CONSULTING ENGINEERS

Acoustics & Building Services

An back to basics overview

Prepared for division QUEENSLAND AIRAH 20th March 2012

ASK Consulting Engineers

- Since 1993, ASK Consulting Engineers has been providing clients from both the private and public sector with a range of specialised acoustic engineering and scientific services.

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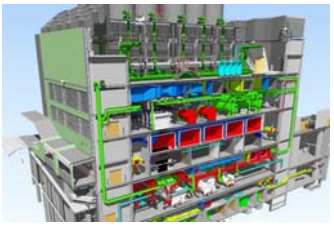
ASK Consulting Engineers is able to offer the following engineering services:

- Architectural Acoustics;
- Environmental Noise
- Transportation Noise;;
- Air Quality and Odour;
- Industrial Noise;
- Expert Witness;
- Vibration;
- Lighting Impact; and
- IEQ Green Star Acoustics.



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ASK Consulting -Key Staff Members

- **Gillian Adams** - Managing Director, Speciality Areas – Expert Witness Hospitals, Education and Stadiums

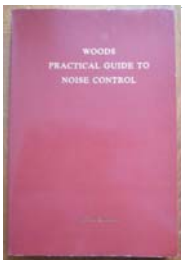
- **Stephen Pugh** – Director, Specialty Areas – Environmental Noise, Mining, Concert Halls, Studios, Complex projects

- **Michael Lanchester** – Associate, Specialty Areas - Health & Lab Buildings, Office Building and Fitouts, Education & Mechanical Plant

- **Andrew Martin** – Air Quality Group Manager – Air Dispersion Modeling, Dust, Pollutants, Greenhouse Gases and Odour .

Fundamentals to cover

- Basic Definitions
- Basic Terminology
- Criteria and Calculation methods
- Steps to reaching a good outcome with HVAC.

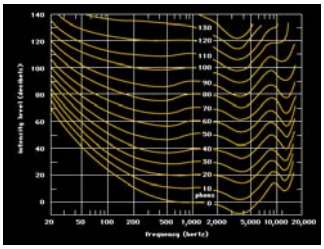


Noise Aspect of Building Services

- **Why is important to control and manage noise from building services ?**
- Simply to maintain sound sending and receiving between people. e.g. talking and listening.
- To facilitate communication lessening stress.
- To allow concentration, relaxation and sleep.
- To control environmental noise to the community. Noise limits are legally enforceable!
- Other acoustical aspects which affect this include: acoustical absorption, transmission, reverberation control, noise intrusion (traffic) and privacy.

Sound Frequency and Modulation

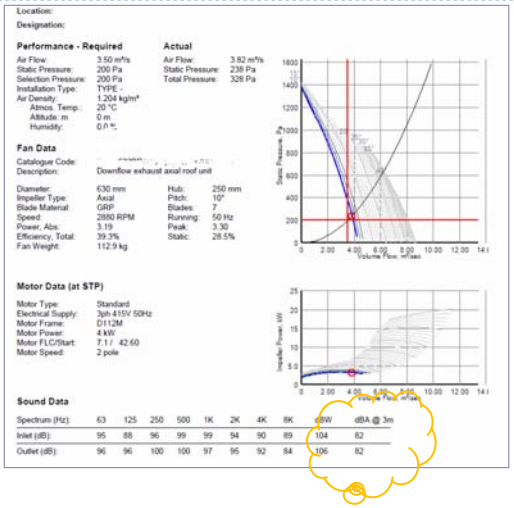
- All sound:
  - Varies in loudness.
    Contains a mix of frequencies
    Varies with time.
- To describe sound we measure :
  1. The overall level;
  2. Frequency distribution; and
  3. Statistical Variation (how it changes).



- Two types of measurement devices we use:
  - 1. The free sound level and intensity meter: Our ears
  - 2. Scientific Sound level meter; and
  - Tip: check out iPhone Faber Soundmeter($21) (incredibly good guide to noise levels on calibrated.)

