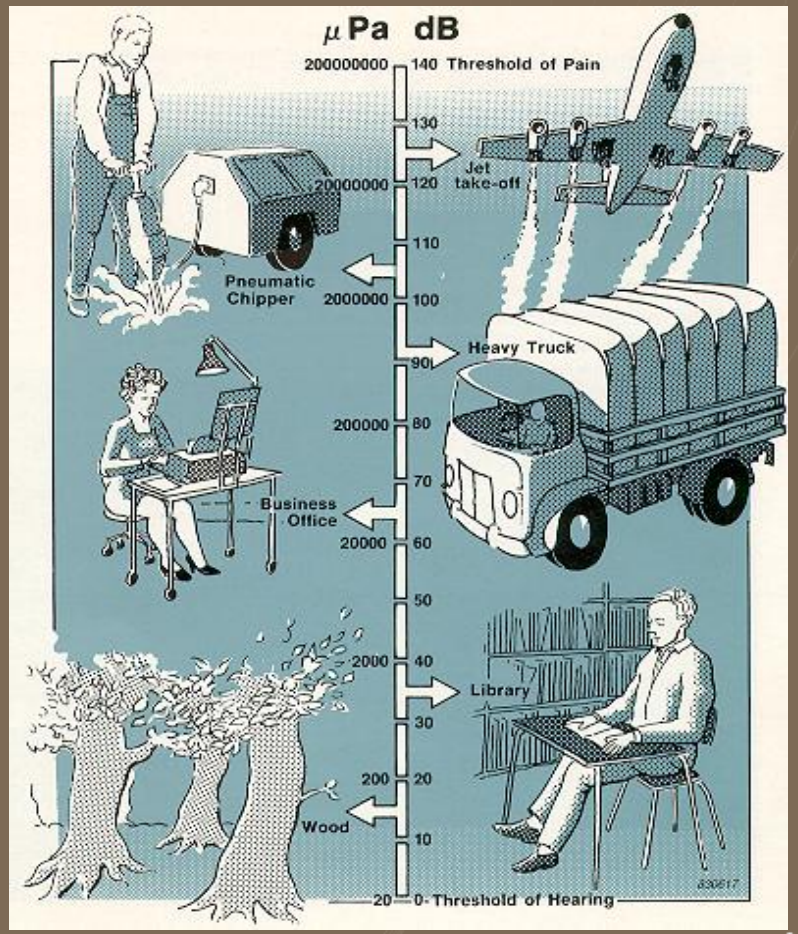
# Noise & Vibration Challenges

- Environmental Noise Compliance
- Acoustic Performance Verification
- Occupational Safety & Health
- Long Term Equipment Viability/Reliability

aercoustics
engineering limited

# Typical Noise Levels



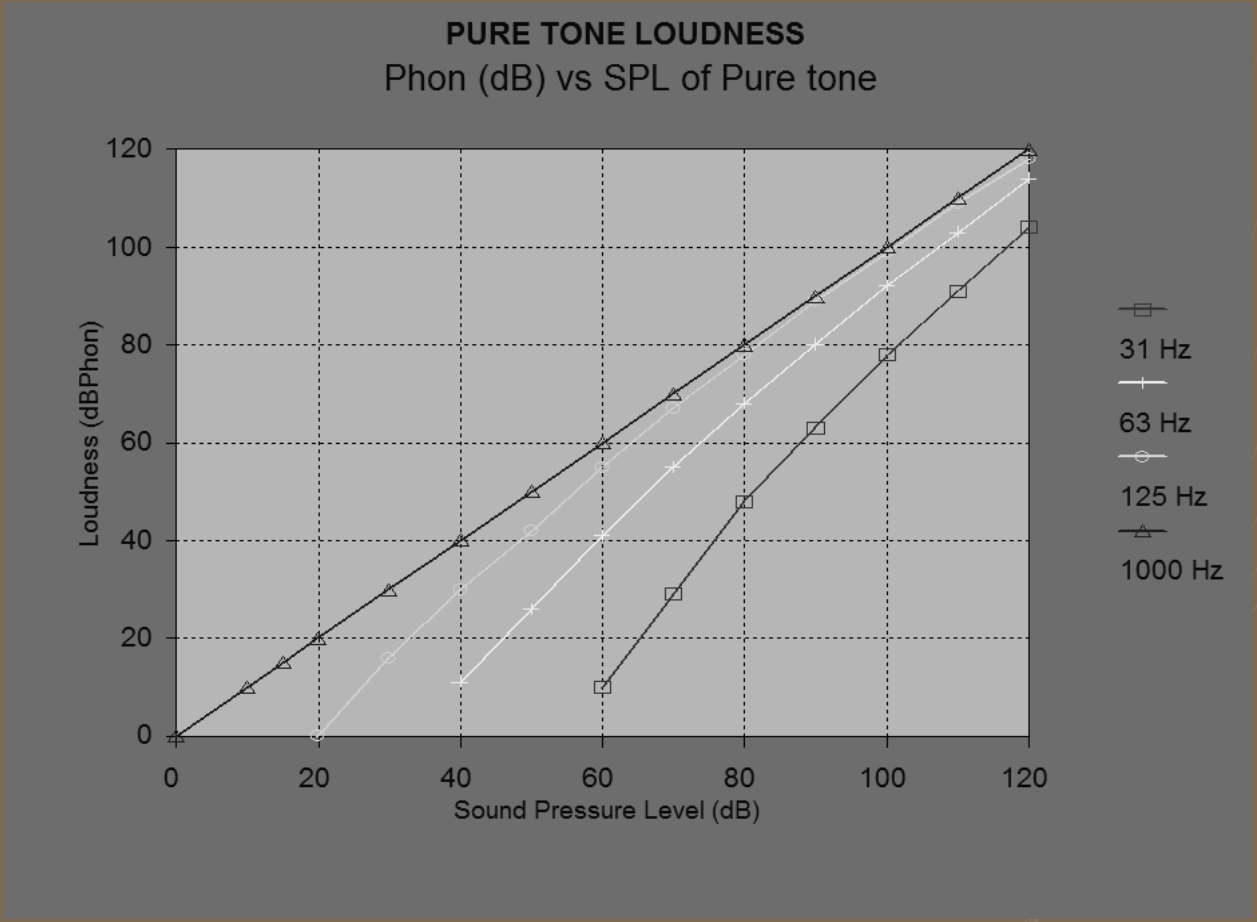

aercoustics engineering limited

# Significant Noise Sources

- Sound Power: Gas Turbine Exhausts ~140-150dB re: 1pW.
- Beware of Low Frequency Noise

