ILLUMINATION AND NOISE SURVEY IN MINES

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
in
Mining Engineering

By

AMIT CHATTOMBA

Roll: 10605039

Department of Mining Engineering
National Institute of Technology
Rourkela-769008
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Under the Guidance of

Prof. D.P. TRIPATHY

Department of Mining Engineering
National Institute of Technology
Rourkela-769008
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Rourkela

CERTIFICATE

This is to certify that the thesis entitled **"ILLUMINATION AND NOISE SURVEY IN MINES"** submitted by Sri **Amit Chattomba**, Roll No. 10605039 in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date:

(Prof. D.P. TRIPATHY)
Dept. of Mining Engineering
National Institute of Technology
Rourkela-769008

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Amit Chattomba

Roll No: 10605039

ABSTRACT

INTRODUCTION

Provision of suitable work environment for the workers is essential for achieving higher production and productivity in both surface and underground mines. Poor lighting and noisy working conditions have negative effects on the workers' morale and adversely affects their safety, health and performance. In order to assess the status of illumination and noise levels in mines, systematic illumination and noise surveys are needed to be conducted using appropriate statutory guidelines so that effective control measures can be taken up in mines. Keeping this in view, this project work was undertaken to carry out illumination and noise survey in few non-coal and coal mines of Orissa.

OBJECTIVES

- Understanding of the basic concepts of illumination and noise.
- To measure illuminance level of luminaries using a digital luxmeter in surface and underground coal/non-coal mines.
- To conduct noise survey in few opencast and underground coal/non-coal mines.
- To assess the adequacy of illumination and noise levels in mines vis-à-vis Indian standards.

ILLUMINATION AND NOISE SURVEY

Illumination survey was carried out at opencast mine of BSL Birmitrapur & Underground Coal Mines of MCL in Orissa, using Digital Luxmeter (Metravi1332).Similarly, noise survey was carried out in opencast mine of BSL Birmitrapur & Underground Coal Mines of MCL in Orissa, using Sound level meter (CEL 283). The results of studies were compared with the existing standards and due inferences were obtained.

CONCLUSIONS

The results obtained from illumination survey in mechanized unit of pathpahar mines of BSL reveal that at loading points, near crushers, mini crushers & dumping yards were adequate and are within the limits of Indian standards whereas illuminance levels in electrical substation, store room, rest rooms and electrical control rooms were inadequate.

From the survey results in underground coal mines of MCL, it was found that roadways were comparatively narrow and is not easy to illuminate uniformly because of limited height in underground. The excessive length of roadways in a mine below ground makes it uneconomical to provide lamps at all places; therefore, they are concentrated at places, which are most active i.e. pit bottoms, loading point etc. The illuminance level measured in inclined shafts & travelling roadways conveyance for man riding of Hirakhand Bundia mines were adequate.

The illuminance level measured in inclined shafts & travelling roadways in different levels of Nandira colliery, Talchir were fairly satisfactory. From the survey it was observed that most of the underground mines use florescent lights which provide better light distribution, longer lives, higher efficacy, better color concentration, and less glare potential.

Noise has become an integral part of mining environment. Introduction of more and more mechanization, powerful equipment is expected to increase more noise problems thereby inducing noise doses with associated physiological and psychological problems to the exposed populations. Repeated or prolonged exposure to excessive noise levels will lead to hearing impairment. Potential sources of noise emissions include compressors, drilling machines, crushers, or other mechanical equipment used at a mine. Wherever possible, such noise sources should be muffled with an effective acoustic absorbing material so as to reduce noise emissions to tolerable levels. Increasing the distance between the noise source and the listener is often a practical method of noise control. Where such noise control measures are not possible, comfortable and practical personal hearing protection devices, such as approved ear plugs or ear muffs, should be worn by every person exposed to noise levels exceeding 90 dBA.

The results obtained indicated that the sound pressure levels of various machineries used in Pathpahar mines of BSL, & underground coal mines of MCL were higher than the acceptable limits (>90dB (A)). In the mines under study, most of the mine workers were exposed to SPL (sound pressure level) beyond TLV (90dBA) due to machinery noise. Therefore, control measures should be adopted in mines for machinery as well as hearing protection aids should be supplied to the workers in order to protect the mine workers from NIHL (Noise induced hearing loss) & to keep the environment safe.

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INTRODUCTION

The provision of adequate illumination and the need to ensure a safe visual working environment is a challenge faced by almost all mining industries. Lighting in mines presents special problems because of the dark surroundings and low reflectance. In opencast mines where work is being carried out at night shifts, effective illumination is required to achieve production and safe operation of various machinery at different work areas. Open-cast mines cover a large area and continually change their shape as mining proceeds. Lighting provision is mainly important in the underground coal mining industry as there is no natural light, and large machines operate in a confined, dusty and a potentially explosive environment.

Noise that is defined as unwanted sound has been a source of discontent ever since people began living together. The problem has been further aggravated by the rapid industrialization consequent upon technological advancements to meet the ever increasing demand of industrial products. So far as mining industry is concerned, the noise pollution is not new. The introduction of mechanization has undoubtedly accentuated the noise problem. Mining by opencast methods has become most favorable due to its high productivity, economic viability, better safety, higher conservation, etc. The availability of large diameter drills and various types of explosives facilitate use of hundreds of tonnes of explosives to break the overburden rocks as well as coal. In pit crushing system with mobile crusher and large capacity coal handling plants are being installed. All these activities are major sources of noise pollution.

The advancements in underground mining technology, higher capacity of underground projects and mechanized shaft sinking and drilling activities are being undertaken for exploitation of deep seated reserves which need planning of large output mines with their captive mineral handling plants, coal washeries, thermal power plants, etc. Noise is generated from various machineries deployed underground for drilling, loading and transportation activities and often exceeds permissible noise levels of 90dBA. All these generate high levels of noise within the mine premises as well as in the surrounding localities/ residential areas.

In order to assess the status of illumination and noise levels in mines, systematic illumination and noise surveys are needed to be conducted using appropriate statutory guidelines so that effective control measures can be taken up in mines. Keeping this in view, this project work was undertaken to carry out illumination and noise survey in few non-coal and coal mines of Orissa.

Objectives of the Project:

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CHAPTER: 02

LITERATURE REVIEW

CHAPTER -02

LITERATURE REVIEW

2.1 ILLUMINATION IN MINES

2.1.1 PHOTOMETRIC TERMINOLOGIES

- **Light Physics**

Two major systems of units are currently used for the quantification of light: illumination Engineering society (IES) and international systems of units (SI). The primary difference between IES and SI systems is that the IES system uses US standard measures for linear dimensions .In the unit definitions while the SI system uses metric measures.US coal mine lighting regulations customarily use IES units.

All standard systems of light units employ certain fundamental concepts that are based on the convenient and meaningful approaches to light energy measurement and quantification .These basic concepts are luminous flux, illumination (illuminance), luminous intensity, and luminance.

- **Luminous flux**

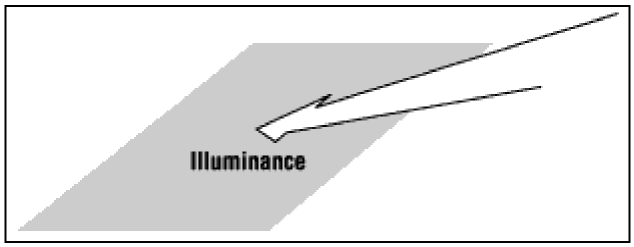
The luminous flux symbol is Ø, and the lumen (lm) is the flux unit n used in both the IES and SI systems. Luminous flux is the time flow rate of light energy. Flux is a power quantity in the same manner as horsepower. The unit of luminous flux, the lumen, is most frequently used to describe the lighting power of light sources.

- **Lumen (unit)**

The lumen (symbol: **lm**) is the SI unit of luminous flux, a measure of the perceived power of light. Luminous flux differs from radiant flux, the measure of the total power of light emitted,
in that luminous flux is adjusted to reflect the varying sensitivity of the human eye to different wavelengths of light.

- **Illuminance**

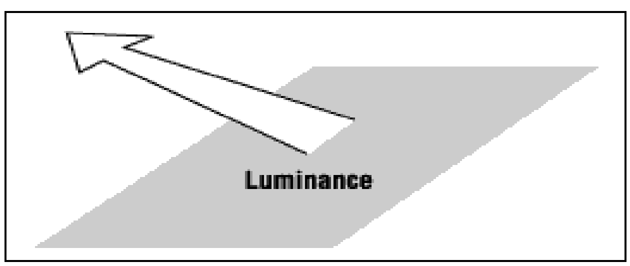
Illuminance is the amount of light falling on a surface. The unit of measurement is lux (lx) and lumen /min^2 the SI system (or lumens per square meter = 10.76 foot candles, fc). A light meter is used to measure it. Readings are taken from several angles and positions.



(Source: http://www.ccohs.ca)
Figure 2.1 Illuminance

- **Luminance**

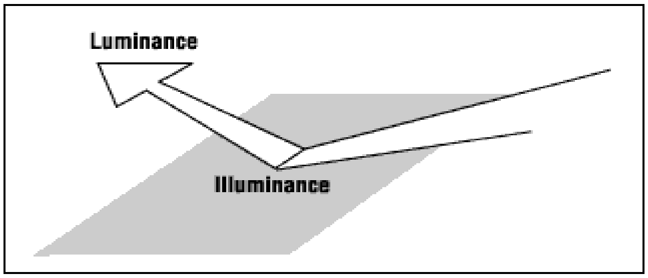
Luminance is the amount of light reflected from a surface. The unit of measurement is candela per square metre (equals 0.29 foot-lamberts). An illuminance meter is used to measure it. Several measurements are made and averaged. Luminance tables are consulted for reference values.



(Source: http://www.ccohs.ca)
Figure 2.2: Luminance

- **Reflectance:**

This is the ratio of reflected luminous flux to incident luminous flux. In other words, the ratio of light energy reflected from a surface to the amount striking it. Objects with higher levels of reflectance will appear brighter than those of lower reflectance under the same lighting conditions.

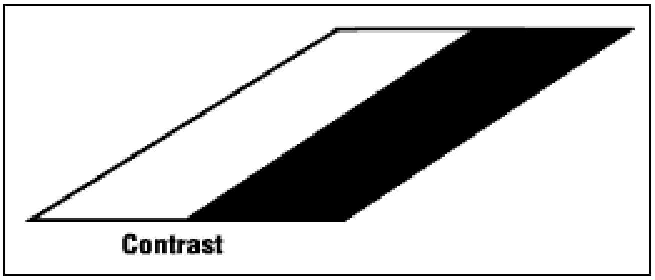


(Source: http://www.ccohs.ca)

Figure 2.3: Reflectance

- **Contrast:**

The relative difference in luminance between two adjacent surfaces. In other words, how bright one surface looks compared to the other or the background against which it is being viewed.



(Source: http://www.ccohs.ca)

Figure 2.4: Contrast

- **Glare**

There are two types of glare: disability glare and discomfort glare .Disability glare is defined as glare resulting in decreased visual performance and visibility. The cause is stray light which enters the eye and scatters inside. This produces a veiling luminance over the retina, which has the effect of reducing the perceived contrast of the objects being viewed. Discomfort glare causes fatigue and pain caused by high and non-uniform distributions of brightness in the observer's field of view.

- **Luminaire**

The complete lighting assembly, less the support assembly. For purposes of determining total light output from a luminaire, lighting assemblies which include multiple unshielded or partially shielded lamps on a single pole or standard shall be considered as a single unit.

- **Differences between lumens and lux**

The difference between the unit's lumen and lux is that the lux takes into account the area over which the luminous flux is spread. A flux of 1000 lumens, concentrated into an area of one square metre, lights up that square metre with an illuminance of 1000 lux. The same 1000 lumens, spread out over ten square meters, produce a dimmer illuminance of only 100 lux.

- **Horizontal Illuminance**

The measure of brightness from a light source, usually measured in foot-candles or lumens, which is taken through a light meter's sensor at a horizontal position on a horizontal surface.

- **Vertical Illuminance**

The measure of brightness from a light source, usually measured in foot-candles or lumens, which is taken through a light meter's sensor at a vertical position on a vertical surface.

- **Uniformity Ratio**

It describes the uniformity of light levels across an area. This may be expressed as a ratio of average to minimum or it may be expressed as a ratio of maximum to minimum level of illumination for a given area.

- **Direct Illumination**

Illumination resulting from light emitted directly from the lamp, off of the reflector or reflector diffuser, or through the refractor or diffuser lens, of a luminaire.

- **Flood or Spotlight**

Any light fixture or lamp that incorporates a reflector or a refractor with a diffusing glass envelope to concentrate the light output into a directed beam in a particular direction.

- **Lighting Fixture**

The assembly that houses the lamp or lamps and can include all or some of the following parts:
a housing, a mounting bracket or pole socket, a lamp holder, a ballast, a reflector or mirror, and/or a refractor or lens.

- **Full Cutoff Light Fixture**

A luminaire light distribution where no light is emitted above the horizontal, and where the intensity at 80 degrees from nadir is no greater than 100 candela per 1000 lamp lumens.

- **Height of Luminaire**

The height of a luminaire shall be the vertical distance from the ground directly below the centerline of the luminaire to the lowest direct-light-emitting part of the luminaire.

2.1.2 EFFECTS OF LIGHTING ON HUMAN HEALTH AND PSYCHOLOGY

Medical research on the effects of excessive light on the human body suggests that a variety of adverse health effects may be caused by light pollution or excessive light exposure, and some lighting design textbooks use human health as an explicit criterion for proper lighting. Health effects of over-illumination or improper spectral composition of light may include: increased headache incidence, worker fatigue, medically defined stress, and increase in anxiety. Common levels of fluorescent lighting in offices are sufficient to elevate blood pressure by about eight points. Specifically within the USA, there is evidence that levels of light in most office environments lead to increased stress as well as increased worker errors. The case against light pollution is strengthened by a range of studies on health effects, suggesting that excess light may induce loss in visual acuity, hypertension, headaches and increased incidence of carcinoma.

2.1.3 LIGHT AND VISION RELATIONSHIPS

This section addresses the visual needs of the worker, which are the ultimate basis for illumination design. These needs are defined by (1) the requirements for optimal functioning of the visual sensory system, and (2) the light needed to establish an appropriate level of visibility necessary for safe, efficient work performance. The lighting design process begins by carefully determining these needs. Then practical, technical, and economic factors are considered in establishing an appropriate system design. It identifies the visual needs of coal miners and indicates, in general terms, what can be done to accommodate those needs. First, the functions of the eyes and the rest of the visual sensory system are examined. Then, various environmental factors that affect the visibility of surroundings.

2.1.3.1The Eye and its Function

The eye (fig.2.5**)** is the organ of sight. It senses the light that enters it and acts as the first processor of this light. It then provides this information to the brain information for determination of the form, size, shape, color, position, and motion of the objects in view. To understand how light and vision interact, it is helpful to consider the eye as a mechanism made up of two subsystems: (1) the light control system and (2) the receiver- decoder system. The parts of each system are outlined in the following tabulation.

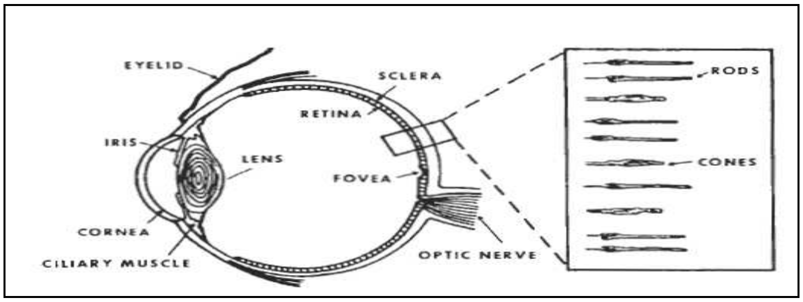
Table 2.1: Parts of light control & receiver-decoder system

Light control system	***Receiver-decoder system***
Eyelid	Retina and its photoreceptors, Which are the rods and cones
Cornea	
Iris-pupil.	
Lens and its ciliary muscle.	

(Source: www.cdc.govnioshminingpub.9073.pdf)

2.1.3.2 Parts of the Light Control System

The light control system focuses light on the light sensitive surface of the eye and controls the amount of light to which the receiver decoder system is exposed. The parts of the light control system (see figure 2.5) are the- Eyelid: A flap of skin that covers and protects the eye. Under extreme brightness, it closes to reduce the amount of light entering the eye. Cornea: The clear, bulging, front portion of the sclera. It permits light to be transmitted into the eye and works in conjunction with the lens to focus light on the retina. Iris-pupil: The iris is the colored portion of the eye consisting of muscle tissue that extends over the lens. The iris defines the circular opening called the pupil (the pupil itself is not an actual structure). Light passes through the pupil to the lens. The iris automatically controls the size of the pupil and, therefore, acts as a diaphragm controlling the amount of light entering the eye. Lens-ciliary muscle: The lens is a flexible, transparent capsule surrounded by a ring of muscle tissue, called the ciliary muscle, directly behind the iris. The lens works in conjunction with the cornea to focus light on the retina. The ciliary muscle rounds or flattens the lens, thereby for objects at various distances from the eye.