Airborne Noise Terminology

- **Sound Pressure** is the noise level measured at specific distance from a noise source. 1.0m and 3.0m distance is common. (dB and dBA)
- **Sound Power** is the noise level at the surface of the source. dBW.
- **Sound Spectra** can either be pressure or power. Can be A-weighted sometimes.
- Fan data dBA @3.0m represents calculated noise with noise into a sphere. It is not real world and is only a comparative tool only.



Sound Levels

- The decibel (dB) is a logarithmic unit of measurement that expresses the magnitude of a physical quantity (usually power or intensity) relative to a reference level.
  Levels normally encountered in buildings are between 20 dB to 100 dB

dB(A) – The "A" scale represents how a human ear responds. Humans don't hear low frequency very well and cannot hear very high pitched sounds. (Older people loose high-end first .).

Noise Level	Space
20 dB(A)	Fully-sealed Audiometric Booth (Quietest Level I have recorded)
25 dB(A)	Quiet Bedroom in Brookfield
30-35 dB(A)	Quiet Private office
40 dB(A)	Typical private office
45 dB(A)	Typical Open Plan office (no talking)
50-60 dB(A)	Shopping Centre Mall
60-75 dB(A)	Air Handling Plantroom
75-90 dB(A)	Chiller Plantroom
95-115 dB(A)	Diesel Generator Plantroom
129 dB(A)	Under wing of F-111 Zone 5 after-burner (Loudest Level continuous noise I have recorded)
180 dBpeak	Elephant Gun at the Ear

Reverberation

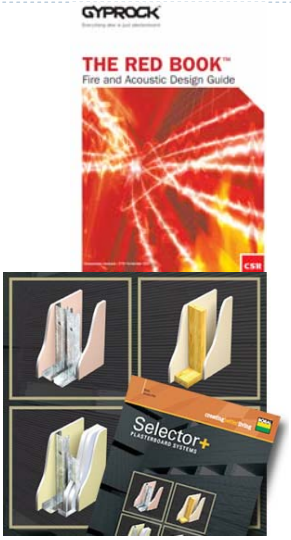
- **Reverberation** is the persistence of sound in a particular space after the original sound is removed. Measured in seconds. Referred to as RT60.
- We need to have specific reverberation times in rooms for their intended activity and allow them to function.
- ...otherwise it causes difficulty in speech, communication, additional noise and stress.
- Reverberation is a function of room volume and the area of acoustical **absorption**. The larger the volume the longer the RT. The more absorption present the shorter the time.

Absorption

- The absorption coefficient of a material is a number between 0 and 1 which indicates the proportion of sound which is absorbed by the surface compared to the proportion which is reflected back into the room.
- A large, fully open window would offer no reflection as any sound reaching it would pass straight out and no sound would be reflected. This would have an absorption coefficient of 1.
- A thick, smooth painted concrete ceiling would be the acoustic equivalent of a mirror, and would have an absorption coefficient very close to 0.
- Suppliers of acoustical absorption have test data.
- Surfaces are highly absorptive have poor transmission.

Transmission

- Transmission is the path of noise through building elements. Partitions/walls, floor, roof/ceiling, glazing and openings.
- Must be Holistic viewpoint - Wall performance limited by minor elements (e.g. doors, windows, details)
- **Main Terminology:**
- Rw (STC prior to 1999), Dw (NIC prior to 1999)
- Transmission loss (TL); and
- Numerous others (about 20 terms) we wont bore you with….
- High transmission loss products are poorly absorptive.



