Workplace Noise Assessment and Control

Norwich & District Safety Group

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Acknowledgements

A number of sources have been consulted to provide diagrams and graphics used in this presentation. The following websites and organisations are gratefully acknowledged:

- Health and Safety Executive (HSE)
- Workplace noise images (Google search)
- National Institute of Occupational Safety and Health (NIOSH)
Basics of sound
The amazing human ear!
Noise-Induced Hearing Loss
What the law says
Noise assessment
Effective noise control
Hearing protection & Audiometry
Useful sources of information
A brief introduction to BOHS

♦ A multidisciplinary, learned and professional society established since 1953 (*60th anniversary in 2013*)

♦ The voice of the occupational hygiene community in the UK

♦ An unrivalled source of information and expertise for members and non-members alike

♦ An examining board, through the Faculty of Occupational Hygiene, awarding qualifications in occupational hygiene and allied subjects

♦ For anyone with an interest in occupational hygiene, or a need for our services
The BOHS

The Society’s aim is simple:

To help to reduce work-related ill-health

The result is dramatic:

A healthy worker in a healthy working environment

www.bohs.org
BOHS in East Anglia

♦ Organise meetings, network events, joint seminars

♦ Previous meetings have covered COSHH, Noise at Work, REACH, LEV, Asbestos…

♦ Links with local H&S groups (e.g. N&DSG, IOSH, FISHnet, OHPAG)

♦ Keen to collaborate with fellow H&S professional groups
Physics of sound

Sound is characterised by it’s...
- Amplitude
- Wavelength (metres)
- Frequency (cycles/sec. or Hertz)
- Speed (344 m/sec. in air)

Properties of sound...
- Sound **power** - total sound energy per unit of time (Watts)
- Sound **intensity** - sound power per unit area (Watts/m²)
- Sound **pressure** - force per unit area (Pascals)

NOTE: "C" stands for compression and "R" stands for rarefaction
Noise is sometimes defined as “unwanted sound”

- Measured in **decibels** on a logarithmic scale
- Huge range of SPL – loudest *10 billion times* as intense as the softest!
- Other important factors are:
  - Frequency
  - Continuous (+/- 3dB) or variable noise pattern
  - Impulse noise (rise time <35 milliseconds)
Decibels

- Decibel scale starts at the threshold of hearing (0 dB = 20 µPa)
- Sound level change of 1 dB can just be detected by the human ear, but typically we don’t notice a difference until it reaches 3 dB or more.
- A doubling of sound pressure = 3 dB. But an increase of 10 dB is needed to be perceived as a doubling in loudness.

Adding and subtracting decibels

Two sources of equal intensity produce a sound level 3 dB higher than one alone.

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<th>If levels differ by</th>
<th>Add to the higher level</th>
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<tr>
<td>0 or 1 dB</td>
<td>3 dB</td>
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<tr>
<td>2 or 3 dB</td>
<td>2 dB</td>
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<tr>
<td>4 to 9 dB</td>
<td>1 dB</td>
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<tr>
<td>10 dB or more</td>
<td>0</td>
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The ear is an amazing organ – complex, delicate, yet resilient and able to respond to an enormous range of sounds. Hearing is one of the most vital of our senses. Through hearing we are able to communicate, gain pleasure from music, enjoy entertainment, and be aware of warning sounds.

- **Outer ear** (pinna & ear canal) – acts as a funnel to collect sound waves and transmit them to the eardrum
- **Middle ear** (ossicles) – amplification of sound waves reaching inner ear
- **Inner ear** (cochlea and semi-circular canals) – transduces energy of sound wave into nerve impulses
How the ear works

- Highly sensitive “hair cells” in the inner ear move in response to pressure wave.
- Response varies with frequency.
- Movement of hair cells is translated into neural impulses and carried to the brain along the auditory nerve.

The clip was copied from the HSE website and has been reproduced from “The Hearing Video” by the kind permission of WorksafeBC.
Human hearing ranges from 20 Hz to 20,000 Hz, and is most sensitive to human speech frequencies from 400 – 5000 Hz.

“A” weighting closely matches the ear’s response at different frequencies.

The threshold of hearing between 1000 – 4000 Hz for a young person is around 20 µPa (= 0 dB).

Our hearing ability decreases naturally with age (“presbycusis”).

