Environmental Noise Controls

Oregon GOSH 2025

Wednesday, March 5

COLORADO ANALYTICS

Colorado Analytics

- Fort Collins, Colorado
- Consultants in acoustics, noise, and vibration
- Specialize in industrial and manufacturing noise control
- Active in environmental and community noise
- Sometimes architectural acoustics
- Merged with Associates in Acoustics in 2019
- Have worked on 5 continents, all 50 U.S. states, and a few US territories

Who Is This Guy?

- Taylor Elementary Citizen of the Year, 1983
- Studied mechanical engineering
- Doing acoustics since 2002
- Focused on manufacturing / industrial noise since 2012
- Independent since 2016
- Acoustics and vibration measurement
- Environmental / community noise
- Architectural acoustics
- Mechanical / industrial noise and vibration control

Topics

- Basics of Environmental Noise and Measurement
- Noise Regulations and Other Considerations
- Common Environmental Noise Sources In Industry
- Noise Mitigation Strategies

Basics of Environmental Noise

What it is

How to measure it

Noise

Unwanted or harmful sound.

Environmental Noise

Unwanted or harmful sound that crosses a property boundary.

Common Environmental Noise Sources

- Industrial operations
- Roads, rail, airports
- Construction
- Sports and live music

Effects of Environmental Noise

- Impact on human health and well-being
  - Sleep disturbance
  - Stress and cardiovascular side effects
  - Reduced enjoyment of property
- Economic and legal implications
  - Reduced property value
  - Noise complaints and lawsuits
  - Regulatory penalties

Quantifying Environmental Noise

Just measure the decibels, right?

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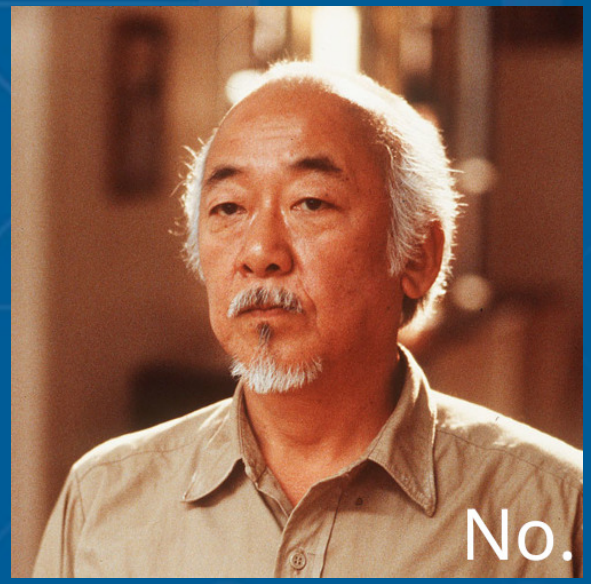
Just measure the decibels, right?



Decibel Is Not a Unit (not really)

- Mathematical trick to make big numbers easier to deal with and to make consistent comparisons between numbers that scale logarithmically.
- Used for many quantities in acoustics
  - Sound pressure (Pascals)
  - Sound intensity (Watts / sq m)
  - Sound power (Watts)
  - And a number of quantities derived from these
- Used for many other quantities in signal processing