Basic Acoustical Design Considerations

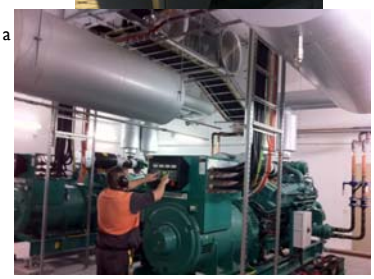
- All too commonly, acoustical design is based upon throwing something in an hoping it works based on experience. No calculations are done.
- Commonly this results in over-design or under design.
  - "Let's put a noise barrier up."
  - "We'll put an attenuator on the fan discharges."
  - "I know, wrap it in wavebar. That will solve it."
  - "Suck it and see, we'll add attenuation if it needs it."
- Selecting attenuation is somewhat similar to structural engineering in that noise control methods should be "designed" to meet an outcome rather than guesswork or trial and error.
- There are three main considerations in design:
  1. How much noise does is generated ?
  2. What outcome am I trying to achieve?
  3. What noise reduction is necessary?

- Noise level of the equipment
- - Necessary Noise reduction
- Outcome you need

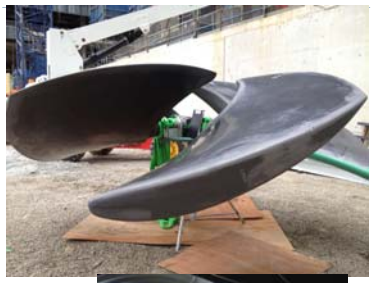
Noise Source Data

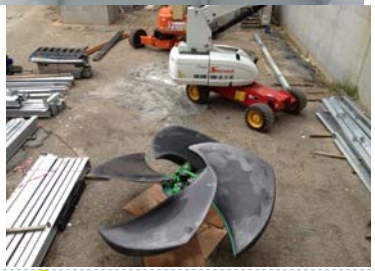
- To supply equipment, suppliers must be able to provide suitable noise data for design purposes.

- All acoustical calculations use noise level spectra apart from the most basic calculations. Supplier data should therefore always include spectra.
- Data received we receive is often problematic.
  - Pool Heater Noise Level - 62 Db
- Where ? Measured to what code ? Is it A-weighted ?
- "Our Pumps are the quietest on the market, we've never had a problem."
- Ask questions, is this sound pressure or power?
- Is it A-weighted spectra?
- Is inlet or outlet the same ?
- Be wary about unrealistically low data especially on " cheap" plant sourced in Asia. Some plant doesn't meet their claims.



Example - Low Noise Plant





Acoustic Standards and Codes

- Australian Standards
- Building Code of Australia 2012
- **Agency Guidelines**

  University Guidelines – UQ, QUT and Griffith

  Government Department Requirements

  DEHP & Council

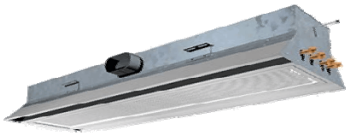
- Aust. Assoc. of Acoustical Consultants (AAAC):

  "*Star Rating Guide for Apartments*"

- Specific client requirements and conveyed expectations.

Internal Criteria and Limits

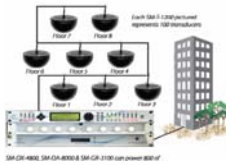
- These are the Goals and Outcomes we want to hit. They come from:
  - Customer Specifications,
  - AS/NZS 2107
  - NR Curves, NC Curves etc



- Australian Standard has two limits. A recommended and a maximum. Which one do you aim for:
- The satisfactory design sound level is the level of noise that has been found to be acceptable by most people for the environment in question and also not to be intrusive.
- The maximum design sound level is the level of noise above which most people occupying the space start to become dissatisfied with the level of noise.
- AS/NZS 2107 Has one big problem at the moment:
  - No Lower limits.
- Chilled beams and building being too quiet creating privacy problems.

