

**The British Occupational Hygiene Society**  
Faculty of Occupational Hygiene

**MODULE SYLLABUS**

**M104 - NOISE AND AN INTRODUCTION TO VIBRATION**

**AIM:** To provide the student with an appreciation of the nature of noise and vibration hazards in the workplace and the effects of noise, and vibration, on people. It also details the approach in carrying out noise and vibration assessments in the workplace and in the general environment, and to determine the significance of measurement data in relation to the various standards for compliance.

On successful completion of this module the student should be able to:-

- describe the consequences to health and well being of excessive exposure to noise, and vibration;
- understand the measurement (including dosimetry) of noise, and vibration in relation to current standards;
- conduct surveys in the workplace to assess risks from noise;
- understand the principles of surveys in the workplace to assess risks from vibration;
- advise on the need and means of control including PPE;
- appreciate and advise on environmental noise assessment and concerns
- understand current legislation and standards in these fields.

**CONTENT:**

TOPIC	TIME ALLOCATION
1. PHYSICS OF NOISE, AND VIBRATION	10%
2. HUMAN RESPONSE TO NOISE, AND VIBRATION	10%
3. MACHINERY NOISE, AND VIBRATION	10%
4. ASSESSMENT OF NOISE RISK	20%
5. NOISE CONTROL AND HEARING PROTECTION	20%
6. INTRODUCTION TO ENVIRONMENTAL NOISE	10%
7. INTRODUCTION TO THE ASSESSMENT AND CONTROL OF VIBRATION	10%
8. LEGISLATION	10%

**Note:** Reference is made in this syllabus to HSE guidance or other documentation. This may not be the most up-to-date relevant publications from HSE/other sources and is intended as guidance for candidates only.

## RECOMMENDED DOCUMENTATION

- i. The Control of Noise at Work Regulations 2005.
- ii. Hearing and noise in industry, W Burns and D W Robinson 1970, HMSO.
- iii. Guidance on the Control of Noise at Work Regulations 2005 (HSE L108-2005).
- iv. Sound Solutions HSG138 (1994)
- v. The Control of Vibration at Work Regulations 2005
- vi. Guidance on the Control of Vibration at Work Regulation 2005 – Hand-Arm Vibration (HSE L140-2005)
- vii. Guidance on the Control of Vibration at Work Regulation 2005 – Whole Body Vibration (HSE L141-2005)
- viii. Hand / Arm Vibration Solutions HSG 170 (1997).

## 1. PHYSICS OF NOISE AND VIBRATION (10%)

### 1.1 Properties of sound

Propagation of sound by longitudinal wave motion  
Relationship between frequency, wavelength and velocity  
Velocity of sound - dependence on temperature and bulk modulus  
Infra sound and ultra sound - definitions and common sources  
Simple harmonic motion

### 1.2 Definitions and measurements units - noise

Sound pressure and sound pressure level.  
Sound intensity and intensity level, reference values.  
Range of sound pressures in audio range.  
Definition and application of decibel scale.  
Relationship between sound pressure and sound power level.  
Time varying sources, definition and use of equivalent continuous sound level.  
Characteristics of impulse and impact noise.  
Equivalent continuous sound level and usage.  
Understanding of weighting scales A and C, comparison with linear levels and awareness of other weighting scales.  
Frequency characteristics of sound.  
Octave, third octave and narrow band spectra.  
Summation of sound pressure levels and calculation of sound power levels

### 1.3 Definitions and measurements units - vibration

Units of measurement - understanding of acceleration amplitude.  
Velocity amplitude and displacement amplitude.  
Choice of measurement parameters, dynamic range and frequency information required.  
Relationship and implications of mass and stiffness and damping, natural frequency and static deflection.

### Educational objectives

The student should know the basic concepts and the definitions of the various terms that are used to measure noise and vibration.

## **2. HUMAN RESPONSE TO NOISE, AND VIBRATION (10%)**

### **2.1 The ear and its response to sound**

Structure of the ear - outer, middle and inner ear.  
Frequency selectivity and auditory filter, masking, stereo cilia, aural reflex.  
Trauma, tinnitus, damage to hair cells.  
Temporary threshold shift and recovery times, Permanent threshold shift.  
Noise induced hearing loss.  
Relationship between hearing loss, noise exposure levels and exposure times.  
Speech frequencies.  
Speech interference levels, loudness and phon scales.

