NOISE SURVEY AND NOISE MODELLING OF OPEN CAST MACHINERIES IN MINES

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

Bachelor of Technology
In
Mining Engineering

By

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Rourkela-769008

Session 2013-14

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CERTIFICATE

This is to certify that the thesis entitled **“NOISE SURVEY AND NOISE MODELLING OF OPEN CAST MACHINERIES IN MINES”** submitted by Sri **Cikan Pradhan**, Roll No. **110MN0399** in partial fulfilment 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.

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I will be failing in my duties if I didn't mention the reference and inspiration from the works of others whose details are mentioned in reference section. I acknowledge my indebtedness to all of them.

At the last, my sincere thanks to all my friends who have patiently extended all sorts of help for accomplishing this assignment.

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ABSTRACT

Obtaining a suitable work environment for the labourer's is fundamental for attaining higher processing and benefit in both surface and underground mines. Noisy working conditions have negative consequences for the labourer's resolve and badly affect their wellbeing and execution. To survey the status of noise (noisy) levels in mines, various reports on noise reviews are required to be directed utilizing suitable statutory rules so viable control measures might be taken in mines. Keeping this in view, this project work was embraced to do noise review in few open cast non coal and coal mines of Odisha.

OBJECTIVES

- ✓ Understanding of the basic concepts of noise.
- ✓ To conduct noise survey of some HEMM (Heavy Earth Moving Machineries) in few opencast coal/non-coal mines.
- ✓ To predict the correct sound level from the attenuated one by VDI- 2714 noise prediction mathematical model.
- ✓ To assess the adequacy of the actual noise levels in mines vis-à-vis Indian standards.
- ✓ To propose any remedial measures if required.

CHAPTER 1

INTRODUCTION

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Noise is generated by almost all opencast mining operations from different fixed, mobile and impulsive sources, thereby becoming an integral part of the mining environment. It is defined as sound without agreeable musical quality or as unwanted sound. In opencast mines, noise is a common environmental factor as generated by the heavy earthmoving machineries. The equipment and environment conditions continuously change as the mining activity progresses. Depending on their placement, the overall mining noise emanating from the mining equipment varies in quality and level. In opencast mines most of the mining machineries produce noise levels in the range of 90-115 dBA, exposure to which over long time can result in noise induced hearing loss and other non-auditory health effects in the miners. Hearing loss can impair the quality of life through a reduction in the ability to communicate with each other. Overall, it affects the general health of the human beings in accordance with the World Health Organization's (WHO) definition of health. **Hearing loss** (HL) can be defined as **"the decibel difference between a patient's thresholds of audibility and that for a person having normal hearing at a given frequency"**. In mining industry, hearing loss or hearing damage is considered as a serious health problem, as reported by various health organizations like the U.S. Environmental Protection Agency(USEPA), the National Institute for Occupational Safety and Health (NIOSH) and the WHO etc. In 1976, a study carried out by the National Institute for Occupational Safety and Health, for coal mining concluded that the coal miners had health conditions worse than the national mean and the hearing damage to coal miners were serious. The impacts of noise in opencast mines depend upon the sound power level (SWL) of the noise generators, prevailing geo-mining conditions and the meteorological parameters of the mines. The noise levels need to be studied as an integrated effect of the above parameters. In mining conditions, the equipment conditions and the environment continuously change as the mining activity progresses. Depending on their placement the overall mining noise emanating from the mines varies in quality and level.

METHODOLOGY

Thus, for environmental noise prediction models, the noise level at any receiver point needs to be the resultant sound pressure level (SPL) of all the noise sources. The need for accurately predicting the level of noise emitted in opencast mines is well established. Some of the noise forecasting models used extensively in Europe are those of the German Draft Standard **VDI-2714 Outdoor Sound Propagation**, Conservation of Clean Air and Water in Europe (CONCAWE) and Environmental Noise Model (ENM) of Australia. These models are generally used to predict noise in petrochemical complexes and mines. These standards or algorithms were proposed in between 1970-1985. Out of these standards, some are not suitable to predict noise accurately as these standards do not take into consideration the attenuations factors such as ground effect, vegetation, barriers, industrial areas etc.

