

noise



Go Quiet Instead of Deaf

BOHS: 27/04/15

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Industrial Noise and Vibration Centre: www.invc.co.uk

Noise Control Instead of Ineffective PPE...

PPE does not work well in the real world

HSE research proving that hearing protection is not effective across most industrial applications provides a gold plated opportunity for the legal profession to drive a coach and horses through hearing damage claim defences based on PPE use.



Minimising Hearing Damage Risk

Consequently, as real-world PPE performance is so compromised, the best way to guarantee low levels of risk at low cost is to reduce noise levels as far as practical.

How to Recommend Self-financing Noise Control

The Noise Control Audit

This workshop paper demonstrates how occupational health and other professionals can add value to noise risk assessments by linking to best practice in engineering noise control to reduce the risks of hearing damage dramatically.





The “You must control Noise at Work Regulations”

HSE Quotes

- *Health surveillance can be regarded as a tax on the failure to control risk...*
- *The most important thing about the risk assessment is that it identifies, in an Action Plan, what needs to be done to protect employees from noise.*
- *Employers would be expected to use the information and Action Plan produced by the risk assessment to set about managing noise risks...*

HSE: “...if solutions have been identified “stop assessing and start controlling.....”



The “You must control Noise at Work Regulations”

HSE “...these regulations are concerned with controlling noise, not measuring it ...”

- Hearing protection cannot be used for long term risk management unless it can be proved that noise control is impractical
- Companies should not repeat risk assessments that do not include useful and practical information on noise control

Paraphrasing HSE research: “most noise assessments aren’t worth the paper they are written on...”

- Companies should carry out a Noise Control Audit
 - *assess the noise control options using the best of current technology*
 - *generate cost v noise reduction trade-offs for each item of noisy plant*
 - *plan the most practical and cost effective noise control programme*



“Get a quote...”

HSE “...these regulations are concerned with controlling noise, not measuring it ...”

- “We have a noise problem. Get a few quotes from silencer and enclosure manufacturers”. Unfortunately, variations on this theme are common in meetings across the land...
- The audit process itself involves treating machines as collections of noise sources and not as monolithic "noisy black boxes". In each case, the potential noise sources for each item of plant are listed and their relative contributions ranked. Unless this has been done, the choice of potential noise control measures is based on guesswork.



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Real World PPE Performance

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Conservation v Noise Level

In an imperfect real-world the actual performance of PPE may be very low (wear-rate being the most crucial factor)

dB(A)	Requirements
80 - 85	Hearing protection advised. Implement education. Protectors must be available.
85 - 95	Hearing protection mandatory. Most protectors from reputable suppliers provide adequate protection.
95 - 105	Only high quality protectors, carefully used, can provide sufficient protection.
105+	Protection cannot be guaranteed without very stringent controls and checks.



PPE in the Real World – HSE Research

Issuing PPE is not a simple or reliable solution...

No Protection

- 40% of PPE users got no protection whatsoever
- real world performance of a substantial proportion of the remaining 60% was inadequate
- even in companies with generally effective PPE use, 14% did not wear them when and where required

Factors

- peer group pressure / group behaviour; reluctance to enforce
- need to hear traffic, radios - communication problems
- attitude - imposition without consultation
- incorrect fitting (plugs); inadequate protector provision
- use of PPE as the sole control measure without a comprehensive noise control programme

HSE Research Report RR720:

INVC summary: www.invc.co.uk/profile/resources/technical-notes/#hseppe



In real use the performance of hearing protection is dramatically less than predicted by the manufacturers data. To estimate the performance of hearing protectors, the HSE recommendation to allow for imperfect fitting and condition has been to apply a field correction factor of 4dB - but...

Muffs – additional losses in performance...

- 6dB loss after 1 month of use (headband stretch)
- 2 - 10dB due to glasses, goggles, dust masks
- 14 - 21dB worn over clothing (hoods etc)

Plugs

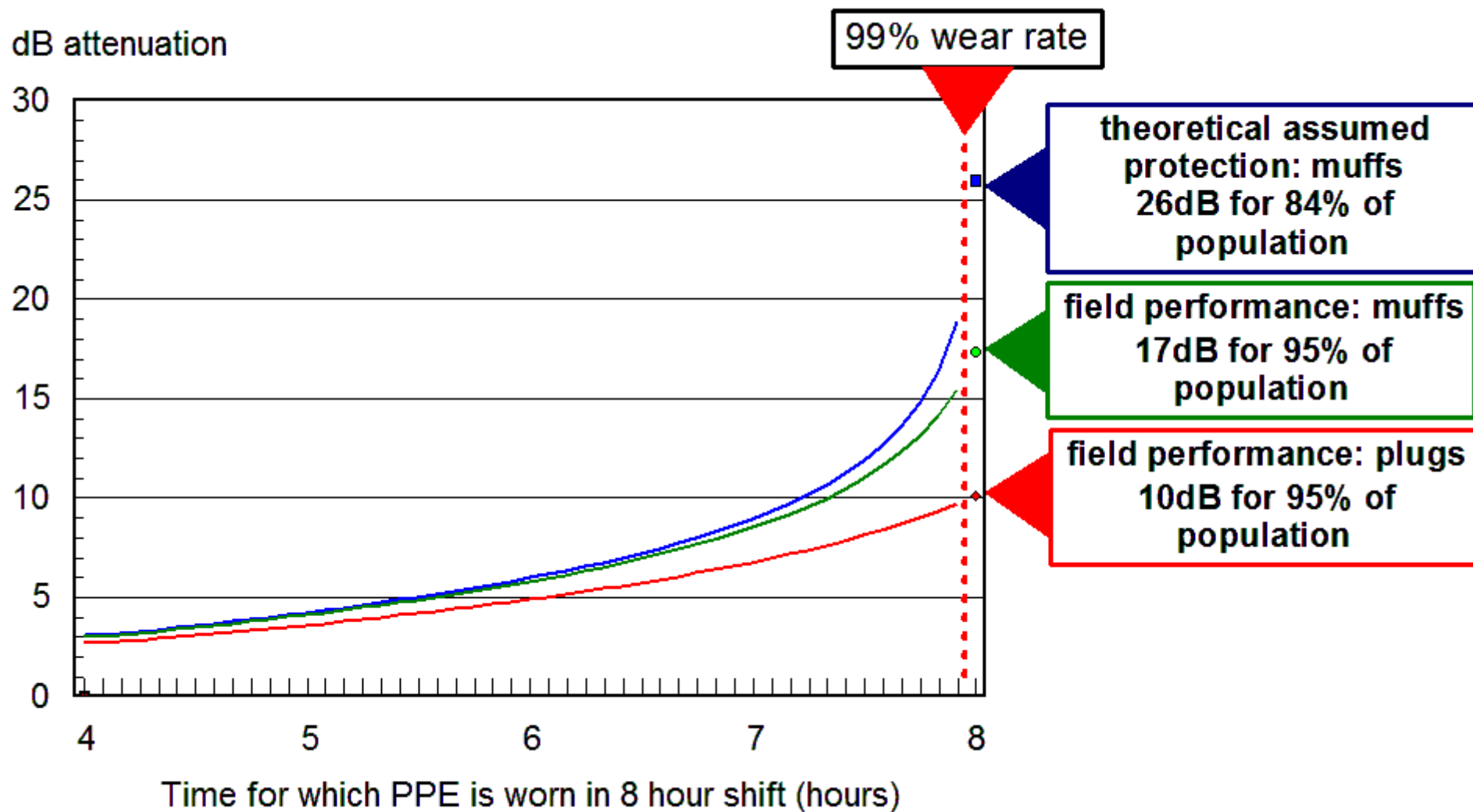
- >50% of compressed foam plugs not inserted correctly
- attenuation as low as 9dB if not properly fitted
- banded ear-canal caps - negligible protection under band pressure