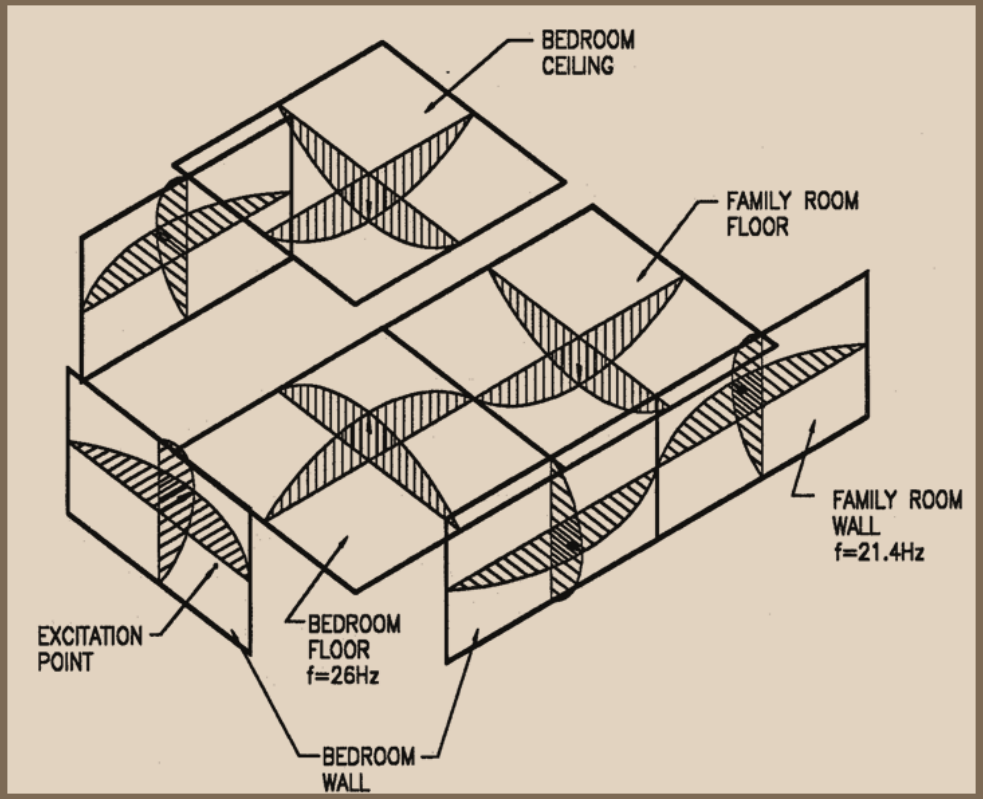
aercoustics
engineering limited

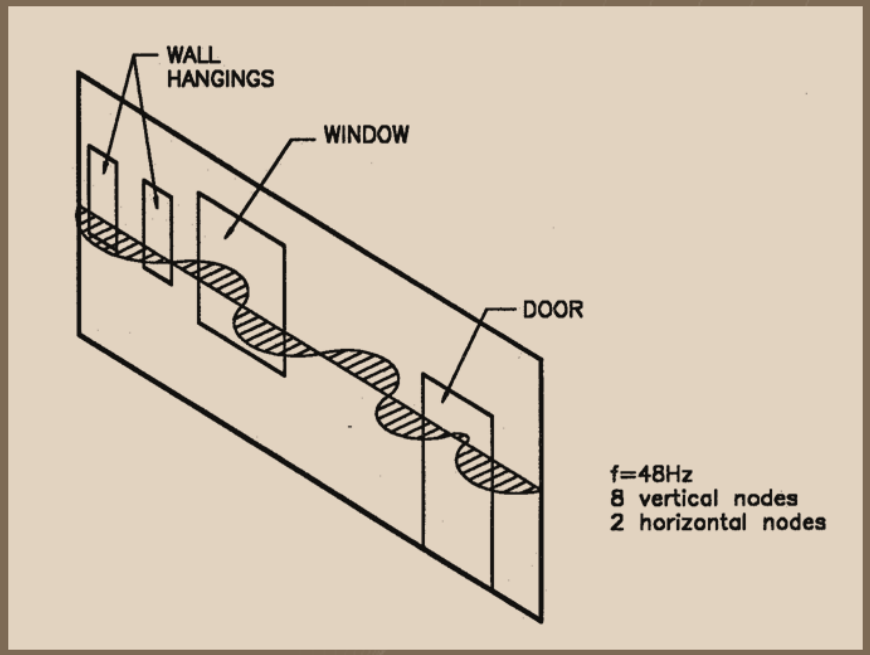
# Changes In Perceived Loudness




aercoustics
engineering limited

# Modal Behavior of Lightweight Dwelling Structures

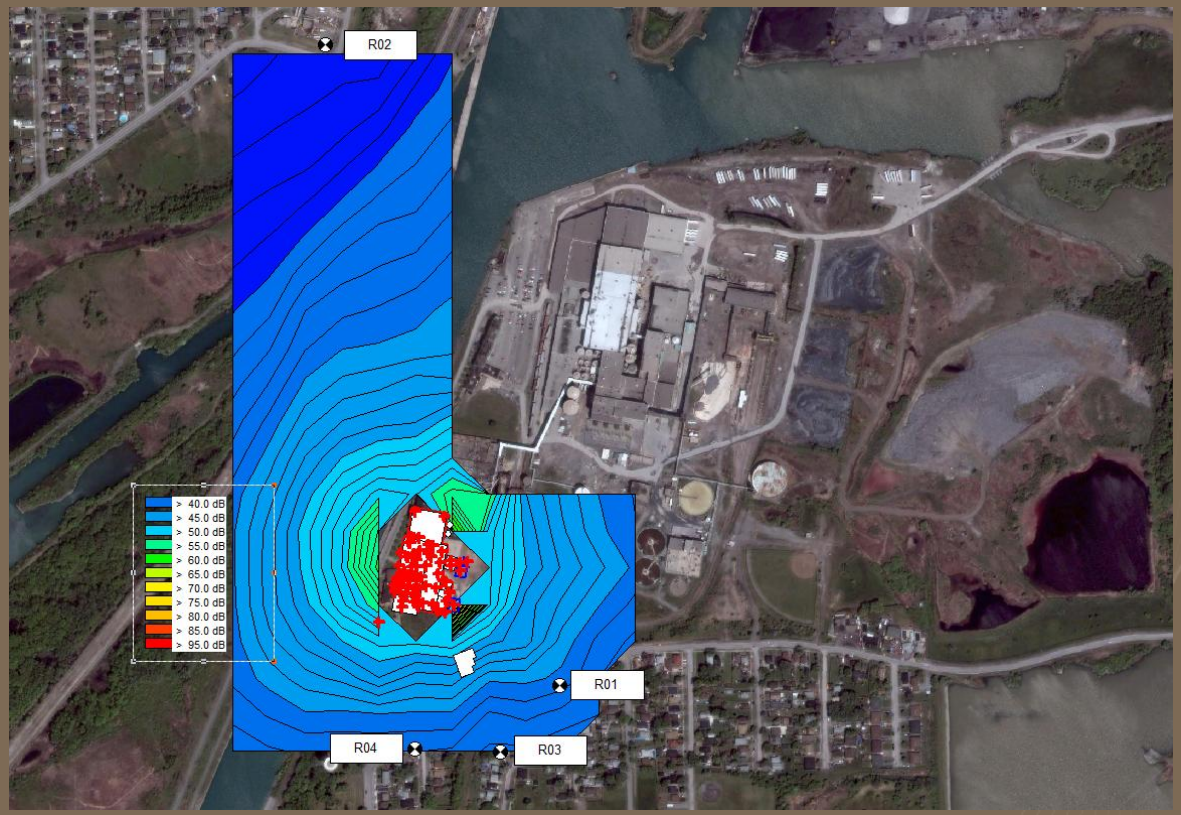



aercoustics engineering limited

# Environmental Noise Compliance

- Definition of Sound Level Limits
- Outdoor Sound Propagation Modelling
- Noise Control Management Plan




aercoustics
engineering limited

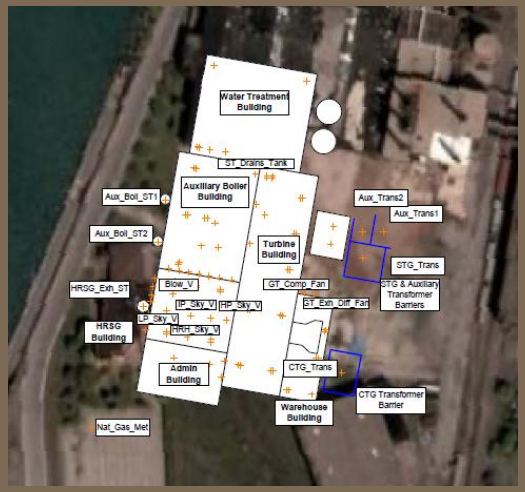
# Sound Level Limits

- Usually Set By Province