To overcome this problem, International Standard Organization (ISO) proposed an empirical noise prediction model in 1996. The algorithm used in these models relied for a greater part on the interpolation of experimental data which is a valid and useful technique, but their applications are limited to sites which are more or less similar to those for which the experimental data were assimilated. In the empirical models, nearly all influences are taken into account even when they cannot be separately recognized. This is the main advantage of these models. However, the accuracy of these models depends on the accuracy of the measurements, similarities between the conditions where the noise attenuation is analyzed and the conditions where the measurements are carried out, and the statistical method that is used to make the empirical model. The deterministic models are based on the principles of physics of sound and therefore, can be applied in different conditions without affecting the accuracy. But their implementation usually requires a great database of meteorological characteristics such as atmospheric pressure, atmospheric temperature, humidity, wind and so on, which is nearly difficult to obtain. Hence, the implementation of the noise prediction models is usually restricted to the special area where the meteorological data can be available. All the noise prediction models treat noise as a function of distance, SWL, different forms of attenuations such as geometrical absorptions, barrier effects, ground topography, etc. Generally, these parameters are measured in the mines and best fitting models are applied to predict noise. Mathematical models are generally complex and cannot be implemented in real time systems. Additionally, they fail to predict the future parameters from current and past measurements. It has been seen that noise prediction is a non-stationary process and soft-computing techniques like Fuzzy systems (Mamdani Fuzzy Inference System, Takagi-Sugeno-Kang Fuzzy Inference System), Adaptive neural network-based fuzzy inference systems (ANFIS), Neural networks (Multi-layer Perceptron(MLP), Radial Basis Functions (RBF), Functional Link Artificial Neural Network(FLAN), Neural Fuzzy, PPN) etc. have been tested for non-stationary time-series

The Objectives of the Project Work:

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CHAPTER 2

LITERATURE REVIEW

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LITERATURE REVIEW

TERMINOLOGIES OF NOISE

Sound and noise:

Sound is the thing that we listen. Noise is unwanted sound. Sound is a manifestation of vitality which is emitted by a vibrating body and on arriving at the ear causes impression of hearing through nerves. Sounds transformed by all vibrating bodies are not capable of being heard. The frequency limits of audibility are from 20 HZ to 20,000 HZ.

A noise created by and large comprises of three inter-related components- the **source**, the **beneficiary** or receiver and the **transmission path**. This transmission path is typically the environment through which the sound is transmitted, however can incorporate the structural materials of any building holding the receiver.

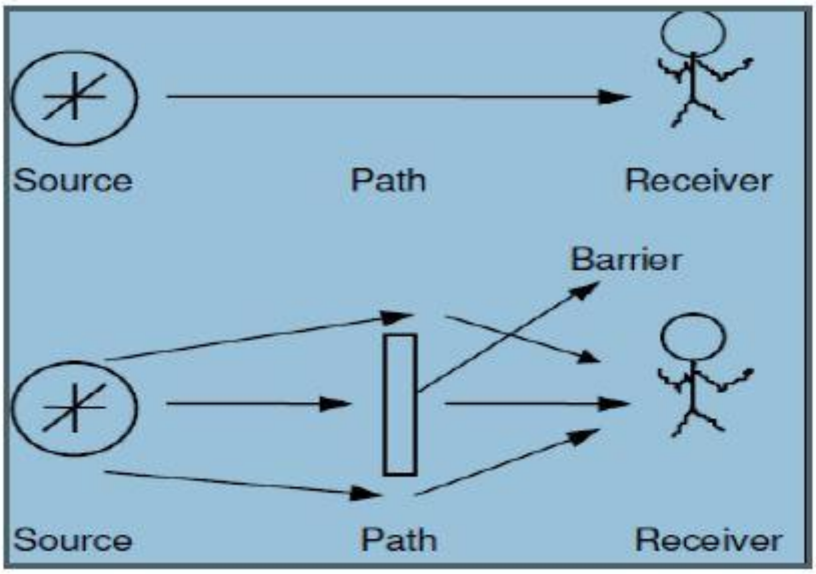

Fig 1: Inter-relationship between the elements of noise
Source: (http://discovery.bits-pilani.ac.in)

Noise may be persistent or discontinuous. Noise may be of high frequency or of low frequency which is undesired for a typical hearing. The segregation and separation between sound also noise additionally relies on the propensity and enthusiasm of the individual/species accepting it, the encompassing conditions and effect of the sound created throughout that specific term of time.

Decibel (dB)

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})**
Where **P** = signal power (W) , **P_{ref}**= reference power (W) = 10^{-12} W

Sound Power Level (SPL)

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 -
Lw: **Lw = 10 log (N / No)**

Where, **Lw**= 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 105 W, 170 dB.

Sound Intensity Level

Sound Intensity is the Acoustic or Sound Power (W) per unit area. The SI-units for Sound Intensity is W/m^2.The Sound Intensity Level can be expressed as:

LI = 10 log (I / I_{ref})

Where **LI** = 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 (L_P). 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/m2 or Pa.