HSE Research Report RR720:

INVC summary: www.invc.co.uk/profile/resources/technical-notes/#hseppe



PPE – Performance v Wear Rate



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Reporting

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Assessment Reports: the Action Plan



2002 HSE figures

63% of noise assessments were deemed "inadequate" i.e. a reassessment would be required to bring them up to the necessary standard



- Audit the noise control options (options, costs, benefits and priorities) and evaluate existing noise control measures
- Short term: PPE zones and signs; types and availability of PPE; employee training requirements...
- Longer Term: noise control programme; Buy Quiet policy; company procedures / responsibilities; health surveillance



DNA Report Template

Digital Noise Assessment “best practice” report based on 25 years of reporting refinements to create the industry benchmark template.

- *customisable template Word document covering all the regulatory requirements*

Action Plan summary

- *editable managers’ Action Plan summary to track implementation of risk management recommendations*

Technical Notes

- *up-to-date technical notes: regulations, PPE, dose calculation, health surveillance, Buy Quiet policy, noise control, training*

Example Report

- *pdf report example including factory plan or tabular (mobile plant) noise levels*

The templates are available as free issue to workshop delegates via www.invc.co.uk/noise/noise-assessment/digital-noise-assessment-template/

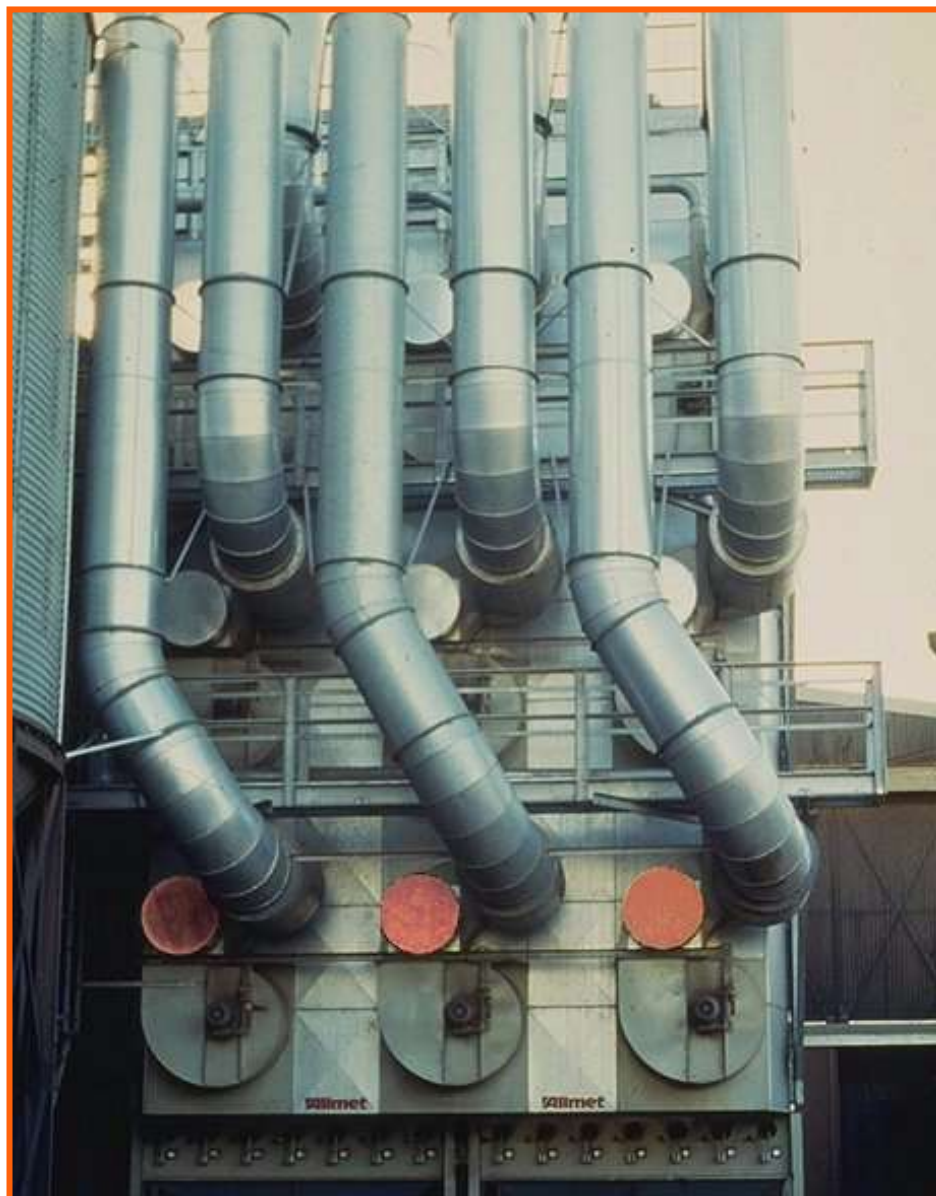
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Noise Control Audit The Process

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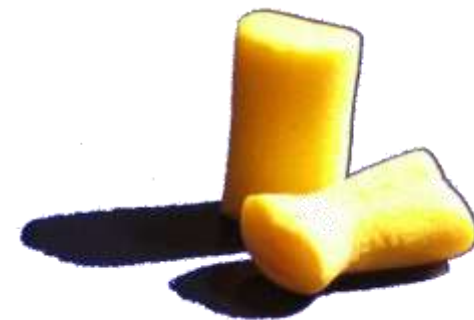
Placebo Silencers



Noise Control Best Practice Elements



- Attitude
- Noise Control Audit
 - *based on detailed diagnosis and costing of the options and benefits using the best of current technology*
- Develop detailed noise control recommendations for each category of occupational plant
 - *implement as retro-fit on the first of each type of machine / plant*
- Implement Noise Control Programme
 - *based on the results of the audit*
- Update Noise Assessment
 - *de-regulate areas; reduced PPE costs ...*
- Buy Quiet purchasing policy



This approach can produce noise control measures that actually improve productivity and reduce costs - in contrast to reliance on conventional enclosures and acoustic guarding.



Noise Control is

Noise control is not a safety issue

- Noise control is an engineering problem that should be solved by engineering means, in particular through noise control at source.
- Effective noise control must be based on an accurate diagnosis and not on assumptions.

Accurate diagnosis is the key to all noise control

- All the options must be considered, not just the conventional high cost palliatives of enclosures and silencers. These techniques should only be used where it can be proved that there is no engineering alternative.