### **2.2 Audiometry**

The role of audiometry in industry, Management of Health and Safety at Work Regulations 1999 - health surveillance. The Control of Noise at Work Regulations 2005  
A Guide to audiometric testing programmes - HSE Guidance Note MS26 (1)  
Audiometer types - screening, diagnostic, research.  
Test signal frequencies, pure tone and bone audiometry.  
Audiogram accuracy - sources of error, ambient noise in audiometer booths.  
Non organic hearing loss, organic hearing loss.  
Presbycusis, Noise induced hearing loss - 4 kHz dip.  
Hearing handicap levels and categorisation.

### **2.3 Noise exposure limits**

Exposure Action Values and Exposure Limit Values of the Control of Noise at Work Regulations 2005. Daily and Weekly Personal Noise Exposures.  
Risk of hearing damage between the Lower and Upper action levels.  
Exposure standards for infra sound and ultra sound.

### **2.4 Vibration effects and limits**

Exposure Limit Values and Exposure Action Values for hand/arm and whole body vibration of the Control of Vibration at Work Regulations 2005  
Requirements for health surveillance  
Health effects of whole body vibration, vibration dose.  
Sensitivity to vibration at different frequencies.  
BSEN ISO 2631-4:2001 (2) Fatigue - decreased proficiency and exposure limits, reduced comfort.  
Vibration sources and effects  
Vibration in buildings, 1-80 Hz BS 6472 1992.(3)  
Segmental vibration, hand arm vibration - neurological and vascular effects.  
8-hour energy equivalent weighted acceleration.  
Relationship between time to development of vascular symptoms and weighted vibration and exposure time.  
Vibration from powered hand tools and other processes.

## **Educational Objectives**

The student should be aware of the main effects on the body following excessive exposure to noise, and vibration. This should include awareness of the various limits to noise, and vibration, exposure and the role of health surveillance, including audiometry, in reducing risk.

### **3. MACHINERY NOISE, AND VIBRATION (10%)**

Power sources - electrical motors.

Fluid movers - air movers, pumps, sources of noise generation, hydraulic noise.

Understanding valve noise, jet noise and duct noise.

Impact noise and sources.

Compressor types and characteristics.

Machine tools and hand held power tools, wood working machinery.

Tonal components from rotating machinery, fan blade passage and gear meshing frequency.

Near field and far field and implications for sound measurements.

#### **Educational Objectives**

The student should gain a good understanding of the major sources of industrial noise, and vibration, and community noise.

### **4. ASSESSMENT OF NOISE RISK (20%)**

#### **4.1 Sound level meters**

Basic principle of operational components with consideration of simple digital processing techniques.

Understanding of type classification in accordance with BSEN 61672-1:2003 (4)

Sound level meters.

Understanding of type and the accuracy at reference and in field conditions.

Microphone types; polarised, pre-polarised, piezoelectric and knowledge of others and limitations.

Directional characteristics of sound level meter and microphones.

Operational considerations eg. battery checks, calibration, BS7580:1997 (6) wind effects, body reflections.

#### **4.2 Frequency analysis**

Octave band and third octave band analysis - characteristics and filter band widths.

Analogue and digital filters.

Narrow band analysis.

Current instrumentation for real time analysis.

Uses of frequency analysis for noise source identification.

Time history analysis and techniques.

#### **4.3 Personal noise dosimetry**

Principles of instrumentation operation, field accuracy and sources of error.

Importance of supporting dosimeter assessments with appropriate sound level meter measurements.

Instrument types BS EN 61252:1997 (5) and facilities, supporting software.

Sampling techniques and sources of error.

#### **4.4 Sound power and sound intensity measurements**

Uses and significance of sound power and intensity.

Sound power - reference sources and field measurement.

Sound intensity - instrumentation for measurement.

## 4.5 Noise measurements and assessments

Observation of work practices and processes.  
Types of noise measurements eg. sound level meter, dosimeter, octave bands.  
Survey and sampling techniques.  
Role and application of noise dosimetry.  
Significance of measurement periods.  
Use and significance of terms dB(A), dB(C), dB(lin), SPL, Leq, Lmax, LEP,d, LEP,w.  
Calculation of LEP,d from time varying exposures.  
Use nomogram in Guidance Notes for calculation of LEP,d  
Role and application of octave band analysis.  
Calculation of dB (A) values from octave band analysis.  
Interpretation of noise measurements eg. source identification, noise contouring, hearing protection zones.  
Report requirements and presentation.