- Differentiate Between ‘Urban & Rural’
- Differentiate Between ‘Day & Night’
- Night-Time Limits Typically 5 dB Lower
- For Co-Gen Power Plants Night-Time Limits Apply
- Night-Time Limits Typically 40 dBA
- Beware of Low Frequency Noise Complaints

aercoustics
engineering limited

# Outdoor Sound Propagation Modelling

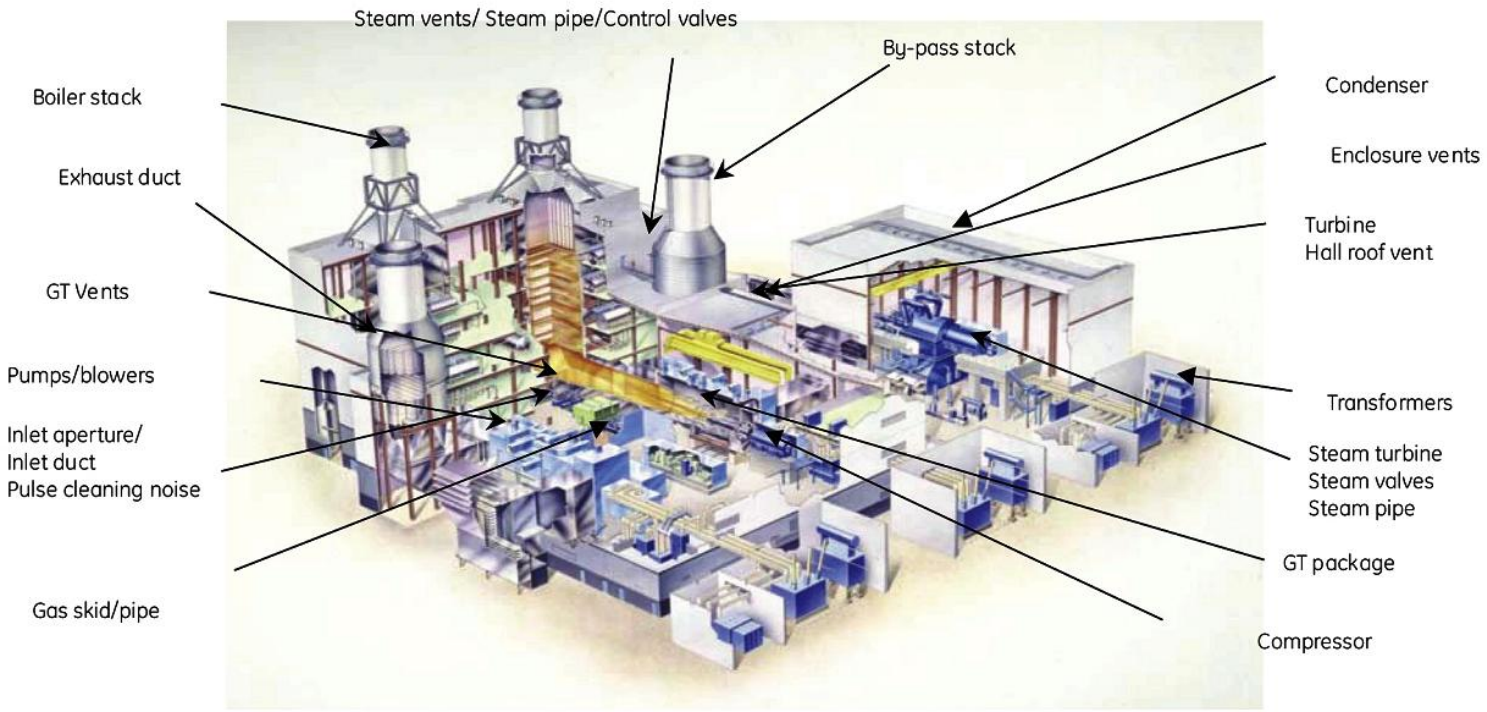
- Identify Off Property Points of Reception
- Identify Noise Sources & Rank Their Emissions
- Consider Terrain & Meteorological Conditions
- Determine Sound Levels at Receptors
- Noise Controls Needed to Achieve Sound Limits




