INTRODUCTION OF NOISE & LEGAL REQUIREMENT
OBJECTIVE

At the end of this session, participant will be able to:

• Differentiate between sound & noise.
• Identify level of noise that will effect human ear at workplace.
• Identify daily noise dose.
• Understand minimum requirement of legislation in Malaysia.
• Understand responsibilities of employer & employees.

SCOPE OF PRESENTATION

01 Background

02 Sound & Noise

03 The Effects of Noise

04 Legal Requirement
BACKGROUND

OCCUPATIONAL SAFETY AND HEALTH MASTER PLAN 2016-2020

OSHMP 2020 employs five main strategies founded on the endeavour to increase stakeholder awareness, responsibility and commitment to OSH. All parties must more together to fulfil their respective responsibilities and roles to create safe and healthy workplace through the inculcation of the value of a Preventive Culture.
BACKGROUND

STRATEGIC PLAN FOR ENFORCEMENT OF NOISE EXPOSURE REGULATION : 2018-2020

ENFORCEMENT
- Early Detection - NICE
- Proactive - NCaPP
- Reactive - Nforce

STANDARD SETTING
- ICOP
- Guideline

PROMOTION & PUBLICATION
- Best Practices Compilation
- Courses

HUMAN RESOURCE
- Empowering OSH Practitioner
BACKGROUND

COMPLIANCE OF NOISE REGULATIONS

EXPOSURE ASSESSMENT

TIER 1: NICE Early Detection
Ensure workplace complies with Reg. 9,10,12 & 20

EXPOSURE CONTROL

TIER 2: NCaPP Proactive
Ensuring the workplace performs self-regulation

TIER 3: Nforce Reactive
Avoiding the occurrence of a new case in NIHL at the same workplace

REPORTED OCCUPATIONAL DISEASES AND POISONING 2017

<table>
<thead>
<tr>
<th>Type of diseases</th>
<th>Reported cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational Lung Diseases (OLD)</td>
<td>102</td>
</tr>
<tr>
<td>Occupational Skin Diseases (OSD)</td>
<td>117</td>
</tr>
<tr>
<td><strong>Occupational Noise Related Hearing Disorders (HD)</strong></td>
<td><strong>4787</strong></td>
</tr>
<tr>
<td>Occupational Muscular - Skeletal Disorders (OMSD)</td>
<td>801</td>
</tr>
<tr>
<td>Occupational Poisoning</td>
<td>105</td>
</tr>
<tr>
<td>Disease cause by Physical Agent</td>
<td>23</td>
</tr>
<tr>
<td>Disease cause by Biological Agent</td>
<td>32</td>
</tr>
<tr>
<td>Occupational Cancer</td>
<td>6</td>
</tr>
<tr>
<td>Psychosocial Problem</td>
<td>10</td>
</tr>
<tr>
<td>Other Types of Occupational Diseases</td>
<td>6</td>
</tr>
<tr>
<td>Non Occupational Diseases</td>
<td>31</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6020</strong></td>
</tr>
</tbody>
</table>
SOUND & NOISE

WHAT IS SOUND?

• A form of energy that is transmitted by pressure variations.

• The vibrating chords set air particles into vibration and generate pressure waves in the air.

• Travel through other media, such as water or steel.

• Mechanical energy in the form of pressure variances in an elastic medium. It cannot travel through a vacuum. There is no sound in outer space.

WHAT IS NOISE?

• Unpleasant or unwanted sound.

• When unwanted noise gets loud enough:-
  - It is unpleasant.
  - It is distracting.
  - It is tiring & stressful.
  - Higher levels cause permanent hearing damage.
LIKENESS OF DAMAGE

**Depends mainly on:**
- Volume (loudness)
- Frequency (pitch)
- Exposure time
- Can be work exposure, social exposure or both

HEARING MECHANISM

- The human ear can distinguish sound pressure within a very large area.
SOUND & NOISE

RANGE OF HUMAN HEARING

- The human ear is capable of responding to frequencies ranging from 20Hz to 20kHz.
- The ear is less efficient at low and high frequencies.
- 500Hz to 4kHz is most sensitive.

![Graph showing hearing threshold vs frequency for different age groups](image)

DEFINITION OF NOISE in Industrial Hygiene field

- Noise is defined as the sound that can cause hearing loss if workers are exposed while doing their job.
- Thus, it is directly defined as physical term “Level of Sound Pressure”.
- For example, >90dB(A) for 8-hrs is noise whether it is wanted or not.
SOUND & NOISE

TYPES OF NOISE

- Steady state
  - Continuous or Non-continuous
- Fluctuating

- Impulsive
  - Single events
  - Repeated impulses
- Intermittent
  - Steady or Fluctuating

STEADY-CONTINUOUS NOISE

- Noise which has negligibly small fluctuations of sound level within the period of observation

STEADY-NON CONTINUOUS NOISE OF TWO DISCRETE TIME SEGMENTS

- Noise which has negligibly small fluctuations of sound level within the period of observation
SOUND & NOISE

FLUCTUATING NOISE

- Noise whose intensity rises or falls by more than 3 dB

IMPULSIVE NOISE

- Rapid rise (<0.5 sec) in sound level that involve a peak at intervals of greater than one per second
SOUND & NOISE

INTERMITTENT NOISE

• Steady-Intermittent Noise
• Fluctuating-Intermittent Noise

Steady-Intermittent Noise

Sound level which suddenly drop to the ambient level several times during the period of observation and the time during which the level remains at a constant value different from that of the ambient level being of the order of one second or more.

