Is this too Noisy
(or perhaps too Quiet)?

Getting Acoustics Right

CIBSE London Branch
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Agenda

• Am I a Nuisance? What is the (legal) limit for noise?

• Planning ahead. Where does noise fit in the Planning System?

• Quiet by Design. How (not) to design a quiet building.

Questions/ Discussion
Introduction

Aims
• Not trying to make everyone ‘acoustic experts’
• Identify the areas where acoustics affects your own work
• Help you to avoid some of the common pitfalls that can occur

Why
• Easier for everyone if the people we work with understand what we are talking about and why/how we arrive at our conclusions
• Better understanding helps us to help you
• Help you to make (more) informed decisions about acoustic matters that arise as part of your ‘everyday’ work
What is a decibel?

- A change of 3dB is often regarded as a ‘just noticeable’ difference.
- A change of 10dB sounds about twice/half as loud; 20dB sounds about four times as loud / quieter.

<table>
<thead>
<tr>
<th>Sound pressure level Lp dB(A)</th>
<th>Indication of environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>140</td>
<td>Threshold of pain</td>
</tr>
<tr>
<td>120</td>
<td>Rock concert</td>
</tr>
<tr>
<td>100</td>
<td>Night club (loud)</td>
</tr>
<tr>
<td>80</td>
<td>Beside busy, fast road</td>
</tr>
<tr>
<td>60</td>
<td>Normal conversation</td>
</tr>
<tr>
<td>40</td>
<td>Office</td>
</tr>
<tr>
<td>20</td>
<td>Quiet bedroom</td>
</tr>
<tr>
<td>0</td>
<td>Threshold of hearing</td>
</tr>
</tbody>
</table>
What is the Legal Limit?
What is the Legal Limit?

Noise at Work 80/ 85/ 87dB(A); 135/ 137/ 140dB(C)
Noise Act 34dB/ +10dB above $L_{A99,1min}$

Noise Emissions from Outdoor Equipment – some limits, some recording

WHO – sleep disturbance, day time annoyance (indoors/ outdoors)
BS 8233 – range of guidance (under review)
BS 4142 – likelihood of complaint (under review)
Building Regulations – Part E
Schools – BB93 (under review), BSF (discontinued), PSBP
ETSU-R 97 – wind turbines

Planning Policy: NOEL, LOAEL, SOAEL
Sustainability – BREEAM, LEED

Parameters – dB(A), NR, NC, … $L_{Aeq,T}$, $L_{AMax}$
What is a ‘suitable’ level?

What factors should be considered when identifying a ‘suitable’ sound level?
What is a ‘suitable’ level?

Criteria:
• Noise type/character, receptor(s)
• Minimal cost (size, etc)
• Inaudibility
• No louder (or possibly quieter) than previous installation
• Absolute limit
• Effect upon pre-existing noise level

Influencers:
• Noise producer
• Neighbours
• Enforcing authority
• Politics
• National / local policy

*Highest demonstrably suitable level (avoid excessive/unnecessary cost)*?
What’s the difference between sound and noise?

Noise = Unwanted Sound

(Unwanted by whom? Context, Level, …)

Music, Conversation, Aircraft
### What is the difference between Planning & Nuisance?

<table>
<thead>
<tr>
<th>Planning</th>
<th>Nuisance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protect Amenity</td>
<td>Prevent Statutory Nuisance</td>
</tr>
<tr>
<td><strong>Circular 11/95</strong></td>
<td><strong>Abatement Notice</strong></td>
</tr>
<tr>
<td>6 Tests for a valid Condition:</td>
<td>Appeal (21 days) grounds inc:</td>
</tr>
<tr>
<td>Necessary</td>
<td>Not justified</td>
</tr>
<tr>
<td>Relevant to planning</td>
<td>Serious defect/ error</td>
</tr>
<tr>
<td>Relevant to development</td>
<td>Unreasonable</td>
</tr>
<tr>
<td>Enforceable</td>
<td>Insufficient time</td>
</tr>
<tr>
<td>Precise</td>
<td>Defence: Best Practicable Means</td>
</tr>
<tr>
<td>Necessary</td>
<td></td>
</tr>
</tbody>
</table>
What’s the best solution for me?