aercoustics
engineering limited

# Plant Acoustic Modelling

## Typical combined cycle gas turbine plant noise sources

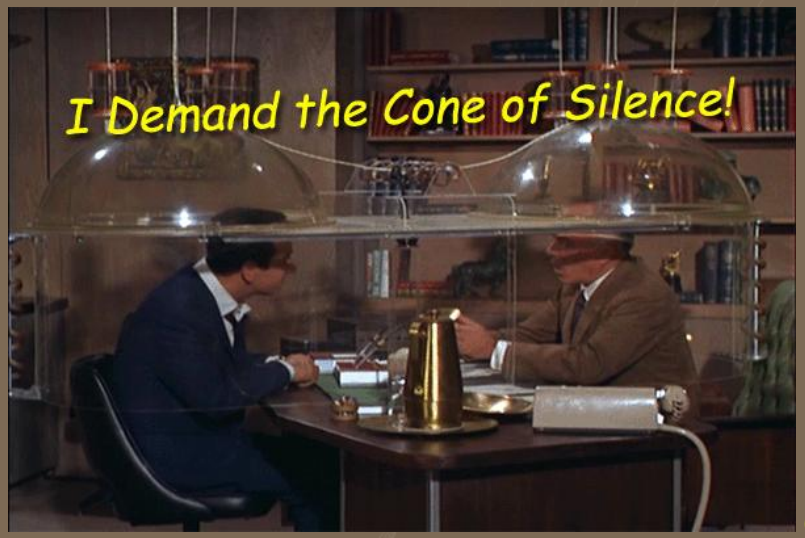



**Typically 30-50 noise sources**

aercoustics engineering limited

# Noise Control to Meet Sound Limits

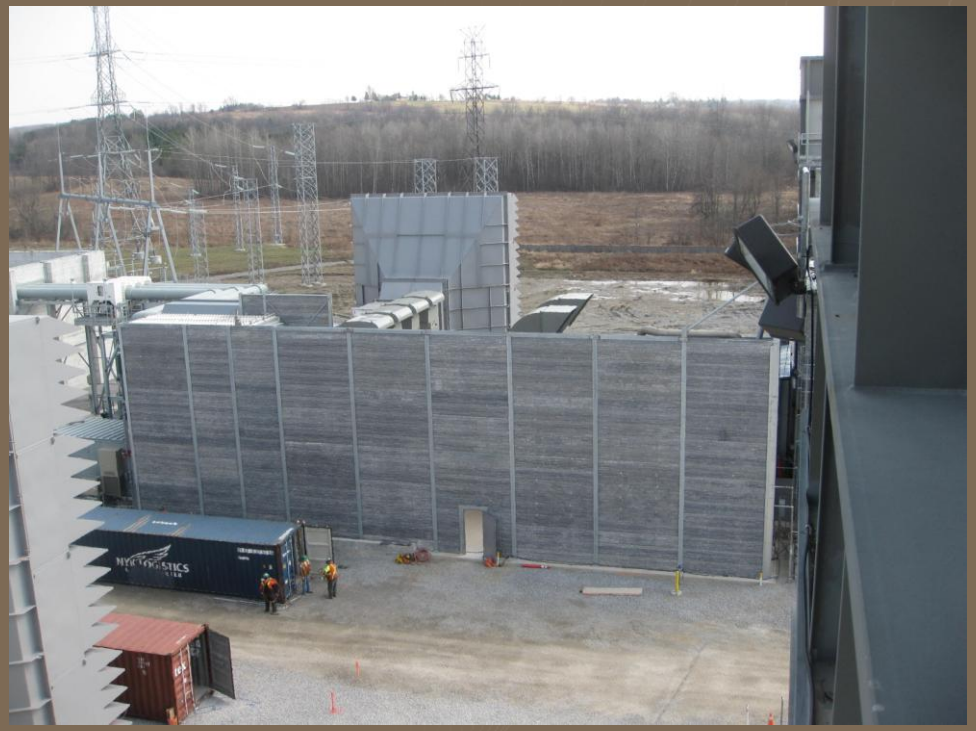
- Minimize Potential of Noise Complaints
  - Can be Unexpected Financial Burden
  - Technically Difficult to Retrofit Mitigation
- Acoustic Design Options for Noise Control
  - Barriers
  - Enclosures
  - Silencers / Baffles
  - Quiet Equipment Design
  - Unique Attenuation Measures