Fluctuating-Intermittent Noise

Sound level which suddenly drop to the ambient level several times during the period of observation and the time during which the level is fluctuating is different from that of the ambient level being of the order of one second or more.
## Typical Level of Occupational Noise

<table>
<thead>
<tr>
<th>Task</th>
<th>Avg. Noise Level (dB-A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating forklift</td>
<td>87</td>
</tr>
<tr>
<td>Cutting Wood</td>
<td>93</td>
</tr>
<tr>
<td>Cutting lawn</td>
<td>94</td>
</tr>
<tr>
<td>Installing trench conduit</td>
<td>95.8</td>
</tr>
<tr>
<td>Welding</td>
<td>98.4</td>
</tr>
<tr>
<td>Grinding</td>
<td>99.7</td>
</tr>
<tr>
<td>Chipping Concrete</td>
<td>102.9</td>
</tr>
<tr>
<td>Working near Generator</td>
<td>116</td>
</tr>
<tr>
<td>Lathe</td>
<td>81</td>
</tr>
<tr>
<td>Welding Equipment</td>
<td>94.9</td>
</tr>
<tr>
<td>Hand Power Saw</td>
<td>97.2</td>
</tr>
<tr>
<td>Screw Gun, Drill</td>
<td>97.7</td>
</tr>
<tr>
<td>Rotohammer</td>
<td>97.8</td>
</tr>
<tr>
<td>Chop saw</td>
<td>98.4</td>
</tr>
<tr>
<td>Stationary Power tool</td>
<td>101.8</td>
</tr>
<tr>
<td>Chipping Gun</td>
<td>103.0</td>
</tr>
</tbody>
</table>

*Source: San Diego State University, Environmental Health & Safety*
THE EFFECTS OF NOISE

- **Temporary hearing loss**
  - Cilia (hairline cells) are flattened
  - Hearing returns after a short period away from noise

- **Permanent hearing loss**
  - Permanent damage or destruction of hair cells in the ears.
  - Hearing cannot be restored

![Image: Inner Ear Pathology]

*The cilia (sensory hairs) appear normal*

![Image: Inner Ear Pathology]

*Loss of cilia as a result of Noise*
THE EFFECTS OF NOISE

**Tinnitus**
- Ringing, buzzing or whistling in the ears, when there is no external sound

**Hearing Loss**
- **Temporary hearing loss**
  Short term exposure to high noise levels
- **Acoustic trauma**
  Short term exposure to very high noise levels
- **Permanent hearing loss**
  Excessive exposure to harmful noise levels

**Other Health Problems**
- Increased heart rate
- Increased breathing rate
- Hypertension
- Sleep disturbance
- Lack of concentration
- Fatigue and aggression

**Hearing Loss**
- Other Health Problems
THE EFFECTS OF NOISE

CAUSES OF HEARING LOSS...

Age related hearing loss (Presbyacusis)

Noise Induced Hearing Loss (NIHL)

Ototoxic drugs

Tumour

Ototoxic chemicals

Trauma / injury
THE EFFECTS OF NOISE

SIGNs OF HEARING LOSS

• Difficulty hearing people speak.
• Inability to hear certain high-pitched or soft sounds.
• Noise or ringing in ears.
• Getting complaints that the radio or television is too loud.
• Trouble understanding conversation at a distance or in a crowd.
• Others can hear something you can’t.

THERE IS NO CURE FOR HEARING DAMAGE!

• Normal hearing can never be restored.
• Hearing aids do not restore noise-damaged hearing.
• Best, prevention program at earliest/beginning stage.
THE EFFECTS OF NOISE

NON-AUDITORY HEALTH EFFECTS

Effects of noise on the body

Physical stress reaction
- Increase in muscular tension
- Increase in heart rate
- Rise in blood pressure

Long-term health effects
- Cardiovascular disease
- Fatigue
- Depression

Psychological effects
- Stress
- Anxiety
- Reduced concentration

Effects of noise on the company

Communication
- Misunderstanding
- Reduced social support
- Auditory fatigue

Job performance
- Reduced teamwork
- Reduced productivity
- Reduced precision

Health & Safety Outcomes
- Absenteeism
- Sickness absence
- Time loss accidents
LEGAL REQUIREMENT

FACTORIES & MACHINERY (NOISE EXPOSURE) REGULATIONS, 1989

• Made under the Factories & Machinery Act, 1967.
• Come into force on 1 February, 1989.

