Unit - 4

Measurement of Energy

Units of Measurement

How is energy measured? It is measured in various units by various industries or countries in much the same way as the value of goods is expressed in Dollars in the U.S. and Yen in Japan and Pounds in Britain.

The table below identifies different units for measuring energy.

Different Units for Measuring Energy

Unit	Definition	Used In	Equivalent to
British Thermal Unit BTU	A unit of energy equal to the amount of energy needed to raise the temperature of one pound of water by one degree Fahrenheit. Equivalent to energy found in the tip of a match stick.	Heating and Cooling industries	1 BTU = 1055 Joules (J)
Calorie or small calorie (calorie)	The amount of energy needed to raise the temperature of one gram of water by one degree Celsius.	Science and Engineering	1 calorie = 0.003969 BTUs
Food Calorie, Kilocalorie or large calorie (Cal, kcal, Calorie)	The amount of energy needed to raise the temperature of one kilogram of water one degree Celsius. The food calorie is often used when measuring the energy content of food.	Nutrition	1 Cal = 1000 cal, 4,187 J or 3.969 BTUs
Joule (J)	It is a smaller quantity of energy than calorie and much smaller than a BTU.	Science and Engineering	1 Joule = 0.2388 calories and 0.0009481 BTUs
Kilowatt Hour (kWh)	An amount of energy from the steady production or consumption of one kilowatt of power for a period of one hour.	Electrical fields	1 kWh = 3,413 BTUs or 3,600,000 J
Therm	A unit describing the energy contained in natural gas.	Home heating appliances	1 therm = 100,000 BTUs

Methods:

Various methods exist for assessing physical activity and energy expenditure, and each of them has advantages and limitations as summarized in Table. Understanding of these methods is important to

decide which method to use for the specific study context. The purpose of this review was to discuss the components of TEE and present different methods of physical activity and energy expenditure assessment, with emphasis on each method's advantages and limitations.

Table 1

Advantages and limitations of different methods for physical activity and energy expenditure measurement

Methods	Advantages	Limitations
DLW	• Highly accurate method, considered a gold standard for the measurement of TEE.	• High cost of the method (including the high price of DLW and expensive equipment for analysis).
	• Allows freedom of activity to participants.	• Expertise required for the personnel.
		• The method does not provide any specific details on physical activity.
Direct calorimetry	• It is the most accurate method for quantifying the metabolic rate.	• High cost of the method.
		• Subject confinement required for 24 hr or more.
Indirect calorimetry	• Accurate and non-invasive method.	• Relatively high cost.
	• Provides information on the metabolic fuels being combusted.	• Trained personnel needed for the method's correct use.
	• Allows the assessment of energy expenditure in the field environment.	
Accelerometry	• Objective measurement of physical activity.	• Inaccuracy of predictive equations to translate activity counts into energy expenditure, especially when used across

	• Can be used both in laboratory and field settings.	a range of various activities.
	• Non-invasive method and less burdensome to subjects.	
	• Relatively inexpensive.	
Heart rate monitor	• Objective tool for the measurement of physical activity and energy expenditure.	• Inaccurate in measuring sedentary and light activities.
	• Relatively low cost.	• Electrical or magnetic interference from common electrical devices.
	• Noninvasive and versatile method.	
	• Can be used both in controlled settings and in free living conditions.	
Pedometry	• Inexpensive and non-invasive method.	• Limited to measuring only walking activity.
	• Used to assess the most common activity (walking).	• Inaccurate for assessing the distance covered and energy expended.
	• Can motivate people to maintain physical activity.	
Self-report methods	• Low cost, allowing their use in studies with large sample size.	• Low accuracy and reliability, especially linked with their dependency on the participant's memory.
	• Low burden to subjects.	
	• Provide information on physical activity patterns.	

Noise and Vibration

Hand Arm Vibration

Regular exposure to vibration from hand-held tools or vibrating equipment can cause several kinds of injury to the hands and arms and can cause permanent damage. It is estimated that up to 300,000 working days are lost each year in the UK due to hand-arm disability related absences. Together these injuries are known as 'hand arm vibration syndrome'.