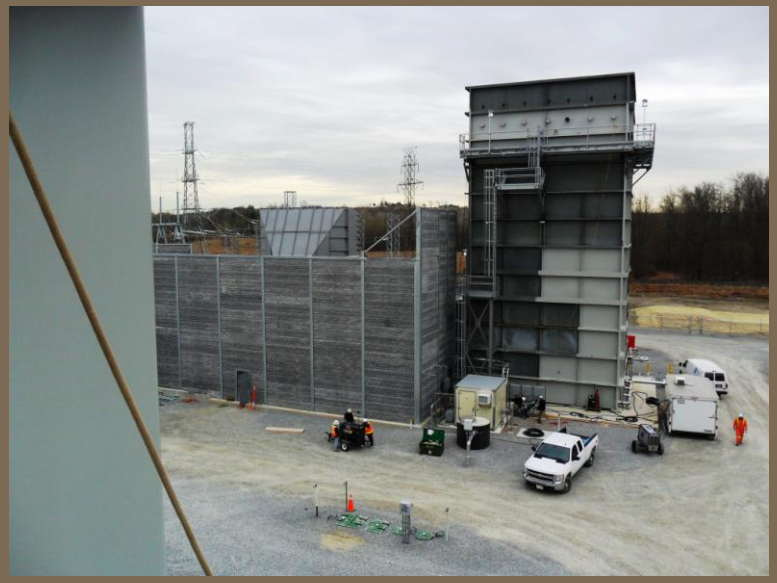



aercoustics
engineering limited

Noise Controls

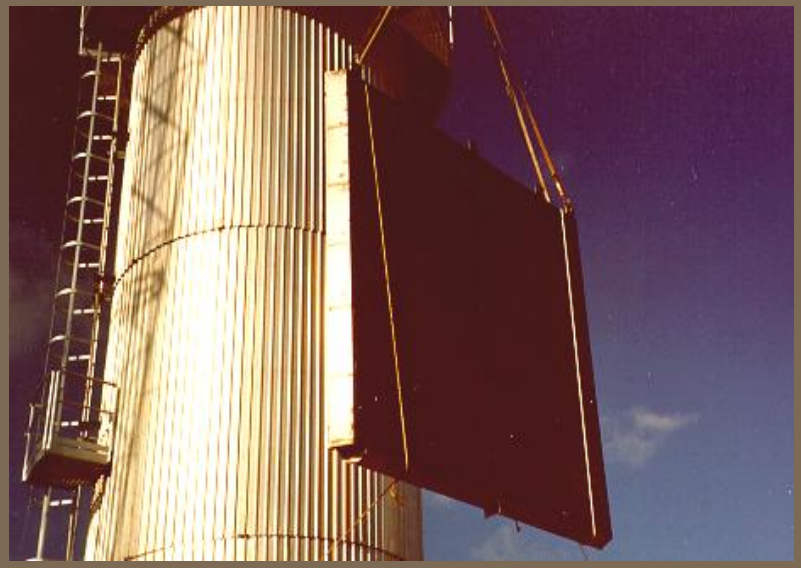
# Barriers as Noise Control





aercoustics
engineering limited

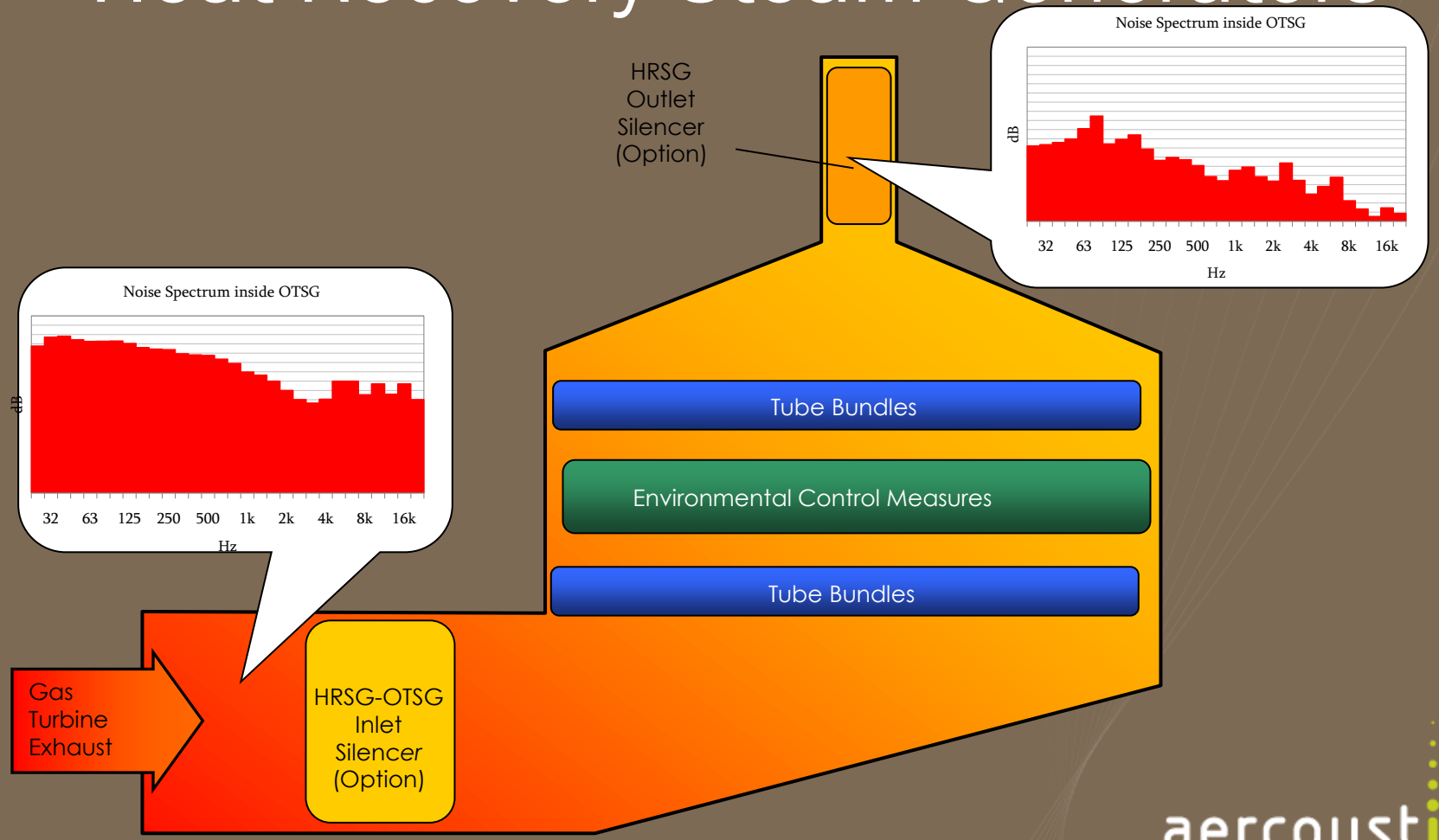
# Passive Noise Control Measures



- Silencers

aercoustics engineering limited

# Inherent Noise Control Features In Heat Recovery Steam Generators



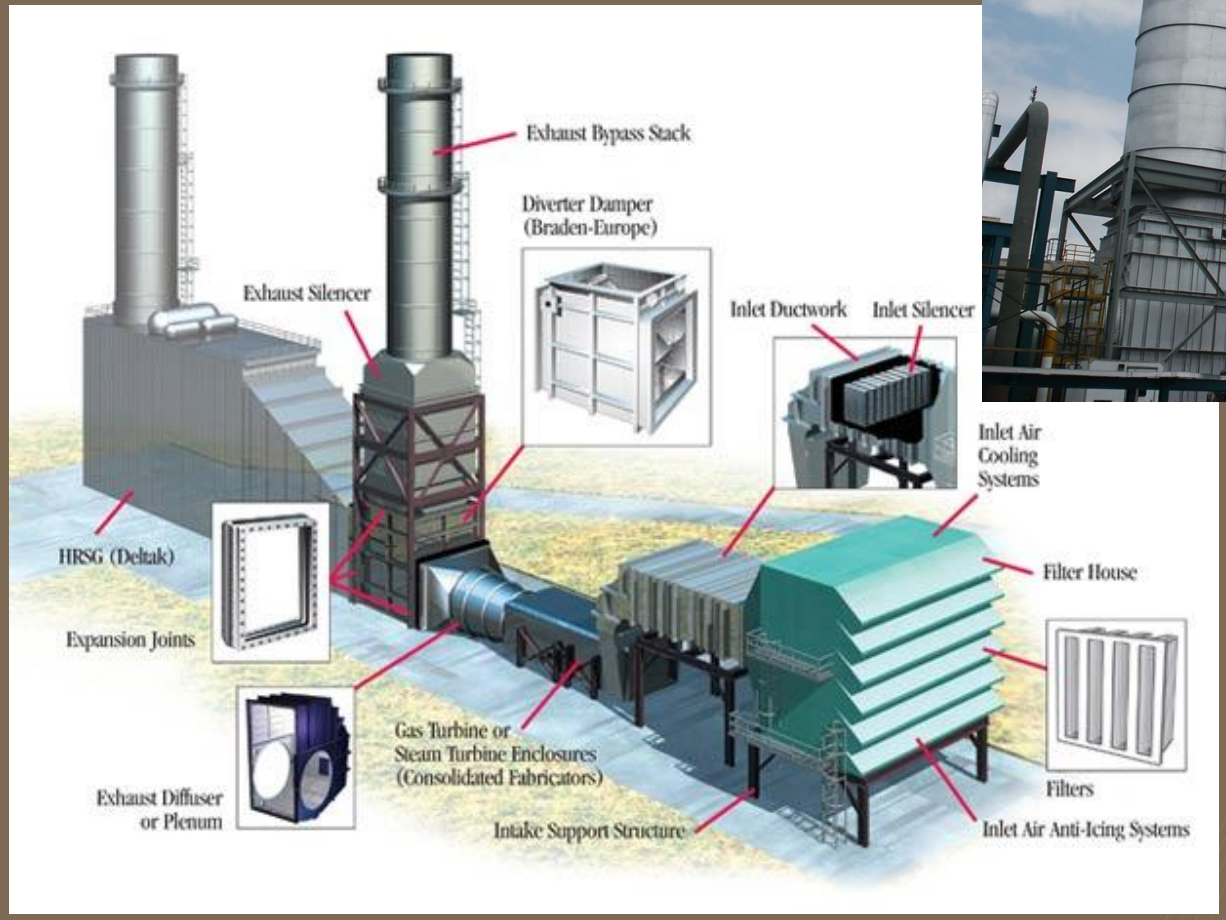

aercoustics
engineering limited

# Noise Attenuation Mechanisms

- Casing Radiated Noise
  - High Transmission Loss construction
- Exhaust Stack Noise
  - Membrane absorption at interior surface
  - Reactive attenuation in gas flow path