OBJECTIVES OF NOISE REGULATIONS

• To prevent the occurrences of noise-induced deafness
• Legal guidance (stipulating minimum standard and procedure) to preserve worker’s hearing

EMPLOYER’S RESPONSIBILITIES

• Conduct noise exposure monitoring.
• Reduce employees’ exposure to noise through engineering, administration and the use of personal protective equipment.
• Establish audiometric testing program.
• Institute training and education program.
• Establish proper record-keeping.
LEGAL REQUIREMENT

PERMISSIBLE EXPOSURE LIMIT

Reg. 5 & 6 - Nobody is allowed to be exposed over:

- **90dB(A)** for 8 hours or First Schedule or Daily noise dose of 1.0
- **115dB(A)** at any time
- **140dB** for impulsive noise

EXPOSURE MONITORING

- Employer shall conduct employee exposure monitoring to determine if any employee may be exposed to noise level at or above the action level.
- Assessment conducted by Competent Person using equipment of IEC standard.
- **EXPOSURE MONITORING**
  - Reg 9 - INITIAL MONITORING
  - Reg 10 - POSITIVE INITIAL EXPOSURE MONITORING
  - Reg 11 - NEGATIVE INITIAL EXPOSURE MONITORING
  - Reg 12 - ADDITIONAL MONITORING WHENEVER CHANGES IN Production, Process, Equipment, Control measures, Personnel
- **EMPLOYEE NOTIFICATION** - Within 2 weeks
LEGAL REQUIREMENT

NOISE CONTROL

An occupier shall establish:

- Valid baseline audiogram
- A record of the medical and occupational history, particularly in relation to past ear diseases and exposure to noise.

within six months from the day the employee commences work

NO COST ~ EMPLOYEES

AUDIOMETRIC TESTING PROGRAMME
**LEGAL REQUIREMENT**

**AUDIOMETRIC BOOTH**

An audiometric test shall:-

- conducted by a technician under supervision of a registered medical practitioner.
- Quiet 14hours.
- be carried out in a room with background noise level meeting the requirements specified in second schedule.
- be of pure tone, air conduction, with test frequencies including 500, 1000, 2000, 3000, 4000 & 6000 Hz separately

**AUDIOMETRIC MEASURING EQUIPMENT**
Approved type and shall be calibrated and maintained at regular intervals.

---

**SECOND SCHEDULE**

(Regulation 20 (4) (c))

Maximum Allowable Octave - Band Sound Pressure Levels for Audiometric Test Rooms

<table>
<thead>
<tr>
<th>Octave-band centre frequency (Hz)</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Pressure Level, dB</td>
<td>27</td>
<td>30</td>
<td>35</td>
<td>42</td>
<td>41</td>
</tr>
</tbody>
</table>
LEGAL REQUIREMENT

AUDIOMETRIC TESTING PROGRAMME

Frequency of Audiometric Testing

1. Every year for an employee exposed to limit prescribed in:-
   - Reg.5(1)
     noise level exceeding equivalent continuous sound level of 90dB(A)
     or
     Exceeding the limits specified in the First Schedule
     or
     Exceeding the daily noise dose of unity
   - Reg. 5(2) 115dB(A) at any time

2. Every year for an employee whose baseline audiogram shows hearing impairment or annual audiogram show standard threshold shift.

3. Every two years for an employee exposed to noise level at or above the Action Level but less the limit prescribed in Reg.5.
LEGAL REQUIREMENT

AUDIOGRAM (NORMAL)

A chart, graph or table resulting from an audiometric test showing an employee’s hearing threshold levels as a function of frequency

![Graph showing audiogram (normal)](image1)

AUDIOGRAM (HEARING IMPAIRMENT)

![Graph showing audiogram (hearing impairment)](image2)

AUDIOMETRIC TEST RECORDS

- Name & job location, date audiogram, name of person conducting the test, model, make & serial number of equipment, date of last calibration
- Retain as long as the employee is employed and five years thereafter.

Shifted by 25 dB or more
LEGAL REQUIREMENT

AUDIOGRAM (STANDARD THRESHOLD SHIFT)

CONCLUSIONS

Participant will be able to:

- Differentiate between sound & noise
- Identify level of noise that will effect human ear at workplace.
- Understand minimum requirement of legislation in Malaysia
- Understand responsibilities of employer & employees

- Sound is a form of energy that is transmitted by pressure variations and below PEL
- Noise is unwanted sound and effect human ear

Nobody is allowed to be exposed over:-
- 90dB(A) for 8hours/First Schedule/daily noise dose of 1.0
- 115dB(A) at any time
- 140dB for impulsive noise

Factories & Machinery (Noise Exposure) Regulations, 1989

- To ensure the safety, health and welfare at work of all his employees
- To co-operate with employer and comply with any instruction or measure on OSH
INTRODUCTION TO NOISE CONTROL
SESSION OUTCOMES

By the end of this session the participants should be able to:

• Understand the overall concepts of noise control
• Use noise control methods based on Hierarchy of Control in order to improve workplace from noise hazard.

WHEN THE NOISE CONTROL REQUIRED?

Nobody are allowed to exposed over:-

• 90dB(A) for 8hours or First Schedule or Daily noise dose of 1.0
• 115dB(A) at any time
• 140dB for impulsive noise

Employer to conduct exposure monitoring that consist of:

• Area Monitoring
• Personal monitoring

| Regulation 15 – the occupier shall reduce and maintain exposure to noise level below the limits by:-- | engineering control as far as reasonable practicable |
KEY ACTIONS OF NOISE CONTROL

The key actions for controlling noise should include:

• prioritising and tackling the immediate risks.
• identifying possible methods.
• assessing the reduction levels that can be achieved by introducing cumulative controls.
• assigning responsibilities.
• monitoring controls and performance.

UTILISING NOISE MAPPING FROM AREA MONITORING

• Noise contours will indicate the noise sources.
• Noise sources with the higher noise level could be identified and action to be prioritised.
• Priority given to higher machines or process emitting higher noise levels.