Planning is more stringent than Nuisance/Complaint
There are no/few fixed limits for noise

What do you want to do?
• Make sure there won’t be any complaints?
• Do what the Council wants?
• Achieve an arguably/demonstrably ‘suitable’ level?
• Do the bare minimum?
• Do nothing?

It’s up to You (to make an informed decision)!
What’s the difference between the noise level at Source and at the Receptor?

- Directivity e.g. flat bed condenser ~6dB higher from fans
- Distance attenuation – 6dB per doubling of distance
- Multiple sources – x2 = 3dB, x3 = 5dB, x10 = 10dB
- Barriers, Bunds – typically around 5dB to 15dB
- Foliage – acoustically transparent, can reflect sound
- Ground/ Atmospheric Attenuation – long distance effects
- External e.g. garden/ Internal e.g. bedroom criteria

(Frequency, Wavelength, Velocity relationship)
Noise Limits & Locations

What’s wrong with a ‘Boundary’ Condition/ Limit?
Boundary Conditions

Why used:
1. Convenient point to consider/ access
2. But - monitoring positions must be a reliable indicator of noise level at the locations to be protected.

Problems:
1. Aim is to protect the noise receptor (not site boundary)
2. Levels at Boundary and Receptor depend upon relative distance between Source, Receptor & Boundary
3. Boundary Condition/ Limit may result in much lower level than necessary/ reasonable
So how much noise should I create?

- Identify a ‘suitable’ level at the noise receptor
  - Amenity/ Nuisance?
  - Aims?
    - Little likelihood of complaint – Bare minimum?

- Agree the level with appropriate parties
  - Receptors/ complainant, local authority, …

- Convert this to appropriate source noise level(s)
  - Distance, Directivity, Screening, …
Planning Ahead.
Where does Noise fit in the Planning System?

National Planning Policy Framework (NPPF) – [2012]

• Avoid new development’s significant adverse impacts on health and quality of life
• Mitigate development’s other adverse impacts on health and quality of life, including by Conditions
• Recognise development may create noise avoid unreasonably restricting existing business development due to changes in nearby land uses
• Identify and protect areas of tranquillity
Clarifies NPPF

- Significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development.

- If impact between LOAEL (Lowest Observed Adverse Effect Level) and SOAEL (Significant Observed Adverse Effect Level): All reasonable steps taken to minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development. **This does not mean that such adverse effects cannot occur**
Noise Policy Statement for England (NPSE)

No Observed Effect Level (NOEL)
• WHO indicates steady level of 30dB(A) in bedrooms?

Lowest Observed Adverse Effect Level (LOAEL)
• WHO indicates steady level of 40dB(A) in bedrooms?

Significant Observed Adverse Effect Level (SOAEL)
• No firm level, depends on context
Current Government Planning Policy

Noise should not be treated in isolation but should be considered as part of a development’s sustainability.

It may even be appropriate to create an adverse noise impact if this facilitates a more significant beneficial impact in another aspect of the development’s sustainability.
Some other Guidance/ Standards

BS 4142: 1997 Method for Rating Industrial Noise affecting mixed Residential and Industrial areas

BS 8233: 1999 Sound insulation and noise reduction for Buildings – Code of practice

Both of these Standards are currently under revision
Are Conditions/ Notices always Reasonable?