(Source: www.cdc.govnioshminingpub.9073.pdf)
Figure 2.5: Parts of the eye

2.1.3.3 Parts of the Receiver-Decoder System

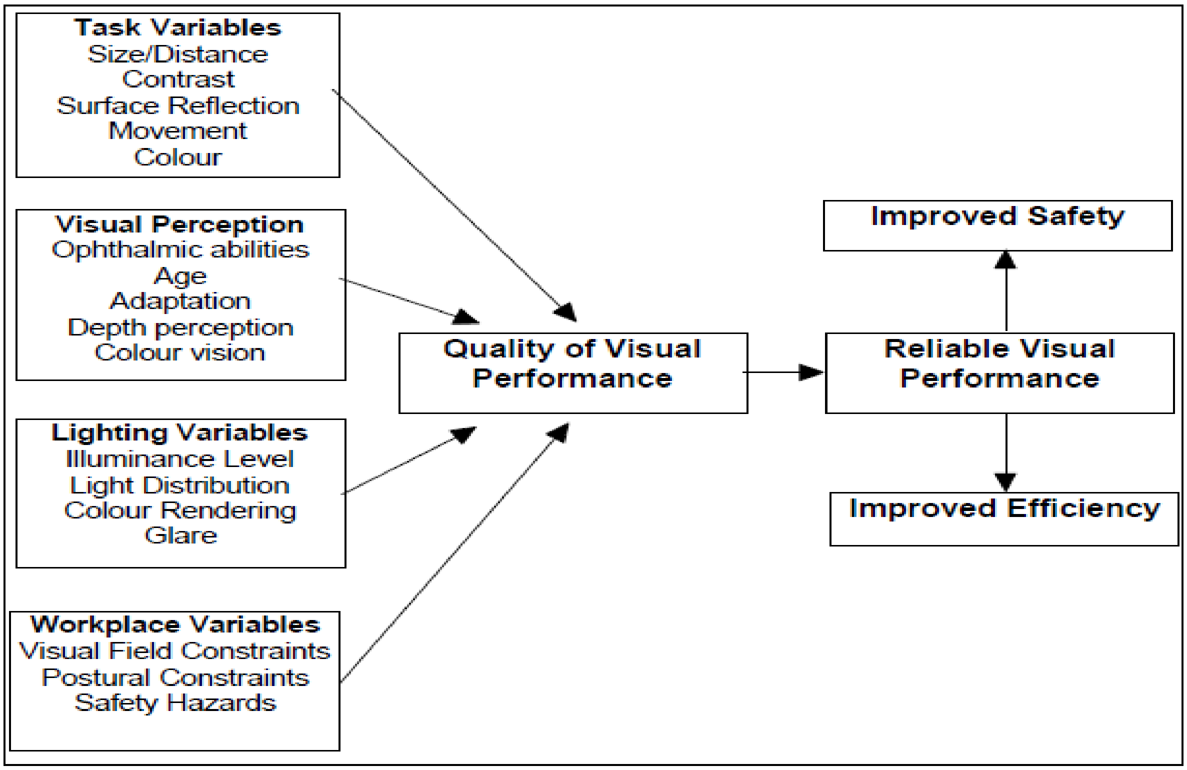
The retina is a thin sheet of nerve tissue that lines the back of the eye. Photoreceptors are specialized cells of the retina. The retina contains two types of photoreceptors rods and cones. The names are based on the shapes of these cells (figure 2.5). The functions of the rods and cones differ in many ways, as will be discussed. The receiver-decoder system uses the retina and its photoreceptors to (1) process characteristics of incoming light-brightness and color-and (2) pass this information on to the brain for final interpretation. This basic knowledge is extremely important to illumination designers so that they are aware of factors under their control that could impair or enhance these various functions, and they can take appropriate measures in their designs.

2.1.4 FACTORS AFFECTING VISUAL ENVIRONMENT

Levels of illumination are only one of the factors that determine the quality, and hence safety, of a visual environment. In coal mining, other factors that have been identified as affecting the overall quality of the visual environment are:

- inherent vision of the mine population
- low surface reflectance, usually less than 5%, which almost eliminates secondary reflections and indirect lighting;
- suspended dust and water vapor cause backscattering reducing apparent illuminance;

- mounting height restrictions and job tasks place the luminaries in the worker's direct line of sight causing glare;
- mounting positions restrict the size, location and light distribution of the luminaries;
- Luminaries must meet the safety requirements for use in hazardous atmospheres.



(Source: ECSC, 1990)

Figure 2.6: Major factors influencing visual environment and visual performance

2.1.4.1 Glare

Glare is a major problem in the coal mining industry. To decrease this, it is better to have lower powered lights with small distances between them, than to have high powered lights far apart. The following ways to reduce glare in the mining industry:

- Move Illuminance sources out of the direct field of view;
- Shielding of sources from direct view;
- Keeping differences in luminance between visible source and background small;

- Keeping background and source illuminance high;
- Position work and lighting properly;
- Avoid specular surfaces;
- Use light of the correct quality.

2.1.4.2 Reflectance

It is found that underground work environments differ significantly in surface luminance and reflectance, output of luminaries and types of visual impairment that are present. For a given illuminance, light levels and distribution can be enhanced by improving the reflectance of surfaces. Generally light colored surfaces reflect more light than dark colored surfaces. Some typical percentages of reflectance in coal mines are shown in Table 2.2:

Table 2.2 Reflectance of typical surfaces in Coal Mines

Surface	**Reflectance**
Coal	3-15%
Calcitic stone dust	59%
Dolomite Stone dust	9%
Rust	9%
Fresh whitewash	65-95%
Faded white wash	20-60%

As it can be seen from the above table, whitewashing a wall can increase its light reflecting ability considerably. Most underground mines make use of whitewash as a cost effective means of improving lighting performance, and the need to whitewash particular locations is required by legislation in some countries.

Similarly, stone dusting as well as being a safety measure for mitigating the effect of explosions, can also improve the reflectivity.

2.1.4.3 Contrast

In terms of providing a safe and efficient visual working environment, lighting levels do not address the problem fully. Detecting the presence of a potential hazard is probably the most common and also the most critical visual task in terms of ensuring safety (for example, the need for drivers to see pedestrians or other obstructions, the need for pedestrians to see slip, trip, fall hazards, etc.). In such situations, it is frequently the contrast between the visual target and the background that is most important in determining the reliability of hazard detection. However, with more light the eye can see more detail, hence less contrast is required.

2.1.4.4 Visibility

Determining what areas miners need to see in order to perform their job efficiently and safely are generally referred to as visual attention areas.

Poor sightlines are common to a large range of underground mobile machinery. A study in the United States (US Department of Labour, 1980) concluded that approximately 36% of the fatalities involving underground coal mine mobile equipment between 1972 and 1979 were directly or indirectly caused by improperly designed operator compartments.

2.1.5 LIGHT MEASURING TECHNIQUES AND INSTRUMENTATION

Instruments are required to evaluate lighting systems and components. The field of light measurement is called photometry, and the instruments used to measure lighting are called photometers. Many types of photometers are available to measure light energy and related quantities, including illumination, luminance, luminous intensity, luminous flux, contrast, color and visibility.

The photometer is one of the most important tools for illumination system design and evaluation. Specific uses for underground mine illumination system measurements are-

- Verification of compliance with illumination and luminance specifications in the regulations;
- Evaluation of illumination system design options;
- Calculation of reflectance of mine and mine simulator surfaces;
- Checking light distribution;
- Checking illumination reduction over time; and

- Evaluation of discomfort and disability glare.

In the underground mine lighting applications, the photometer is used to verify compliance with mine safety and health administration (MHSA) lighting regulations and in the design and evaluation of lighting systems.

Before taking measurements with a photometer, care must be taken to insure that a luminaire or illumination system is in the proper condition to satisfy the purpose of the measurements.

2.1.5.1 PORTABLE PHOTO ELECTRIC PHOTOMETERS

The portable photoelectric photometer consists of a photocell that receives light and converts it into an electrical signal that is conditioned through an electrical circuit and is displayed on a visual meter. The meter reading is proportional to the light energy level received by the photocell.

- **Photocell Characteristics**

Photocells used in portable photometers have been improved significantly in the past few years. New design photometers that utilize silicon photocell technology have distinct advantages when compared with selenium photocell photometers. Silicon photocells are more stable and exhibit a more uniform (linear) response in output with a change in light level.

- **Color Correction**

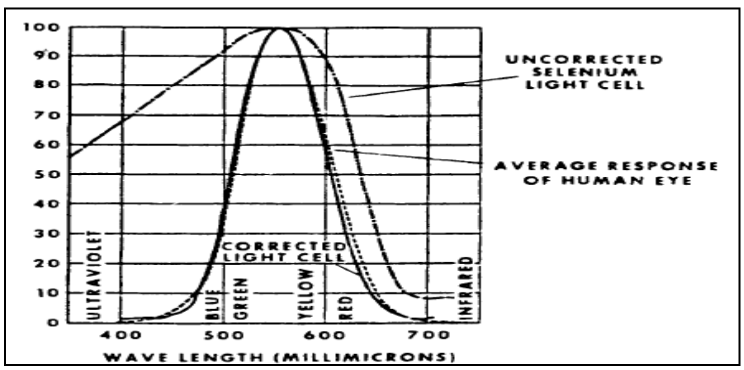
The response of the human eye (spectral luminous efficiency) for photopic (daylight) vision is shown in figure 2.7, along with the response curve for a typical uncorrected selenium photocell. The response of the cell differs significantly from that of the eye. This difference would cause a significant error in the measurement of visible light if the cell were not color corrected. This problem is corrected by the placement of filters on the surface of the photocell, which adjusts the response of the assembly to closely match that of the human eye. The response of a color-corrected photocell is also shown in figure 2.7.

- **Calibration**

Calibration is a method by which the response of a photometer is set to match a working standard. Probably the most significant source of error in illumination measurements is inaccurate instrument calibration. Photometers are particularly susceptible to loss of calibration and should always be checked both before and after any series of light measurements.

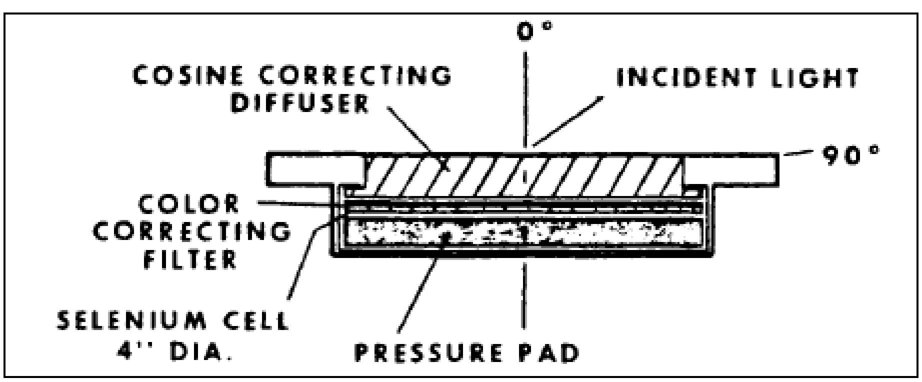
- **Cosine Correction**

The response of a photocell changes as the angle of light falling on its surface changes. At high angles of incidence, a greater portion of incoming light is reflected from the cell surface. This is because the reflectance of most surfaces increases as the angle of incidence increases. Errors in light measurement caused by these factors alone may be as much as 25 pct. The problem is corrected by placement of a diffusing cover over the photocell. This cover adjusts the level of light received by the cell to the correct proportion for various angles of incidence (fig 2.8).



(Source:www.cdc.govNioshminingpubspdfsic9074.pdf)

Figure 2.7: Function of color correcting filter on response of photocells.



(Source:www.cdc.govNioshminingpubspdfsic9074.pdf)

Figure 2.8: Diffusing cover for cosine correction on photometers.

- **Temperature and Humidity Effects**

Wide temperature variations effect the performance of photocells. Prolonged exposure of selenium photocells at temperature above 120 ºF (49ºC) will permanently damage them. Silicon photocells are less susceptible to temperature variation when compared with selenium photocells.

- **Sensitivity**

Illumination and luminance levels in underground coal mines are very low. A meter with high sensitivity and accuracy permits the very necessary fine tuning of lighting systems needed to meet the stringent lighting regulations.

- **Calibration**

Calibration is a method by which the response of a photometer is set to match a working standard. Probably the most significant source of error in illumination measurements is inaccurate instrument calibration. Photometers are particularly susceptible to loss of calibration and should always be checked both before and after any series of light measurements.

- **Contamination**

In mines, dust can rapidly accumulate on the photo detector surface and diminish measurement accuracy. Moisture and dust can enter photometer enclosures and cause movement corrosion or wear. These factors can easily affect the accuracy and useful life of an instrument. Photometers should be kept in a well sealed case and, to avoid contamination.

- **Photometer Zeroing**

It is important to check photometer zeroing prior to taking measurements. If an analog meter is used, this requires setting the meter reading to zero with the photocell completely covered. It should be verified that the meter remains correctly zeroed, when the photometer scale selector is changed.

2.1.5.2 PHOTOMETRIC MEASUREMENTS

Photometric measurements in mines are of three types: illuminance measurement, Luminance measurement, and reflectance measurement.

2.1.5.2.1 Illuminance measurement

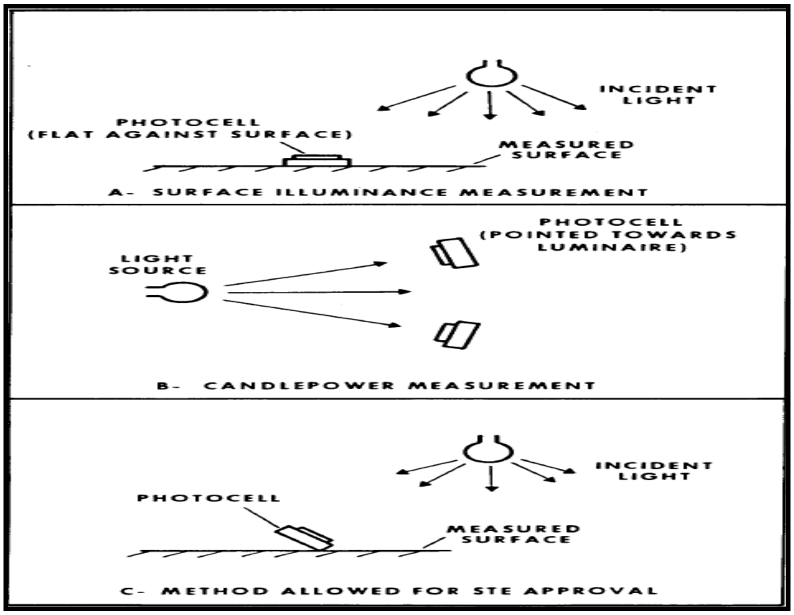
This process measures the incident light (in lux) received by a surface. Most countries specify their lighting standard in lux, so this method is most widely used in mine surveys .Three different techniques can be used in mine illumination surveys:

i. Direct planar measurement
ii. Separate measurements for direct and diffused light
iii. Maximum reading method

In the planar measurement method, the general illuminance level of the work place is measured using photocell photometer. The photometer is laid on the surface and readings are taken on points at regular intervals.

In the second method, Separate determinations of the quantity of light reaching the measuring point directly from the source and the light reaching the same point after one or more reflections from the walls and roof are made .The illuminance due to direct light is measured by pointing the photocell toward the lamp and masking all other light sources. The reading obtained is then resolved normal to the surface and the reading noted is then corrected by using a calibration curve.

In the maximum reading method: in this method the photocell is pointed at the light source and the reading is normally resolved to the plane being considered. The resolved component is assumed to be the illuminance at the point of measurement.



(Source:www.cdc.govNioshminingpubspdfsic9074.pdf)

Figure 2.9: Photocell orientation for making illumination measurements

2.1.5.2.2 Luminance measurement

The photometer is aimed at the surface to be measured. Luminance measurements state that the photometer shall be held approximately perpendicular to the surface being measured. They also require that the sensing element be at a sufficient distance from the surface to allow the light sensing element to receive reflected light from a field not less than 3 ft^2 nor more than 5 ft^2.

2.1.5.2.3 Reflectance measurement

Design of mine illumination requires a thorough knowledge of reflectance of the rock surface in the mine. Four different methods are employed. These are

i. Incident –reflected light comparison
ii. Standard chips comparison
iii. Reflectance standard comparison
iv. Sphere reflectometry

In the first method, a photometer is placed about 0.1 m from the surface and a reading of the luminance is given off by the surface is recorded. The meter is then turn around and the incident light is measured .The reflectance is then calculated as the ratio of reflected to incident light.

Accurate measurements of the reflectance of surfaces such as a coal face can be a complex task because, when a surface is not a diffuser, the reflected flux can be scattered non-uniformly. Methods for the measurement of the reflectance of coal surfaces are briefly discussed in the following paragraphs. No standard method has been established for the measurement of coal reflectance.