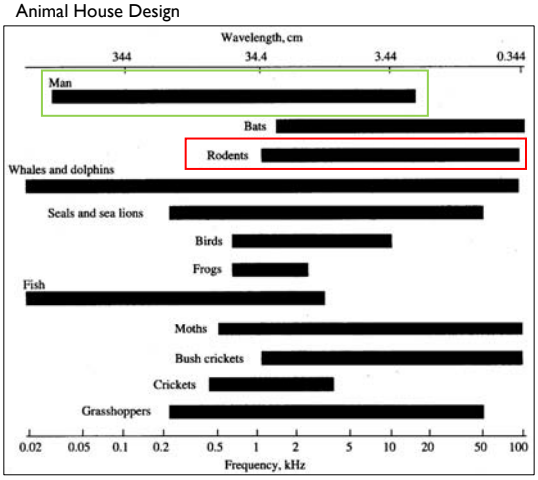
ISO International Organization for Standardization

STANDARDS Australia



Internal Criteria Special Case

- Animal House Design

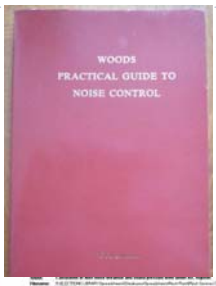


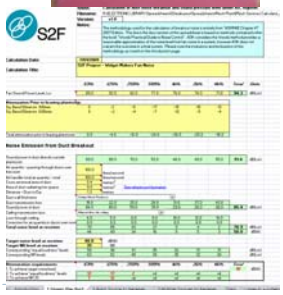
Environmental Criteria and Limits

- Set by Council, Development Approval or State Government Agency.
- Most commonly set at a background noise level +5 dBA
  This requires the background noise level to be determined during the day, evening and night. (When the plant runs.)
- These noise limits are legally enforceable ! Fines can be imposed. However they usually only as a last resort by agencies.
- If you install plant that doesn't meet the limits, you are essentially providing something that client cannot use without breaking the law. – Just like selling an un-roadworthy car.

Design Methods

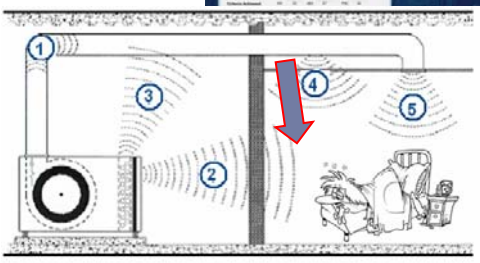
- Woods Practical Guide to Noise Control (Now Free ?) Everyone should read it cover to cover.
- http://www.venttech.co.nz/wp-content/uploads/2012/WPG_NC.pdf
- Fantech Software or other propriety software.
- Spreadsheet Calculation Methods –
- Ducted Systems Assessment order of Priorities:
  1. Noise Level in duct when leaving the Plantroom; then
  2. Noise from Duct Breakout; then lastly
  3. Noise to the Register.
- Co-ordination between architects, mechanical engineer and acoustic consultant is important.
- With the right tools it is not at all difficult. It just takes time.
- Download the Woods. Run the examples in the book.



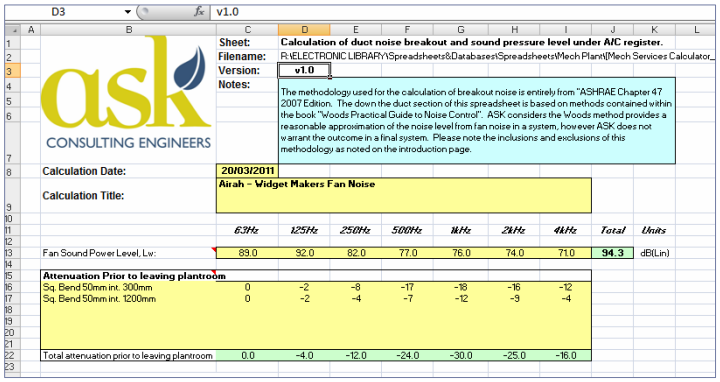


Design Methods - Software

- Fantech Software is useful and powerful tool. Good for calculations to the register.
- However shouldn't be used exclusively. Additional calculations are necessary for breakout noise.