Cooling Tower installation in London – Condition requiring 10dB(A) below background noise level – bespoke high performance attenuation and enclosures cost circa £120K, standard manufacturer’s attenuation £10K’s lower cost

Complaints regarding plant noise nuisance in Cambridge garden – agreed with Council no need to issue Abatement Notice (despite duty to do so if they felt Nuisance may occur) – as problem would be resolved before garden used in Spring
What to do about an unreasonable condition / notice

Look at factors such as: specified locations, parameters, levels, times, assessment methodology

Carefully review planning conditions; possibly renegotiate a more appropriate ‘interpretation’ of an otherwise invalid condition

Consider appealing a notice (limited time); what is the reason for the complaint?
Quiet by design. How (not) to design a Quiet Building.
Specifying a noise (sound) level

Environmental noise (sound pressure) levels almost invariably specified in dB(A).
Building Services noise levels may be specified differently e.g. NR, possibly NC.

What may be unsuitable about a specification of:

38dB(A) at the nearest dwelling?
NR35 in any office?
Low cost ways to reduce the noise level

Several possibly relatively low cost ways to reduce the noise level

• Slow Down – can be very effective
• Directivity – point it the other way
• Location – put it a long way from the noise sensitive location
• Screening – put it on the other side of a building
• Absorption – stop sound being reflected from other surfaces

What is the likely order of these in terms of cost/benefit?
Give complainants double glazing to keep *them* quiet?

Benefits:
- Relatively low cost
- Pro-active
- Shows commitment
- Positive outcome

Concerns
- Open windows
- Neighbourhood
- New neighbours
How to make equipment even quieter (if necessary) ?

Attenuators
Acoustic Louvres
Acoustic Enclosures/ Containers
Acoustic Screens/ Barriers
Absorptive Treatment/ Room Lining
Vibration Isolation
Mind the Gap!
Beware of Apertures (& weak spots)

Ventilation – Need appropriate open area

Services – May be possible to seal

Unintentional – Visible/ Invisible?

1% gap can limit performance to 20dB
0.1% gap (3mm above 3m wall) can limit performance to 30dB
Specifying/ selecting ‘quiet’ equipment

Speed Control?
‘Rating Penalty’
Sound Power or Sound Pressure Level?
‘Silent’/ ‘Acoustic’ Products!
Fitness for Purpose?
Manufacturer’s Data?
Selecting suitable equipment – worked example

Condenser by wall, 20m from block of flats, producing ‘free field’ level of 40dB(A) at 10m. Target ‘free field’ level of 40dB(A) at window.

- Wall +3dB
- 20m -6dB
- Overlooking flats +6dB (approx)
- Correction +3dB to 10m free field level of 40dB(A) gives 43dB(A) (equates to free field level at window).

Need condenser producing 37dB(A), or variable speed (about 10dB(A)+), alternative location, or possibly absorption to wall (about 2dB(A) to 3dB(A))
Measuring sound & vibration

Competence
• How to use the equipment
• How to take suitable measurements

Instrumentation
• Appropriateness
• Precision
• Calibration

Uncertainty
• Known unknowns; Unknown Unknowns?
Aerodynamic resistance

Often overlooked

Fans may be selected based on zero resistance performance

Many elements impose resistance – splitters, pods, louvres, birdmesh, dampers, grilles

Expanded mesh is not good aerodynamically, nor is ‘insect mesh’

Plenum sections can significantly reduce resistance
Building design

External layout

Internal layout

Materials
- Noise breakout
- Vibration transmission
- Natural ventilation
- Glazing
Why do noise/vibration control systems fail?

Many reasons including:

- Energy leakage – gaps, flanking, bridging
- Attenuation characteristics – frequency spectra, regenerated sound
- Vibration radiated energy (D)
A few examples! (X)
Thank You

Any Questions?

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What difference does distance make to a noise level?

Sound reduces at a rate of 6dB for every doubling of distance from a noise source.

Relatively little difference at large distances.