The delicate hearing mechanism can be damaged by trauma, disease, or exposure to excessive noise.
How noise can affect you

Physical, psychological, and social impacts

- Annoyance – interferes with conversation
- NIHL – permanent damage to hair cells in cochlea
- Ototoxic substances
- Temporary Threshold Shift
- Cardiovascular effects - stress
- Accident risks – interfere with danger signals & alarms
Noise-induced hearing loss

- Exposure to excessive noise
- Short periods of exposure to a high level of noise may produce a reversible hearing loss termed a Temporary Threshold Shift (TTS).
- Prolonged exposure to excessive noise causes permanent (irreversible) damage known as Noise-Induced Hearing Loss (NIHL).
- Individuals vary greatly in their hearing ability and their susceptibility to damage.

“4KHz dip” – indicative of possible NIHL
How big a problem is NIHL?

- >1 million workers exposed to noise levels that puts their hearing at risk
- ~500,000 people in UK with NIHL *
- ~20,000 new cases (caused or made worse by work) each year
- Most cases found in Energy & extraction, Water supply, Construction, and Manufacturing sectors
- **Noise damage is irreversible – there is no cure**

* Estimate based on 1997/98 figures

Legal Requirements

Control of Noise at Work Regulations 2005

- Governs **Exposure** to noise at work
- Sets limits for acceptable exposure
- Noise risk assessment must be done when exposure likely to be above 80 dBA Lepd
- Actions to reduce exposure, proportionate to the risk, if limits are exceeded
- An over-riding duty to reduce risk of hearing damage to the lowest reasonably practicable level
Exposure limit values and action values

Lower EAV…
♦ A daily or weekly personal noise exposure of 80 dBA
♦ Peak sound pressure of 135 dBC

Upper EAV…
♦ A daily or weekly personal noise exposure of 85 dBA
♦ Peak sound pressure of 137 dBC

Exposure Limit Values…
Daily or weekly personal noise exposure of 87 dBA
Peak sound pressure of 140 dBC
What does HSE expect?

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<tr>
<td><strong>a. Noise management system</strong></td>
<td>Effective organisation and arrangements including adequate noise assessment, noise action plan, provision of information, instruction, training, supervision and a health surveillance regime. Evidence of a positive purchasing policy and strong management commitment. Arrangements for reviewing the system.</td>
</tr>
<tr>
<td><strong>b. Control of noise at source</strong></td>
<td>Reasonably practicable measures for controlling noise (other than by provision of EP) are in use and properly maintained.</td>
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<tr>
<td><strong>c. Ear Protection (EP) Programme</strong></td>
<td>EPZs demarcated and fully observed by all personnel. EP is provided and is suitable for the individual and the task. A maintenance/replacement schedule exists including regular checks by a trained person. Evidence of full and proper use.</td>
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What should a responsible employer do to comply?

♦ Carry out a noise assessment; identify all workers exposed above lower and upper EAV; identify principal noise sources
♦ Mandatory hearing protection (HP) for all workers exposed above the upper EAV
♦ Draw up Action Plan to reduce noise at source
♦ Implement an appropriate Hearing Conservation Programme
Elements of a Hearing Conservation Programme

♦ Assessment of noise risk
♦ Engineering and administrative control of noise exposure
♦ Maintenance and use of equipment
♦ Information and training
♦ Hearing protection
♦ Health surveillance and Audiometry
♦ Record-keeping and programme management
Noise assessment

♦ Assess Exposure = average noise level and duration of exposure
♦ Identify and characterise noise sources – to specify engineering controls and select HP
♦ Does current noise exposure of employees lead to risks to their health and safety?
♦ “You are not required to make a highly precise assessment of noise exposure. However your estimate of exposure must be reliable and precise enough for you to be able to assess whether any exposure action values are likely to be exceeded”

(Noise ACOP, clause 147)

“Listening checks”

Do you have to shout when talking to someone 1 metre away? 90dB or more
Do you have to shout when talking to someone 2 metres away? 85 dB or more
Is noise intrusive – comparable to a busy street or crowded restaurant? 80 dB or more
What to measure?