Self-Financing Noise Control

An oxymoron? Potential cost savings at <85dB(A) include:-

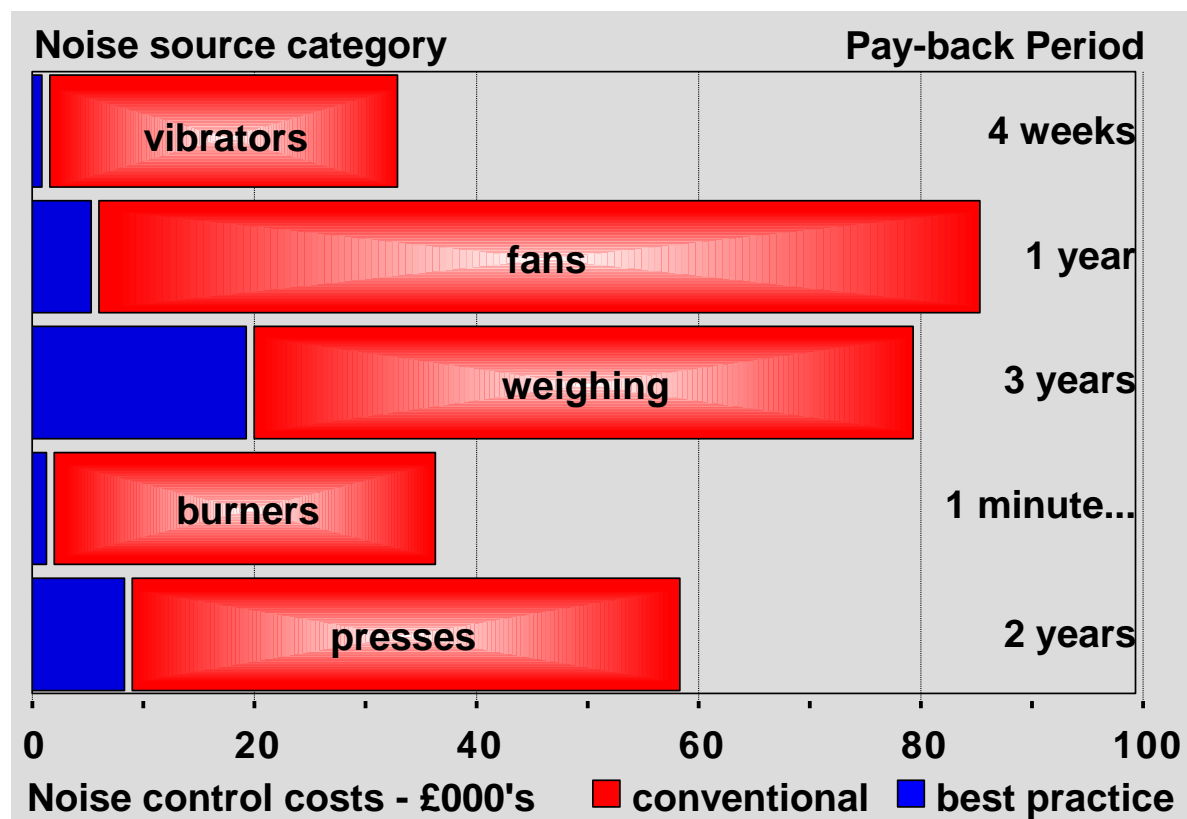
- PPE only advisory: £50 - £200 per head per annum savings
- no requirement for audiometry
- reduced management hassles (policing etc)
- improved working conditions (no PPE)
- improved communications
- no hearing damage claims

Plus the potential for improved efficiency / productivity.



Self-Financing Noise Control

One company had spent £1,600,000 on acoustic enclosures. The Noise Control Audit and subsequent testing proved that using BPM would have saved over £1,000,000 and noise levels would have been substantially lower and operating costs would be significantly reduced (down-time).



doubled through-put

higher efficiency, no cleaning

cleaning down-time reduced

avoided being shut-down...

no enclosures, reduced down-time



Engineering Noise Control: Added Benefits

Reduced Maintenance and Running Costs

- elimination of existing enclosures - improved access; design-in features to reduce down-time
 - *e.g. weighing machines; conveyor wear; substantially reduced air consumption; elimination of fatigue problems*

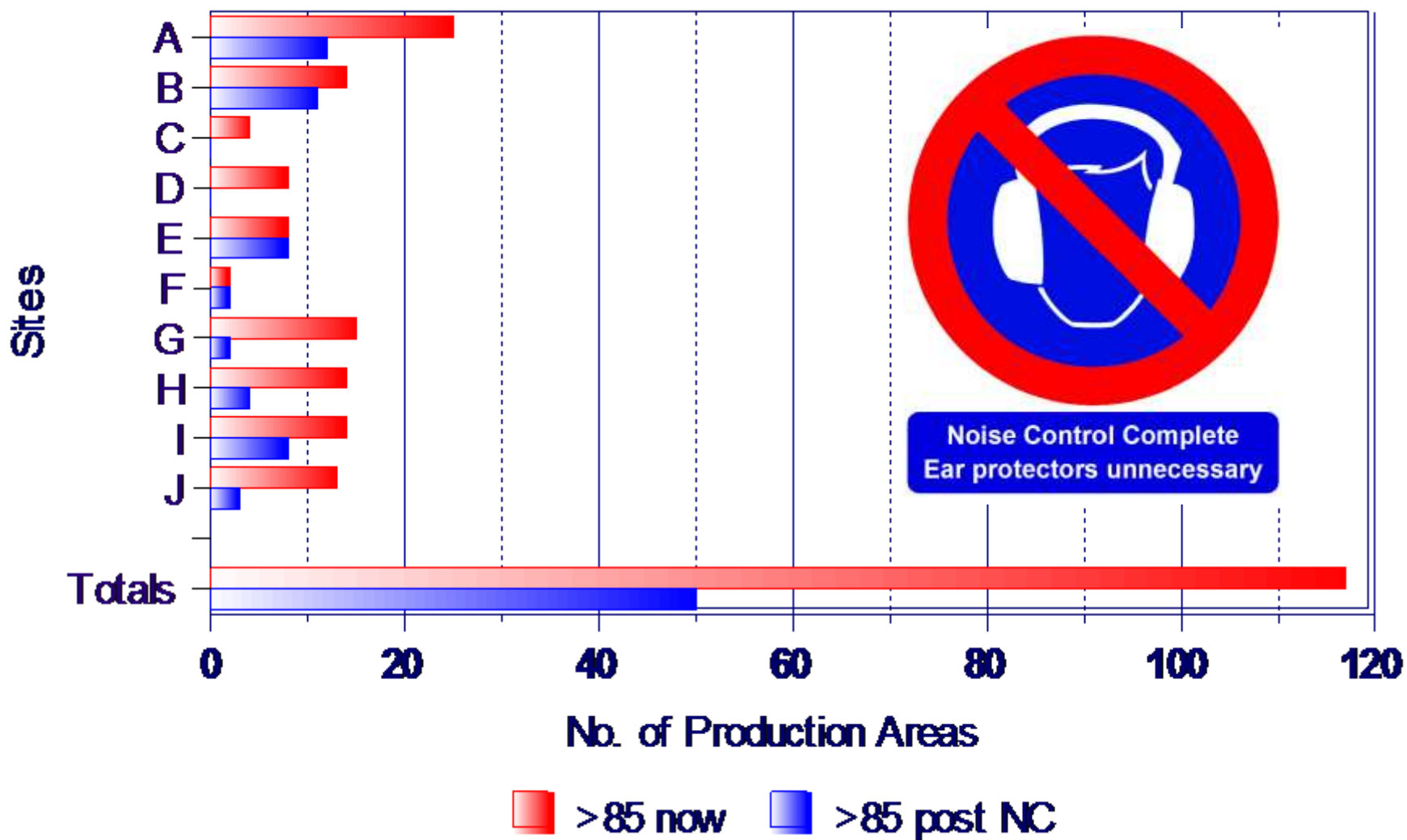
Off-set against Maintenance Costs

- maintenance carried out as part of noise control implementation, off-setting noise control costs against maintenance

Improved Productivity

- noise control mods can increase productivity by improving design
 - *e.g. vibratory feeder/grader modifications doubled throughput; 10% reduction in chocolate coating thickness via enrober modifications; elimination of feed problems on vibrators*

Site Audits: Noise Control Project Benefits



Cadbury conservatively estimate that the noise control programme will pay for itself within 7 years.....