Decibels Need to be Defined

Frequency Domain

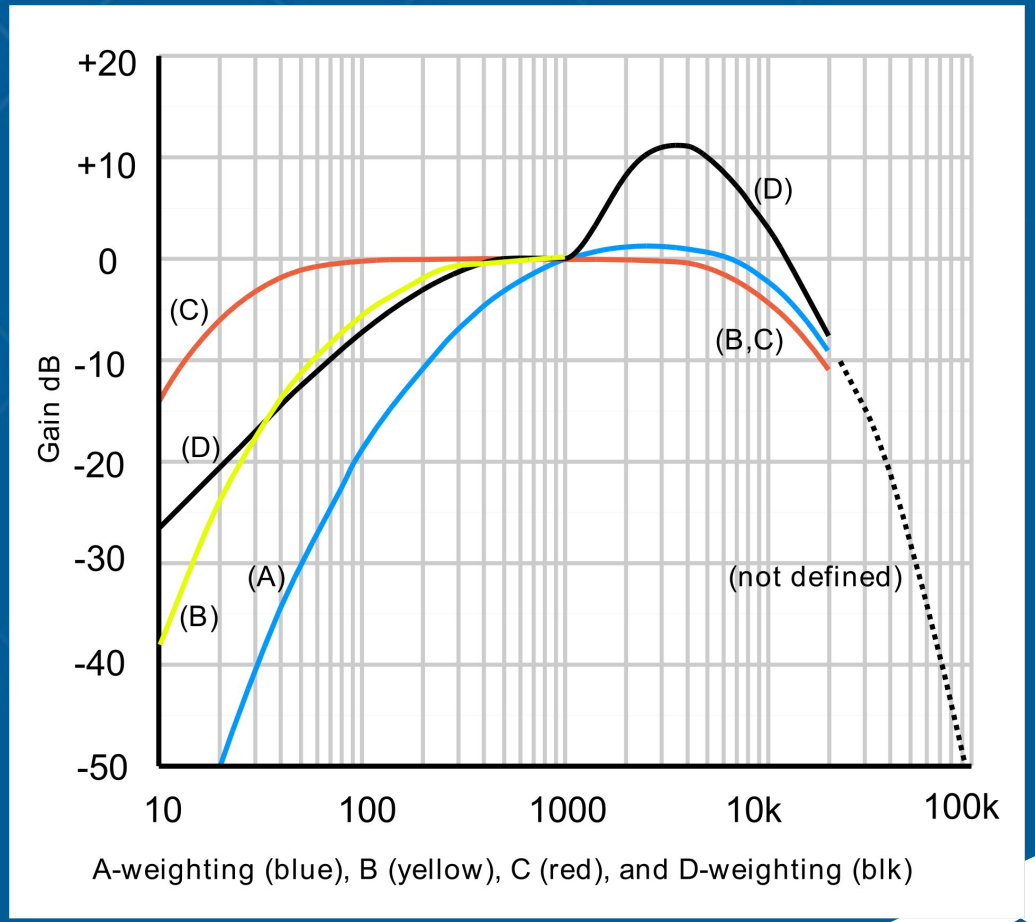
- Frequency bands
  - Octaves
  - 1/3-Octaves
  - FFT
- Broadband (single number)
  - Frequency weighting
    - A
    - C
    - Z

Time Domain

- Max or Instantaneous SPL
  - Slow response
  - Fast response
  - Peak
- Equivalent or Average Level
  - Leq
  - TWA
- Statistical Levels
  - Ln (10, 90, etc)

Frequency Weighting

- A) Approximates human ear response at low levels.
  - Discounts low frequencies, emphasizes high frequencies.
  - Used extensively in regulation and in hearing conservation.
  - Assume A if not otherwise specified.
- C) Approximates ear response at higher levels.
  - Greater emphasis in lower frequencies.
  - Comparing C to A can give an idea of low-frequency content.
- B and D are rarely used



Time Domain

- Leq - Continuous Equivalent Sound Level
  - Logarithmic average of a sound over a given period of time.
  - Most useful for most applications.
  - Good assumption to make when a time setting is not specified.
- SPL – Sound Pressure Level
  - An instantaneous value that is often an exponential average that looks at the most recent 1 second or 1/8 second:
    - “Fast” = 1/8 second
    - “Slow = 1 second
  - Lmax is the highest single SPL measured during a given period of time.
- Ln – Statistical Level
  - The SPL that exceeded for n% of samples during a measurement.
  - L1 will be greater than L5, which will be greater than L50, which will be greater than L90

Measuring Environmental Noise

Spot Measurements

- Handheld Meter
- Duration of seconds to a few minutes
- Check things that can be captured in an instant
  - Lmax
  - constant noise level from continuous running source

(please use a windscreen)

Measuring Environmental Noise

Short Term Measurement

- Meter on a tripod
- Duration of hours
- Checking portion of a day, possibly with multiple simultaneous measurements
  - Loudest hour
  - Effect of single source on multiple locations
  - Comparing ambient before and after specific noise event
  - Sporting or music events

Measuring Environmental Noise

Long Term Measurement

- Protected enclosures for meter and microphone
- Duration of days or weeks
- Characterizing continuing noise at a location.
  - DNL, CNEL, Loudest Hour, L90
- Remote operation possible
- Installations sometimes permanent

Measuring Environmental Noise

- Match the measurement to the criteria
  - Leq, DNL, Lmax…
  - Frequency Weighting
  - At the property line, at point of impact, other
- Match measurements to the goals
  - Planning for noise control?
    - Characterize frequency characteristics of source with octaves or 1/3-octaves measured at 3 ft (small source) to 30 ft (large source)
  - Trying to identify the source?
    - Take frequency measurements at the point of impact
    - Take frequency measurements at all potential sources
    - Compare spectra for frequencies that match

Noise Regulations and Other Considerations

The criteria that drive environmental noise studies

Common Metrics in Environmental Noise

- LAeq – A-weighted Leq (broadband)
  - Time often specified, e.g. 1 hour or 15 minutes.
  - “Loudest Hour” is often used in traffic noise analysis.
- LAmax – A-weighted max SPL
  - Often using the “slow” time constant. Assume this if not specified.
- DNL – Day-Night Level
  - The logarithmic average of the 1-hour LAeq values for all 24-hours in a day.
  - Night hours, 10pm to 7am, get a 10 dB penalty before the average is calculated.
  - Used by HUD and other Federal agencies, and by extension many state agencies.
- CNEL – Community Noise Equivalent Level
  - Similar to DNL, but with a 5 dB penalty for evening hours, 7pm to 10pm.
  - Used frequently in California and in airport noise evaluation.