2.1.5.3 INSTRUMENTATION FOR MEASURING ILLUMINANCE

(source: http://www.metravi.com/1332.html)

2.10 Digital Luxmeter

❖ **Features**

- CE Approval
- With Lux and fc rwo units select function
- With PEAK/DATA HOLD function
- Cosine corrected: f'2 <3%
- Display with backlight

❖ **Specifications**

- Display: 3 1/2 digit liquid display (LCD) with maximum reading of 1999
- Over range: (OE) is displayed

- Low battery indication: the  is displayed when the battery voltage drops below the operating level
- Measurement Range: 2.5 times per second, nominal
- Operating Environment: 0°C to 50°C (32°F to 122°F) at < 70% relative humidity
- Accuracy: Stated accuracy at 23°C ± 5°C (73°F ± 9°F) < 70% relative humidity
- Battery: standard 9V battery (NEDA 1604, IEC 6F22 006P)
- Battery life: 200 hours typical with carbon zinc battery
- Dimensions: 190mm (H) x 65.5mm (W) x 35mm (D)
- Weight: 210g including battery
- Photometric Formulas:

  10.764 foot candles = lux (lumens / meter2)

  0.0929.lux = foot candles (lumens / foot2)
- Range: 200lux, 2000lux, 20klux, 200klux, 200fc, 2000fc, 20kfc, 200kfc
- Resolution: 0.1lux, 0.1fc
- Spectral Response: Metravi photopic (The Metravi photopic curve is an international standard for the color response of the average human eye)
- Acceptance Angle: f2 < 3% cosine corrected (150°)

  Total accuracy for Metravi standard illuminant A(2856K) ± (3% rdg + 10 dgts)

  The Metravi standard illumination A can be realized by means of Metravi standard source A, which is defined as : A gas-filled tungsten-filament lamp operating at a correlated color temperature of 2856K
- Temperature Coefficient: 0.1x (specified accuracy) / °C (<18°C or > 28°C), 0.056x (specified accuracy) / F° (<64.4°F or 82.4° F)
- Peak hold response time: > 50mS pulse light

2.1.6 ASSESSMENT OF WORLD-WIDE VISIBILITY STANDARDS

A review of current world-wide illumination standards and guidelines in coal mines was undertaken to assess their applicability to the conditions in the coal mining industry. Where lighting levels are specified in legislation or standards, the method of specifying actual levels of lighting varies from country to country. The majority specify levels in terms of illuminance.

2.1.6.1 International Mining Legislation

- **South Africa**

In South African mines, the statutory requirement for illumination and lighting is given in Chapter 15 of the Minerals Act, 1991. Within this, Regulation 15.1 states that all persons working in non-illuminated areas shall carry a light; Regulation 15.2 states that 'adequate' lighting should be provided at various locations underground, such as shaft stations and loading areas; Regulation 15.3.1.States that the moving parts of certain types of machinery shall be 'clearly visible' and Regulation 15.3.2.Specifies a minimum illumination requirement of 10 lux at a distance of 20m for all self-propelled mobile machines.

- **United Kingdom**

The statutory regulation behind lighting in UK coal mines is still the Coal and Other Mines (Safety Lamps and Lighting) Regulations 1956 .Within this, Regulation 17.1 states that it is the duty of the Manager to: - "secure the provision and maintenance of suitable and sufficient lighting at the following places below ground at all times: -

- shaft or outlet entrances and sidings which are regularly used;
- top and bottom of inclines that are regularly used;
- sidings, landings, pass-byes, junctions off-takes, places where vehicles are regularly coupled or are attached to a haulage rope, and places where vehicles are regularly filled mechanically;
- motor and engine houses",

And that such arrangement must be "arranged so as to minimise eyestrain and glare". Section 23 of the same regulations also states particularly areas underground where the roof and walls should be whitened. These include the shaft stations, top and bottom of every incline and every siding, junction and pass-bye.

- **Australia**

The current New South Wales Regulations in Australia, [the Coal Mines (Safety Lamps and Lighting - Underground Mines) Regulations, 1984] are very similar to UK legislation. Here, Section 31 puts duties on the Manager to provide 'suitable and sufficient' fixed lighting at specified places underground, and again states that such lighting shall be arranged to minimise glare and eye strain.

- **India**

Standards of underground lighting in India

Good visibility is essential for work persons carry on any job in a safe and efficient manner .Regulations 151 of CMR, 1957 and Reg.146 of MMR ,1961 require adequate general lighting to be provided at specified places both on surface and in underground .It also requires that the lighting provided in a mine shall as far as possible be so arranged as to prevent glare or eye strain .In terms of Reg.154(2)b of CMR ,1957 ,the Director General of Mines Safety may, form time to time by notifications in the official Gazette specify the standard of lighting to be provided in any specified area or place in a mine.

Table 2.3: Minimum standards recommended for underground lighting

Place	Minimum average illumination level lux
(a) pit bottoms	15-30
(b)Main junctions	12.5
(c) Roadways	4
(d)Haulage engines, control gear and haulage drum	15

(Source: CMR, 1957)

The roof and side should be properly white- washed and stone dusted on the floor as required under the statue to achieve the illumination to the standards for providing necessary visibility for safe and efficient work at different places.

The standard of lighting in depillaring area should be at less 1.5 lumens/Sq.ft at the floor level .Suitable flood lighting may be arranged by 4 or more 250 W bulbs with reflector (matt surface) in degree I gassy mine .In degree II and III gassy seams a cluster of 15 to 20 cap lamps should be placed on suitable stand in the area in addition to individual lights.

Table: 2.4 Standard of illumination at certain places

Sl. no	Place /Area	Minimum	
1.	At the bottom of a sinking shaft	10 Lux	Vertical
2.	At the mechanized quarry face	15 Lux	Horizontal
3.	At coal depot where wagons are loaded	10 Lux 3 Lux	Vertical Horizontal
4.	At fully mechanized longwall face	10 Lux	Vertical

(Source: Ghatak.S (1997), A study of mine management legislation and general safety .chapter 3, pp-103)

Lighting standards for opencast mines

The general lighting scheme of an opencast mine generally connected to common power source. The electric power failure may occur at any time when the whole area may be plunged in absolute darkness which may lead to an accident .Individual lights may, therefore, be provided to individual workers in addition to the general lighting scheme in the opencast mines.

The very high benches ,up to 45m high ,made by draglines or other heavy earth moving machinery (HEMM) are very difficult to keep properly illuminated .It may become difficult to pinpoint the places require dressing ,from the working points over the draglines or Shovels .Moving flood lights, akin to the hunters search light on the boom of the draglines or on the bucket of the shovels ,may be mounted and these flood lights may be rotated at will lighting up every nook and corner of the high benches.

Table 2.5: The minimum standards recommended for Opencast mines:

Sl.no	Place /Area to be illuminated	Manner in which it is to be illuminated	Minimum standard of illumination (Lux)	Plane level in which the illumination to be provided
I.	General working area as determined by the manager in writing	-	0.2	At the level of surface to be illuminated
II.	Work place of heavy machinery	So as to cover the depth and height through which the machine works	5.0 10.0	Horizontal Vertical
III.	Area where drilling rig works	So as to illuminate the full height of the rig	10.0	Vertical
IV.	Area where bulldozer or other tractor mounted machine works	-	10.0	At the level of crawler tracks
V.	Places where manual work is done	To be provided at level of the surface on which work is done	5.0 10.0	Horizontal Vertical
VI.	Place where loading or unloading or transfer ,loading of dumpers ,trucks or train is carried on	-	3.0	Horizontal
VII.	Operators cabin of machines or mechanism	To be provided upto a height of 0.8m from floor level	30.0	Horizontal
VIII.	At hand picking points along conveyor belt	To be provided upto a distance of not less than 1.5m from picker	50.0	On the surface of conveyor belt

IX.	Truck hauling roads	To be provided at the level of the road	0.5 to 3.0	Horizontal
X.	Rail haulage track in the pit	To be provided at the level of the rail heads	0.5	Horizontal
XI.	Roadways and footpaths from bench to bench	-	3.0	Horizontal
XII.	Permanent paths for use of persons employed	-	1.0	Horizontal

(Source: Ghatak.S (1997), A study of mine management legislation and general safety .chapter 3, pp-104)

- **United States**

The US regulations are probably the most prescriptive in terms of specifying illumination requirements. Provision 75.1719-1(d) of the Codes of Federal Regulations (Mine Safety & Health Administration, 1988) states that: "The luminous intensity (surface brightness) of surfaces that are in a miner's normal field of vision of areas in working places that are required to be lighted shall not be less than 0.2 cd/m² [0,6 foot lamberts].

2.1.6.2 Illumination Standards

In order to expand or clarify legislative requirements, the Inspectorate and/or mining companies of some countries have provided guidance or recommended illumination levels of different areas and operations underground.

Good visibility is essential for work persons to carry on any safe job in a safe and efficient manner. Defining appropriate illumination levels for underground coal mines is a complex task.

Table 2.6 demonstrates the level of variation across countries for each of the specified areas and operations. In considering health and well being, Odendaal (1997) states that the recommended minimum light level for general underground work is 54 lux, higher than many of the values in the Table 2.6.

Table 2.6: Summary of International Illumination Levels (in lux)

	Shafts	Loading	Around Machines	Haulages	Headings	u/g workshop
Belgium	20-50	20	25	10		
Hungary	40-100	40-60	20-50	2-10		20-50
Canada (British Columbia)	21			21	53	
Poland	30	30	10	2-10	5-15	30
UK (British Coal)	70	30		2.5		50-150
European Coal & Steel Community	40-90	15-80		5-15	10-30	
West Germany	30-40	40	80	15		
Czechoslovakia	15	20	20	5		
South African Gold Mines	20-160	160		20		400

(Source: ECSC, 1990; MVS, 1992; Piekorz, 1997)

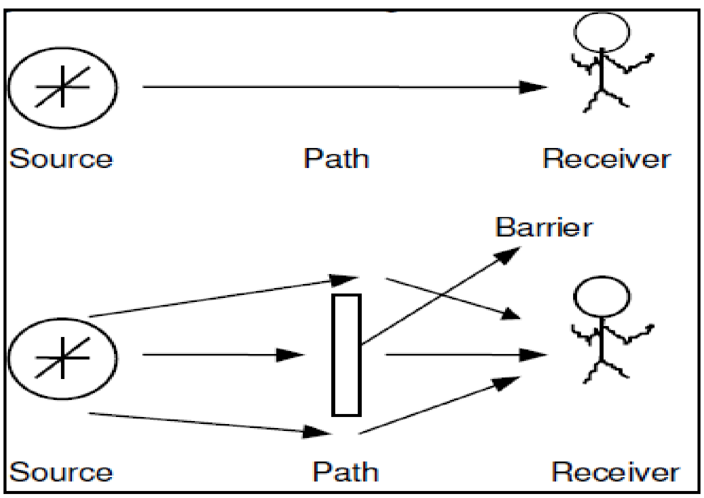
2.2 NOISE SURVEY IN MINES

2.2.1 TERMINOLOGIES OF NOISE

- **Sound and Noise**

Sound is what we hear. Noise is unwanted sound. Sound is a form of energy which is emitted by a vibrating body and on reaching the ear causes sensation of hearing through nerves. Sounds produced by all vibrating bodies are not audible. The frequency limits of audibility are from 20 HZ to 20,000 HZ.

A noise problem generally consists of three inter-related elements- the source, the receiver and the transmission path. This transmission path is usually the atmosphere through which the sound is propagated, but can include the structural materials of any building containing the receiver.



(Source : http://discovery.bits-pilani.ac.in)

Figure2.11: Inter-relationship between the elements of noise

Noise may be continuous or intermittent. Noise may be of high frequency or of low frequency which is undesired for a normal hearing. The discrimination and differentiation between sound and noise also depends upon the habit and interest of the person/species receiving it, the ambient conditions and impact of the sound generated during that particular duration of time.

- **Decibel**

The decibel (dB) is a logarithmic unit of measurement that expresses the magnitude of a physical quantity (usually power or intensity) relative to a specified or implied reference level. Since it expresses a ratio of two quantities with the same unit, it is a dimensionless unit. A decibel is one tenth of a bel, a seldom-used unit.

The decibel can be expressed as: **decibel = 10 log (P / P_{ref})** **(1)**

Where **P** = signal power (W) **P_{ref}** = reference power (W)

- **Sound Power Level**

Sound power is the energy rate - the energy of sound per unit of time (J/s, W in SI-units) from a sound source. Sound power can more practically be expressed as a relation to the threshold of hearing - 10^{-12} W - in a logarithmic scale named Sound Power Level - L_w:

$$\mathbf{L_w = 10 \log (N / N_o)} \quad \mathbf{(2)}$$

Where, **L_w** = Sound Power Level in Decibel (dB) **N** = sound power (W)

- The lowest sound level that people of excellent hearing can discern has an acoustic sound power about 10^{-12} W, 0 dB
- The loudest sound generally encountered is that of a jet aircraft with a sound power of 10^{5} W, 170 dB.

- **Sound Intensity Level**

Sound Intensity is the Acoustic or Sound Power (W) per unit area. The SI-units for Sound Intensity are W/m^2.

The Sound Intensity Level can be expressed as: **L_I = 10 log (I / I_{ref})** **(3)**

Where **L_I** = sound intensity level (dB), **I** = sound intensity (W/m^2), **I_{ref}** = 10^{-12} - reference sound intensity (W/m^2)

- **Sound Pressure Level**

Sound pressure converted to the decibel scale is called sound pressure level (Lp). The zero of the decibel scale (0 dB) is the sound pressure of 0.00002 Pa. This means that 0.00002 Pa is the reference sound pressure to which all other sound pressures are compared on the dB scale. This is the reason the decibels of sound are often indicated as dB re 0.00002 Pa. The SI-units for the Sound Pressure are N/m^2 or Pa.

The Sound Pressure Level:

$$\mathbf{L_p = 10 \log(p^2 / p_{ref}^2) = 10 \log(p / p_{ref})^2 = 20 \log (p / p_{ref})} \qquad \textbf{(4)}$$

Where $\mathbf{L_p}$ = sound pressure level (dB) **p** = sound pressure (Pa) $\mathbf{p_{ref}}$ = 2 x 10^{-5} - reference sound pressure (Pa)

If the pressure is doubled, the sound pressure level is increased with 6 dB (20 log (2)).

- **A-weighted decibels**

The sensitivity of the human ear to sound depends on the frequency or pitch of the sound. People hear some frequencies better than others. If a person hears two sounds of the same sound pressure but different frequencies, one sound may appear louder than the other. This occurs because people hear high frequency noise much better than low frequency noise.

Noise measurement readings can be adjusted to correspond to this peculiarity of human hearing. An A-weighting filter which is built into the instrument de-emphasizes low frequencies or pitches. Decibels measured using this filter are A-weighted and are called dB(A). Legislation on workplace noise normally gives exposure limits in dB (A). A-weighting serves two important purposes:

1. Gives a single number measure of noise level by integrating sound levels at all frequencies

2. Gives a scale for noise level as experienced or perceived by the human ear.

- **Frequency analysis**

Frequency analysis is measuring noise level at each frequency or pitch. Frequency analysis is not required when the purpose of noise measurement is to assess compliance with regulatory exposure limits or to assess risk of hearing loss. For such purposes the A-weighted noise level in dB(A), percent noise dose or time-weighted average (TWA) equivalent sound level is sufficient. The frequency analysis is usually needed only for the selection of appropriate engineering control methods.

Sometimes it is necessary to determine the actual frequency distribution of the noise. A detailed frequency analysis is called narrow band analysis. In this method the entire audible frequency range is divided into frequency windows of fixed width of a few hertz and noise level is measured in dB units at each of these frequency windows. Narrow band analysis is normally not needed for workplace noise. Such analysis is used for engineering measurements. For workplace noise we need octave band analysis.

Octave bands are identified by their centre frequency. The band width increases as the centre frequency increases. The audible sound frequency range (approximately 20 to 20,000 Hz) has been divided into 11 octave bands for this purpose. An octave band filter set can be attached to an SLM to measure the sound level in each octave band.