  - Diffusion / Scattering of sound
  - Viscous losses
  - Bulk-reacting Silencers (optional)

aercoustics
engineering limited

# Silencing: Bypass Exhaust




aercoustics
engineering limited

# High Temperature Silencer Design

- Most silencers based on standard design curves that do not work for high temperatures and flows!
- Acoustic Properties Scale Up With Temperature
- Effect of Flow
- Reactive and membrane effects

aercoustics
engineering limited

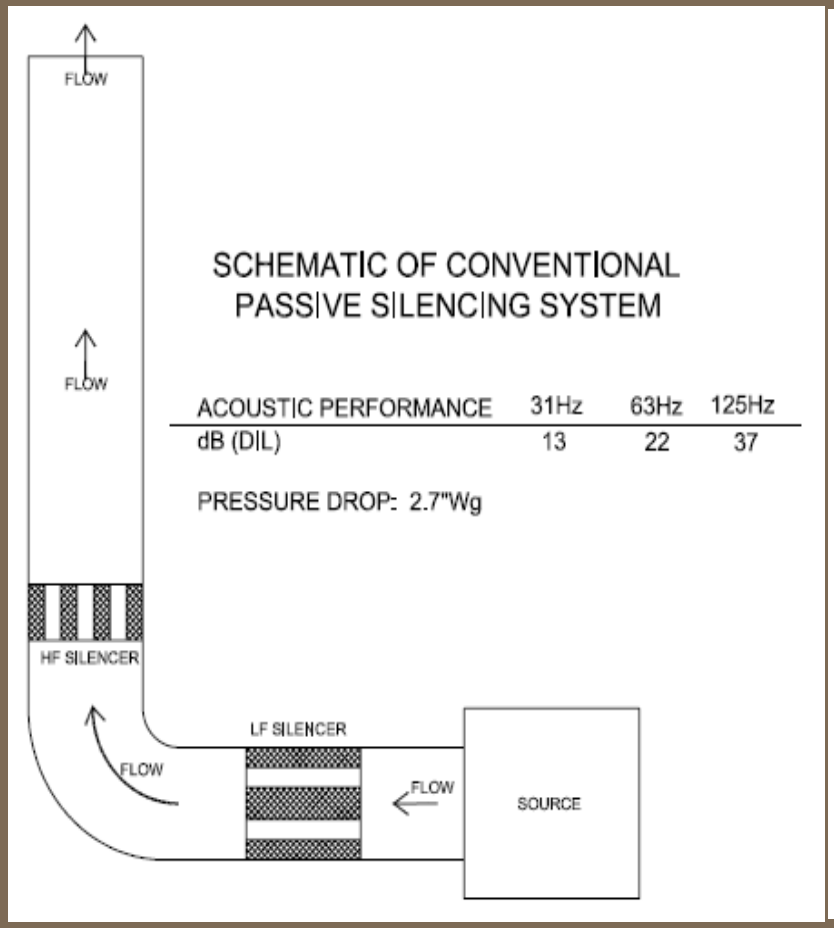
# Expected Acoustic Inputs For Design

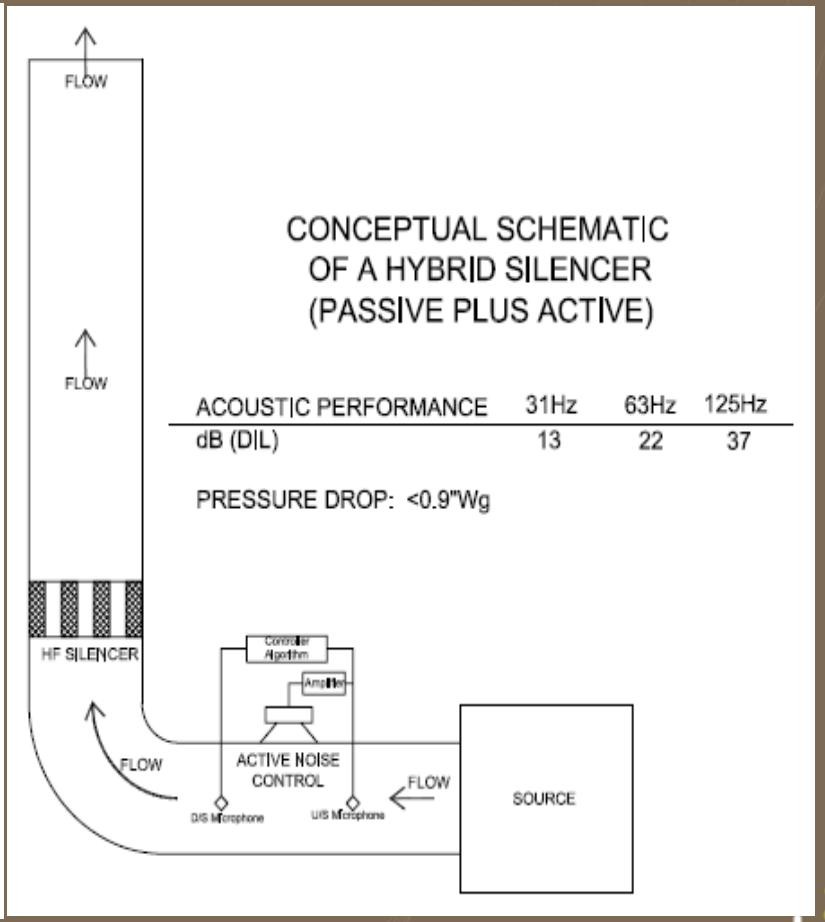
- Length of silencer
- Gauge of liner
- % open area of liner
- % open area
- Flow resistivity of liner material