UTILISING NOISE MAPPING FROM AREA MONITORING

Contouring

Zoning
CONSIDERING FACTORS OF NOISE CONTROL

The employers should consider the following factors:-

- the scale of the noise problem and its impact on the business (including workers).
- cost and effort required to reduce noise exposure.
- the effectiveness of planned control measures.
- the number of individuals who would benefit from those control measures.

NOISE CONTROL BASIC STRATEGY

Control at source.

- Example - control at design stage (Prevention through Design (PtD), reduction of speed and pressure.

Reduction at path

- Example - adding barriers or enclosing the equipment, adding sound-absorbent materials.

Reduction at receiver

- Example - relocating the employee from the sound field, limiting his working time in the area, or through the use of hearing protective devices (HPD).

Source: personal.city.edu.hk
SOURCE / PATH / RECEIVER MODEL

Basic treatment strategies using engineering controls. “Typical” noise reductions associated with each strategy are listed below :-

<table>
<thead>
<tr>
<th>SOURCE CONTROL</th>
<th>DIRECT PATH CONTROL</th>
<th>INDIRECT PATH CONTROL</th>
<th>RECEIVER CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to 8 dB</td>
<td>10 to 25 dB &amp; up</td>
<td>4 to 6 dB</td>
<td>10 to 25 dB &amp; up</td>
</tr>
</tbody>
</table>

Source: Info@CitySoundproofing.com
NOISE CONTROL AT SOURCE

The improvement techniques include the following:

- reduction of impact forces,
- reduction of speed and pressure,
- reduction of frictional resistance,
- isolation of vibrating elements.
NOISE CONTROL AT PATH

This can be done in several ways:
• to absorb the sound along the path,
• to deflect the sound in some other directions by placing a reflecting barrier in its path,
• to contain the sound by placing the source inside a sound-insulating box or enclosure.

NOISE CONTROL AT RECEIVER

Protecting the Receiver

The following two techniques are commonly employed
• Alter work schedule
• HPD

HIERARCHY OF CONTROL
ELIMINATION

• Physically removing the hazard
• The most effective hazard control which can be done by changing a work process in a way that will get rid of a hazard

  • Is the process necessary?
  • Can we achieve what we want in a different way?
  • Can we get another option to do it?

SUBSTITUTION

• The second most effective way to control a hazards
• Involves removing something that produces a hazard (similar to elimination), and replacing with something that does not produce a hazard.
  
  e.g.: substitute quieter process / equipment for noisy ones.

• To be an effective control, the new product must not produce another hazard.
  
  i) ‘Change of process’ – same outcome, different mechanism
  
  ii) ‘Change of technique’ – same objective – different way of getting there
  
  iii) ‘Change of equipment’

SUBSTITUTE QUIETER PROCESS OR EQUIPMENT:-

New quieter generators have sound proofing and produce only 75 dBA at 1 meter and 65 dBA at 7 meters under load.

Replacing a large jackhammer with a middle range one reduce the noise level by 10 dBA.

Individually vacuum pump install at production machine (40 units). Noise level (90 dB)

Installation of centralize vacuum pump at facilities plant building complete with noise absorption material (rockwool with cement board). Noise level reduce to avg < 70 dB
ENGINEERING CONTROL

- Engineering controls are defined as: “Methods that reduce noise exposure by decreasing the amount of noise reaching the employee through engineering design approaches. Engineering controls isolate the noise from the worker through noise reduction” (adapted from NIOSH, 1996a).
- The next best approach to use when a hazard cannot be eliminated or a safer substitute cannot be found.
- Physical changes to the work area or process that effectively minimize a worker’s exposure to hazards.
- These controls focus on eliminating or reducing that actual source of the hazard.

PRINCIPLES OF ENGINEERING CONTROL

- Absorption
- Insulation
- Distance
- Silencer
- Vibration isolation
- Damping
ADMINISTRATIVE CONTROL

Definition

Administrative controls are defined as: “Methods that reduce exposure by limiting the time a worker is exposed to noise through administrative approaches. Administrative controls isolate the worker from the noise by reducing exposure” (adapted from NIOSH, 1996a).

Administrative Control EXAMPLE

- Organize schedules so that noisy work is done when few workers are present;
- Notify workers and others in advance so they can limit their exposure;
- Provide quiet areas for rest breaks;
- Limit time workers spend in noisy areas. (refer schedule 1).
ADMINISTRATIVE CONTROL...CONT’D

Schedule 1: Noise Exposure Regulation

<table>
<thead>
<tr>
<th>Noise Level (dB (A) – slow)</th>
<th>Duration of Exposure Permitted per day (hours – minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>16 - 0</td>
</tr>
<tr>
<td>86</td>
<td>13 - 56</td>
</tr>
<tr>
<td>87</td>
<td>12 - 8</td>
</tr>
<tr>
<td>88</td>
<td>10 - 34</td>
</tr>
<tr>
<td>89</td>
<td>9 - 11</td>
</tr>
<tr>
<td>90</td>
<td>8 - 0</td>
</tr>
<tr>
<td>91</td>
<td>6 - 58</td>
</tr>
<tr>
<td>92</td>
<td>6 - 4</td>
</tr>
<tr>
<td>93</td>
<td>5 - 17</td>
</tr>
<tr>
<td>94</td>
<td>4 - 36</td>
</tr>
<tr>
<td>95</td>
<td>4 - 0</td>
</tr>
<tr>
<td>96</td>
<td>3 - 29</td>
</tr>
<tr>
<td>97</td>
<td>3 - 2</td>
</tr>
<tr>
<td>98</td>
<td>2 - 50</td>
</tr>
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<td>99</td>
<td>2 - 15</td>
</tr>
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<td>100</td>
<td>2 - 0</td>
</tr>
<tr>
<td>101</td>
<td>1 - 44</td>
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<td>102</td>
<td>1 - 31</td>
</tr>
<tr>
<td>103</td>
<td>1 -19</td>
</tr>
<tr>
<td>104</td>
<td>1 - 9</td>
</tr>
<tr>
<td>105</td>
<td>1 -0</td>
</tr>
<tr>
<td>106</td>
<td>0 - 52</td>
</tr>
</tbody>
</table>