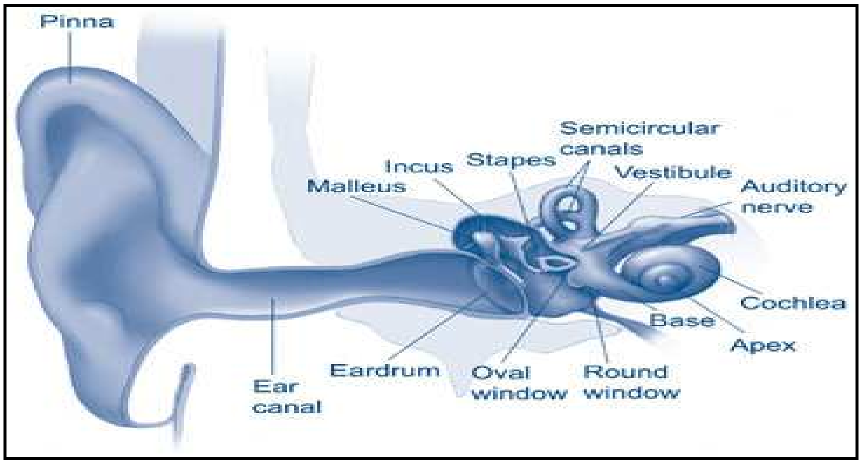
2.2.2 MECHANISM OF HEARING

The ear can be divided into three parts: the outer, middle, and inner ear (figure 2.12). Each of these parts plays a different part in transmitting sound to the brain. The outer ear collects sound waves and causes the eardrum to vibrate. The middle ear has three small bones (the hammer, anvil, and stirrup) connected to the eardrum. As our eardrum vibrates, these bones vibrate, too. The bones transmit their vibrations to the inner ear where they end up at a special snail-shaped structure called the cochlea. The cochlea is a rolled-up, tapered canal that is filled with fluid. The vibrations cause the fluid in the cochlea to vibrate (bend back and forth). This in turn causes tiny hair cells in your ear to vibrate. When the hair cells bend (vibrate), it is converted into an electrical impulse by the auditory nerve. The impulses travel along nerves to the brain, where they are translated into the sensation of hearing or sound.

The hair cells respond to noise vibrations in two basic ways:

1. Only certain hair cells bend to any particular frequency of sound. Thus, hair cells respond only to the frequency to which they are sensitive.

2. The amount of bending the hairs undergo depends on how much energy (decibels) the noise has—the greater the energy, the more bending that takes place (i.e., the louder the noise will sound).



(Source:www.nidcd.nih.gov/health/hearing/noise.asp)

Figure 2.12: The sound pathway

2.2.2.1 EFFECTS OF NOISE ON HUMAN HEALTH

How noise affects will depend upon how long we are exposed to a sound, the loudness of the sound, and the ability of our body to recover after that exposure.

- **Temporary threshold shift**

Temporary threshold shift (*TTS*) is a temporary loss of hearing. If we are exposed to a very noisy job, by the end of the shift we may have noticed a loss of hearing sensitivity. The greatest portion of temporary hearing loss occurs within the first two hours of exposure.

The hair cells in our inner ear become exhausted from the excessive noise exposure and require more energy (decibels) before they will bend and send nerve impulses to the brain. This effect is "temporary" because the hair cells get a chance to rest while we are away from work, and by the next morning, they have recovered their sensitivity. Recovery usually begins within one or two hours after being removed from the exposure. Full recovery from a TTS occurs within about 14 hours.

- **Permanent threshold shift**

Permanent threshold shift is a permanent hearing loss that is very similar to the pattern of temporary hearing loss, except that we do not recover. Some of the hair cells are physically destroyed by the constant pounding and bending, leading to nerve loss. The more exposure to loud noise, the more hair cells is destroyed. This eventually leads to total deafness. Permanent loss does not respond to any known treatment or cure.

- **Tinnitus**

Tinnitus is a ringing in the ears, similar to high-pitched background squealing with TVs and computers. It may accompany temporary and permanent hearing loss. Tinnitus is most noticeable in quiet conditions (e.g., sleeping at night) and may be a warning signal of permanent hearing loss.

- **Non-Auditory Effects**

Noise can affect more than just our hearing. First of all, the psychological effects of noise-induced hearing loss can be distressing Noise can be a major cause of stress, adding to nervousness and anxiety. Noise may increase the heart rate and raise blood pressure by constricting blood vessels. Noise exposure can produce a permanent increase in blood pressure leading to heart disease.

- **Presbycusis**

Presbycusis is a hearing loss as a result of aging. Its onset and the amount of damage vary among people. It usually begins around age 50. Some people may never have hearing loss from Presbycusis. Family/genetic factors influence the extent of the loss. Presbycusis can be accelerated by noise exposure.

2.2.3 NOISE MEASUREMENT

2.2.3.1 Planning noise measurement

Before taking field measurements, it is important to determine the type of information required. While making the measurement we must understand:

- The purpose of measurement: compliance with noise regulations, hearing loss prevention, community annoyance ,noise control, etc.,
- The sources of noise, and times when the sources are operating,
- Type of noise - continuous, variable, intermittent, impulse, and
- Locations of exposed persons.

The initial measurements are noise surveys to determine if

- noise problem exists and
- Further measurements are needed.

The second step is to determine personal noise exposure levels; that is, the amounts of noise to which individual employees are exposed. If the workplace noise remains steady, noise survey data can be used to determine employee exposures. However, noise dosimetry is necessary if the workplace noise levels vary throughout the day or if the workers are fairly mobile.

Note: It is recommended that prior to starting measurements the following check-list procedure is followed.

CHECKLIST

- Has a site plan been produced?
- Are all sections identified?
- Are all machines/processes correctly identified and located?
- Have all areas been classified for type of noise?
- Is the appropriate instrumentation available?
- Is the instrumentation in good working order?
- Are there sufficient batteries?

- Is the calibrator functioning properly?
- Have the instruments to be used been checked for calibration /response within the prescribed period?
- Are the conditions in the workplace representative of normal activity?
- Have all areas with noise levels above recommended limits been identified.

2.2.3.2 Noise measurement method

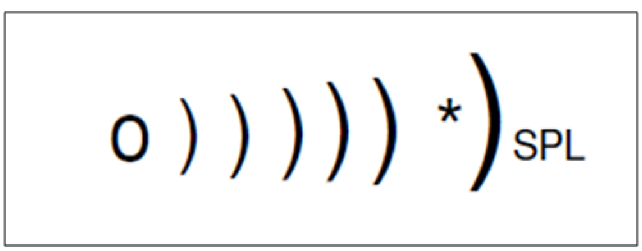
The intensity of sound is measured in sound pressure levels (SPL) and common unit of measurement is decibel, dB. The community (ambient) noise levels are measured in the A - weighted SPL, abbreviated dB (A). This scale resembles the audible response of human ear. Sounds of frequencies from 800 to 3000 HZ are covered by the A - weighted scale. If the sound pressure level, L1 in dB is measured at r1 meters, then the sound pressure level, L2 in dB at r2 meters is given by,

$$\mathbf{L2 = L1 - 20\ log10\ (r2/r1)} \qquad \textbf{(1)}$$

If the sound levels are measured in terms of pressure, then, sound pressure level, LP is given by,

$$\mathbf{LP = 20\ Log10\ (P/Po)\ dB(A)} \qquad \textbf{(2)}$$

The Lp is measured against a standard reference pressure, Po = 2 x 10-5 N/m2 which is equivalent to zero decibels. The sound pressure is the pressure exerted at a point due to a sound producing source (figure. 2.13).



(**Source:** http://www.minex.org.nzpdfSUR_Noise.pdf)

Fig. 2.13: Definition of sound pressure

2.2.3.3 Noise Measuring Instruments

The most common instruments used for measuring noise are the sound level meter (SLM), the integrating sound level meter (ISLM), and the noise dosimeter. It is important that we should understand the calibration, operation and reading the instrument when in use. Table 1 provides some instrument selection guidelines.

2.2.3.3.1 Sound Level Meter (SLM)

A Sound level meter is the simplest instrument available to determine noise levels. The meter usually contains the following basic elements: (1) a microphone to sense the sound-wave pressure and convert pressure fluctuations into an electrical voltage, (2) an input amplifier to raise the electrical signal to a usable level, (3) a weighting network to modify the frequency characteristics of the instruments,(4) an output amplifier,(5) a rectifier to determine the rms value, and(6) an indicating instrument to display the measured sound level. The response of the meter and the characteristics of the indicating instrument depend significantly upon whether the instrument is of type 1,2 , or 3.The SLM must be calibrated before and after each use. With most SLMs, the readings can be taken on either SLOW or FAST response. The response rate is the time period over which the instrument averages the sound level before displaying it on the readout. Workplace noise level measurements should be taken on SLOW response. Impulse characteristics and peak-hold features are sometimes provided as special features.

To take measurements, the SLM should be held at arm's length at the ear height for those exposed to the noise. With most SLMs it does not matter exactly how the microphone is pointed at the noise source. The response rate is the time period over which the instrument averages the sound level before displaying it on the readout. Workplace noise level measurements should be taken on SLOW response.

A Type 2 SLM is sufficiently accurate for industrial field evaluations. The more accurate and much more expensive Type 1 SLMs are primarily used in engineering, laboratory and research work. Any SLM that is less accurate than a Type 2 should not be used for workplace noise measurement.

An A-weighting filter is generally built into all SLMs and can be switched ON or OFF. Some Type 2 SLMs provide measurements only in dB(A), meaning that the A-weighting filter is ON permanently.

A standard SLM takes only instantaneous noise measurements. This is sufficient in workplaces with continuous noise levels. But in workplaces with impulse, intermittent or variable noise levels, the SLM makes it difficult to determine a person's average exposure to noise over a work shift. One solution in such workplaces is a noise dosimeter.

(Source: www.casellausa.com)

Figure 2.14: Integrating Sound Level Meter

- **Specification**

Accuracy: Sound level meter: IEC 651, BS 5969 and ANSI S1.4 in the type 2 category. DIN 45 634 Maximum RMS hold and energy average as Leq, Lim or LTm (3 or 6 second), 40dB dynamic range linear scaled meter.

Ranges: 30 - 70 dB, 60 - 100 dB and 90 - 130 dB Overload indicator provided.

Measuring Limits: Self-noise less than 25dB (A) or less than 40dB (Flat).135dB absolute maximum.

Microphone: 17 mm (0.67 inch) electret condenser type

Frequency Response: dB(A) or Flat

Display: 47 mm (1.9 inch) meter movement covering 40 dB dynamic range.

Time Weightings: Fast, Slow and Impulse as per standards.

Maximum Hold: Analogue hold of maximum RMS level with a decay rate of less than 1 dB/5 min at 20ºC.

LEQ Calculation: By means of 10msec samples of RMS level. Minimum measurement duration 1 second, maximum greater than 24 hours.

Calibration: Field calibration checks by means of CEL-184 or CEL-182 Acoustic Calibrators (NB coupler type CEL-3379 necessary for X version).

Auxiliary Output: 3.5 mm jack feed of conditioned AC output at 1.0V for FSD via 3k3 Ohms.

Batteries: 3 x 6 F22 (or equivalent) - 2 for sound level meter and one for calibrator.

Temperature Range: 10 to +50ºC operational. -15 to +60ºC storage.

Humidity Range: 30% to 90% for ±0.5 dB

Electromagnetic Interference :< MSD for 400 A/M

Vibration Interference :< 62d B (Flat) for 1 m/sec/sec

Dimensions: 235mm x 75mm x 54mm (9.2in x 3in x 2.1in)

2.2.3.3.2 Integrating Sound Level Meter (ISLM)

The integrating sound level meter (ISLM) is similar to the dosimeter. It determines equivalent sound levels over a measurement period. The major difference is that an ISLM does not provide personal exposures because it is hand-held like the SLM, and not worn. The ISLM determines equivalent sound levels at a particular location. It gives a single reading of a given noise, even if the actual sound level of the noise changes continually. It uses a pre-programmed exchange rate, with a time constant that is equivalent to the SLOW setting on the SLM.

2.2.3.3.3 Noise Dosimeter

A noise dosimeter is a small, light device that can be clipped to a person's belt with a small microphone that fastens to the person's collar, close to an ear. It stores the noise level information and carries out an averaging process.

A noise dosimeter requires the following settings:

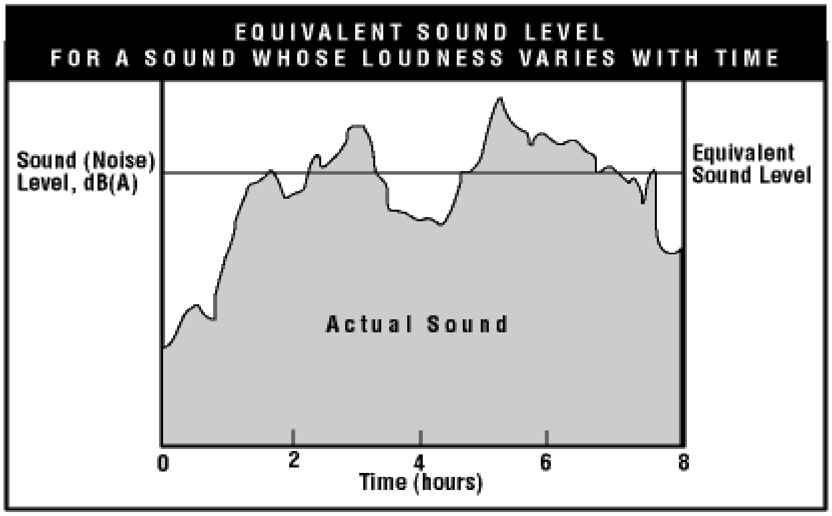
(a) Criterion Level: exposure limit for 8 hours per day five days per week. Criterion level is 90 dB(A) for many jurisdictions, 85 dB(A) for some and 87 dB(A) for Canadian federal jurisdictions.

(b) Exchange rate: 3 dB or 5 dB as specified in the noise regulation.

(c) Threshold: noise level limit below which the dosimeter does not accumulate noise dose data.

Wearing the dosimeter over a complete work shift gives the average noise exposure or noise dose for that person. This is usually expressed as a percentage of the maximum permitted exposure. If a person has received a noise dose of 100% over a work shift, this means that the average noise exposure is at the maximum permitted. For example, with a criterion level of 90 dB(A) and an exchange rate of 3 dB(A), an eight-hour exposure to 90 dB(A) gives a 100% dose. A four-hour exposure to 93 dB(A) is also a 100% dose, whereas an eight-hour exposure to 93 dB(A) is a noise dose of 200%.

Dosimeters also give an equivalent sound or noise level. This is the average exposure level for noise over the time dosimeter was on. It has the same total sound energy as the actual, variable sound levels to which a person is exposed over the same time period. Scientific evidence suggests that hearing loss is affected by the total noise energy exposure. If a person is exposed over an eight-hour work shift to varying noise levels, it is possible to calculate an equivalent sound level which would equal the same total sound energy exposure. This would have the same effect on the person's hearing as the variable exposure actually received (Figure 2.15).



(Source: http://www.ccohs.ca/oshanswers/phys_agents/noise_measurement.html)

Figure 2.15: The shaded area under the line that shows how the sound level changes over time (the "curve") represents the total sound exposure over eight hours.

(Source: www.niehs.nih.govhealthdocshearing-man.pdf)

Figure 2.16: Noise Dosimeter

Table 2.7: Guidelines for Instrument Selection

Type of Measurement	Appropriate Instruments (in order of preference)	Result	Comments
Personal noise exposure	1) Dosimeter	Dose or equivalent sound level	Most accurate for personal noise exposures
	2) ISLM*	Equivalent sound level	If the worker is mobile, it may be difficult to determine a personal exposure, unless work can be easily divided into defined activities.
	3) SLM**	dB(A)	If noise levels vary considerably, it is difficult to determine average exposure. Only useful when work can be easily divided into defined activities and noise levels are relatively stable all the time.
Noise levels generated by a particular source	1) SLM**	dB(A)	Measurement should be taken 1 to 3 metres from source (not directly at the source).
	2) ISLM**	Equivalent sound level dB(A)	Particularly useful if noise is highly variable; it can measure equivalent sound level over a short period of time (1 minute).
Noise survey	1)SLM	dB(A)	To produce noise map of an area; take measurements on a grid pattern.
	2) ISLM	Equivalent sound level dB(A)	For highly variable noise.
Impulse noise	1) Impulse SLM	Peak pressure dB(A)	To measure the peak of each impulse.
* SLM stands for Sound Level Meter ** ISLM stands for Integrating Sound Level Meter			

(**Source:** http://www.ccohs.ca/oshanswers/phys_agents/noise_measurement.html)

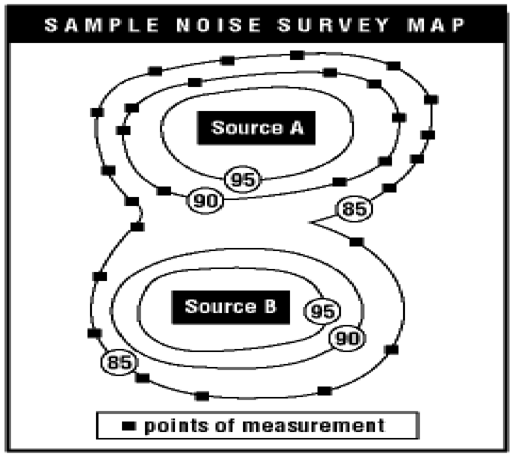
2.2.4 NOISE SURVEY

Many machines do not operate constantly or at a constant noise level. Exposure to noise varies due to mobility of workers, mobility of noise sources, variations in noise levels or a combination of these factors. Noise measurements should include max. and min, SPLs produced in dB(A) in any survey & all noise levels less than 80 db(A) may be ignored. If the survey indicates that worker is exposed to noise >115db(A) then he should be provided with hearing protection.

A noise survey takes noise measurements throughout an entire mines or section to identify noisy areas. Noise surveys provide very useful information which enables us to identify:

- Areas where employees are likely to be exposed to harmful levels of noise and personal dosimetry may be needed,
- Machines and equipment which produce harmful levels of noise,
- Employees who might be exposed to unacceptable noise levels, and
- Noise control options to reduce noise exposure.