Other Metrics and Adjustments in Environmental Noise

- “decibels”- ???
  - Likely copied from the next town over.
  - Choose your own adventure!
  - Most literal reading is usually LAmax, but that’s probably not what they meant. Do your best.
- Adjustment to Limits for Sound Quality
  - Tonal Sounds
    - Sometimes defined as a single frequency band being X dB louder than its side bands, sometimes not defined.
  - Impact Noise
    - Sometimes defined as sounds last X ms, sometimes not defined.

Time of Day and Zoning Adjustments

- It is common to have different specified limits based the time of day and on the nature of the receiving property.
- Ordinances frequently present limits in a table.
- Nighttime at residential will have the lowest limits.

Zoning District of the Property on Which the Sound is Received	*Maximum Number of Decibels Permitted from 7 a.m. until 11 p.m. of the Same Day*	*Maximum Number of Decibels Permitted from 11 p.m. until 7 a.m. of the Following Day*
Residential	55 dBA	50 dBA
Mixed use and other	65 dBA	60 dBA
Industrial	80 dBA	75 dBA

Other Metrics Appearing in Environmental Noise

- L90 – SPL exceeded 90% of the time
  - Often used to represent the true ambient level.
  - Typically serves as a basis for comparison.
  - Almost always based on A-weighting and “slow” response.
- L10, L5 – SPL exceed 10% or 5% of the time
  - Used to represent the highest levels regularly occurring at a location.
  - More meaningful than Lmax for analysis of longer periods.
- L1 – SPL exceeded 1% of the time
  - Wise regulators use this instead of Lmax
    - *as they understand that Lmax happens just once during a measurement and could easily have been something you’re not meaning to measure, like maybe a squirrel chewing on your windscreen or some kids messing with your equipment. I mean, it could have been anything!*
- Octave Bands
  - Some regulations set limits per octave band in addition to broadband levels.

Sources of Noise Regulation

- City Code of Ordinances
  - Most common source of applicable noise regulation
  - Wide range in quality
- City Plan
  - Sometimes limits are set in the City Plan that apply to certain properties
  - Not common
- County Ordinances
  - Usually only for counties with many homes in unincorporated areas
  - Also for city-sized counties like Los Angeles
  - Sometimes related to liquor licenses
- State Statutes
  - Typically very vague or very simple
- Federal Regulations
  - Apply in specific instances where a Federal entity is involved, e.g. HUD, FHWA, FRA

Regulations Vary

Some are descriptive only.

> *c. Yelling, shouting, hooting, whistling, singing or using noise makers like whistles, fireworks, sound amplifying equipment or air horns within a residential district, or at any time and place in a manner so as to unreasonably disturb or interfere with the peace, comfort, and repose of owners or possessors of real property.*
>
> – *Vancouver Washington*

Regulations Vary

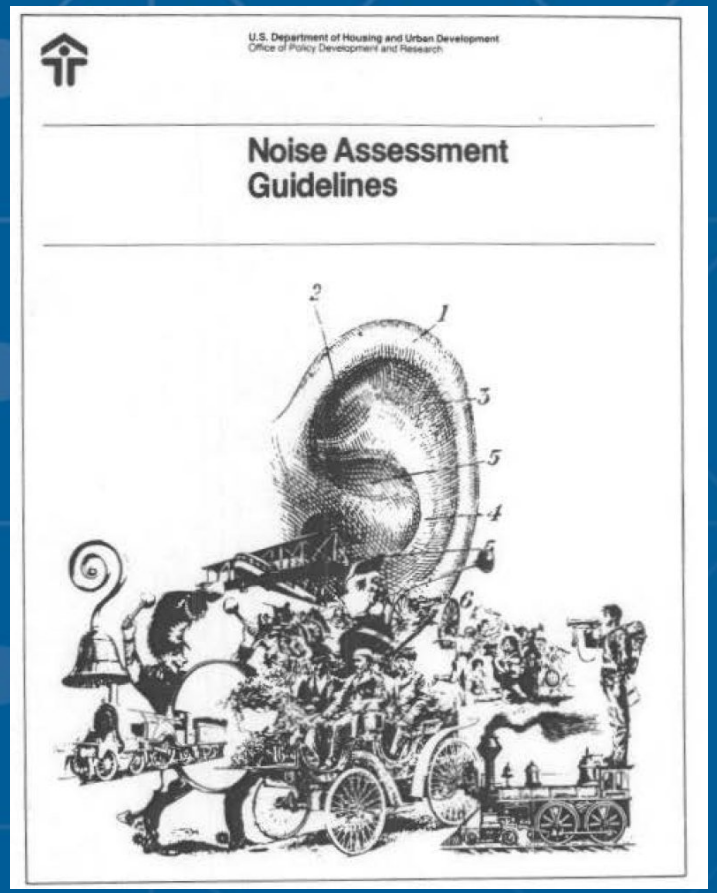
Some are thorough with useful technical details.