HEARING PROTECTIVE DEVICE(HPD)

- Provision of HPD should only be considered when all other control methods are impractical.
- What might be some drawbacks of reliance solely on HPD to protect workers?
HEARING PROTECTIVE DEVICE

Employee exposure to excessive noise depends upon a number of factors, including:

- The loudness of the noise as measured in decibels (dB).
- The duration of each employee’s exposure to the noise.
- Whether employees move between work areas with different noise levels.
- Whether noise is generated from one or multiple sources

HPD REQUIREMENT

- Performing a “hazard assessment” of the workplace to identify and control physical and health hazards.
- Identifying and providing appropriate HPD for employees.
- Training employees in the use and care of the HPD.
- Maintaining HPD, including replacing worn or damaged HPD.
- Periodically reviewing, updating and evaluating the effectiveness of the HPD program.

In general, employees should:

- Properly wear HPD,
- Attend training sessions on HPD,
- Taking care, clean and maintain HPD, and
- Inform a supervisor of the need to repair or replace HPD.
TYPES OF HPD

Single-use earplugs
• are made of waxed cotton, foam, silicone rubber or fiberglass wool.

Pre-formed or molded earplugs
• disposable or reusable

Earmuffs
• require a perfect seal around the ear
• Glasses, facial hair, long hair or facial movements such as chewing may reduce the protective value of earmuffs.

TRAINING HPD

Employees must be trained to know at least the following:
• When HPD is necessary.
• What HPD is necessary.
• How to properly put on, take off, adjust and wear the HPD.
• The limitations of the HPD.
• Proper care, maintenance, useful life and disposal of HPD.

PROPER WAY OF WEARING HPD

Source: www.mscdirect.com
NOISE REDUCTION RATING (NRR)

The NRR describes the average sound level reduction (attenuation) provided by a hearing protection device (HPD) in a laboratory test. It doesn’t take into consideration:

- the loss of protection that occurs when hearing protectors are not fit properly
- they are not worn for the entire time that the wearer is exposed to noise

An Example of Reducing the NRR

- 8-hour TWA noise exposure: 93 dB(A)
- NRR of hearing protectors: 29 dB

Subtract 7 dB from the NRR: 29 dB - 7 dB = 22 dB(A)
Divide by 2: 22 ÷ 2 = 11 dB(A) (Derating)

Subtract 11 dB(A) from the 8-hour TWA noise exposure: 93 dB(A) - 11 dB(A) = 82 dB(A)
Decide if 82 dB(A) (known as the “Protected Exposure”) is below the PEL for noise
SNR

OUR REF: UC-EP03C
Soft COEDED PU foam earplugs which expand gradually to conform exactly to the size and shape of virtually any ear canal. Extremely high SNR 37 for very noisy environments. Extremely cost effective.

EN 352-2:2002

A simple indication of protection levels

<table>
<thead>
<tr>
<th>A-weighted noise level (dB)</th>
<th>Select a protector with an SNR of...</th>
</tr>
</thead>
<tbody>
<tr>
<td>85-90</td>
<td>20 or less</td>
</tr>
<tr>
<td>90-95</td>
<td>20 - 30</td>
</tr>
<tr>
<td>95-100</td>
<td>25-30</td>
</tr>
<tr>
<td>100-105</td>
<td>30 or more</td>
</tr>
</tbody>
</table>

WHY HPD?

HPDs are often rejected by workers for many reasons, such as:

FACTS TO KNOW?

- Percentage of workers who wear HPDs can vary from 0% to more than 49% (Suter, 2002)
- 34% of workers exposed to noise never used hearing protection (Tak, et al., 2009).
FACTS TO KNOW?

• Federal regulations issued by the EPA mandate that hearing protectors be labeled with a noise reduction rating (NRR), which was designed to predict the amount of protection of wearers would achieve by wearing the devices correctly. (EPA, 1979).

• Research has shown that fewer than 5% of workers actually receive the protection predicted by the NRR (Berger, et al., 1994).

CONCLUSION

• Noise exposure monitoring is essential to determine the needs of noise control.

• Implement noise control based on Hierarchy of Control in order to improve workplace from noise hazard

• Do not depend solely on HPD
NOISE REDUCTION THROUGH ENGINEERING CONTROL
OBJECTIVES

By the end of this session the participants should be able to:

- Utilise noise mapping information
- State the 3 methods of noise control
- State 6 engineering control principles
- List example of Noise Control

HOW IS NOISE LEVEL MEASURED?