**TYPES OF SURVEY**

(A) **Area survey** – identify areas >80dB, delineate HPZ

(B) **Individual exposure assessment** – identify those at risk, comply with Regulations

(C) **Noise control survey** – detailed measurements of sources and acoustic environment to specify control options

- **LAeq** – equivalent continuous A-weighted sound pressure level
- **LCpeak** – maximum C-weighted peak level
- **Frequency analysis** – useful for noise characterisation and selection of suitable HP

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Quantifying noise exposure

- Using SLM – measure $LA_{eq}$ at worker’s ear for each defined job or task. Then combine task $LA_{eq}$ with duration during the working day and combine all tasks to calculate 8-hour $LEP_{A,d}$.

- Using dose meters – affix to worker’s shoulder so microphone measures noise as the person moves around.
Measure average noise level (LAeq) for each task.

Determine duration of exposure for each task.

Use ready-reckoner from ACoP to calculate ‘noise exposure points’ for each task.

Sum individual task points to give total exposure points for a day.

Read off daily noise exposure (LEP,d)
Some things to remember when measuring noise

♦ Initial walk-through to get subjective impression of noise levels and sources.
♦ Understand process and work patterns through talking with managers, supervisors and employees.
♦ Calibrate before and after each set of measurements; if +/- 1dB for class 1 instruments, data is void.
♦ Measure for long enough to gain a representative sample; if noise is steady then 1-2 mins. is usually sufficient.
♦ Exposure measurements taken close to worker’s ear.
♦ Prescribed path measurements @ 1m distance from machine.
♦ Measure peak levels if there are loud impact or impulse noises.
♦ May need to simulate use of portable/intermittent sources.
HSE rightly emphasise control of noise above measurement, but...

...accurate measurements and sensible interpretation of data is essential to manage risk and not waste money on ineffective or un-necessary controls.

Develop competence in-house or get advice from noise specialists.

- Make a suitable and sufficient noise risk assessment
- Measure noise exposures
- Assess effectiveness of noise control measures
Noise control:
Source – Path – Receiver concept

- Noise exposure can be controlled by:
  - (A) reducing noise level at source
  - (B) attenuating noise as it passes through air
  - (C) protecting the person through use of PPE

- Control at source is always the best approach if feasible
- Often a combination of measures is needed
Noise control:
Aerodynamic & Mechanical noise

Aerodynamic noise
*Generally mid - high frequency*
- Fan noise
- Compressed air
  - Air jets
  - Pneumatic exhausts
  - Air motor exhausts
- Combustion

Mechanical noise
*Generally low - mid frequency*
- Impacts
  - Presses
  - Mechanical handling
- Rotating machinery
  - Gears, bearings, pumps
- Frictional forces
  - Cutting tools
  - Brakes
Noise control options

- Selection of quiet equipment, processes
- Design, planning, layout
- **Control at source**
- Materials handling
- Enclosures, Barriers, Cladding
- Silencers, Attenuators
- Vibration control
- Room treatment
Deciding on the best option

Noisy equipment (machines and processes) should be regarded as collections of noise sources – not ‘monolithic noisy units’

1. List all possible sources of noise within each machine
2. Rank each source in terms of relative contribution to overall noise (listen, run each source separately, frequency analysis)
3. Select noise control options for dominant sources (may need noise control engineering expertise)
Employers have a duty under the PUWER Regs. to ensure that all equipment and machinery is suitable – including the impact of noise emissions on employees…

♦ “Buy quiet” (e.g. general duty motors can be 10 db(A) quieter than typical units)
♦ All new equipment to meet maximum noise limit (noise exposure vs. noise emission)
♦ Onus of compliance on the supplier
♦ Insert noise requirement in MoC procedure
♦ Large projects/new buildings designed for low noise environment
Noise control at source

Examples...

♦ Low noise motors (up to 10 dBA quieter)
♦ Centrifugal fans (maximum fan efficiency = minimum fan noise)
♦ Damping material (e.g. SDS) to reduce vibration
♦ Smooth ducts and pipes
♦ Plastic mallets!
Materials handling

- Belt conveyors preferred to roller conveyors
- Control conveyor speed to match process needs (avoid stop/start action)
- Minimise fall height - use adjustable height conveyors & rubber flaps in collection bin
- Use abrasion-resistant rubber or plastic linings
- Lubricate bearings/rollers
- Enclose conveyor lines
Sound energy will be absorbed by a porous material...