Noise survey is conducted in areas where noise exposure is likely to be hazardous. Noise level refers to the level of sound. A noise survey involves measuring noise level at selected locations throughout an entire mines or sections to identify noisy areas. This is usually done with a sound level meter (SLM). A reasonably accurate sketch showing the locations of workers and noisy machines is drawn. Noise level measurements are taken at a suitable number of positions around the area and are marked on the sketch. The more measurements are taken, the more accurate the survey. A noise map can be produced by drawing lines on the sketch between points of equal sound level. Noise survey maps, like that in Figure 2.11 provide very useful information by clearly identifying areas where there are noise hazards. The SLM must be calibrated before and after each use.



(Source:http://www.ccohs.ca/oshanswers/phys_agents/noise_measurement)

Figure 2.17 Sample of noise survey map

2.2.5 NOISE STANDARDS/ GUIDELINES

2.2.5.1 Ambient Noise Standards

Noise (ambient standards) published in the Gazette No. 643 dt 26.12.89, succeeded by The Noise pollution (Regulation and Control) rules, 2000 (Gazette of India, vide SO123(E), dated 14.2.2000 and subsequent amended vide SO 1046(E) dated, 22.11.2000).

Table 2.8: The Noise pollution (Regulation and Control) rules, 2000

Area Code	Category of Area	Limits in dB (A) Leq	
		Day Time	Night Time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence zone	50	40

(Source: http://www.cpcb.nic.in/divisionsofheadoffice/pci2/noise_rules_2000)

Note-1: Day time reckoned in between 6.00 am to 9.00p.m

Note 2: Night time reckoned in between 9.00p.m. to 6.00am

Note 3: Silence zone is defined as areas up to 100 meter around such premises as Hospitals, Educational institutes, and Courts. The Silence zones are to be declared by the competent authority.

Note 4: Mixed categories of areas should be declared as "one of the four above mentioned categories" by the Competent Authority and the corresponding standards shall be applied.

2.2.5.2 Work Place Noise Standards

DGMS Circular No.18 (Tech), 1975 A warning limit of 85-dB (A) may be set as the level below which very little risk to an unprotected ear of hearing impairment exists for an eight-hour exposure.

* The danger limit value shall be 90-dB (A) above which the danger of hearing impairment and deafness may result from an unprotected ear.

* A worker should not be allowed to enter, without appropriate ear protection, an area in which the noise level is 115-dB (A) or more.

* Personal protective equipment shall be worn, if there are single isolated outbursts of noise, which can go above 130-dB (A) "Impulse", or 120-dB (A) "Fast". ¨ No worker shall be allowed to enter an area where noise level exceeds 140-dB (A).

2.2.6 NOISE CONTROL

A. Generation, Transmission and Reception.

Before steps are taken to develop noise control solutions, the problem should be analyzed in terms of; the source of the noise, the pathway of transmission and the receivers being exposed.

B. Identify the Source - Frequently, a single piece of mining equipment will combine several individual sources of noise.

C. Determine the Transmission Pathways - Sound can be propagated over long distances through structures and noise from individual sources may reach the receiver through different pathways.

D. Consider the Receivers - Consider options on the amount of exposure to the noise rather than the noise itself

E. Distance Considerations - Sound, which propagates from a point source in free air, attenuates (reduces by) 6 dB for each doubling of the distance from the source. Sound propagating in an enclosed space is attenuated less than this value, because of contributions to the sound level brought about by reflection from walls and ceilings.

F. Addition of Noise from Several Sources - Noises from different sources combine to produce a sound level higher than that from any individual source. Two equally intense sources operating together produce a sound level that is 3 dB higher than one alone. Note that decibels cannot be directly added, as they are logarithmic values.

G. Sound Insulation - When a sound meets a wall or partition, only a small proportion of the sound energy passes through as most is reflected.

H. Sound Absorption - Sound energy is absorbed whenever it meets a porous material. Porous materials that are intended to absorb sound are called sound absorbents and they absorb between 50 to 90% of the incident sound energy.

2.2.6.1 NOISE CONTROL - ADMINISTRATIVE CONTROLS

A. Administrative controls may include the following:

a. Avoiding purchasing hazards by adopting a "buy quiet" policy, there is a growing demand for quieter plant and manufacturers are responding to this.

b. Establishment of job procedures that will reduce employee exposure e.g. Job Rotation.

c. Planned plant maintenance specifically for noise control.

d. Setting targets for noise levels in existing work areas.

e. Cover off noise management in employee induction and training.

f. Cover off noise control in work agreements with contractors.

g. Protection of visitors on site.

h. Monitoring employees by initial audiogram and regular repeats.

i. The use of warning signs.

j. The use of hearing protection related to designated hearing protection areas.

2.2.6.2 NOISE CONTROL – ENGINEERING CONTROLS

A. When attempting to attenuate noise, it should be borne in mind that noise radiates from most machinery as both airborne and as structure-borne sound at the same time.

B. Enclosure of Machines - Where it is not possible to prevent or reduce the noise at its source, it may be necessary to enclose the entire machine. A relatively simple sealed enclosure can reduce noise by 15 to 20 dB(A).

C. Attenuation of Structure-Borne Sound - Preventing transmission of vibration from machines to the load-bearing structure can considerably reduce structure-borne sound:

a. Large heavy machines should be mounted on foundations which are completely separated from buildings or other structures

b. Place other machines on a stable foundation and where possible use an elastic separation such as rubber blocks or steel springs.

D. Severely vibrating machines may require separate foundations and isolation joints between floor slabs to prevent propagation of structure-borne noise.

E. Attenuation by Using Absorbents - Hard surfaces on the ceiling, floor and walls of an enclosed processing plant or workshop will reflect back nearly all the sound reaching them.

F. Sound Insulated Rooms - Cabins should be constructed of materials with good sound attenuation properties and ideally will have:

a. Double glazed windows - (two 6 mm glass panes with 50 mm air space can give 10 dB(A) attenuation).

b. Ventilation openings with attenuators such as acoustic louvers.

d. An adequate air conditioning system, to avoid doors being left open.

2.2.6.3 NOISE CONTROL – HEARING PROTECTION

A. Hearing protection is not an acceptable alternative to noise control – but there are circumstances where this is likely to be the only option.

B. As part of a hearing protection programme, employers need to consider:

a. The need for hearing protectors;

b. Defining hearing protector areas;

c. Selection of hearing protectors

d. Issuing of hearing protection to individuals;

e. Cleaning, maintenance and replacement of hearing protectors;

f. Training and education of people wearing hearing protectors.

Ear Muffs

Ear muffs for construction look like stereo headphones (Figure 2.12). They have soft plastic cushions that are filled with foam or liquid. These cushions provide a seal around the entire ear. Attenuation is less likely to vary with ear muffs than with ear plugs. Ear muffs have better attenuation at lower frequencies than most plugs. Ear muffs and plugs can be worn together for extra protection if noise is high enough (>105 dB). Attenuation will not be doubled, but will increase by about 5 to 10 dB.

(Source: www.niehs.nih.govhealthdocshearing-man.pdf)

Figure 2.18: The examples of ear muffs are the E-A-R's Model 100 (left) and Howard Leight® Model LM-7H (right)

CHAPTER: 03

ILLUMINATION AND NOISE SURVEY IN MINES: CASE STUDIES

3.1 ILLUMINATION AND NOISE SURVEY IN PATHPAHAR DOLOMITE QUARRY: CASE STUDY

3.1.1 INTRODUCTION

- **Location:-**The Pathpahar Dolomite quarry of Bisra Stone Lime Company Limited is situated at Birmitrapur District-Sundargarh Orissa on NH-23 and towards North of Rourkela at a distance of 30 KM and it is well connected by rail also. The lease hold area is 1961.93 Acres or 793.966 Hectors falls between 22^o-15’ N to 22^o-30’N latitude and 84^0-30’E to 84^o-45’ E longitude in the SOI Topo-Sheet No.73/B/16.

- **Brief history:-**The Company started mining and operation of Lime Kiln at Birmitrapur in 1922. In the year 1962 after closing the limekiln it switched over to the production of flux grade limestone and dolomite to full fill the requirements of steel plants of eastern India. The company came under the Administrative Control of Government of India, Ministry of Steel, in the year 1980.
- **Geology: -** The rocks of this area belong to the Birmitrapur stage of the Gangpur series of middle Dharwarian age. All the rocks of this series are meta-sedimentary in nature. In the lease hold proper Limestone overlies Dolomite i.e. the limestone is younger than dolomite.

- **Mining Plan:-** For convenience of mining, the deposit has been divided into four mines, viz. Kaplas East, Kaplas West, Gurpahar and Patpahar. There are very low grade stones in between the limestone and dolomite bands which mean mining has to be carried out in a selective manner. The estimated reserves of limestone and dolomites are 375 MT and 265 MT respectively.

- **Limestone winning and transportation:-**Total limestone production is done by drilling & blasting with dumper loading and transportation system. Blasted coal is loaded by loaders on to dumpers and transported to the apron feeder of feeder breaker. Part of sizing in done on the mine site manually so as to obtain the apron feeder feed size. Further crushing is done in the crusher from which various product of different sizes are obtained and are then directly transported to the railway sidings and from there to the customers.

Figure3.1: Location of BSL Mines

(Source : http://wikimapia.org/)

Figure 3.2: Aerial view of Pathpahar Dolomite quarry

3.1.2 Illumination Survey

An illumination survey in the Pathpahar mines was conducted on 17.02.2010. Survey work was carried out at mechanized unit of Pathpahar crusher plant. The light sources used in Pathpahar crusher plant was generally Metal halide, high pressure sodium vapor lamps (HPSV) & Fluorescent tube lights (FTLs). The Approximate luminance of metal halide light is 10^5-10^6 cd/m^2 that of fluorescent type of light is 5×10^4-2×10^5cd/m^2 (clear bulb).The color retention of metal halide is good and excellent for Fluorescent light.

The lights were installed mainly near working areas like near crushers, mini crushers, weigh bridge room, bunkers, dumping yard where the operations of transportation works are active at night time. The lights installed in the Pathpahar crusher plant were of single sided arrangement & with irregular spacing.

The measurement employed in illuminance measurement survey was direct planar measurement. In this method, the general illuminance level of the workplace is measured using a photocell photometer. The photometer was laid on the surface and readings were taken on points at regular intervals. It was carried out through using an instrument called digital Luxmeter (Metravi 1332).
The results of illuminance level of light sources have been given in Table 3.1.

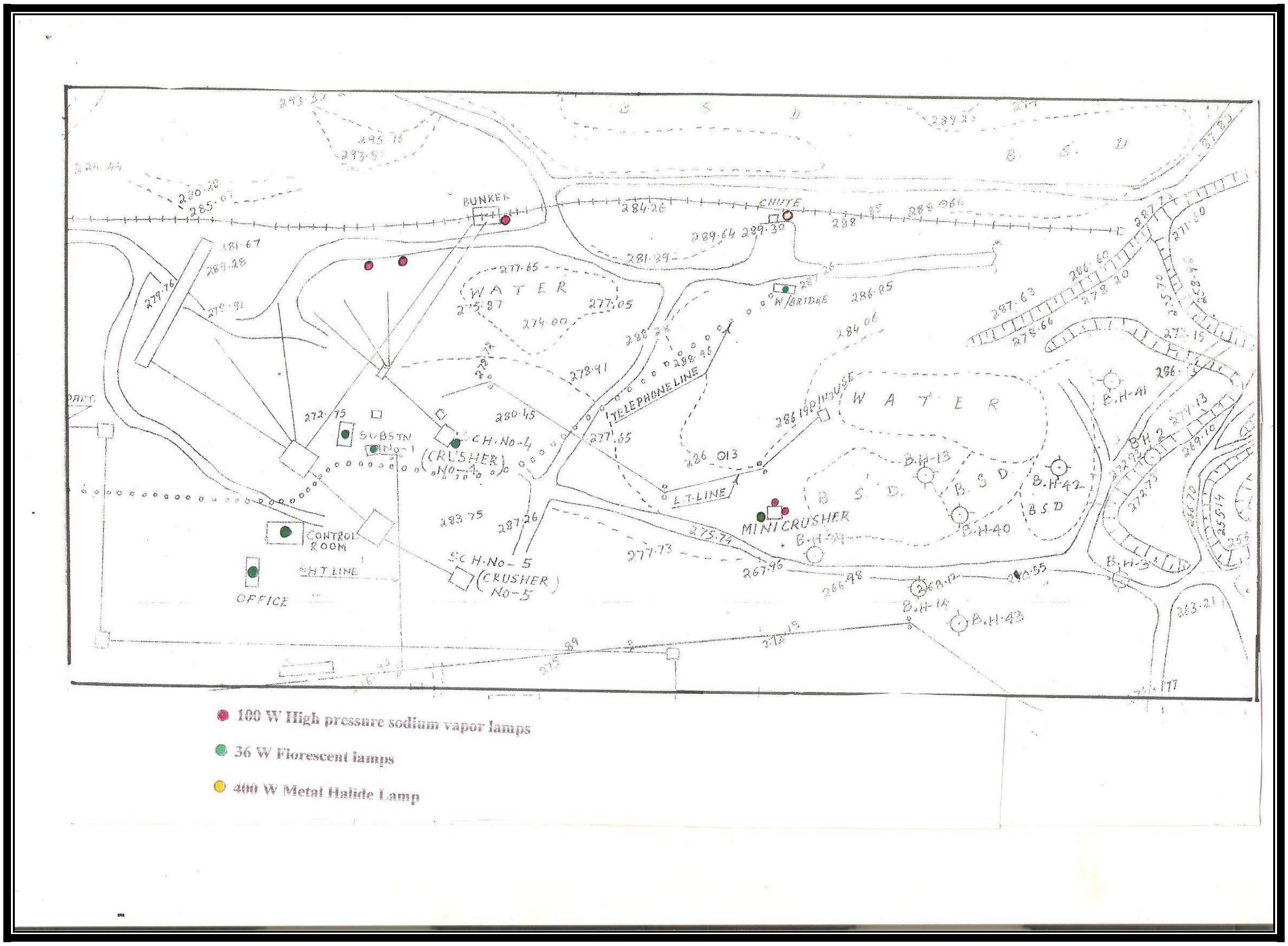


Figure 3.3: Location of light sources in Pathpahar mines

Table: 3.1 Illumination measurements at Pathpahar

Measurement Areas	Pole no.s	Light source	Make	Illuminance level (lux)	Remarks
Near mini crusher *No. of luminaries:3* *Ht. of poles:5m*	1	100 W HPSV	Philips	34.7 lux at 5m distance (horizontal)	Satisfactory
	2	100W HPSV	Philips	24.3 lux	Satisfactory
	3	2×36 W FTLs	Bajaj	26.9 lux at 5m distance	Satisfactory
Near main Crusher *No. of poles :1* *Ht.of pole:10m*	4	2×36 W FTLs	Bajaj	11.7 lux at 10m distance (vertical)	Satisfactory
Near Bunker *Ht of luminaire:5m*	5	70W HPSV	Bajaj	25.6 lux	Satisfactory
Dumping yard *No. of luminaries:2* *Ht. of poles:10m*	6	100 W HPSV	Bajaj	20.4 lux (vertical)	Satisfactory
	7	100 W HPSV	Bajaj	23.6 lux (vertical)	Satisfactory
Loading point *No. of luminaries:1* *Ht. of poles:10m*	8	400 W Metal halide	Philips	38.4 lux (vertical)	Satisfactory
Near weigh bridge *No. of luminaries:1* *Ht of poles:3m*	9	36 W FTLs	Bajaj	42.6 lux(vertical)	Satisfactory
Electrical substation room 11kv/433 V SCH 4 *No. of luminaries :2*		40 W FTLs	Bajaj	67.8 lux(vertical)	Unsatisfactory
Rest room *No .of luminaries:2* *Ht of luminaries:3m*		36 W FTLs	Philips	54.6 lux(vertical)	Unsatisfactory
Store room No. of luminaries: 3		36 W FTLs	Philips	52.6 lux (vertical)	
Electrical control room (SCH 5) Room no.1 *No. of luminaries: 4* *Ht.of luminaries:5m*		40 W FTLs	Philips	36.6 lux (vertical)	Unsatisfactory
Electrical control room (SCH 5) Room no.2 *No. of luminaries: 4* *Ht.of luminaries:5m*		40W FTLs	Philips	55.2 lux (vertical)	Unsatisfactory

3.1.3NOISE SURVEY

- **Description of the field experiments**

The field experiments were carried out at mechanized unit of Pathpahar dolomite quarry. The main noise sources at the projects were as follows: shovel, drill, main crushers, mini crushers, DTH, loader, belt conveyer, jack hammer drilling and compressor. The sound pressure levels of noise sources were taken at different distances of interval 1m from the source. In order to understand the noise effects on the workers' locations, management buildings and the areas in the vicinity of the mining and industrial plants, measuring of noise levels were carried out in Pathpahar dolomite quarry.