Sound Level Meter (SLM) is used to measure noise at source

- To find out where noise may or may not be a problem
- Measure SPL, 1/1 & 1/3 Octave Band-Frequency (Hz)

Engineering noise control survey

- Confirm noise contribution of specific machines, machine components or processes
- Determine frequency distribution of specific machines, machine components or processes
- Determine and prioritize suitable controls for machinery/processes
CONVERTING NOISE SPECTRUM TO OVERALL NOISE LEVEL

<table>
<thead>
<tr>
<th>Octave Band Frequency (Hz)</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1K</th>
<th>2k</th>
<th>4k</th>
<th>8k</th>
</tr>
</thead>
<tbody>
<tr>
<td>L_A</td>
<td>53</td>
<td>66</td>
<td>76</td>
<td>84</td>
<td>87</td>
<td>86</td>
<td>82</td>
<td>67</td>
</tr>
</tbody>
</table>

Difference of the two levels | Increment to be added to higher level |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 1</td>
<td>3 dB</td>
</tr>
<tr>
<td>2 – 4</td>
<td>2 dB</td>
</tr>
<tr>
<td>5 – 9</td>
<td>1 dB</td>
</tr>
<tr>
<td>10 or more</td>
<td>0 dB</td>
</tr>
</tbody>
</table>

Overall Noise Level: 92 dB(A)

NOISE CONTROL MEASURES

Noise Reduction
- Substitution
- Engineering Control

Exposure Reduction
- Administrative Procedures and Arrangements
- Use of Hearing Protection Devices

NOISE REDUCTION

Substitution
- Change to quieter methods of work
- Replacing equipment with less noisy ones for both production & material handling

Engineering Controls (the use of engineering principles to reduce noise levels)
- Reduce noise at source
- Prevent or reduce propagation
SOURCE / PATH / RECEIVER MODEL

Basic treatment strategies using engineering controls. “Typical” noise reductions associated with each strategy are listed below:

<table>
<thead>
<tr>
<th>SOURCE CONTROL</th>
<th>DIRECT PATH CONTROL</th>
<th>INDIRECT PATH CONTROL</th>
<th>RECEIVER CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to 8 dB</td>
<td>10 to 25 dB &amp; up</td>
<td>4 to 6 dB</td>
<td>10 to 25 dB &amp; up</td>
</tr>
</tbody>
</table>

Source: Info@CitySoundproofing.com

CONTROL AT SOURCE

Proper design/selection
Proper maintenance
Modification/replacement
Use of enclosures
Reduction of impact forces
Vibration damping
EXAMPLE OF CONTROLLING NOISE AT SOURCE

• Pump

CONTROL AT PATH

- Barriers
- Shields
- Absorptive Lining
CONTROL AT PATH

1. Noise paths found in a workplace. The quiet area is subjected to reflected noise from a machine somewhere else in the building.

2. The correct use of absorption in the roof will reduce the reflected noise reaching the quiet area.

3. Segregation of the noisy operation will benefit the whole workplace.

Source: www.hse.gov.uk
TYPICAL NOISY EQUIPMENT

SELECTION OF NOISE CONTROL MATERIAL

- Absorption materials – fibrous, lightweight & porous
- Transmission loss materials
- Damping materials – homogeneous layer & constrained layer.
- Vibration isolators
- Material selection – adsorbent
- Curtain

Sound Absorption Coefficients

- Machines - contain cams, gears, reciprocating components and metal stops (often located in reverberant areas)
- The type, amount, configuration and placement of absorption material depends on the specific application.
• An absorption coefficient:
  - close to **(1.0)** means the material will absorb all sound impinging randomly on the surface
  - close to **(0)** means the material will absorb little acoustic energy.

### Sound absorption coefficient of COMMON materials (Good)

<table>
<thead>
<tr>
<th>Material</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125</td>
</tr>
<tr>
<td>Fibrous glass</td>
<td></td>
</tr>
<tr>
<td>1 inch thick</td>
<td>0.07</td>
</tr>
<tr>
<td>2 inch thick</td>
<td>0.20</td>
</tr>
<tr>
<td>4 inch thick</td>
<td>0.39</td>
</tr>
<tr>
<td>Polyurethane foam (open cell)</td>
<td></td>
</tr>
<tr>
<td>¼ inch thick</td>
<td>0.05</td>
</tr>
<tr>
<td>½ inch thick</td>
<td>0.05</td>
</tr>
<tr>
<td>1 inch thick</td>
<td>0.14</td>
</tr>
<tr>
<td>2 inch thick</td>
<td>0.35</td>
</tr>
<tr>
<td>Hairfelt</td>
<td></td>
</tr>
<tr>
<td>½ inch thick</td>
<td>0.05</td>
</tr>
<tr>
<td>1 inch thick</td>
<td>0.06</td>
</tr>
<tr>
<td>Carpet</td>
<td>0.02</td>
</tr>
</tbody>
</table>