The Sound Pressure Level:

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

Where $\mathbf{L_P}$= sound pressure level (dB)
p = sound pressure (Pa)
$\mathbf{p_{ref}}$= 2 x 10^{-5}Pa; reference sound pressure (Pa)
If the pressure is doubled, the sound pressure level is increased with 6 dB (20 log2).

A-weighted decibels

The affectability of the human ear to sound relies upon the frequency or pitch of the sound. Individuals hear a few frequencies superior to others. In the event that an individual hears two qualities of the same sound pressure however diverse frequencies, one sound may seem louder than the other. This happens since individuals hear high frequency noise much superior to low frequency noise.

Noise estimation readings might be conformed to compare to this eccentricity of human hearing. An A-weighting channel which is incorporated with the instrument de-stresses low frequencies or pitches. Decibels measured utilizing this channel are A-weighted and are called dB (a). Legislation on working environment noise regularly gives exposure restricts in dB (A).
A-weighting serves two critical purposes:

- ✓ Gives a single number measure of noise level by integrating sound levels at all frequencies.
- ✓ 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 recognized by their centre frequency. The band width expands as the middle frequency increments. The audible sound frequency range (20 Hz to 20,000 Hz) has been separated into 11 octave bands for this reason. An octave band channel set could be connected to a SLM to measure the sound level in every octave band.

MECHANISM OF HEARING

The ear can be divided into three parts: the outer, middle, and inner ear (**fig 2**). 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:

- ✓ Just certain hair cells curve to any specific frequency of sound. Along these lines, hair cells react just to the frequency to which they are sensitive.
- ✓ The measure of twisting the hairs experience relies on upon the amount energy (decibels) the noise has the more amazing the energy, the additionally twisting that happens (i.e., the louder the noise will sound).

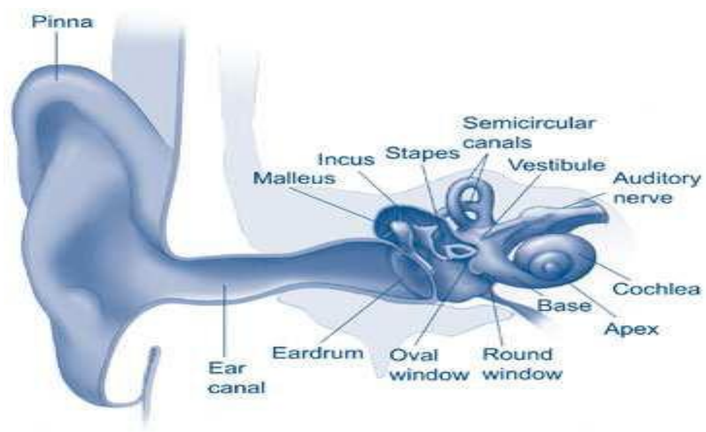

Fig 2 Schematic diagram of human ear
Source (www.nidcd.nih.gov/health/hearing/noise.asp)

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 14hours.

Permanent threshold shift

Permanent threshold shift is a permanent hearing loss that is very much alike to the example of temporary hearing loss, with the exception of that we don't recuperate. A percentage of the hair cells are physically crushed by the consistent pounding and bending, prompting nerve loss. The more exposure to loud noise, the more hair cells is destroyed. This leads to complete deafness. Permanent hearing loss can't be treated by any known medication 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 notice able 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.

NOISE MEASUREMENT:

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.

To be Noted: It is highly essential 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.

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, L_1 in dB is measured at r_1 meters, then the sound pressure level, L_2 in dB at $r_2$meters is given by,

$$L_2 = L_1 - 20 \log10 (r_2/r_1) \qquad (1)$$

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

$$L_P = 20 \text{ Log10 } (P/P_O) \text{ dB (A)} \qquad (2)$$

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.

Identify Sources of Noise

Point Sources:

Sound propagation from a single point source is purely spherical. Thus the sound energy in any particular direction is inversely proportional to the increasing surface area of the sphere. If *SWL* represents the continuous sound power output of the source measured at 1 meter, then at a distance of *r* meters, the sound pressure level becomes;

SPL = SWL (point) - 10log (4 pi r²) OR
I = W / (4 p r²)
which is known as the standard ***inverse square law*** for point sources. It is most often referred to as a 6dB reduction in relative intensity per doubling of distance. If the ground is quite hard and reflective, compensation must be made for these ground reflections. In this case 11 is replaced by 8dB.

Fig 3: Point source

Line sources:

Line sources can then be considered as consist of an infinite number of evenly distributed individual point sources. In the case of an ideal line of infinite length, the results approximate that of purely cylindrical propagation. Thus the sound energy in any perpendicular direction is inversely proportional to the increasing circumference of the cylinder. In case of line sources, the SPL is:

SPL = SWL (line) - 10log (4 pi r^2)
This results in only a 3dB reduction in relative intensity per doubling of distance.