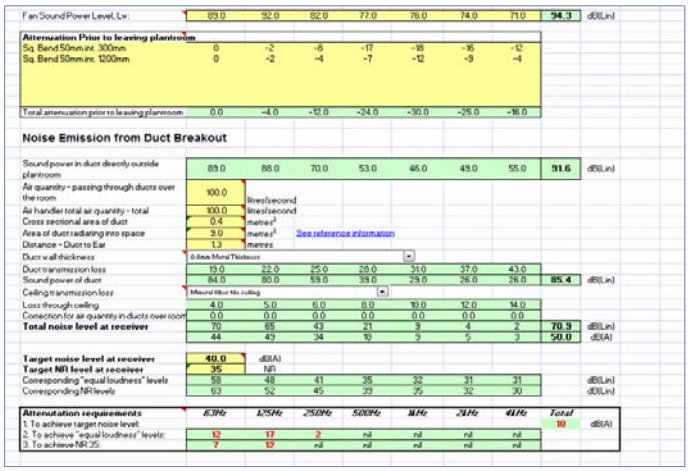


My Methods – How much sound power is leaving the plantroom ?



Sheet:	Calculation of duct noise breakout and sound pressure level under A/C register.								
Filename:	R:\ELECTRONIC LIBRARY\Spreadsheets&Databases\Spreadsheets\Mech Plant\[Mech Services Calculator_								
Version:	v1.0								
Notes:	The methodology used for the calculation of breakout noise is entirely from "ASHRAE Chapter 47 2007 Edition. The down the duct section of this spreadsheet is based on methods contained within the book "Woods Practical Guide to Noise Control". ASK considers the Woods method provides a reasonable approximation of the noise level from fan noise in a system, however ASK does not warrant the outcome in a final system. Please note the inclusions and exclusions of this methodology as noted on the introduction page.								
Calculation Date:	20/03/2011								
Calculation Title:	Airah – Widget Makers Fan Noise								
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	Total	Units
Fan Sound Power Level, Lw:	89.0	92.0	82.0	77.0	76.0	74.0	71.0	94.3	dB(Lin)
Attenuation Prior to leaving plantroom									
Sq. Bend 50mm int. 300mm	0	-2	-8	-17	-18	-16	-12		
Sq. Bend 50mm int. 1200mm	0	-2	-4	-7	-12	-9	-4		
Total attenuation prior to leaving plantroom	0.0	-4.0	-12.0	-24.0	-30.0	-25.0	-16.0		

My Methods – What is required for breakout noise control ?



Fan Sound Power Level, Lw:	89.0	92.0	82.0	77.0	76.0	74.0	71.0	94.3	dB(Lin)
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Sq. Bend 50mm int. 300mm	0	-2	-8	-17	-18	-16	-12		
Sq. Bend 50mm int. 1200mm	0	-2	-4	-7	-12	-9	-4		
Total attenuation prior to leaving plantroom	0.0	-4.0	-12.0	-24.0	-30.0	-25.0	-16.0		
Noise Emission from Duct Breakout									
Sound power in duct directly outside plantroom	89.0	88.0	70.0	53.0	46.0	43.0	55.0	91.6	dB(Lin)
Air quantity – passing through ducts over the room	100.0	litres/second							
Air handler total air quantity - total	100.0	litres/second							
Cross sectional area of duct	0.4	metres²							
Area of duct radiating into space	3.0	metres²	See reference information						
Distance - Duct to Ear	1.3	metres							
Duct wall thickness	0.8mm Metal Thickness								
Duct transmission loss	15.0	22.0	25.0	28.0	31.0	37.0	43.0		
Sound power of duct	84.0	80.0	59.0	39.0	29.0	26.0	26.0	85.4	dB(Lin)
Ceiling transmission loss	Mineral fibre tile ceiling								
Loss through ceiling	4.0	5.0	6.0	8.0	10.0	12.0	14.0		
Correction for air quantity in ducts over room	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Total noise level at receiver	70	65	43	21	5	4	2	70.9	dB(Lin)
	44	43	34	18	5	5	3	50.0	dB(A)
Target noise level at receiver	40.0	dB(A)							
Target NR level at receiver	35	NR							
Corresponding "equal loudness" levels	58	48	41	35	32	31	31		dB(Lin)
Corresponding NR levels	63	52	45	39	35	32	30		dB(Lin)
Attenuation requirements	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	Total	
1. To achieve target noise level:								10	dB(A)
2. To achieve "equal loudness" levels:	12	17	2	nil	nil	nil	nil		
3. To achieve NR 35:	7	17	nil	nil	nil	nil	nil		