Productivity Improvements and Cost Savings



wash line <85, lower cost,
improved drying

Chocolate enrober vibrator

- Re-design eliminated fatigue cracking; improved control of coating thickness – 10% chocolate savings...

Vibratory Feeders

- Food: noise control project doubled throughput and eliminated blockage issues
- Pharma plastics: 27dB(A) reduction plus elimination of fatigue cracking and blockages

Moulding Vibrators

- Chocolate weight s.d. across moulds reduced from 1.2gms to 0.2gms/sweet



The Noise Control Audit

The audit is available as an add-on to conventional risk assessments.

Objectives

- generate cost v noise reduction trade-offs for each item of noisy plant
- assess the noise control options across the company using the best of current technology
- plan the most practical and cost effective noise control programme possible across the company

The results of the Audit also take into account factors such as:-

- hygiene: access / maintenance
- productivity



Where the audit proves that control is impractical, it also provides certification so that PPE can be used for long term risk control.



BPM Noise Control Audit Steps

- List **all** the potential noise sources on each piece of noisy plant
- Rank the sources
- Assess **all** the noise control options for the dominant source
 - *potential reduction in noise from this source*
 - *operational, productivity, hygiene constraints*
 - *operator acceptance*
 - *cost*
- If engineering control is not practical for the dominant source, then you have proved that screening / enclosure etc are the only options

The results are used to generate cost v noise reduction trade-offs for each item of noisy plant and to plan the most practical and cost effective noise control programme possible across the company.



Useful Noise Generation Categorisation

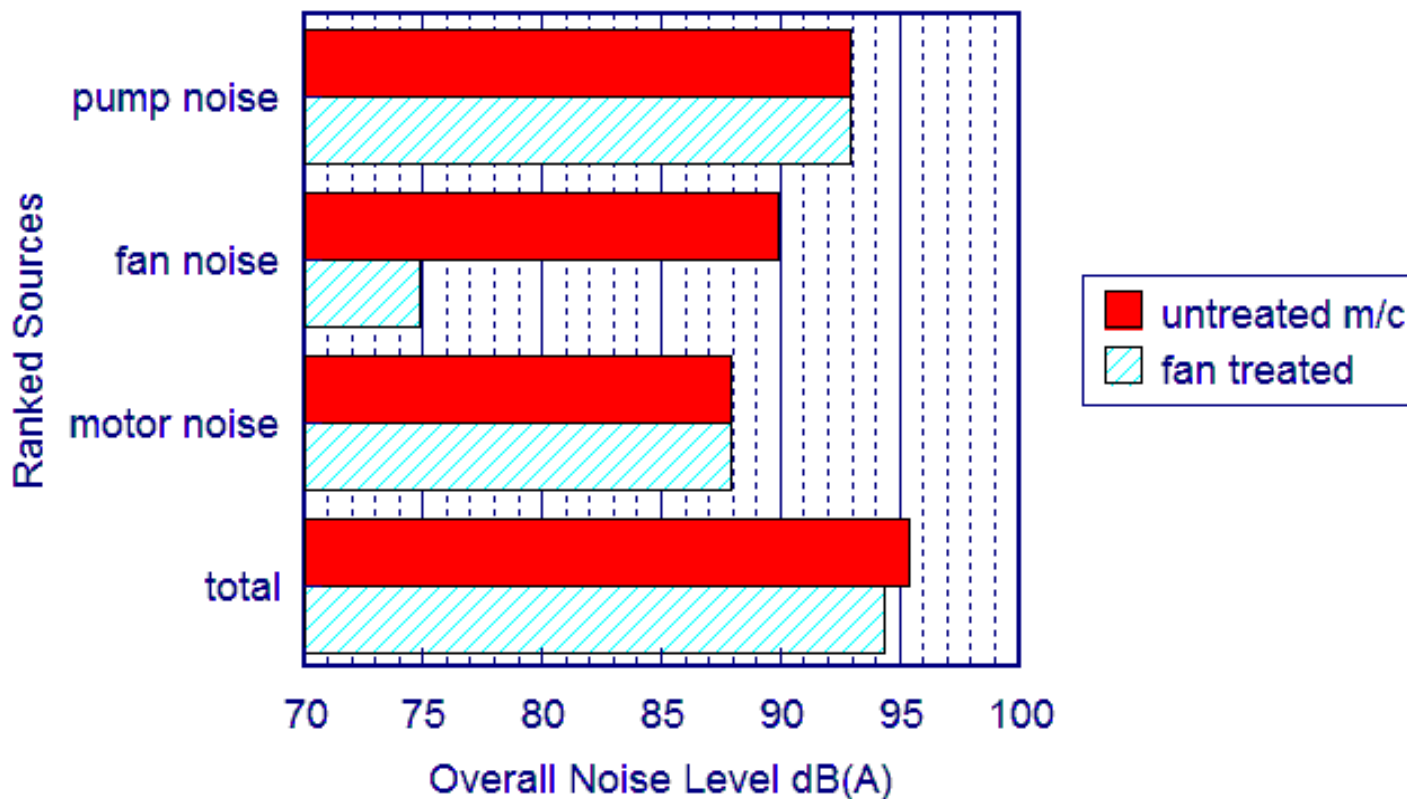
Aerodynamic

- fans
- flow induced
- pneumatics
 - nozzles
 - exhausts
- combustion

Mechanical

- impacts
 - presses, stops etc
 - mechanical handling
- rotating machines
 - gears, pumps, motors
 - bearings
 - electrical forces
- friction forces
 - cutting tools, brakes

Addition of Multiple Sources



Unless the dominant source is treated first, the overall noise reduction will be very disappointing



Source Ranking Techniques

- Listen
- Run each source separately - may require manipulation of interlocks etc
- Cover all sources and then uncover each in turn
- Use narrow band frequency analysis for tonal noise and correlate with mechanical components (gear-mesh, speed, blade pass etc) – free phone apps...
- Measure each source close in and predict contribution (close-microphone + $10\log(\text{area})$)
- Measure surface vibration velocity and calculate contribution

easy

A vertical red double-headed arrow is positioned to the right of the list, spanning from the top of the 'Listen' item to the bottom of the 'Measure surface vibration velocity' item.