4m to 32m achieves 18dB(A) reduction
10m to 30m only achieves 10dB(A) reduction

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>dB(A)</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>76</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>64</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>62</td>
<td>20</td>
</tr>
<tr>
<td>16</td>
<td>58</td>
<td>24</td>
</tr>
<tr>
<td>20</td>
<td>56</td>
<td>26</td>
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<tr>
<td>30</td>
<td>52</td>
<td>30</td>
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<td>32</td>
<td>52</td>
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<tr>
<td>50</td>
<td>48</td>
<td>34</td>
</tr>
<tr>
<td>100</td>
<td>42</td>
<td>40</td>
</tr>
</tbody>
</table>
What can affect distance attenuation? (R)

What may affect whether 6dB attenuation is achieved with every doubling of distance from a noise source (and why)?
Adding decibels is not straightforward (1 + 1 = 4)

Acoustics is logarithmic.

It is all ‘relative’.

Two identical sources are 3dB louder than one; four identical sources are 6dB louder than one (doubling and doubling again).

25dB + 25dB = 28dB  
51dB + 51dB = 54dB

One noise source that is much louder than another is largely unaffected by the quieter noise source (more than 10dB difference makes little difference to the higher noise level).
### Adding the noise from multiple sources

Two same levels, result is 3dB higher

Two similar levels, smaller increase to the higher level

Greater difference in levels, slight increase to the higher level

Large difference in levels, result is same as higher level

<table>
<thead>
<tr>
<th>Difference between levels</th>
<th>Add to higher</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 1dB</td>
<td>3dB</td>
</tr>
<tr>
<td>2 – 3dB</td>
<td>2dB</td>
</tr>
<tr>
<td>4 – 10dB</td>
<td>1dB</td>
</tr>
<tr>
<td>More than 10dB</td>
<td>No change</td>
</tr>
</tbody>
</table>

$51\text{dB} + 51\text{dB} = 54\text{dB}$  
$53\text{dB} + 51\text{dB} = 55\text{dB}$  
$63\text{dB} & 51\text{dB} = 63\text{dB}$
Multiple noise sources - example

When combining several noise sources always add the lowest levels first (including the results of intermediate calculations):

62 & 48 & 51 & 49 & 50 & 57
62 & 48 & 51 & 49 & 50 & 57 : 48 & 49 = 52
62 & 48 & 51 & 49 & 50 & 57 : 52 : 50 & 51 = 54
62 & 48 & 51 & 49 & 50 & 57 : 52 : 54 : 52 & 54 = 56
62 & 48 & 51 & 49 & 50 & 57 : 52 : 54 : 56 : 56 & 57 = 60

What would the answer be if added up in the order listed?
How does an acoustic screen / barrier work?

Sound (diffracts) bends around the top of the barrier
Less energy bends, most continues in the original direction.

Barrier just intersecting direct path provides 5dB attenuation.
As barrier projects further into direct path it provides more attenuation.
How much attenuation can an acoustic barrier provide?

Better high frequency than low frequency attenuation

Usual limit around 10dB(A) to 15dB(A).

Possibly more, but increasing cost for ever decreasing improvement in performance.
What limits an acoustic barrier’s performance? (R)

Limiting factors:

• Nearby surfaces
• Canyon effect
• Gaps
• Insufficiently dense material

Many materials/objects can act as acoustic barriers:

• Stone/masonry walls
• Buildings
• Timber fences
• Earth bunds
• Proprietary ‘acoustic screens’
Which type of foliage gives the best attenuation? (R)

Despite the popular myth

foliage does not provide any worthwhile acoustic attenuation

Broad leafed trees can reduce bund screening

Foliage rustling in the wind can provide masking
(only when there are leaves on trees & a breeze)
A little bit of physics (it had to be somewhere)! 