### Sound Absorption Coefficient of Surface Materials (Bad)

<table>
<thead>
<tr>
<th>Material</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125</td>
</tr>
<tr>
<td>Brick: Glazed</td>
<td></td>
</tr>
<tr>
<td>Brink: Glazed</td>
<td>0.01</td>
</tr>
<tr>
<td>Unglazed</td>
<td>0.03</td>
</tr>
<tr>
<td>Unglazed, painted</td>
<td>0.01</td>
</tr>
<tr>
<td>Concrete block painted</td>
<td>0.10</td>
</tr>
<tr>
<td>Concrete / terrazzo</td>
<td>0.01</td>
</tr>
<tr>
<td>Wood</td>
<td>0.15</td>
</tr>
<tr>
<td>Glass</td>
<td>0.35</td>
</tr>
<tr>
<td>Gypsum board</td>
<td>0.29</td>
</tr>
<tr>
<td>Plywood</td>
<td>0.28</td>
</tr>
</tbody>
</table>
PRINCIPLES OF ENGINEERING CONTROL

- Absorption
- Insulation
- Distance
- Silencer
- Vibration isolation
- Damping
Absorption

- Sound energy is absorbed whenever sound meets a porous material
- Porous materials intended to absorb sound is called absorbents
- Absorbents usually absorb 50-90% incident sound energy

Examples: ABSORPTION

Insulation

- When sound meets a wall or partition, only a small proportion of sound energy passes through, most are reflected back
- A wall of 10dB insulation allows 10% of the sound energy to pass through
  - 20dB corresponds to 1%
  - 30dB corresponds to 0.1%, etc.
Examples: INSULATION

### Distance

**Attenuation by DISTANCE**

- Sound that propagates from a point source in free air attenuates by 6dB for each doubling of distance from source
- For indoors, attenuation is less due to contributions to the total sound level from reverberant sound brought about by reflection from walls and ceilings

**Examples: DISTANCE**

Simple Method of knowing how much sound is reduced by DISTANCE

\[
\text{SPL}_2 = \text{SPK}_1 - 20 \log \frac{r_2}{r_1}
\]

**Example:** Noise level is 90 dB (SPL₁) at 1 meter (r₁). Calculate noise level (SPL₂) at distance 2 meter (r₂)?

\[
\text{SPL}_2 = 90\text{dB} - 20 \log (2/1)
\]

\[
= 83.97 \text{dB}
\]

*Source: OSHA Technical Manual*
Use of SILENCER

- The length, diameters of the chamber and opening determines the frequency and level of attenuation respectively
- Use of absorption and insulation principles

Examples: SILENCER

Vibration isolation

- Isolation of vibrating machines from floors or room from vibrating floors
- By mounting vibration sources on flexible supports
  - spring used for heavy machinery
  - rubber, cork, expanded polystyrene used for light structures
Examples: VIBRATION ISOLATION

Vibration isolating mount rubber
Damping

- Reducing the amplitude of vibration reduces resonance peaks hence reducing the noise radiated
- Stiffening the vibrating surfaces with metal, spray-on damping material, hardboard

Examples: DAMPING

Source: OSHA Technical Manual
EXAMPLE OF ENGINEERING NOISE CONTROL

Packing Machine – Wall Insulation

Before Treatment – 91 dB(A)      After Treatment – 83 dB(A)

Circular Silencers - Applications

Cooling Towers

Ventilation Fans
Exhaust Silencers - Applications

Vacuum Chamber

Acoustic Enclosure/panels - Applications

During Installation

After Installation

Acoustic Barrier
Acoustic Enclosure/panels - Applications

Before Treatment – 89 dB (A)                                     After Treatment – 83 dB(A)

Acoustic Barrier – Cooling Tower

Acoustic Canopy for Genset              Acoustic Enclosure for Press Machine
Acoustic Enclosure/panels - Applications

Before Treatment – 88 dB(A)  
After Treatment – 81 dB(A)

Before Treatment – 87 dB(A)  
After Treatment – 82 dB(A)
MVU Fan Coolers

Before Treatment – 87 dB(A)  After Treatment – 81 dB(A)

PVC Strips Curtain - Applications
# Desirable Features of Equipment Design for Noise Reduction