Source Isolation Techniques

- Run each source separately - may require manipulation of interlocks etc
- Cover all sources and then uncover each in turn



Power press – aerodynamic source
<https://youtu.be/OzoktrFxT5w>



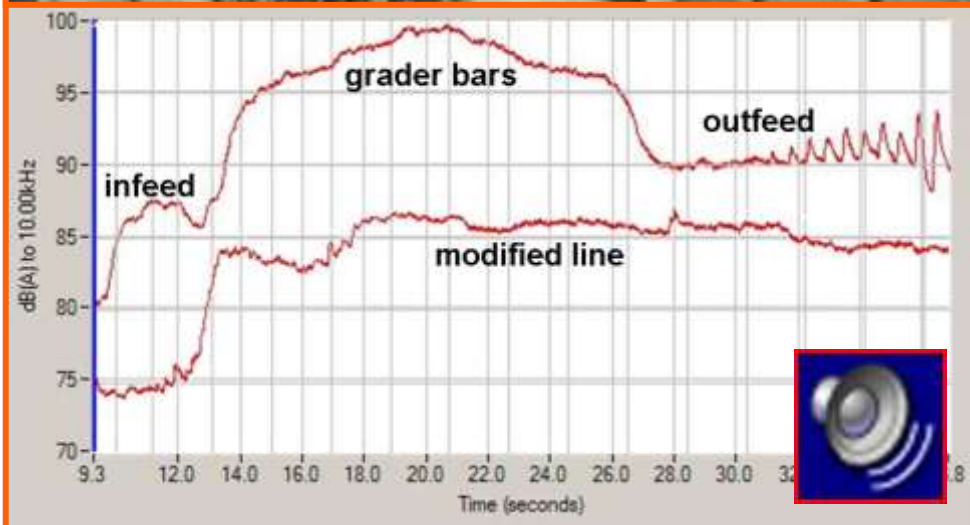
Power press – mechanical sources
<https://youtu.be/UQ3YBExzWiw>



Production line sources
<https://youtu.be/3vkZcT42YCQ>

More diagnostic videos on the INVC Youtube Channel at:-
<https://www.youtube.com/user/INVCLimited>

Vibratory Grader Diagnosis



MOTIVATION

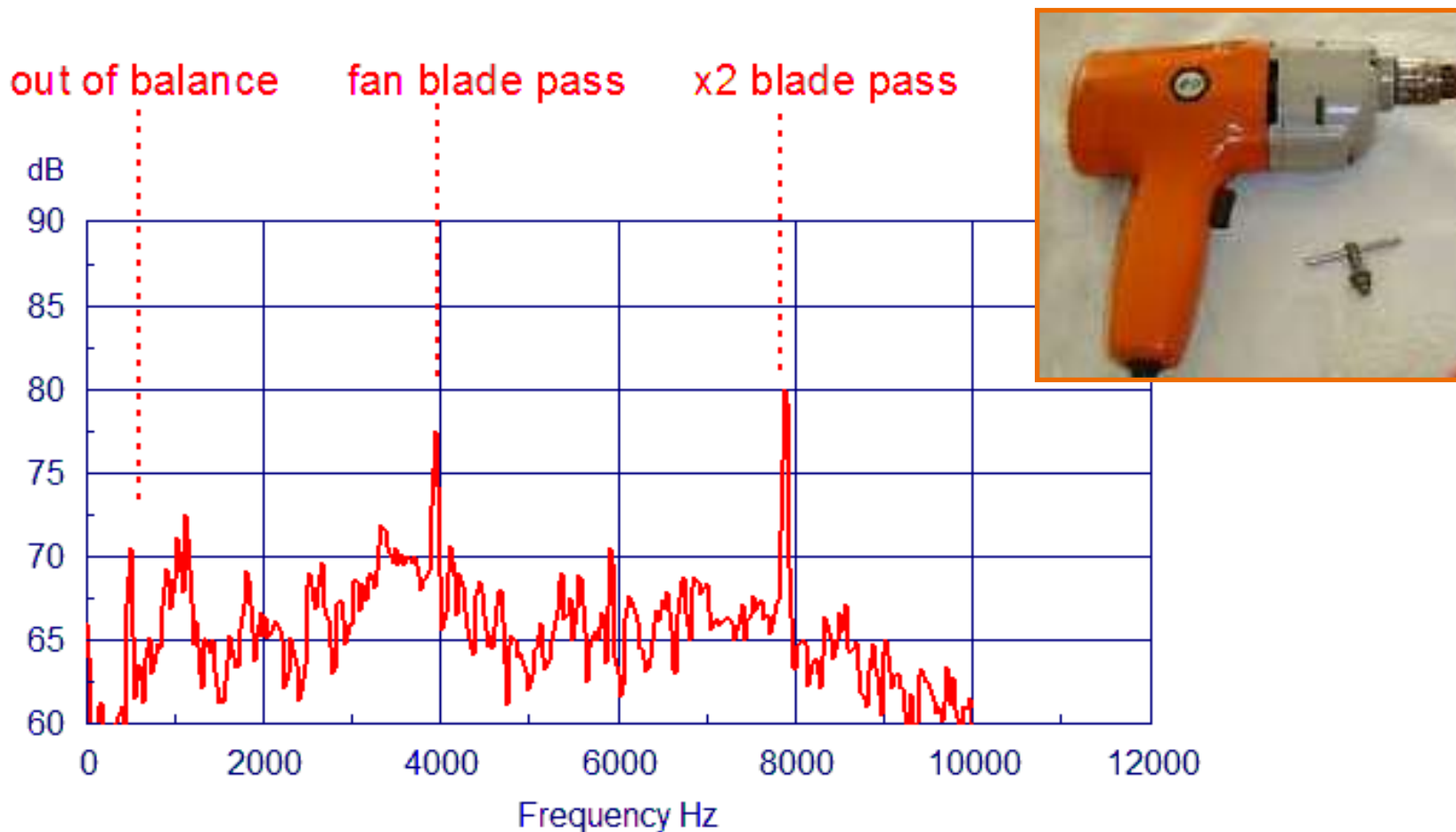
Client using the "Buy Quiet" standard.

- noise tests carried out during proving trials (in-house)
- new machine ordered subject to implementation of INVC noise control recommendations
- noise reduced from 99dB(A) down to 85dB(A) at £4k (£250k machine) without affecting hygiene, access or maintenance

If designed-in instead of retro-fit, £1k cost + £25k saved on supplier enclosure...

Source Identification – Frequency Analysis

Narrow band frequency analysis - correlate tones with mechanical components (gear-mesh, speed, blade pass etc) – free phone apps...



How else could you diagnose and rank the sources?

115T Bliss Press



Noise tones match flywheel vibration.
Dynamic vibration absorbers designed and fitted to flywheel inside existing guards.