aercoustics
engineering limited

# Hybrid Active/Passive Noise Control

## -Best of Both Worlds

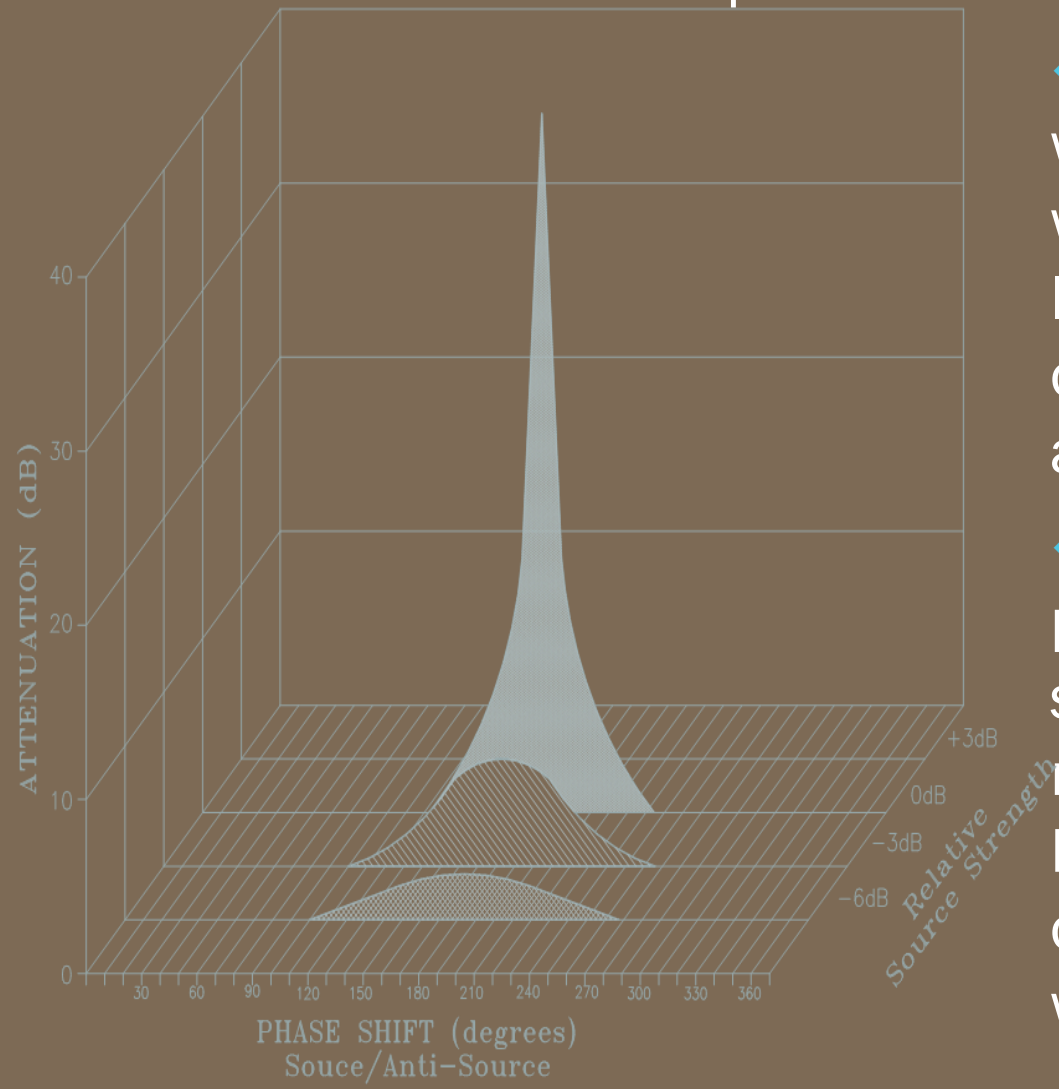



aercoustics engineering limited

# Active Noise Cancellation

## - Phase & Amplitude Sensitivity




- Active Noise Control works best when wavelengths are quite long relative to the size of the surroundings, i.e. at low frequencies.
- For maximum performance and system stability, a close match in Amplitude and Phase is required for the offending and canceling wavefronts.

aercoustics
engineering limited

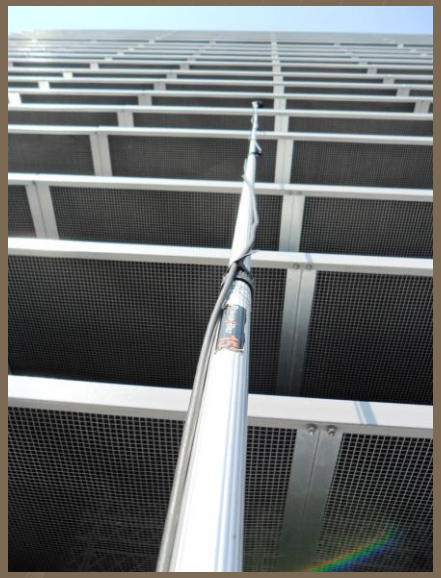
# Active Noise Cancellation System


aercoustics
engineering limited

Permanent System Design & Installation - 16 years running

# Acoustic Performance Verification

- Spot Checks During Commissioning to Ensure:
  - Confirmation of Equipment Sound Guarantees
  - Validation of Acceptable Equipment Vibration
  - Compliance With Environmental Noise Criteria