Hear sound from about 20Hz to 20kHz. 
Sound velocity same regardless of frequency. 
Velocity is wavelength times frequency 

High frequency – shorter wavelength than lower frequencies.
Problems with Boundary Conditions/ Limits

Boundary far from source, close to receptor
Little difference in distance (attenuation) between boundary and receptor

Boundary close to source, far from receptor
Noise level at receptor significantly lower than at boundary (unreasonably quiet) e.g. 4 x distance = 12dB lower
World Health Organisation guidance (R)

Community Noise Guidelines 1999 (relating to anonymous noise)

- 50dB(A) / 55dB(A) outdoors (day time)
- 30dB(A) steady / 45dB(A) occasional maxima in bedrooms
  [45dB(A) steady / 60dB(A) occasional maxima outside dwellings]

Night Noise Guidelines for Europe 2009

- No observable effect limit (NOEL) at night 30dB(A) outdoors
- No observable adverse effect limit (NOAEL) at night 40dB(A) outdoors
- Recommended $L_{night, outside}$ target 40dB(A), interim target 55dB(A)
BS4142: 1997
Method for rating industrial noise affecting mixed residential & industrial areas

Compared rating (average source) noise level (possibly including 5dB ‘rating’ penalty) outside dwelling with background noise (quietest 10%) level

Conclusions:
Rating level at least 10dB below background = ‘complaints unlikely’
Rating level 5dB above background = ‘marginal significance’
Rating level 10dB above background = ‘likelihood of complaints’
Problems/difficulties with BS4142

- What is industrial noise?
- Not suitable for assessing noise measured indoors
- Not suitable when background and rating levels very low
- Is a rating penalty applicable?
- Background noise level specifically excludes consideration of residual noise for 90% of the time
- Provides limited guidance – 15dB range between ‘complaints unlikely’ and ‘marginal significance’.
Same background noise level! (R)
BS8233: 1999 (R)
Sound insulation and noise reduction for buildings. Code of practice

Recommends different levels depending upon room type / use

Provides a wide range of information:

• Acoustic performance of building elements
• Sample acoustic calculations
• Mechanical plant advice
Planning Applications (amenity)

Consider impact on neighbours

Effect of national & local planning policies

Protect particularly quiet areas, avoid significant increase to noisy areas (long term noise reduction)

Balance noise levels/impact with other planning considerations e.g. employment

Prevent [significant] adverse impact upon the amenity of neighbours

Show that it will not disturb the neighbours
Appealing / amending a planning condition

Difficult to draft a valid condition without ‘writing a book’.

Most likely difficulties with the six tests:
- Necessary – may be duplication
- Relevant to planning
- Relevant to the development to be permitted – perhaps not?
- Enforceable – likely to be difficult for low source noise levels
- Precise – may well be some ambiguity
- Reasonable in all other respects – very low noise level may not be

May be possible to agree an ‘interpretation’ of the condition with the LPA (rewrite the condition) rather than appealing it.
Why do people complain about noise?

Too loud
Unpleasant character
Wrong time

Other reasons
Noise Abatement (nuisance)

• Alleged disturbance creating a ‘nuisance’.

• Environmental Protection Act puts duty on local authority.

• Less stringent than amenity (planning).

• Can appeal (within 21 days).
Appealing a Statutory Nuisance Abatement Notice

Statutory Nuisance (Appeals) Regulations 1995

- Not justified
- A (material) informality/defect/error in (connection with) notice
- Notice requirements unreasonable/unnecessary
- Insufficient time to comply
- Best practicable means were already in use (not a defence against a private action)
- More onerous than other relevant conditions’ requirements
- Notice served on incorrect party
Factors to consider when specifying a noise (sound) level

• Location(s) – noise sensitive / monitoring

• Character – parameter(s) / penalty

• Time – different noise sensitive locations / parameter(s)

• Residual noise

• Meteorological effects

• Verification
Specifying a sound level – Location(s)

There may be multiple noise sensitive locations

These may require different criteria

Monitoring positions – accessible and a reliable indicator

Measure or calculate the source noise level?
Specifying a sound level – Character

Sound can have a wide range of characteristics

Must ensure that:

• The specified level is appropriate (‘rating’ penalty?)