- 10dB(A) noise reduction
- £20 materials; 1 day fitter time

Source Ranking – Sound Power



- Measure each source close in and predict sound power contribution (close-microphone + $10\log(\text{area})$)
- Measure surface vibration velocity and calculate contribution

Area (A) = m²

CM = close mic noise level (dB(A))

LW_A = sound power level estimate

$$\text{CM} + 10\log(A) = \text{LW}_A$$

- 1 85dB(A) + 10log(1) = 85dB(A)
- 2 91dB(A) + 10log(0.6) = 89dB(A)
- 3 89dB(A) + 10log(0.2) = 82dB(A)
- 4 98dB(A) + 10log(0.1) = 88dB(A)

Press Noise Control Audit



102dB(A) total – down to 87dB(A)

1: tooling modifications – 97dB(A); 2: clutch – 95dB(A); 3: fan – 92dB(A);
4: cyclone 90dB(A); 5: out-feed 87dB(A)

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Noise Control Techniques

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Scrap Can Extract and Chopper Fans

Problem

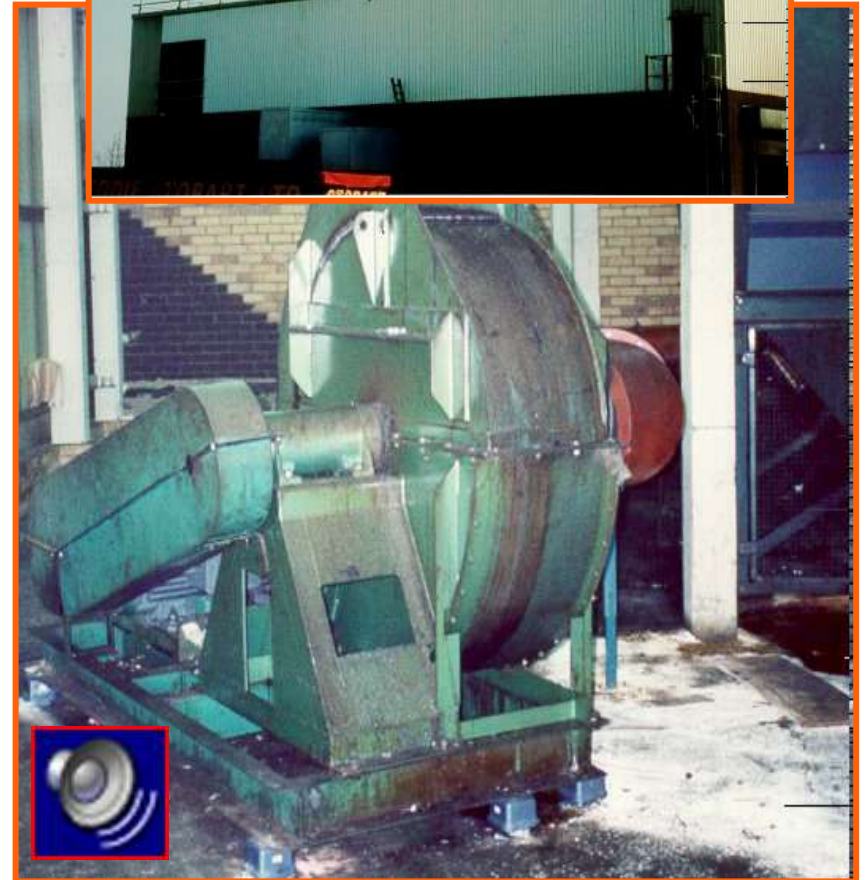
Occupational + environmental tonal noise

Conventional

- silencers, lagging and enclosures
- capital cost > c£35000 + maintenance costs

BPM Engineering

- internal fan modification reduced tones by 23dB and overall noise by 22dB(A)
- cost c £3000 - no maintenance costs (lasts the lifetime of the fans despite passage of cans)



modified fan

Pneumatic Silencers and Nozzles



Silencer Solutions

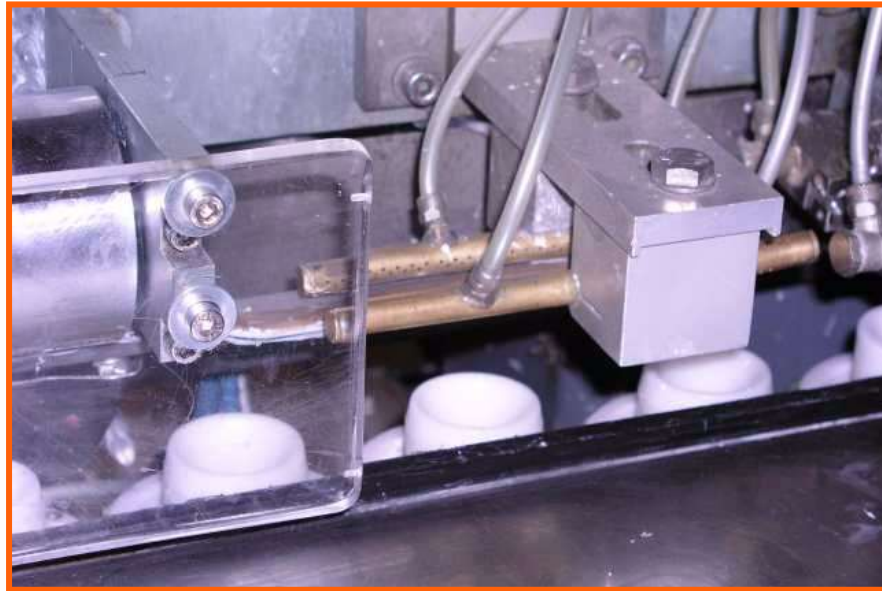
- zero back-pressure silencers
- standardise on 3 sizes
- fix piped silencers to machine and manifold multiple exhausts



Entraining Nozzles

- c10dB quieter for the same thrust
- use c 20% less air
- pay for themselves very quickly
- intrinsically "safe"
- reduce air pressure....

Filler Cooling Pipes



Problem

- 94dB(A) from cooling pipes for sealed tube ends - rapid cooling a necessity

Conventional Solution

- enclosure - high cost with hygiene and productivity issues

BPM Solution

- Coanda effect linear nozzles
 - 12dB(A) noise reduction (82dB(A))
 - improved performance (less turbulence disturbing tubes)
 - 20% less air consumption - pay for themselves very quickly
 - no effect on access or operation





Innovative Noise Control Materials

We are at the forefront in developing applications for new and innovative hygienic noise control materials. The two materials that have had most impact on our work are:-

- High hygiene acoustic absorbent
 - *existing guarding and enclosures*
 - *room acoustics (walls and ceilings)*
- Laminated steel – sound deadened steel sheet
 - *looks like stainless steel, sounds like rubber...*

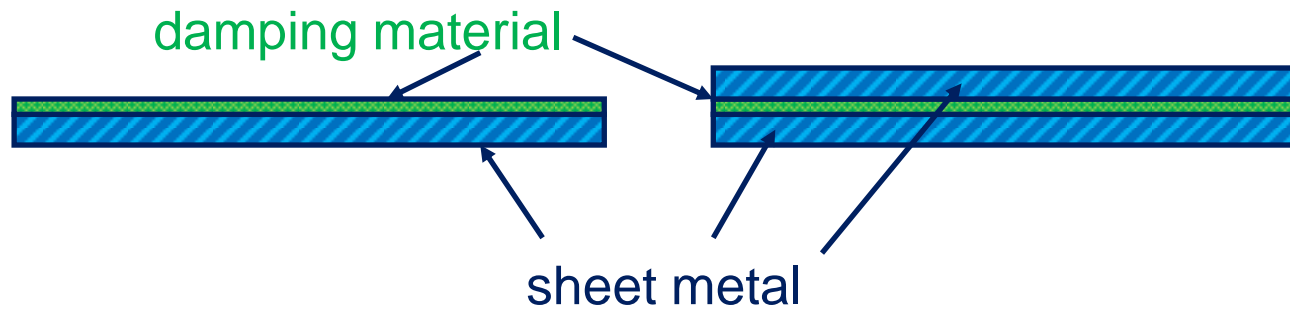
These materials have provided us with two additions to our armoury in developing the next generation of hygienic noise control techniques.