The distances between the sources and the receivers at all locations were changed during the fieldwork. The noise level was measured at a height of 1.6 m from ground level, 1 m from walls and 2 m from crossing to avoid the earth reflection of the sound waves. An averages of five values of noise level of each source were taken. While, the sound pressure level was measured at different distances from the noise sources.

- **Instrumentations**

The instrument used was a standard CEL -283 integrating impulse sound Level meter (U.K) .It measured noise levels produced both near the source and the operator's level covering a range of 40 -120 dB(A) and had a selectable A/ Flat frequency characteristics .Fast slow time constants and impulsive response. Workplace noise level measurements were taken on SLOW response. The A-network was used in the present work, which approximates the human response.

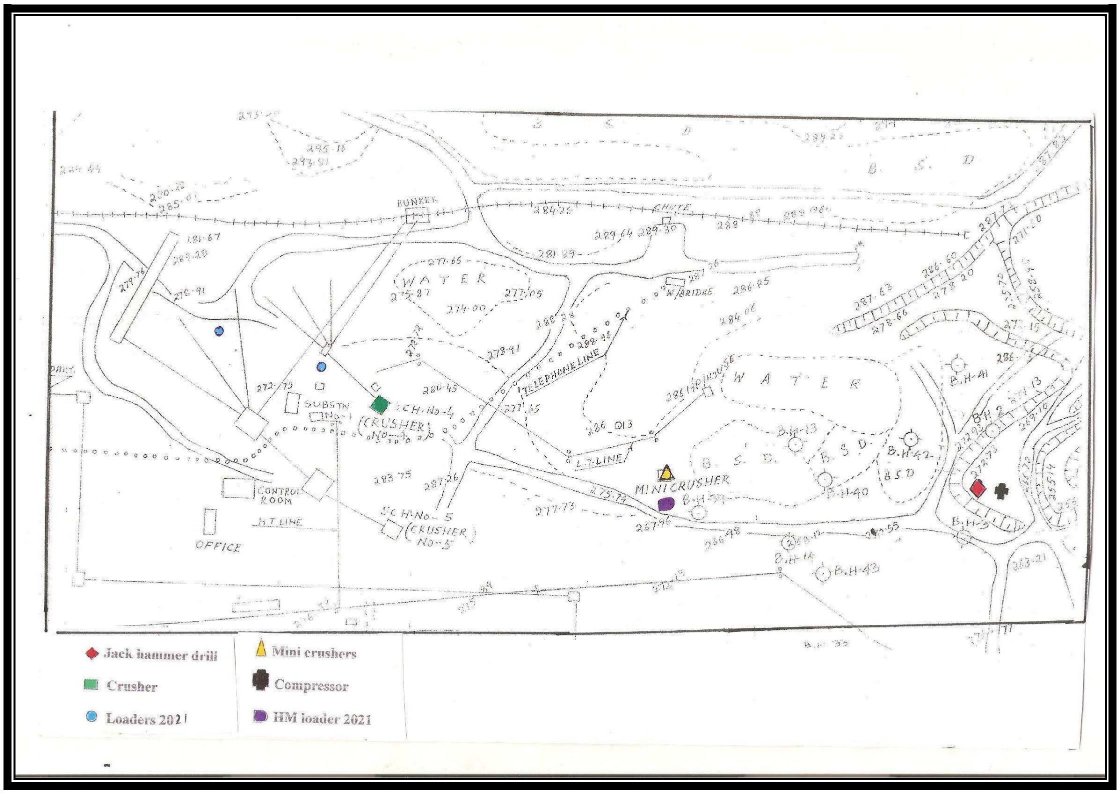


Figure 3.4: Location of noise sources in Pathpahar mines

Table 3.2: Distance of Measurements from Noise Sources in Pathpahar Mines

Noise Source	*Distance*	*Sound Pressure Level, dB(A)*
(SCH 4) CRUSHER	1m	117
	2m	117
	3m	116
	4m	115
	5m	114
Mini Crusher	1m	116
	2m	114
	3m	113
	4m	112
	5m	111
JCB 3D Loader Bucket capacity: 0.8 m^3 Power:50 hp	1m	111
	2m	111
	3m	110
	4m	108
	5m	107
JCB Loader Bucket capacity: 0.8 m^3 Power:50 hp	1m	111
	2m	110
	3m	109
	4m	107
	5m	106
Loader 2021 Make :Hindustan machines Bucket capacity: 1.7 m^3 Power : 124 HP	1m	109
	2m	108
	3m	107
	4m	106
	5m	105
Shovel PC 300 Make : L& T Komatsu Bucket capacity:1.4 m^3	1m	109
	2m	108
	3m	108
	4m	107
	5m	106

Noise sources	*Distance*	*Sound Pressure Level, dB(A)*
Jack Hammer Drill Make :Mine drilling Service Penetration rate:425mm/min RPM**:** 215 Impact/min :2000 Air requirement (at 6 Bar m^3/min-2.4)	1m	120
	2m	119
	3m	118
	4m	116
	5m	113
DTH Drill	1m	117
	2m	116
	3m	114
	4m	113
	5m	111
Compressor Make :Ingersoll rand H450 Cfm,100 Psi	1m	105
	2m	104
	3m	103
	4m	100
	5m	98
Belt conveyor	1m	90
	2m	87
	3m	84
	4m	82
	5m	80

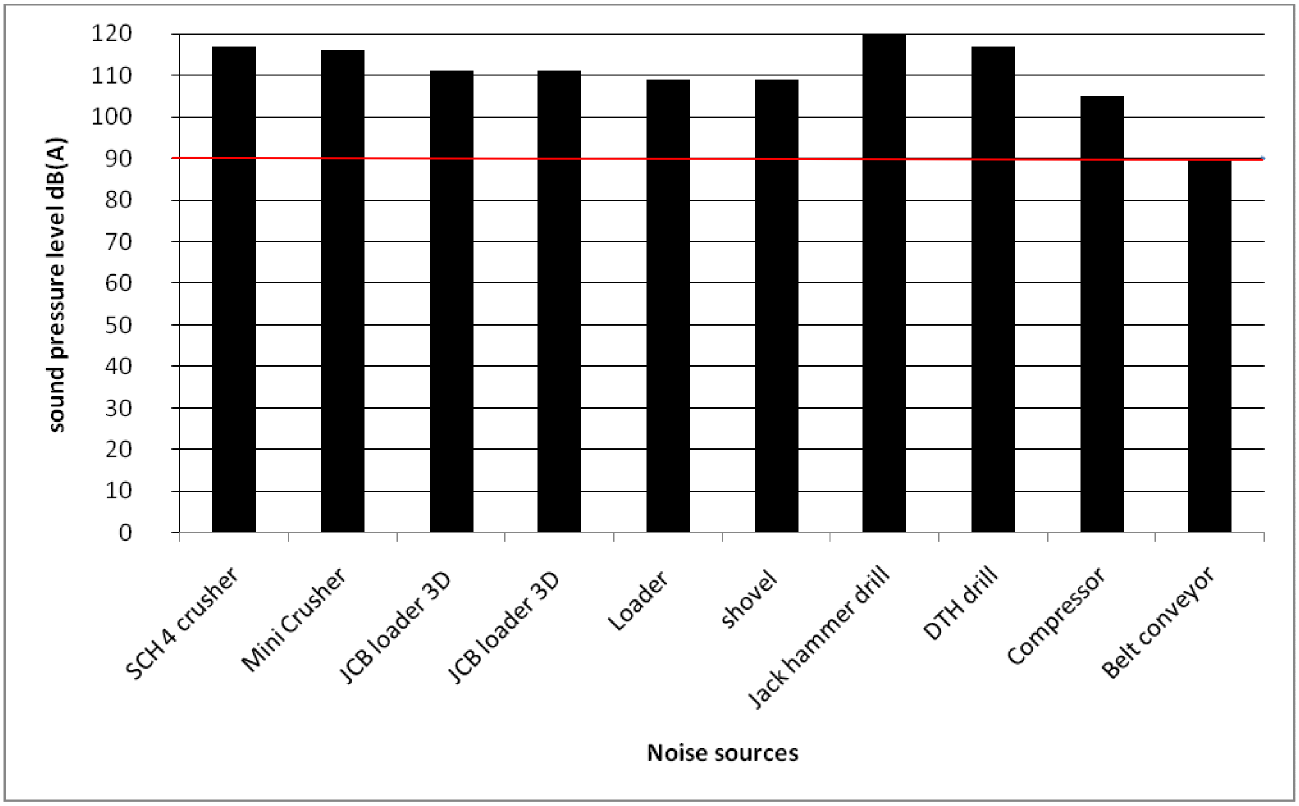


Figure 3.5: Measured sound Pressure Levels at Pathpahar Mines

3.1.4 RESULTS AND DISCUSSION

(A) Illumination Survey

The results of illuminance levels of Pathpahar mine are given in Table: 3.1.it can be seen that the illuminance level near loading points, bunkers, dumping yards, near mini crushers illuminance level were adequate & are within the standards as prescribed by regulations.

Illuminance measurement done in electrical substation, control room, rest room, store room and office were inadequate covering a range of 30-70 lux. According to Indian lighting standards the illuminance level in electrical substation, control rooms, rest rooms, and store rooms should be of 100-200 lux.

In opencast mines mounting height of pole is very important in order to achieve all the required lighting standards nearer to loading or unloading points, bunkers & work place of heavy machinery. With low-wattage of HPSV & FTLs lamps, the pole height should be kept lowered to achieve the necessary lighting standards in transfer points. HPSV lamps, in general, possess better illumination where loading & unloading work is carried on. Mounting height should be higher for high-wattage HPSV lamps for better performance.

(B) Noise Survey

Results of sound pressure levels at Pathpahar dolomite quarry are presented in given Table 3.3 and in figure.3.5. The maximum sound pressure level was found at jack hammer drill of 120 dB (A) & Down the hole drill (DTH) of 117dB (A). This is due to the jackhammer & DTH dealing with hard ore drilling rock, as face dressing or blasting. During the field study it was observed that the workers engaged in drilling operations were not equipped with ear plugs and ear muffs which can lead to hearing loss. So implementation of hearing protectors aid should be provided to the mine workers when exposed to harmful level of noise.

The minimum sound pressure level was found at compressor of small horsepower, when compared with other sources. From figure 3.5**,** it is found that, the sound pressure level due to crushers was higher. This is due to the high horsepower and the friction between the crusher material and the ore.

The sound pressure level from belt conveyers was found to be lower than that from other sources, where it was located in an enclosed compartment. Also, it can be seen that, the sound pressure levels were greater than that acceptable level (90 dBA).The measured noise level at the management building and the workshop area in Pathpahar crusher plant was higher than the acceptable level.

Measurements of noise levels in Pathpahar dolomite quarry prove that the workers are suffering from high noise levels more than the acceptable levels.

3.2 ILLUMINATION AND NOISE SURVEY IN HIRAKHAND BUNDIA MINES: CASE STUDY

3.2.1 INTRODUCTION OF THE MINES

- **Location**

Hirakhand Bundia U/G Mine is located in Orient area of Ib Valley coalfield. It falls within the latitude 20^{O} 48’ 45” & 21^{O} 48’ 30” N and longitude 83^{O} 54’ 00” & 83^{O} 56’ 00” E.

- **Communication**

The area can be approached by rail as well as road. The nearest town is Brajrajnagar. The state highway passes at a distance of 10 km from the project. The nearest rail head on Howrah-Mumbai main line of South Eastern Railways is Brajrajnagar which is about 4 km from the block. Jharsuguda – the district headquarter is about 16 km. away from the area and is well connected by all season motorable road. Sambalpur - the head quarter of Mahanadi Coalfield is about 70 km. away from the block and is well connected by rail and road (NH 200 & NH-10).

- **Topography & drainage**

The area is characterized by undulating topography with general slope towards Ib River which flows from north to south. The average elevation of the area is about 30 m from mean sea level. Lilari nullah flows in the south. The drainage system of the area is mainly controlled by Ib River which flows from north to south towards the eastern part of the block.

- **Project boundary**

North: Himgir-Rampur colliery and Unit-2 of Brajrajnagar lies in the northern side of the mine.
East: V.S.S. Nagar and Telen Kacchar basti are located adjustment to eastern boundary.
South: Ainlapali, Kantatikira and Budhihali villages are on southern side of area.
West: Samaleswari OCP and Chingriguda village are on western side of the mine.

- **Geology**

There are three seams viz. Lajkura, Rampur and Ib seams. Rampur seam (4 sections) and Ib seam (middle section) are being extracted in this mine. The grade of coal is ‘D’. The mineable reserves are 28.245 Mt for HR seam and 6.310 Mt for Ib Middle seam.

- **Mining Technology**

Coal is exploited by mechanized board and pillar method using LHD with roof stitching and bolting. However, there is proposal for deployment of continuous minor for the incremental production.

- **Coal winning and transportation**

Coal from the face is loaded by LHDs on the pony belt conveyor which transfers coal to the gate belt conveyor. The gate belt conveyor transports coal out of the district and loads on to the trunk belt conveyor in 1 DN in the main dip. Incline No.2, where it transfers coal to main belt conveyor installed in the incline. The main belt carries coal to the surface bunker (2 x 75 tons) for truck loading. The coal from the surface bunker is loaded into 16 tons capacity trucks and transported to railway siding which is at a distance of 8 km.

- **Life of the Mine:** The balance life of the mine has been estimated to be 26 years.

- **Coal handling & dispatch arrangement**

The blasted coal is loaded into belt conveyor by LHD. The gate belt feeds to trunk belt installed in main dip up to surface bunker. Coal is loaded into the trucks of 16 t capacity from bunker and transported to Orient railway siding by double lane black topped road.

Figure 3.6: Location of Hirakhand Bundia Mines

(Source : http://wikimapia.org/)

Figure 3.7: Aerial view of Hirakhand Bundia Mines.

3.2.2 Illumination Survey

Illumination survey was conducted in Hirakhand mines from 26/03/2010 to 27/03/10. From the field observation it was observed that travelling roadway was illuminated with 20 W CFL's (Compact florescent lamp) mounted at 2.5 m height in each goal post of a travelling roadway. Walls of coal surface were white washed to have a better reflectivity. Most underground mines make use of whitewash as a cost effective means of improving lighting performance. A total of 55 lamps were used at travelling roadway of a man riding at regular spacing of 15 m. There was no overhang i.e. the lamps were vertical above the road edge. While measuring illuminance of light sources grids were marked along the length of the roads. Illumination levels was measured at each corner of square grid (1×1m) using a digital luxmeter. A measurement of 25 lamps was taken, out of which 3 lamps found defected, Table 3.3 & 3.4 highlights the existing lighting installations in incline and average illuminance level of luminaries.