• The specified parameters are suitable to reliably and accurately measure/assess the noise.
Specifying a sound level – Time

Likely times that the noise source will be operational affect:

• Choice of noise sensitive locations
• Measurement / assessment parameters
Specifying a sound level – Residual noise

Sound pressure level measured includes source and residual (everything else) noise.

Source noise may be difficult/impossible to quantify accurately

Residual noise may be steady, or may vary by 30+dB(A)
Specifying a sound level – Meteorological effects

Weather conditions affect sound level measurements.

Wind direction can have a major effect
• Slight increase downwind
• Major decrease upwind
• Can significantly reduce screening attenuation

Temperature inversions can significantly increase the sound level

Rain increases the residual sound level

Fog & snow reduce sound level
Specifying a sound level – Verification (R)

To verify a sound level need to be able to check it is not exceeded

Must be able to quantify accurately what level is being produced at noise sensitive locations.

If the presence or absence of a material excess cannot reliably be verified, how can the specified level be enforced?
Slower Equipment may be Quieter \(^{(R)}\)

Fan Law indicates about 16dB(A) reduction in noise level for 50% reduction in speed

May not reduce airflow by similar amount due to reduced resistance

Halving number of fans instead only 3dB(A) reduction

Required duty may reduce at more noise sensitive times e.g. Refrigeration Condensers
Pointing the noise in the other direction (directivity) (R)

Directivity – variation in noise with direction from a source

Depends upon:

- Frequency characteristics
- Angle of diffraction
- Directions to noise receptors
- Reflective surfaces

Can often achieve 5dB(A) to 10dB(A). More possible in some situations e.g. put louvres in opposite wall of building
Attenuator (silencer) principles & design (R)

What does an attenuator do?

Passive, reactive and active attenuation

Rectangular (splitter) / circular attenuators

Attenuator configuration

Aerodynamic resistance
Acoustic Louvres (R)

The solution to many noise problems?

Appearance

Performance (compromise)
Cost
Size

Attenuated weather louvres – a better alternative?
Acoustic Enclosures/ Containers\(^{(R)}\)

Conventional materials / Proprietary system

Wide range of performance

Different requirements:
- Attenuation
- Ventilation
- Materials flow
- Access
- Visibility
- Appearance …

Containerised enclosures
Acoustic Barriers/ Screens (R)

Some attenuation

Possibly relatively low cost (diminishing returns)

Range of materials

Limit about 10dB(A) to 15dB(A)

Compromising factors
Acoustically Absorptive Room Lining (R)

Usually not appropriate

Relatively expensive

Only reduces reverberant (reflected) sound

Upper limit about 10dB(A), likely benefit only a few dB(A).

Slightly longer attenuation probably more cost effective
Vibration isolation (R)

Can compromise noise control system

Higher $\frac{F_F}{F_n}$ ratio better

$F_n$ depends on deflection

Softer springs better

Height adjustment

Supporting structure
Does slower mean quieter? 

Bigger, slower plant often selected for 'noise sensitive' locations

Most fan noise due to aerodynamic turbulence

Halving fan speed reduces aerodynamic noise by about 18dB(A) (airflow not halved because resistance decreases)

Halving number of fans reduces noise level by only 3dB(A).

Speed control reduces speed at night, with full speed when necessary (may produce tonal noise)
What is a ‘Rating Penalty’? When is it applicable?

If noise at the listener has ‘acoustically distinguishing characteristics’

Typical features include:
• Tonality
• Impulsivity
• Significant changes in level

Some local authorities attempt to apply a Rating penalty by default (potentially 5dB(A) lower level than necessary)
What is the difference between sound power and sound pressure level? (R)

Sound power is the acoustic energy, sound pressure are the fluctuations it produces (what is heard).

Good analogy with electric heater power and resultant temperature.