Damping Thin Plates

unconstrained layer of
damping material

damping material in
sandwich construction



damping material deforms
only near bends



damping material made to
shear over whole area



Vibratory Feed Hoppers

Problem

Dozens of electromagnetic vibratory feeders for medical components

- 95 - 99dB(A)
- fatigue cracking
- poor feeding

Enclosures

- 2m x 2m x 1m @ c £3000 - total c £100,000 - 10dB(A) reduction

BPM

- change geometry (small plate) to improve feed
- hygienic H.F. damping
- c £250/machine total c £9000; 22dB(A) reduction; eliminated fatigue cracking - less down-time

Weighing Machine Enclosures



- 94dB(A) with enclosure
- 82dB(A) with enclosure removed
- PPE unnecessary; improved productivity, cleaning, access, maintenance ...

Problem

- typically 87- 98B(A) - high hygiene

Conventionally: Enclosure

- Enclosures – c 5dB(A) reduction
 - *usually increases operator noise level by c 3dB(A) under platform!*
 - *c£8000+ capital + access /*
 - *hygiene / maintenance problems*

BPM - engineering control

- engineering source modifications
- 10 - 12dB(A) at <<50% of the cost
- x4 performance + no effect on access or hygiene
- maintenance and cleaning simplified

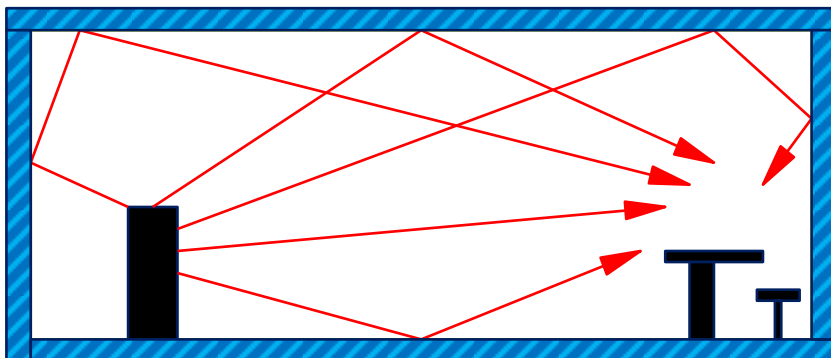
Quiet Tape

- quiet tape uses stronger glue - generating more tension
- may have to adjust machines to use the new tape

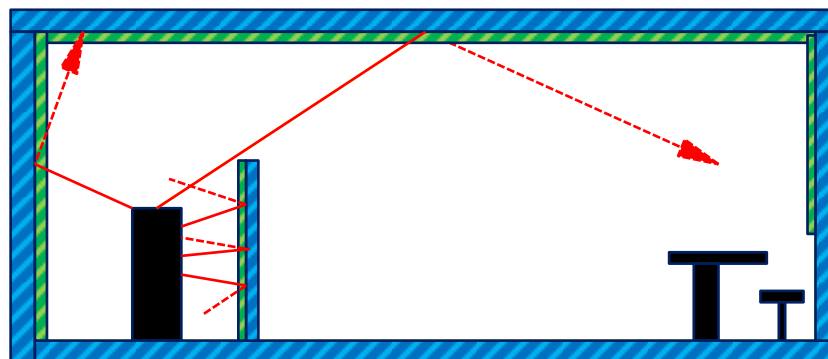
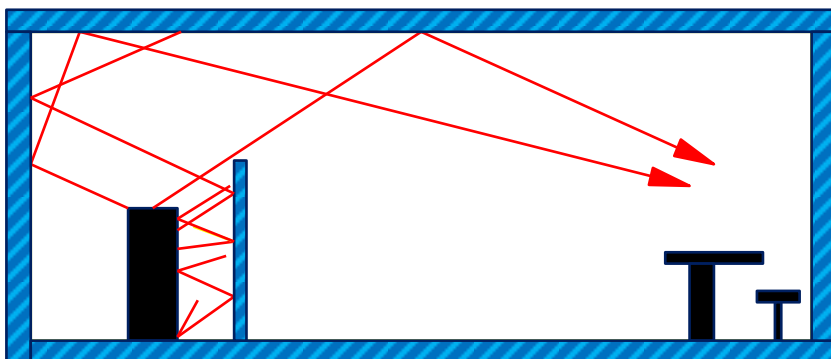
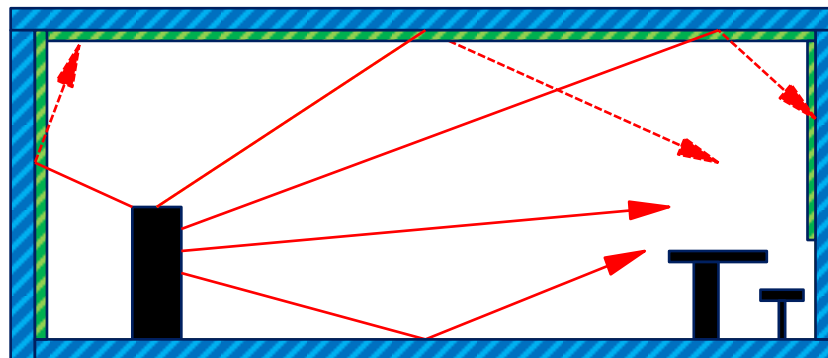