Table 3.3: Illuminance level in inclined shaft

	Source	**Ht. of luminaire**	**Illuminance level (lux) at different Positions**				
			1m	**2m**	**3m**	**4m**	**5m**
1.	20 W CFL	3m	20.4	16.3	11.7	7.6	4.4
2.	20 W CFL	3m	18.6	17.1	12.4	8.3	5.4
3.	20 WCFL	3m	21.7	17.8	13.2	9.4	4.7
4.	20 WCFL	3m	20.7	16.4	12.8	7.9	5.3
5.	20 W CFL	3m	19.3	15.3	11.4	8.6	5.1

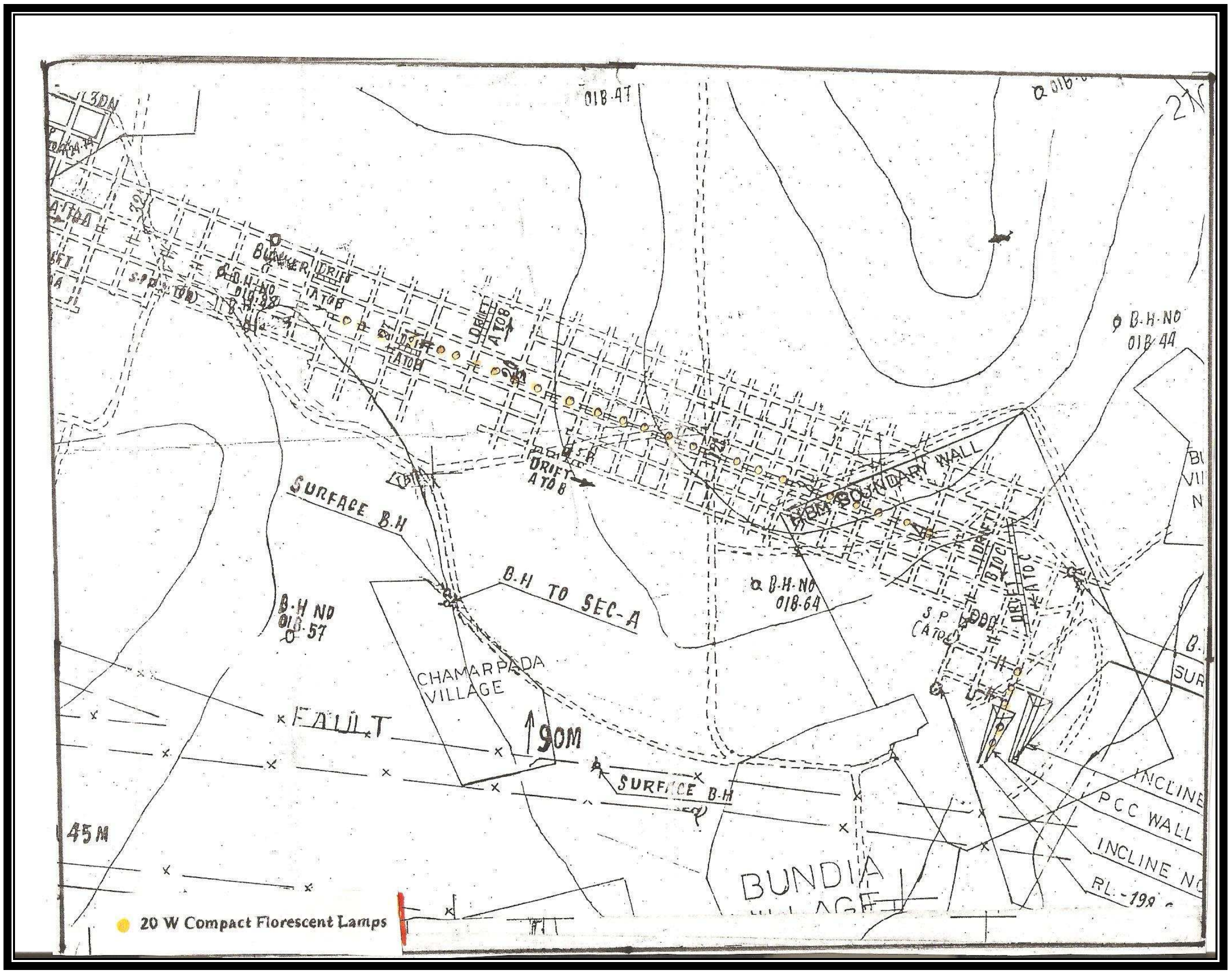


Figure 3.8: Location of light sources in Hirakhand Bundia mines

Table 3.4: Illuminance levels in travelling roadway

Pole no.s	Illuminance level (Lux)				Average Illuminance Level(Lux)
	L1	L2	L3	L4	
Goal post 1	34.2	33.6	30.6	31.7	32.52
Goal post 2	32.6	31.4	29.8	28.6	30.6
Goal post 3	33.5	32.4	30.1	29.7	31.42
Goal post 4	31.8	31.6	29.4	28.5	30.32
Goal post 5	------------------------------ Defective --------------------				
Goal post 6	33.4	32.6	31.3	29.1	31.6
Goal post 7	32.4	33.1	27.4	29.6	30.62
Goal post 8	31.3	30.6	29.4	29.7	30.25
Goal post 9	31.4	29.8	27.5	28.3	29.25
Goal post 10	30.6	31.4	28.1	27.6	29.42
Goal post 11	--------------------------- Defective ------------				
Goal post 12	33.8	32.3	29.1	30.7	31.47
Goal post 13	33.2	29.4	31.5	28.4	30.62
Goal post 14	30.2	31.3	28.4	30.1	30.02
Goal post 15	31.9	32.1	30.2	29.7	30.97
Goal post 16	30.6	29.2	29.3	28.4	29.37
Goal post 17	33.5	29.7	26.4	28.2	29.45
Goal post 18	33.7	32.3	25.1	30.2	30.32
Goal post 19	31.5	29.5	27.7	28.3	29.5
Goal post 20	32.4	31.0	29.2	29.4	30.5
Goal post 21	29.7	30.2	29.6	28.4	29.47
Goal post 22	----------------------------Defective ---------------------				
Goal post 23	30.8	28.6	28.3	28.7	29.1
Goal post 24	31.6	29.7	28.4	27.6	29.35
Goal post 25	32.0	31.5	29.2	26.2	29.72

3.2.3 NOISE SURVEY

- **Description of the Field Experiments**

The field experiment was carried out at Hirakhand Bundia mines from 26/03/2010 to 27/03/10. The main noise sources at the projects were as follows: LHD, coal drill, auxiliary fan, and main fan, belt conveyers in underground & surface. The sound pressure levels of noise sources were taken at different distances from the sources.

The distances between the sources and the receivers at all locations were changed during the fieldwork. The noise level was measured at a height of 1.6 m from ground level. Five values of noise level from each source were recorded. While, the sound pressure level was measured at different distances from the noise sources.

- **Instrumentation**

The instruments used was a standard CEL -283 integrating impulse sound Level meter (U.K) .It measured noise levels produced both near the source and the operator's level covering a range of 40 -120 dB(A) and had a selectable A/ Flat frequency characteristics .Fast slow time constants and impulsive response . The A-network was used in the present work, which approximates the human response.

- **Results**

Results of the noise study are given in Table 3.5

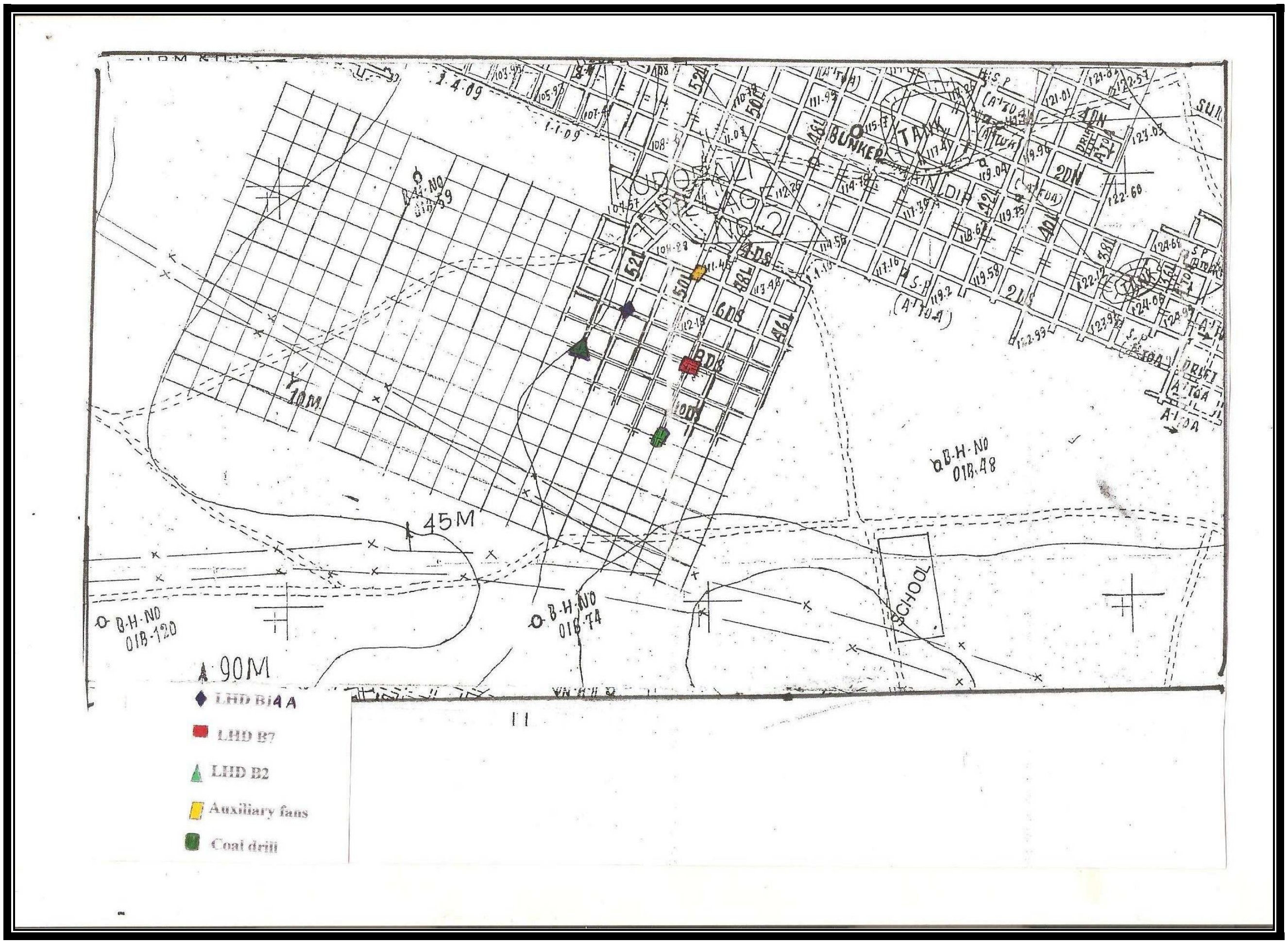


Figure 3.9: Location of noise sources in Hirakhand Bundia mines

Table 3.5: Distance of measurements from noise sources in Hirakhand Bundia Mines

Noise source	Distance	Sound pressure level, dB(A)
LHD B 14A Make :Emco-Elcon (Gujarat) Bucket capacity:1.25 m^3	1m	108
	2m	107
	3m	105
	4m	104
	5m	103
LHD B 7 Make :Emco -Elcon (Gujarat) Bucket capacity: 1.25 m^3	1m	110
	2m	109
	3m	108
	4m	106
	5m	104
LHD B2 Make : Emco-Elcon (Gujarat) Bucket capacity:1.25 m^3	2m	106
	3m	104
	4m	103
	5m	101
	6m	99
Auxiliary fan	1m	117
	2m	117
	3m	116
	4m	115
	5m	114
Coal drill	1m	116
	2m	116
	3m	115
	4m	114
	5m	113
Main fan in surface Model : VF 2000/2 stage Maximum : HP 250 KW Type :axial flow adjustable blade, belt driven Mfd.by :Voltas limited Blade angles:33.5	1m	111
	3m	108
	5m	105
	10m	94
	15m	81

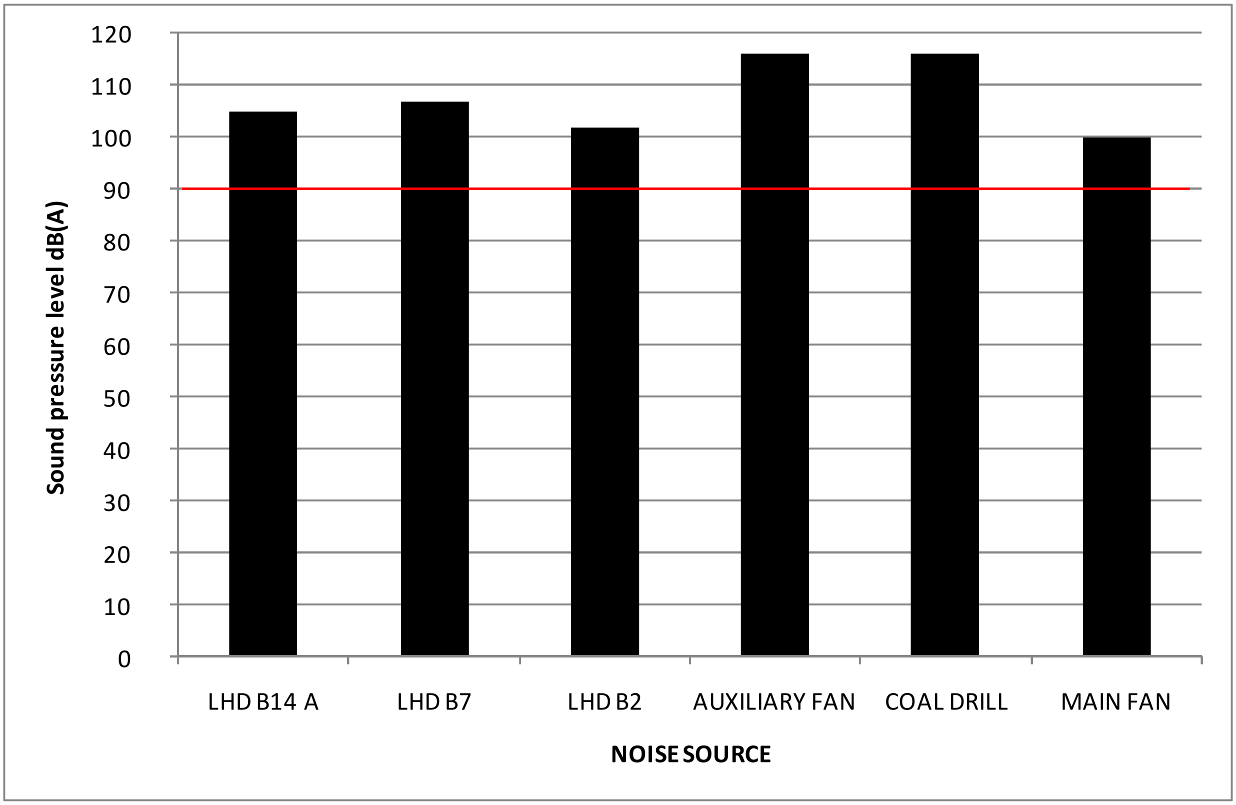


Figure 3.10: Measured sound pressure levels at Hirakhand Bundia mines

3.2.4 RESULTS & DISCUSSION

(A) Illumination Survey

From the field survey, it was observed that the illuminance level measured in inclined shafts & travelling roadways conveyance for man riding of Hirakhand Bundia mines were adequate of average illuminance 30 lux of each light source at floor level.

Taking into account Indian lighting standards in respect of underground mining travelling roadway lighting should be based on a minimum light level of 0.5 lux, an average light level of 4.0 lux.

The roofs and sides were properly white washed and stone dusted on the floor as required under the regulations to achieve illumination to the standards for providing necessary visibility for safe and efficient work at different work places.

Travelling roadways were well illuminated with CFL (compact florescent lamps). The Mine personnel tried to compensate for the effect of low height pole by increasing the tilt angle, but this caused the light resulting in glare problems for the mine workers as the lamp came in his vision.

(B) Noise Survey

Results of sound pressure levels at Hirakhand Bundia mines are presented in given Table 3.5 and in figure 3.10**.** An average of five values of noise level of each source was taken. The maximum sound pressure level was found at auxiliary fan are usually suspended in junctions close to ear level. The noise stems from the motor and from air turbulence, mainly at the intake end. Vibration transmitted from the fan housing to the duct and the suspension system radiates as noise. control measures should be adopted like air intakes may be fitted with silencers containing synthetic fiber sound absorption material noise by as much as 11 dB(A).

Also, it can be seen from the figure 3.10 the maximum sound pressure level was found at the LHD B7. This is due to the LHD B7 dealing with hard ore moving loaded and unloaded. The major sources of noise in LHDs are the engines, its intake and exhaust, the cooling fan for the engine and the drive train. Control measures should be adopted like controlling engine speed; vibration isolation mounts between transmission and structures.

Exhaust fans on surface are the major source of noise in underground mining. Axial flow fans with discharge capacity 2 lakh ft^3/min of air with fan static pressure ranging up to 15 cm of water gauge or more. Moving these large air volumes requires large power input which are ultimately converted to noise because of inefficiencies inherent in any mechanical system. Control measures like provision of inlet and discharge silencers, noise absorbing splitters, replacing worn out parts and planned maintenance should be adopted to reduce the noise levels.

Almost all machineries & equipments in this mine produced higher level of noise (>90dB (A)) than the acceptable noise. According to DGMS Circular No.18 (Tech), 1975 a worker should not be allowed to enter, without appropriate ear protection, an area in which the noise level is 115-dB (A) or more.

3.3. ILLUMINATION AND NOISE SURVEY IN NANDIRA COLLIERY, TALCHER: CASE STUDY

3.3.1 INTRODUCTION

The project report of Nandira colliery was approved by Board of directors, CDL in 15th feb, 1962 and mine was opened in Dec, 1962.The mine was closed down in 1964 on account of sluggish demand of coal and restarted in the year 1970 in order to feed coal to FCI, Talcher. This mine is located in village badajorada of Talchir subdivision .It is 12 kms from Talchir town.

- **Geo mining parameters:** The total area of the mine: 672 Ha
- **Seam details:** Thickness Top section: 2.5 to 5.5 m
Bottom section: 1.0 to 2.5 m
- **Gradient:** 1 in 20 to 40
- **RMR:** 35 to 40,
- **Grade of coal:** Grade C
- **Method of work:** Board and pillar
- **No. of Districts:** 2
- **Mechanization:** Loading by SDLs, transport by Belt conveyors

Figure3.11: location of Nandira colliery, Talchir

(Source : http://wikimapia.org/)

Figure 3.12: Aerial view of Nandira colliery, Talchir

3.3.2 ILLUMINATION SURVEY

Illumination survey was conducted at Nandira colliery from 02/04/10 to 03/04/10. The lighting system was provided by florescent tubes suspended from the roof. Walls of coal surface were white washed to have a better reflectivity. Mainly underground mines make use of whitewash as a cost effective means of improving lighting performance. Incline & Travelling roadway was illuminated with 40 Wattage florescent tube lamps. A survey was done for measuring the illuminance level of luminaries to determine how much illuminance level is given of by the light source. Grids were marked along the length of the roads. Vertical illumination levels were measured at each corner of square grid (3×3m) using a digital luxmeter. Table3.6 highlights the existing lighting installations in inclines, travelling roads and average illuminance level luminaries in the mines.