aercoustics
engineering limited

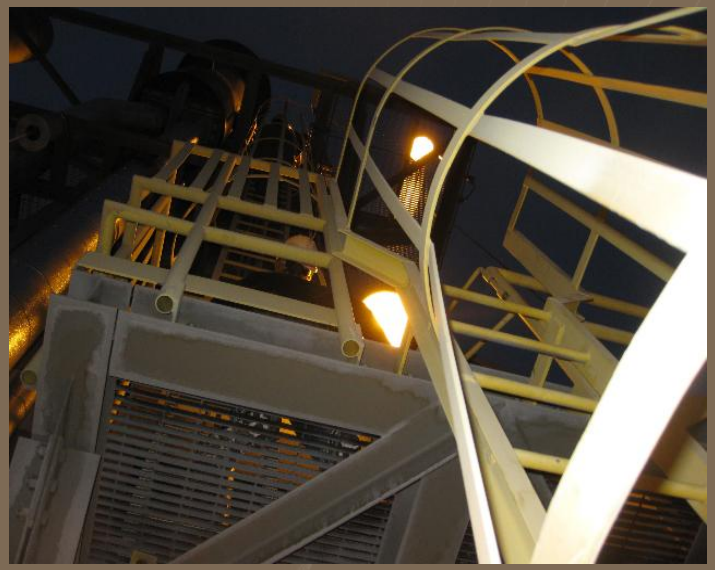
# OSHA

- Occupational Sound Exposure Benchmarks
  - 85 dBA (8-hour exposure)
  - Hearing Conservation Protection Requirements
  - Consideration of Engineered Controls to Reduce  Noise


aercoustics
engineering limited

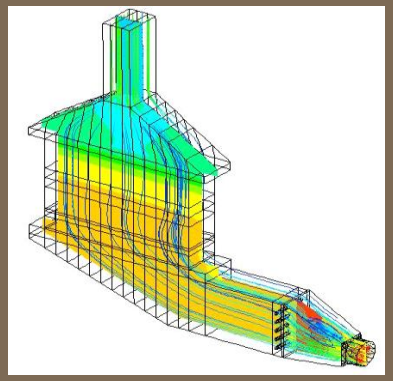
# Occupational Health & Safety Issues

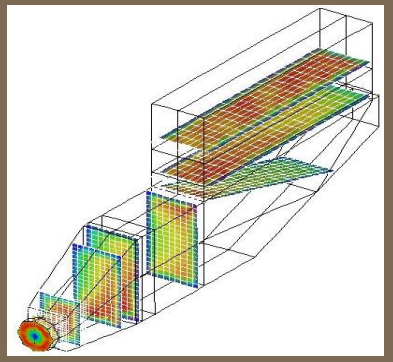
- Maintenance of Integrity in Noise Control Equipment
- Assurance of Acceptable Vibration on Platforms, Catwalks
- Define Zones Where Hearing Protection Is Needed



aercoustics
engineering limited

# Long Term Equipment Viability & Reliability





- Acoustic Analysis at DESIGN Stage
  - CFD Analysis
  - Top of Stack Noise Emission Prediction
  - Casing Radiated Noise Prediction
  - Silencer Specification and Design – Including High Temperature Silencers
  - Dynamic Analysis:  FEA Model
- Acoustic Measurement Techniques
  - Innovative In-Flow Measurement Procedure
  - Accurately Measures Insertion Loss of Components & Exhaust Emissions

aercoustics
engineering limited

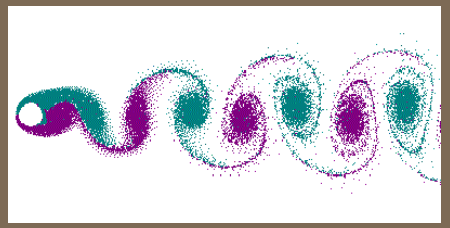
# Inputs Required for Mechanical Design

- Turbulent buffeting force on leading edge
- Turbulent buffeting force on liner panels
- Overall force on silencer support structure
- ***Accurate* CFD** married with an understanding of acoustic requirements

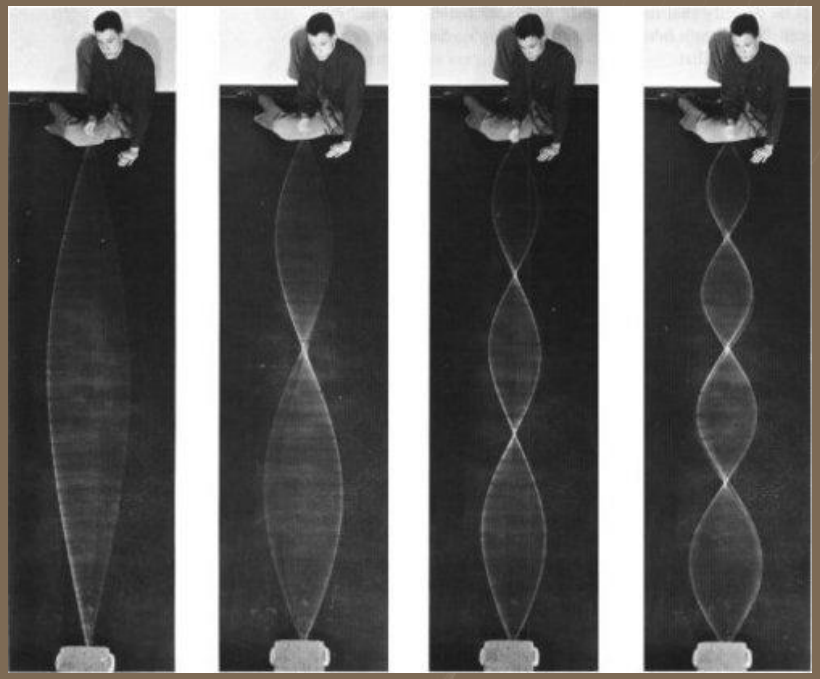
aercoustics
engineering limited

# Acoustic Environment of Exhaust Circuit

- Gas Flow Velocity Can Reach or at Times Exceed 75 m/s
- Turbulence Caused by Tube Bundles and Other Structures



Potential Resonance of Exhaust Circuit Casing With Respect to a Generated Tone



aercoustics engineering limited

# SUMMARY

- What happens if you have a problem
- Acoustics and Vibration Amplitudes as a Tool
- Setting of Cautionary Limits for:
- Environmental, Equipment and Occupational Thresholds

aercoustics
engineering limited

# CLOSURE

*Increase Awareness of Available Tools and Technology to Effectively Deal with Noise and Vibration Control Challenges at Gas Turbine Facilities.*

*Thank You*

aercoustics
engineering limited

aercoustics.com