### Educational Objectives

The student should have the theoretical knowledge and be provided with sufficient practical “hands on” experience in the use of sound pressure level meters/dosimeters to enable him/her undertake a basic noise survey and prepare a technical report.

## 5. NOISE CONTROL AND HEARING PROTECTION (20%)

### Recommended Documentation

HSE Guidance Note HSG 138 (1995) (7)

### 5.1 Engineering control of noise

#### Controlling the noise generated at source by;

Avoiding impacts.  
Increasing damping and use of flexible material to reduce spread of sound through a machine/pipework.  
Use of silencers to minimise air noise at exhausts.  
Use of low noise air nozzles, pneumatic ejectors and cleaning guns.  
Matching air supply pressure to needs of air powered equipment.  
Optimising the design of fans, fan casings and compressors.

#### Modification of the routes by which noise reaches workplaces

Reverberation.  
Use of sound absorbing material to control reflections.  
Use of silencers to reduce noise transmitted along pipes/ducts.  
Use of anti-vibration mountings under machines and non-rigid couplings.  
Use of full or partial enclosure of machines.  
Local use of screens faced with sound-absorbing material.  
Use of “noise refuge”.

#### Use of distance and time to minimise noise exposure

Relocate noisy fans/exhausts/compressors away from people.  
Use of remote control or automated equipment to minimise noise exposures.  
Segregation of noisy areas and limit to essential personnel.

## **5.2 Control of noise generated by administrative means**

Good housekeeping.

Planning.

Maintenance.

General good management.

The necessity of noise reduction measures for machines, tools, plant and equipment to be considered at the design stage.

The preparation of a specification outlining acceptable noise levels generated by new equipment particularly where the noise may affect personnel.

## **5.3 Hearing protection**

Description of various types available.

Performance attenuation.

Individual variability in attenuation, mean attenuation, standard deviation and assumed protection including calculations.

Evaluation of performance against workplace noise spectra.

Selection of protection - weight, cost, comfort, adjustability.

Explanation of when and why protectors are necessary.

Limitations of ear protectors (partial use in noisy areas).

## **Educational Objectives**

The student should be aware of the standard noise control techniques, including their limitations and be able to select the appropriate ear defenders for specific situations.

## **6. INTRODUCTION TO ENVIRONMENTAL NOISE (10%)**

### **6.1 Propagation of sound**

Sources of environmental noise e.g factory and machinery emissions, traffic, trains, aircraft.

Attenuation with distance, spherical wavefronts and point sources, inverse square law, free field radiation.

Propagation of noise from line source.

Effects of wind, temperature gradients, humidity and precipitation, absorption by natural features - ground absorption, air absorption and absorption by vegetation.

### **6.2 Instrumentation**

Sound level meters with Ln facility.

Noise data loggers, environmental analysers.

Tape recorders - data recorders and analogue, dynamic range.

Frequency analysis octave, third octave, narrow band.

Protection of instrumentation, temperature, wind, humidity.

calibration requirements.

### **6.3 Measurement and assessment**

Protocol in BS 4142:1997 (8)

Selection of measurement locations.

Understanding specific noise level LAeq and background noise LA90

Measurement periods. Sources of errors and variation in measured levels.

Influence of environmental conditions. Consideration of tonal components

Reporting protocol and presentation.

## **Educational Objectives**

The student should gain a basic understanding of environmental noise assessment, be aware of the errors and variations in environmental noise measurements and be cognisant of current instrumentation for environmental assessments. The student should, with guidance, be able to undertake simple environmental studies, but where Abatement Notices have been served under EPA 1990, reports by the student may have to be reviewed until experience is gained.

## **7. INTRODUCTION TO THE ASSESSMENT AND CONTROL OF VIBRATION (10%)**

### **7.1 Monitoring instruments**

#### **Vibration transducers**

Piezoelectric accelerometer.

Also aware of existence of proximity probes and velocity pick-up.

#### **Meters**

Elements of a general purpose vibration meter.

Also awareness of swept filter frequency analyser and fast Fourier transform analyser.