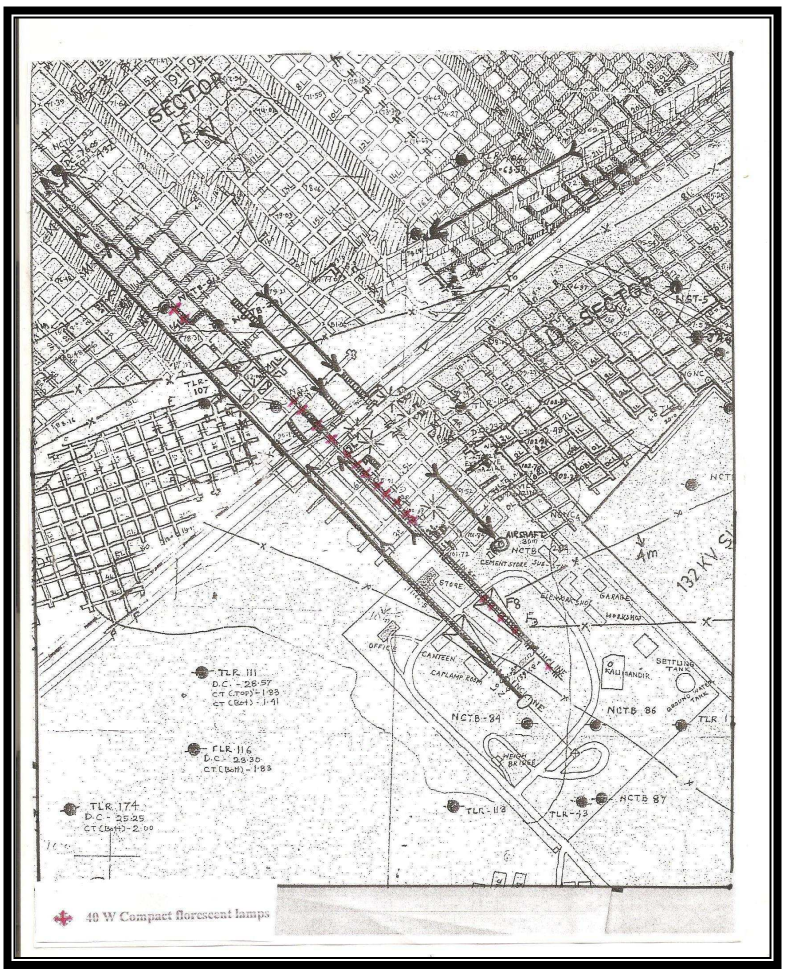


Figure 3.13: Location of light sources in Nandira colliery, Talchir

Table 3.6: Illuminance level in travelling roadway

Measurement areas	No. of lights installed		Minimum illuminance level (Lux)				Average illuminance level (Lux)
			L1	L2	L3	L4	
Incline	5	1	22.4	23.2	18.1	19.6	20.82
		2	23.8	24.2	19.2.	18.7	21.05
		3	24.3	23.2	18.6	17.3	20.85
		4	23.6	22.8	17.6	18.1	20.52
		5	24.5	23.1	20.3	19.4	21.82
3rd level	3	1	22.2	24.5	24.8	25.6	24.27
		2	23.4	22.1	23.8	24.6	23.47
		3	25.5	23.4	24.4	20.1	23.35
4th level	2	1	26.1	24.2	23.8	24.5	24.65
		2	24.8	23.2	23.6	25.0	24.15
5th level	3	1	25.8	24.3	26.1	25.3	25.37
		2	26.4	23.4	25.0	25.7	25.12
		3	24.6	25.9	23.5	22.4	24.15
6th level	4	1	23.4	24.5	20.6	23.5	23.0
		2	24.5	22.8	23.7	22.6	23.4
		3	22.3	21.4	23.1	21.5	22.07
		4	23.8	22.5	21.3	22.9	22.7
8th level	3	1	22.4	23.5	22.7	22.5	22.77
		2	23.6	22.3	21.5	22.7	22.52
		3	24.5	24.7	22.3	20.2	23.1
14th level	4	1	24.6	23.4	23.4	21.5	23.22
		2	23.8	22.4	23.1	20.7	22.5
		3	24.3	22.8	22.0	23.4	23.12
		4	24.5	23.6	21.2	20.4	22.42

3.3.3 NOISE SURVEY

➢ **Description of the field experiments**

The field experiment was carried out at Nandira colliery, Talcher. The main noise sources at the projects were as follows: SDL (Side Dump loader), coal drill, auxiliary fans, main fan, belt conveyers in surface & underground. The sound pressure levels of noise sources were taken at different distances from the sources. The distances between the sources and the receivers at all locations were changed during the fieldwork. The noise level was measured at a height of 1.6 m from ground level. An average of five values of noise level of each source was taken. While, the sound pressure level was measured at different distances from the noise sources.

➢ **Instrumentation**

The instrument used was a standard CEL -283 integrating impulse sound Level meter (U.K) .It measured noise levels produced both near the source and the operator’s level covering a range of 40 -120 dB(A) and had a selectable A/ Flat frequency characteristics .Fast slow time constants and impulsive response. Workplace noise level measurements were taken on SLOW response. The A-network was used in the present work, which approximates the human response.

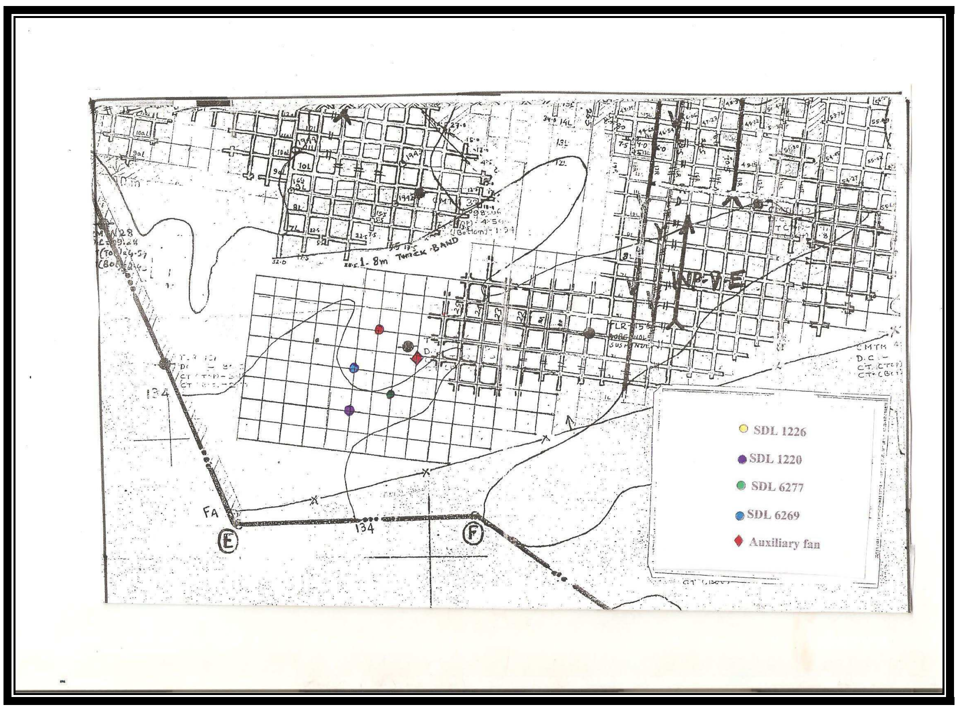


Figure 3.14: Location of Noise sources in Nandira colliery, Talchir

Table 3.7: Distance of measurements from noise sources in Nandira colliery

Noise source	*Distance*	*Sound pressure level, dB(A)*
SDL(Side Dump loader) Model no :1200 Make :TRF Bucket capacity :1.25 m^3	1m	107
	2m	106
	3m	104
	4m	103
	5m	102
SDL(Side Dump loader) Model no: 1226 Make : TRF Bucket capacity : 1.25m^3	1m	110
	2m	108
	3m	107
	4m	105
	5m	103
SDL(Side Dump loader) Model no: 6227 Make : EMCO Bucket capacity : 1.5m^3	1m	109
	2m	108
	3m	107
	4m	106
	5m	104
SDL(Side Dump loader) Make :EMCO Model no:6269 Bucket capacity :1.5 m^3	1m	112
	2m	111
	3m	110
	4m	108
	5m	106
Auxiliary fan no.1 Make :Crompton greaves Type :FLP RPM:2900 Power/kw:15 Discharge (cum/sec) :4.5	1m	118
	2m	118
	3m	117
	4m	117
	5m	116
Auxiliary fan no.2 Make :Crompton greaves Type :FLP RPM:2900 Power/kw:15 Discharge (cum/sec) :4.5	1m	119
	2m	119
	3m	118
	4m	117
	5m	116

Noise source	*Distance*	*Sound pressure level, dB(A)*
Main mechanical ventilator fan Voltas make :PV 200 discharge capacity: 2 lakh ft^3/min	2m	116
	3m	115
	4m	114
	5m	113
	6m	111
Conveyor belt U/G	1m	100
	2m	98
	3m	97
	4m	96
	5m	94
Conveyor belt S/F	1m	98
	3m	96
	4m	93
	5m	90
	6m	88
Coal drill	1m	115
	2m	115
	3m	114
	4m	113
	5m	112

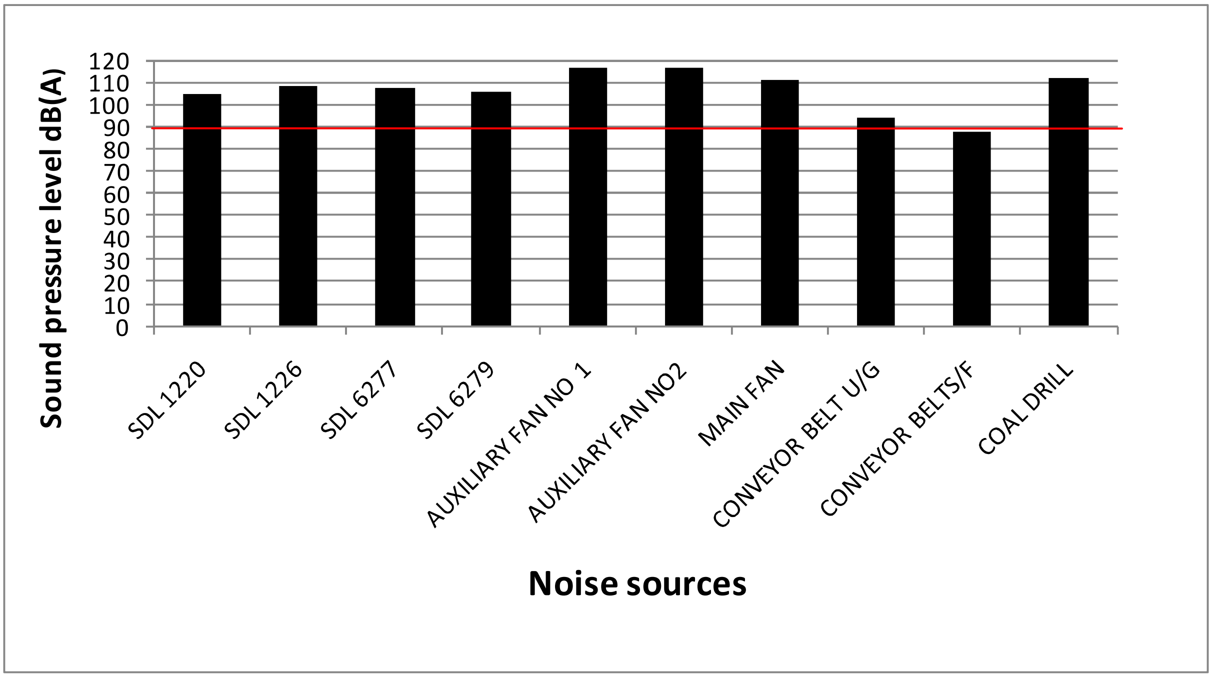


Figure 3.15: Measured Sound pressure levels at Nandira Colliery,Talchir

3.3.4 RESULTS AND DISCUSSION

(A) Illumination Survey

Results of illumination survey are given in Table 3.6. The light sources installed in inclined shaft & travelling roadways of different levels were limited with irregular spacing. Indian lighting standards have specified only minimum light level. The average light level is important aspect in proper lighting designs. Taking into account Indian lighting standards in respect of underground mining travelling roadway lighting should be based on a minimum light level of 0.5 lux, an average light level of 4.0 lux.

Illuminance measurements done in inclined shafts & travelling roadways were adequate of average light level 20.0 to 24.0 lux of vertical illuminance within 3×3m grid.

Dark areas with light levels much less than the standards recommended were noted; these are a result of the irregular pole spacing and also, perhaps, their low height.

The roofs and sides were properly white washed and stone dusted on the floor as required under the regulations to achieve illumination to the standards for providing necessary visibility for safe and efficient work at different work places.

(B) Noise Survey

Results of sound pressure levels at Nandira colliery mines are presented in given Table (3.8) and in figure 3.15.From the survey results it was found that almost all machineries produced higher levels of noise (>90dB (A)).

Main fans on surface are the major source of noise in underground mining. Axial flow fans discharge capacity 400,000 to 700,000 cfm of air with fan static pressure ranging upto 15 cm of water gauge or more. Moving these large air volumes requires large power input which are ultimately converted to noise because of inefficiencies inherent in any mechanical system. The noise in a fan system contains components from various sources, including aero dynamic noise from the fan blade, casing noise, unbalance bearing noise, motor noise and gear noise. Control measures like provision of inlet and discharge silencers, noise absorbing splitters, and speed control can be adopted.

As it can be seen that auxiliary fans produced higher levels of noise. The noise stems from the motor and from air turbulence, mainly at the intake end. Vibration transmitted from the fan housing to the duct and the suspension system radiates as noise. control measures should be adopted like air intakes may be fitted with silencers containing synthetic fiber sound absorption material noise by as much as 11 dB(A).

During the field study it was observed that SDL operators were not equipped with hearing protectors which can lead to temporary or permanent hearing loss. Therefore, control measures should be adopted in mines for machinery noise reduction as well as hearing protection aids should be supplied to the workers in order to protect the mine workers from NIHL (Noise induced hearing loss).

CHAPTER: 04

CONCLUSION

CHAPTER: 04

CONCLUSION

Provision of suitable work environment for the workers is essential for achieving higher production and productivity in both surface and underground mines. Poor lighting and noisy working conditions have negative effects on the workers' morale and adversely affects their safety, health and performance. In order to assess the status of illumination and noise levels in mines, systematic illumination and noise surveys are needed to be conducted using appropriate statutory guidelines so that effective control measures can be taken up in mines. Keeping this in view, this project work was undertaken to carry out illumination and noise survey in few non-coal and coal mines of Orissa.

The results obtained from illumination survey in mechanized unit of Pathpahar mines of BSL reveal that at near loading points, near crushers, mini crushers & dumping yards were adequate and are within the limits of Indian standards whereas illuminance levels in electrical substation, store room, rest rooms and electrical control rooms were inadequate.

From the survey results in underground coal mines of MCL, it was found that roadways were comparatively narrow and is not easy to illuminate uniformly because of limited height in underground. The excessive length of roadways in a mine below ground makes it uneconomical to provide lamps at all places; therefore, they are concentrated at places, which are most active i.e. pit bottoms, loading point etc. The illuminance level measured in inclined shafts & travelling roadways conveyance for man riding of Hirakhand Bundia mines were adequate with average illuminance 30 lux.

The illuminance level measured in inclined shafts & travelling roadways in different levels of Nandira colliery, Talchir were adequate with average illuminance level 24 lux. From the survey it was observed that most of the underground mines use florescent lights which provide better light distribution, longer lives, higher efficacy better color concentration, and less glare potential.

Noise has become an integral part of mining environment. Introduction of more and more mechanization, powerful equipment is expected to increase more noise problems thereby inducing noise doses with associated physiological and psychological problems to the exposed populations. Repeated or prolonged exposure to excessive noise levels will lead to hearing impairment. Potential sources of noise emissions include compressors, drilling machines, crushers, auxiliary fans or other mechanical equipment used at a mine. Wherever possible, such noise sources should be muffled with an effective acoustic absorbing material so as to reduce noise emissions to acceptable levels. Increasing the distance between the noise source and the listener is often a convenient method of noise control. Where such noise control measures are not possible, comfortable and practical personal hearing protection devices, such as approved ear plugs or ear muffs, should be worn by every person exposed to noise levels exceeding 90 dB(A).

The results obtained indicated that the sound pressure levels of various machineries used in Pathpahar mines of BSL, & underground coal mines of MCL were higher than the acceptable limits (>90dB (A)). In the mines under study, most of the mine workers were exposed to SPL (sound pressure level) beyond TLV (90dBA) due to machinery noise. Therefore, control measures should be adopted in mines for machinery as well as hearing protection aids should be supplied to the workers in order to protect the mine workers from NIHL (Noise induced hearing loss) & to keep the environment safe.

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