- Pipe lagging – noise-absorbent external padding
- Line inside of noise enclosure or machine guards with acoustic absorbent (e.g. foam, fibreglass); remember to check and maintain condition!
Enclosure of sources

- Enclosure should wrap around the source as much as possible
- Inner surfaces may be lined with sound absorption material
- Gaps and holes should be eliminated
- Forced ventilation may be needed for cooling; use attenuators on openings
- Provide inspection hatches

Well-constructed enclosures can give 15-20 dB reduction
 Screens and barriers should be placed close to the source.

Lining the barrier with noise-absorbent will reduce reflected noise.

Not so good for low frequencies.

Small area of wall (~10%) with lower Transmission Loss means substantial reduction in attenuation.
Pneumatic exhausts

- Attach silencers to air exhausts and jets
- Use low noise air nozzles (entrained air) – minimise air consumption and reduce noise
- Position fans well downstream of bends, obstructions, and sharp corners
- Install sound attenuators in ducts of process ventilation systems

Compound air nozzles can reduce noise by 20 dB

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Example: reducing air noise from pneumatic drum pump

♦ Drum pump used to transfer liquids
♦ Pump normally operated at 75 p.s.i. for around 5 minutes; noise at ear = 91 dBA
♦ Reducing air pressure to 30 p.s.i. reduced noise level to 79 dBA with minimal drop in liquid transfer flow rate

Noise reduction of 12 dBA
Vibration control

Structure-borne noise can be more significant than airborne noise in many cases.

- Isolate vibrating machines from floor and connected surfaces
- Choose flexible mounts carefully; poor choice may amplify vibrations!
- Use flexible couplings on pipework connections
Hand-held power tools can produce surprisingly high noise levels:

- Belt sander – 93 dBA
- Hand router – 95 dBA
- Jigsaw – 95 dBA
- Air pistol – 91 dBA
- Angle grinder – 101 dBA

100 dBA for **15 minutes** equals an 8-hour exposure of 85 dBA
Maintenance of noise control equipment

- Planned maintenance – repair and replace as needed.
- Regular checks on condition of enclosures, silencers, etc.
- Regular lubrication of moving parts
Hearing protection

♦ Earmuffs vs. earplugs – pros and cons
♦ “Real world” protection is less than expected from standard tests
♦ 100% wear time in noisy areas
♦ Avoid “over-protection” (<70dB leads to difficulties with communication & feelings of isolation)
How to calculate attenuation provided by hearing protection

- **SNR method** – “Single Number Rating”; subtract SNR value from overall C-weighted noise level ($L_C$)
- **HML method** – “High, Medium, Low”; measure A-weighted and C-weighted noise levels, then calculate predicted noise reduction
- **Octave band method** – measure frequency content of noise and compare against manufacturer’s data ($\text{mean} - 2\text{SD}$)

HSE suggest a 4dB “de-rating” to account for real world factors (poor fit, damaged HP, motivation & training, etc.)
Who should be given health surveillance?
- required for all those regularly exposed above upper EAV
- anyone at additional risk due to medical history, previous tests, etc. who are exposed between lower and upper EAV

Health surveillance means regular hearing checks (audiometry), keeping health records, and medical oversight

Audiometry is the only way to show if NIHL is occurring, but it does not prevent hearing loss.
In summary

- NIHL is 100% preventable
- Assessment of exposure is crucial starting point
- There are many low cost, quick-fix solutions available
- Control at source, but suitable hearing protection is vital too
Useful information sources and Publications on Noise

HSE:
“Sound Solutions, techniques to reduce noise at work”, HS(G)138, 1995

OHLearning:
W503, “Noise Measurement and it’s effects”, Student Manual
(available free on website at http://www.ohlearning.com/training/training-materials/w503-noise--measurement-and-its-effects.aspx)

Bruel & Kjaer:
“Primer: Industrial Noise Control and Hearing Testing”, 1992
Useful websites

HSE Noise site  http://www.hse.gov.uk/noise/index.htm
(comprehensive guidance on legislation and good practice)

Institute of Acoustics  http://www.ioa.org.uk/
(the principal UK professional body for those working in acoustics, noise and vibration)

NIOSH Noise site  http://www.cdc.gov/niosh/topics/noise/
(noise pages from website of US regulatory body, part of CDC)

Bruel & Kjaer  http://www.bksv.co.uk/
(specialist supplier of noise and vibration measuring equipment)

British Occupational Hygiene Society  www.bohs.org
(UK professional body with comprehensive information on occupational hygiene)

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