HSE provides information, knowledge and solutions to help protect your workers from hand arm vibration. Our services include measurement, analysis and research related to workplace vibration exposure, especially in demanding conditions requiring specialist measurement techniques. We have a wealth of experience and expertise in the assessment of hand arm vibration in most industrial environments, which enables us to develop effective vibration control strategies for our customers.

Our research provides information to standards bodies, and is incorporated into many British, European and international standards.

You can also draw on our expertise through the **training** that we deliver for managers and staff on awareness, management and control of hand arm vibration exposure.

Workplace Noise

Over one million workers in the UK are thought to be at risk of hearing damage from noise at work. Jobs that place people at risk are not just in heavy industry; they can be as varied as entertainment, textiles manufacture or forestry. We can help you to understand and tackle your workplace noise issues, particularly the more difficult or complex problems.

We have extensive experience of noise measurement. We measure and assess all types of workplace noise from machinery, tools, vehicles, audio headsets, or under crash helmets and hearing protectors. We also provide advice on hearing protection and assess the effectiveness of control measures.

HSE has worked with a wide variety of clients including the military, the police, motorcycle couriers and forestry workers. Our highly qualified scientists are members of the Institute of Acoustics and hold certificates of competency in workplace noise assessment. They also have extensive experience of investigating workplace accidents and take an active part in standards-making and research worldwide.

About Measuring Noise

Any machine that vibrates radiates acoustical energy that can be measured and quantified in three different ways:

1. **Sound pressure** is created when a sound source radiates a pressure wave, and until recently this was the most widely available means of gathering output data from a source.
2. **Sound intensity** is used to quantify how much noise is coming from a source (sound power per unit area), and to construct a map indicating magnitude and vector direction of acoustic energy.
3. **Mechanical vibration** can be measured to identify and quantify the transmission paths of vibration induced noise.

Noise Measurement and Control Techniques

Different noise measurement and control techniques are available and applicable depending on the source and characteristics of the noise.

Frequency Spectrum: Every noise or vibration has its own frequency characteristic or fingerprint. Some are annoying and some can be damaging. PAMI can quickly and effectively identify and source the frequencies that should be eliminated.
Intensity Mapping: Once the characteristics of the noise are identified, PAMI can localize the critical noise emission areas as well as quantify the noise. Identifying critical areas provide a focus for a solution.
Priority Determination: By isolating and prioritizing critical locations of noise emissions, maximum benefit can be realized by attacking the worst offenders first.

Path Determination: Structural steel members act as an expressway for conveying noise. Any vibrating members can transfer sound over great distances, and this path needs to be broken to realize improvement. Specialized techniques can be used to differentiate between structure and airborne noise, and to identify the primary contributor. Once the path of noise is determined PAMI can assist in providing the best location and method of noise-path interruption.

Sound Power Measurement: Sound power is an important characteristic used increasingly to describe the sound emission from machines such as motors, fans, pumps, and hammer mills. PAMI's equipment is able to measure the sound power of a single machine, even within a noisy environment, by canceling out other external sounds.

Applications

PAMI can apply its noise and vibration testing and control program in several situations:

- Sound level readings in any noise environment
- Noise reduction programs in factories
- Vibration level readings of machines and mechanical equipment
- Vibration reduction programs of machines and mechanical equipment
- Specifications and standards testing of products
- Building and structural acoustics.

Benefits

Although the invisible nature of sound poses challenges in measuring and analyzing noise, the advanced technologies PAMI employs allow for accurately identifying the source and characteristics of noise, which help focus on design solutions.

The impact of design changes can be measured immediately, because PAMI's measurement equipment provides instant visual interpretation of noise. The equipment is fully portable to measure noise in any environment, and versatile for quick configuration to measure sound pressure, sound intensity, and mechanical vibration. PAMI's combined knowledge and advanced technology provide services to give clients the edge in the marketplace.