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Source of Noise</th>
<th>Design Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heaters</td>
<td>Combustion at burners</td>
<td>Acoustic air intake plenum</td>
</tr>
<tr>
<td></td>
<td>Inspiring of premix air at burners</td>
<td>Inspiring air intake silencer, Acoustic air intake plenum</td>
</tr>
<tr>
<td></td>
<td>Draft fans</td>
<td>Air intake silencer or acoustic plenum lagging</td>
</tr>
<tr>
<td></td>
<td>Ducts</td>
<td>Lagging</td>
</tr>
<tr>
<td>Motors</td>
<td>TEFC cooling air fan</td>
<td>Acoustic fan shroud, unidirectional fan, and/or intake silencer</td>
</tr>
<tr>
<td></td>
<td>WP II cooling air opening</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical and electrical</td>
<td>Enclosure</td>
</tr>
<tr>
<td>Air fin coolers</td>
<td>Fan</td>
<td>Lower RPM (increase pitch), Tip and hub seals, Increased number of blades, Decreased static pressure drop, More fin tubes</td>
</tr>
<tr>
<td></td>
<td>Speed changer</td>
<td>Belts in place of gears</td>
</tr>
<tr>
<td></td>
<td>Fan shroud</td>
<td>Streamlined air flow, Damping and stiffening</td>
</tr>
<tr>
<td>Centrifugal compressor</td>
<td>Discharge piping and expansion joints</td>
<td>In-line silencer and/or lagging</td>
</tr>
<tr>
<td></td>
<td>Anti surge bypass system</td>
<td>Quite valves, reduced velocity, and stream lining, Lagged valves and piping, In-line silencer</td>
</tr>
<tr>
<td></td>
<td>Intake piping and suction drum</td>
<td>Lagging</td>
</tr>
<tr>
<td></td>
<td>Air intake / air discharge</td>
<td>Silencer</td>
</tr>
<tr>
<td>Screw compressor (axial)</td>
<td>Intake and discharge piping</td>
<td>Silencer and lagging</td>
</tr>
<tr>
<td>Speed changers</td>
<td>Gear meshing</td>
<td>Enclosure, constrained damping on case, or lagging</td>
</tr>
<tr>
<td>Engines</td>
<td>Exhaust</td>
<td>Silencer (muffler)</td>
</tr>
<tr>
<td></td>
<td>Air Intake</td>
<td>Silencer</td>
</tr>
<tr>
<td></td>
<td>Cooling fan</td>
<td>Enclosed intake and/or quitter discharge</td>
</tr>
<tr>
<td>Condensing turbine</td>
<td>Expansion joint on steam discharge line</td>
<td>Lagging</td>
</tr>
<tr>
<td>Atmospheric exhaust and intakes</td>
<td>Discharge jet</td>
<td>Discharge silencer</td>
</tr>
<tr>
<td></td>
<td>Upstream valves</td>
<td>Quiet valve or silencer</td>
</tr>
<tr>
<td>Piping</td>
<td>Excessive velocities</td>
<td>Limited velocities, Smooth, gradual changes in size and direction, Lagging</td>
</tr>
<tr>
<td></td>
<td>Valves</td>
<td>Limited velocities, Constant velocity or a quiet valve, Divided pressure drop</td>
</tr>
<tr>
<td>Pumps</td>
<td>Cavitation of fluid</td>
<td>Enclosure</td>
</tr>
<tr>
<td>Flares</td>
<td>Steam jets</td>
<td>Multiport on air injectors</td>
</tr>
</tbody>
</table>

Source: Guidelines for Control of Occupational Noise 2005
Noise Case Study – Industry, Activity And Techniques
Examples of Noise Case Study

Reciprocating compressor

The Problem
A reciprocating air compressor has been in use for several years, both in a workshop and in mobile noise control demonstrations. Noise levels measured 94dB at 1m and clearly noise reduction was required.

The Solution
The noise reductions were all through maintenance. Initial work involved improving the valve seating. The old valves were observed to have a rough surface and to seal poorly to the casing. New valves were purchased and observed to be similarly rough.

These were then dressed (polished) to achieve a much-improved seal. An oil additive (molybdenum disulphide) was added to the lubricating oil to “smooth out” the surface finish in the cylinder, thus helping to cushion “piston slap”.

The Results
The average reverberant noise level was reduced by 6dB to 87dB and the operators’ noise exposures were reduced by 4dB.

Transfer of components using a conveyor and metal chute

The Problem
A manufacturer of tube fittings used conveyors to transport components through the manufacturing process, and to deposit components into hoppers. In one case the metal products would drop through some 3m, partly along a metal delivery chute, before landing in the hopper. The noise level associated with this was 96dB.

The Solution
- The angle of the conveyor was reduced, to reduce the drop height and the section of the delivery chute was removed.
- The face of the chute was lined with a sheet of plastic.

The Results
The noise level was reduced by 7dB to 89dB.
Metal cutting guillotine

The Problem
A noise assessment revealed that the noise level at the operators position of a metal cutting guillotine was 92dB.

The Solution
- The guillotine was fully serviced and its hydraulics repaired.
- A collecting tray was fitted with rollers and covered with carpet, to reduce the impact of falling off-cut metal.

The Results
The noise level at the operator’s position was reduced by 8dB to 84dB.
ENGINEERING MEASURES

Some engineering measures that may be considered include:

• separating the noisy area using sound-reducing partition.
• enclosure of noisy machinery with sound-absorbing material.
• avoiding metal-to-metal contact by using plastic bumpers.
• using absorbent lining on surfaces to cushion the fall or impact of objects.
• using conveyor belts rather than rollers.
• using acoustical silencers in intake and exhaust systems.
• using rubber mounts to isolate vibrating noise source to separate it from the surface it's mounted to.
• maintaining optimum speed of machinery or its particular components.
• repairing and replacing loose rotating parts, worn bearings and gears.
• using sound-absorbing material on walls, ceiling and floors to reduce the noise level due to reverberation.
• undertaking regular maintenance on equipment (very effective in reducing noise emission if carried out regularly).

OVERALL NOISE CONTROL PROCEDURE

• Plant planning (design & layout).
• Substitution (equipment, process & material).
• Engineering control
  • Control at source (modification of noise generator).
  • Control at path (modification of sound wave).
  • Successful planning for noise control involves:
    - Knowledge of the noise characteristics of each machine and process.
    - Proposed location of each noise source, operator and maintenance workers.
    - Selection of design criteria based on employee exposure time.
• Engineering specification for design and selection of equipment should incorporate a requirement for noise performance data.
CONCLUSION - KEY POINTS

• Excessive exposure to noise can cause loss of hearing
• Engineering noise control can successfully eliminate / reduce the excessive noise levels.
• Effective control of noise in the workplace through pro active approach has obvious benefits for the employees in term of better health and quality of life at present and in future.
• Attitude – New mindset (Do not purely rely on PPE)