### **7.2 Making a survey**

#### **Assessment of the Risk to Health caused by whole body vibration**

Requirements of the Control of Vibration at Work Regulations 2005

Type of equipment in use

Equivalent acceleration value.

Frequencies of the vibration.

Direction of excitement of the vibration.

Time of exposure to vibration.

Assessment without measurement – use of manufacturers' information, subjective judgement

#### **Assessment of the Risk to Health caused by exposure to hand-arm vibration**

Requirements of the Control of Vibration at Work Regulations 2005

Type of equipment in use

Frequency weighted RMS acceleration value.

Probability of developing white finger syndrome.

Assessment without measurement – use of manufacturers' information, subjective judgement

### **7.3 Exposure limits for vibration**

The Control of Vibration at Work Regulations 2005

ISO 2631:1997 (9) Guide for the evaluation of human exposure to whole body vibration.

Guide to measurement and evaluation of human exposure to vibration transmitted to the hand ISO 5349-1:2001(E) (10).

## **7.4 Control of vibration**

### **Whole-body vibration damping**

Use of suspension system for vehicles.  
Use of suspension system for seats of vehicles with stiff suspensions.  
Decrease operator's exposure time by job rotating.

### **Hand-arm vibration damping**

Damping of tool internally.  
Insertion of damping between tool housing and hand.  
Remote operation of tool.  
Decreasing operator's exposure by job rotation.

## **Educational Objectives**

The student should have a basic understanding of the measurement and control of vibration, including what instruments are used, the relevant exposure limits, but they need not have the practical experience to enable them to carry out a vibrations survey.

## **8. LEGISLATION (10%)**

### **8.1 Noise**

Health and Safety at Work etc Act 1974.  
The Control of Noise at Work Regulations 2005.  
Guidance on the Control of Noise at Work Regulations 2005 (L108-2005).  
Management of Health and Safety at Work Regs.1999 (risk assessment).  
Supply of Machinery (Safety Regs) 1992.  
Provision and Use of Work Equipment Regs 1998 (suitability, maintenance, information and training).

### **8.2 Vibration**

The Control of Vibration at Work Regulations 2005  
Guidance on the Control of Vibration at Work Regulation 2005 – Hand-Arm Vibration (HSE L140-2005)  
Guidance on the Control of Vibration at Work Regulation 2005 – Whole Body Vibration (HSE L141-2005)  
Management of Health and Safety at Work Regs.1999 (risk assessment).  
Supply of Machinery (Safety Regs) 1992.  
Provision and Use of Work Equipment Regs 1998 (suitability, maintenance, information and training).

### **8.3 Environment**

Environmental Protection Act 1990.  
Abatement Notices in respect of statutory Nuisance S80.  
Noise and Statutory Nuisance Act 1993.  
BS 4142 1997, and limitations (8)  
Code of Practice for noise control on construction and demolition sites, BS 5228 1997, parts 1-4 (11).

## Educational Objectives

The student should have a knowledge of the main UK legislation pertaining to the protection of workers from noise and pollution/nuisance created by noise, and vibration. including any applicable EC legislation.

## References

- (1) HES Guidance Note MS26, A Guide to Audiometric Testing Programmes
- (2) BSEN ISO 2631-4:2001. Guide to the Evaluation of Human Exposure to Whole Body Vibration
- (3) BS6472:1992 Guide to the Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80 Hz)
- (4) BSEN 61672-1:2003 Electroacoustics. Sound Level Meters. Specifications
- (5) BS EN 61252:1997 Electroacoustics. Specifications for personal sound exposure meters
- (6) BS 7580:1997 Specification for the Verification of Sound Level Meters
- (7) HSE Guidance Note HSG138 (1995). Sound Solutions. Techniques to Reduce Noise at Work
- (8) BS4142:1997 Method of Rating Industrial Noise Affecting Mixed Residential and Industrial Areas
- (9) ISO 2631-1:1997 Mechanical Vibration and Shock, Evaluation of Human Exposure to Whole Body Vibration – Part 1 General Requirements
- (10) ISO 5349-1:2000 (E). Mechanical Vibration – Measurement and Evaluation of Human Exposure to Hand-Transmitted Vibration – Part 1. General Requirements
- (11) BS 5228:1997 Parts 1-4 Code of Practice for Noise Control on Construction and Open Sites