Lastly – Noise to Register

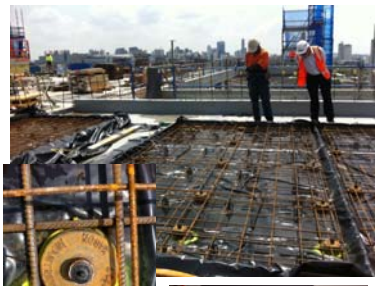
Noise Emission from Register 1

Notes:

Air quantity - to this register:	200.0	litres/second							
Air quantity - total:	1000.0	litres/second							
Distance - Register to Ear:	1.5	metres							
Register location & area (Woods p96):	Grills in centre of wall/ceiling (6 m2)		Reference Information						
Room volume:	22.5	metres³							
Room reverberation time:	0.5 sec - Medium Offices or Open Plan with sound fibre ceiling and carpet								
Duct attenuation components:									
Total Attenuation prior to leaving plantroom	-15.0		-4.0	-12.0	-24.0	-30.0	-25.0	-16.0	
Flexible Duct	-12.0		-15.0	-18.0	-20.0	-22.0	-24.0	-15.0	
Duct Run long	-3.0		-9.2	-7.0	-4.6	-1.6	-1.6	-1.6	
Duct Attenuation Item									
Duct Attenuation Item									
Duct Attenuation Item									
Duct Attenuation Item									
Total	-15.0		-28.2	-37.0	-48.6	-53.6	-50.6	-32.6	
Correction for air quantity:	-9.8		-9.8	-9.8	-9.8	-9.8	-9.8	-9.8	
Correction for register directivity:	6.0		6.0	6.0	7.0	7.0	8.0	8.0	
Calculated system sound power level:	60.2		54.0	35.2	18.6	12.6	13.6	28.6	61.2 dB(Lin)
Calculated Lp(direct):	52.9		46.7	27.9	12.3	6.3	8.3	23.3	53.9 dB(Lin)
Room reverberation time (secs):	0.5		0.5	0.5	0.5	0.5	0.5	0.5	
Correction for room constant:	-8.6		-8.6	-8.6	-8.6	-8.6	-8.6	-8.6	
Calculated Lp(reverb):	51.5		51.4	32.6	18.0	10.0	11.0	26.0	58.6 dB(Lin)
Total noise level at receiver	59		53	34	18	12	13	28	**59.8** dB(Lin)
			37	25	15	12	14	29	**38.9** dB(A)
Target noise level at receiver	**40.0**	dB(A)							
Target NR level at receiver	**35**	NR							
Corresponding "equal loudness" levels:	40		48	41	35	32	31	31	dB(Lin)
Corresponding NR levels:	35		52	45	39	35	32	30	dB(Lin)

Attenuation requirements	*63Hz*	*125Hz*	*250Hz*	*500Hz*	*1kHz*	*2kHz*	*4kHz*	*Total*	
1. To achieve target noise level:								nil	dB(A)
2. To achieve "equal loudness" levels:	1	5	nil	nil	nil	nil	nil		
3. To achieve NR 35:	0	nil	nil	nil	nil	nil	nil		

Interesting Noise Control



Final Points to Remember

- A silent noise environment is not the be all and end all.
- Do calculations. Don't Guess or base design on the last job.
- With the right tools it's not difficult. It just takes time.
- Ask questions about equipment noise if it is not clear, don't make assumptions.
- Use strategic placement, selections, and speed control, prior to attenuators, enclosures and other attenuation.
- When looking environmental noise, keep it simple to ensure limits are met.

Conclusion

- Thanks for listening.

Any questions?

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Poorly Implemented Noise Control