When the permissible dBA level is:	The Maximum Octave Band Sound Pressure Levels Shall Not Exceed:								
-	Octave Band Center Frequency, in Hz								
-	31.5	63	125	250	500	1000	2000	4000	8000
45	64	58	51	46	42	39	36	33	30
50	65	62	56	50	46	43	40	37	34
55	68	65	61	55	52	49	46	43	40
60	72	68	64	60	56	54	51	48	45
65	76	72	68	64	61	59	56	53	50
70	79	76	72	69	66	64	61	58	55
75	82	79	76	73	71	69	66	63	60

G. Octave band measurements: When the Noise Control Officer makes a finding that the frequency characteristics of the sound are such that the A-scale levels specified in Section 18.10.010 are inadequate to protect the public health, welfare, or safety, octave-band sound pressure level measurements must be performed.

– *Portland Oregon*

Regulations Vary



HUD Noise Guidebook

Some have their own complete publications

Regulations Vary

Most are good enough.

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Industrial	80 dBA	75 dBA

– *Boulder Colorado*

Construction and Industrial Noise

- Some regulations have separate limits for noise generated at industrial facilities.
- Many regulations have special considerations for construction noise.
  - Specific time of day that noise is allowed
  - Understanding that noise production is temporary
  - Occasionally set requirements to compensate residents affected by noise from nighttime activities

Other Considerations

Complaints

When the source of noise is an industrial or commercial facility, it is common for neighbor complaints to be the driving force behind environmental noise control efforts, not regulation.

Many noise ordinances are not exceeded even while neighbors find noise intrusive.

This is often due to the nature of the noise source and its tendency to stand out against ambient noise.

Responding to Complaints

Management at some industrial or commercial sites will go as far as establishing that they are compliant with the local regulation and no further.

At others, management will allocate considerable resources to satisfying neighbors and resolving complaints.

Complaint-Driven Noise Studies

When free from regulatory requirements, the engineer can focus on understanding and mitigating intrusive noise. These studies are based on more meaningful, but more technical criteria such as comparing noise from the source to ambient noise at the receiver on a frequency-by-frequency basis.

Common Environmental Noise Sources In Industry

The types of noise sources we have studied most often

Characteristics of Problematic Noise Sources

- Constant operation
- Tonal, especially low-frequency
- Impulsive or irregular noise
- Nighttime noise
- New equipment

Air Handling (HVAC)

- Frequently rooftop mounted
- Continuous operation, especially problematic at night when ambient noise is low
- Generally not the most intrusive noise sources, typically only a problem when neighbors are close or when systems are balanced

Exhaust Fans

- High Velocity
- Often tonal
- Usually roof-mounted
- Typically have short, straight exhaust ducts that empty nearly 100% of noise energy into the atmosphere

Exhaust Stacks

- Typically related to ID exhaust fans for large operations such as power plants.
- Have some low-frequency tonality driven by blade-passage frequency of the fan.
- Release noise high in the air.
- Possible for stack length to result in resonance at fan frequency.

Air Compressors and Vacuum Blowers

- Not typically located outdoors.
- Usually OK if exhaust or inlet has a tuned silencer.
- With no silencer or with wrong silencer, create highly tonal noise in mid-low frequencies that can carry long distances.

Emergency Generators and Backup Power Systems

- More likely to be a noise ordinance concern than a neighbor issue as they run infrequently.
- Engine exhaust is primary noise source. Must penetrate any enclosure or building that houses the gen-set.
- Exhaust systems require expensive silencers for effective noise control, which is not always budgeted.

Trucking and Rail

- Usually problematic when there are nighttime operations.
- Impact noise from loading / unloading and coupling / decoupling.
- Backing alarms.
- Diesel refrigeration trailers (“reefers”).

Outdoor Air Cooled Chillers

- Easily responsible for the most annoyed neighbors of all noise sources we have studied.
- Integrated scroll compressors create tonal noise in multiple, dissonant pitches.
- Typically located adjacent to buildings that reflect additional noise energy towards the neighbors.