Heater of constant power will produce different temperature, depending on room conditions.

Sound source of constant sound power will produce different sound pressure level, depending on room conditions.

Sound power level enables comparison of different equipment noise levels irrespective of measurement location. Sound pressure levels must be qualified with information about the measurement conditions.
Are ‘acoustic’ / ‘silent’ products really quiet? 

A ‘silent’ product is clearly ‘optimistic’.

A percentage noise reduction is highly likely to be misleading.

Foam linings are sometimes used for an ‘acoustic’ version. 
(may achieve a reduction of about 2dB(A) - ‘just noticeable’)

Some ‘quiet’ products really are; others are not.

The best way to tell is to compare sound power levels 
(also assuming that the noise source is not highly directional).
Is noisy equipment ‘fit for purpose’? 

If supplier’s equipment cannot achieve duty is it ‘fit for purpose’?

If supplier’s equipment produces unsuitable noise level for the location, is it ‘fit for purpose’?

If not, can client insist that supplier rectifies the defect at their own cost?

Can supplier negate any responsibility by stating that they have not considered noise when selecting equipment?
How good is manufacturer’s data? (R)

Manufacturer’s data varies considerably in quality and reliability.

May be:
- Estimate from components
- Spot measurements
- Sound level XXdB or XXdB(A)
- Favourable conditions?

Sound power levels: ISO 3740 to 3747 and ISO 9614
What needs to be considered with manufacturers’ data?

Assuming that the data is reliable:

• Operating conditions

• Parameters

• Directivity

• Character

• Repeatability / consistency, …
Sound / vibration measuring competence (R)

Must be able to identify a range of appropriate measurement factors including:

- Location(s)
- Parameter(s)
- Time(s)
- Instrumentation (also correct use)
- Meteorological conditions
Sound / vibration measurement instrumentation

- Cost
- Accuracy / reliability
- Functionality
- Ease of use
Analysers typically give measured level to nearest 0.1dB
• What is the uncertainty in source noise?
• What is the uncertainty in residual noise?
• What effect does residual noise have on source noise?

What is a reasonable uncertainty in measurement repeatability?

What is a reasonable uncertainty in measurement reproducibility?

How much reliance can we place on a sound level measurement?
What does 10dB or 20dB attenuation really mean?

10dB reduction = 10% of energy = 90% energy reduction

20dB reduction = 1% of energy = 99% energy reduction

30dB reduction = 0.1% of energy = 99.9% energy reduction

If 1% of energy bypasses control system, performance limited to 20dB

QA becomes increasingly (logarithmically) important with increasing performance
Flanking sound

Flanking sound can travel through the structure, around the noise control system

Bypass party walls

Dry linings

Partitions / false ceilings
Attenuation frequency characteristics

Attenuation must be selected to match the frequency characteristics of the noise source.

If not an otherwise effective attenuator may be useless.

- Loud broadband ‘featureless’ noise
- ‘Standard’ attenuator much better at higher frequencies
- Quieter noise but with prominent (annoying) drone
Vibration radiated sound

Vibrational energy radiates as sound

Particularly from lightweight surfaces

Compromise noise control systems
Vibration isolation compromising factors (R)

- Structural stiffness
- Variation in supporting surface height
- Variation in point load
How not to do it!
(unstable springs)
How not to do it!
(splitter infill falling out)
How not to do it!
(inadequate structure, unsuitable vibration isolation)
How not to do it!
(new unattenuated grille – previous attenuation system)
How not to do it !
(Bit warm)

BELAIR RESEARCH LIMITED
Guaranteed solutions to your noise and vibration problems

ACOUSTICAL CONTROL ENGINEERS LIMITED
Guaranteed solutions to your noise and vibration problems
How not to do it!
(Birdmesh ?)
How not to do it!
(painted nested springs)
How not to do it!
(unsuitable mesh)
How not to do it!
(overheating?) (R)