Reverberation and Barriers

REVERBERANT



ABSORBENT LINING



REVERBERANT + BARRIER

ABSORBENT + BARRIER

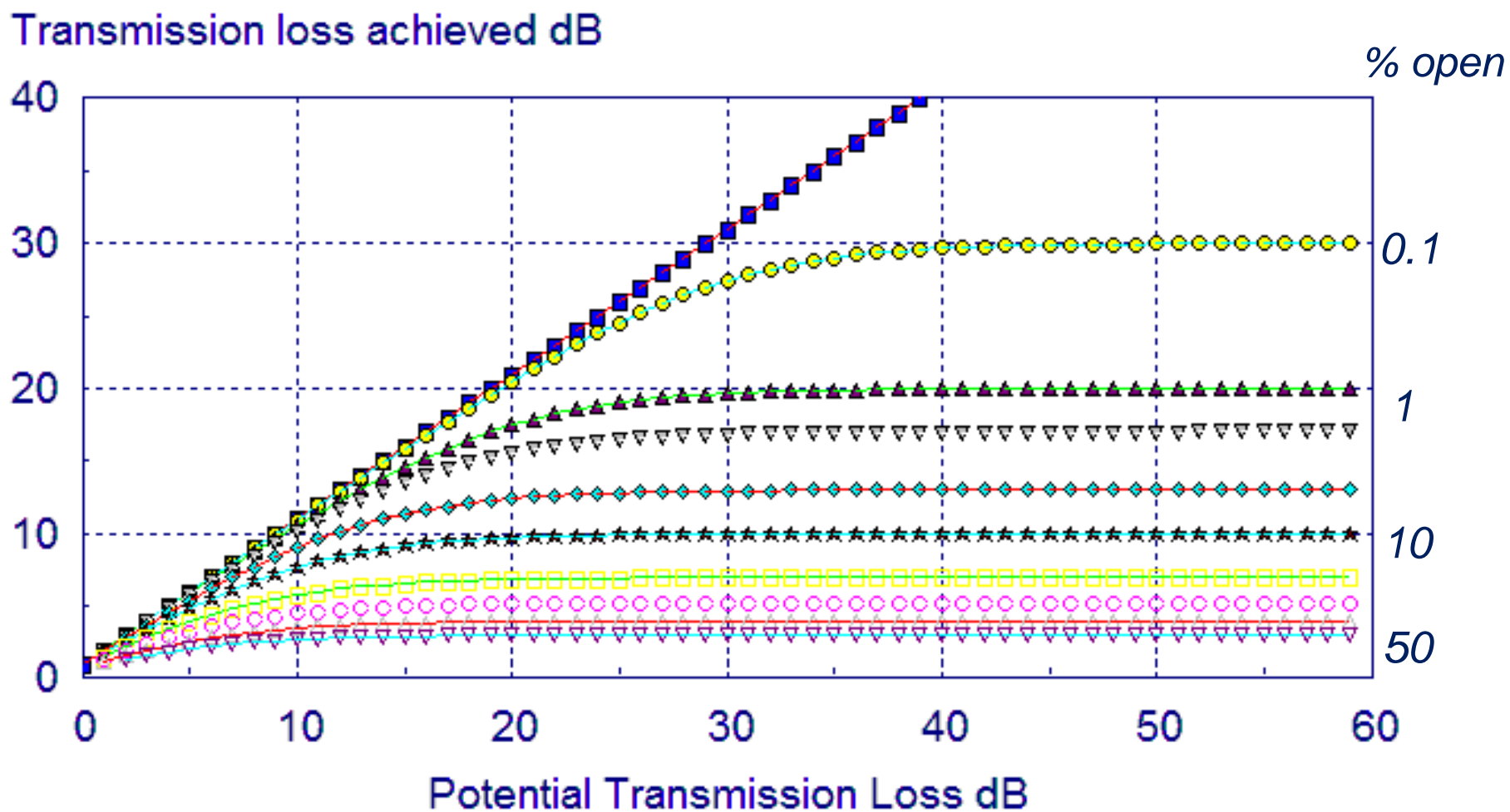
Common Enclosure Problems



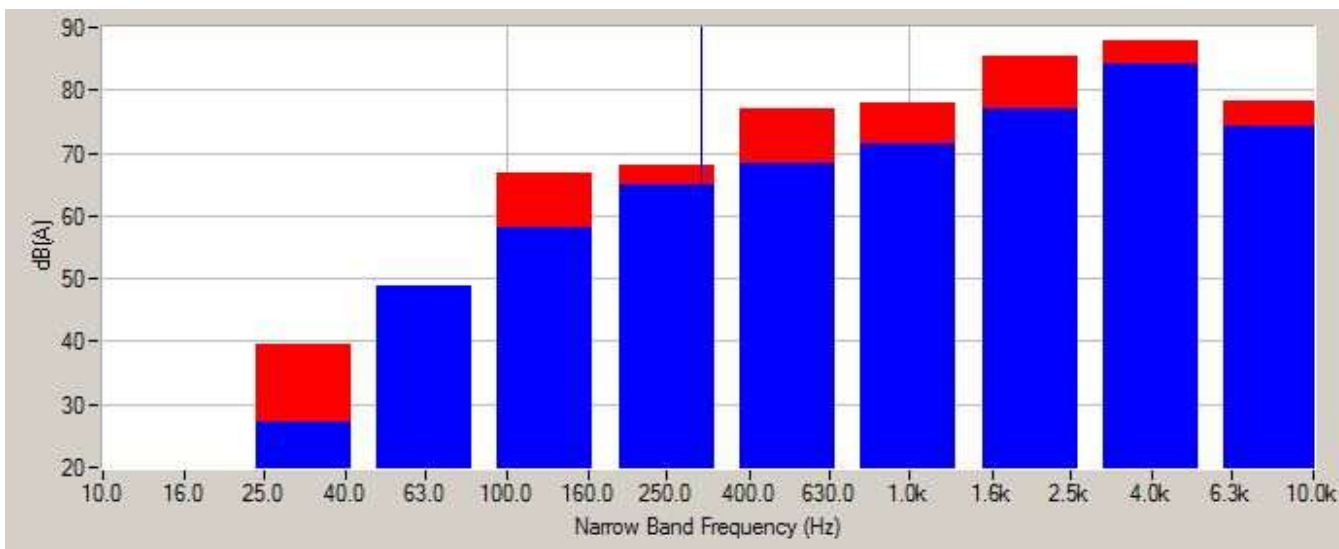
Enclosure issues <https://youtu.be/2T4XBxyOIB4>



Effect of Leaks on Transmission Loss



Hygienic Acoustic Absorbent - Bottling



91dB(A) without absorbent

83dB(A) with absorbent

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Buy Quiet

Purchasing Policy

Industrial Noise and Vibration Centre: www.invc.co.uk

Buy Quiet Noise Control

Probably the single most cost effective long term noise control measure that a company can take.

BUT....



Do not allow your suppliers to spend your money on noise control without close scrutiny and evidence that they have followed diagnostic best practice

- most suppliers do not have technical expertise in noise control and usually buy-in proprietary materials, enclosures, silencers etc and add these to the cost - regardless of Best Practicable Means using the best of current technology

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Remote Control of Noise

Industrial Noise and Vibration Centre: www.invc.co.uk

2nd Opinion: Remote Control of Noise



video
sound
photos



@

email -
internet

@

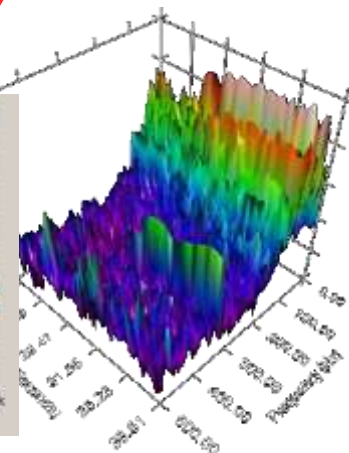
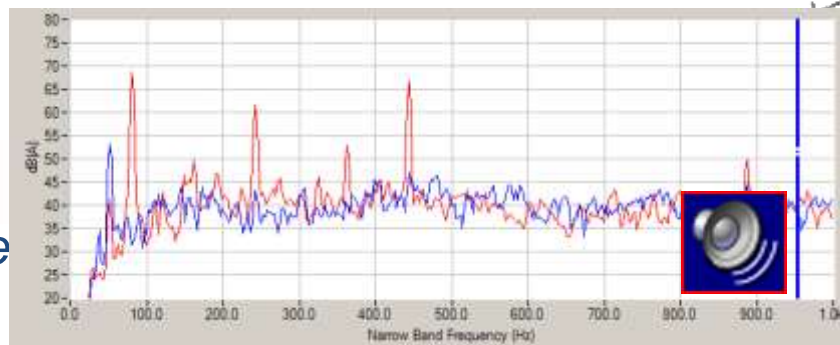
BPM

BAT

Costs

database
experience

Specialised analysis



Remote Control of Noise



BP Refinery: \$1.25m conventional silencers: \$0.25m via engineering
– no impact on efficiency, no site visit

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