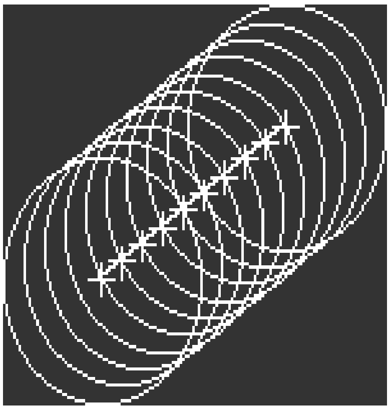
Fig 4: Line source

Plane Sources:

For a plane source, integrating an infinite number of point sources distributed in two dimensions produces a flat surface. Thus, propagation away from a planar source approximates a plane wave. The sound energy of each point source is therefore assumed to propagate in a straight line perpendicular to the plane, meaning that no geometric spreading need be considered as there is no change in distributed surface area as the wave propagates.

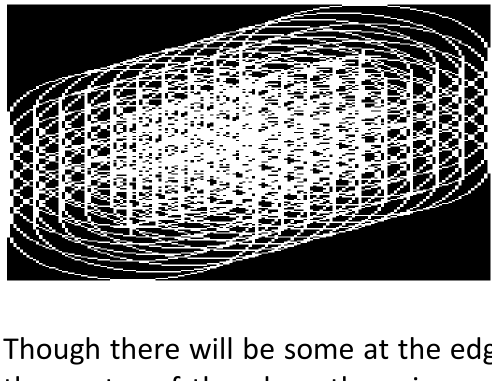
Fig 5: Plane source

Though there will be some at the edges of a finite planar source, however, at close range near the centre of the plane there is no diminution with distance. Therefore, the sound pressure level can be written as:
SPL = SWL (plane)

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.

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.

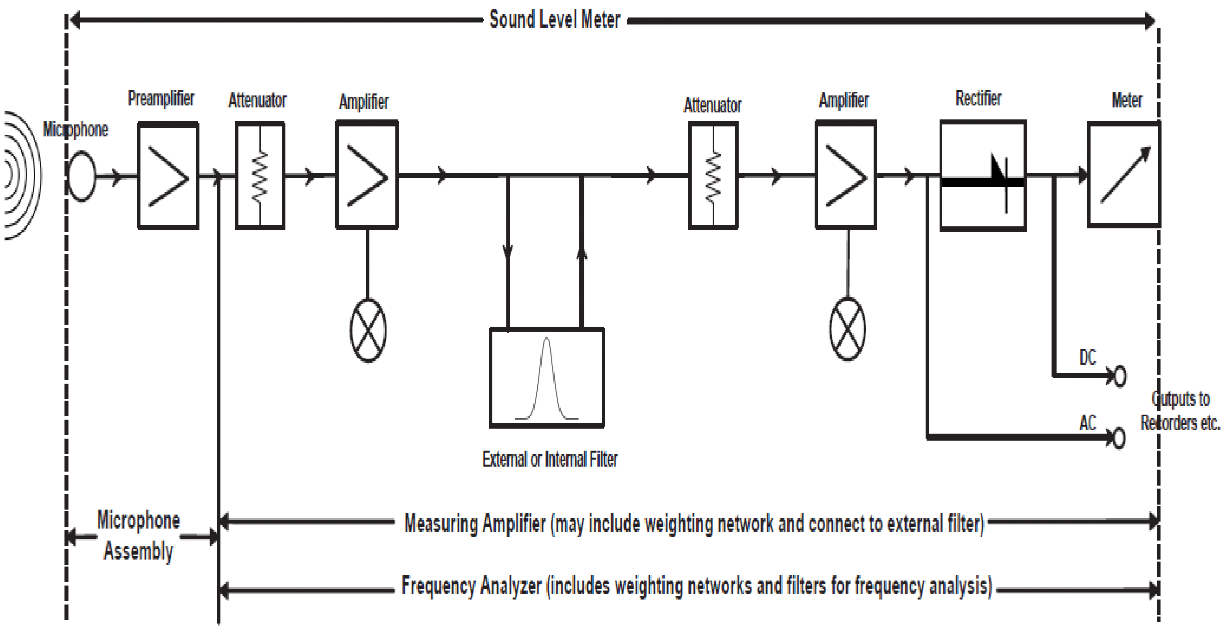

Fig 6: (Circuit diagram of Sound Level Meter)

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.

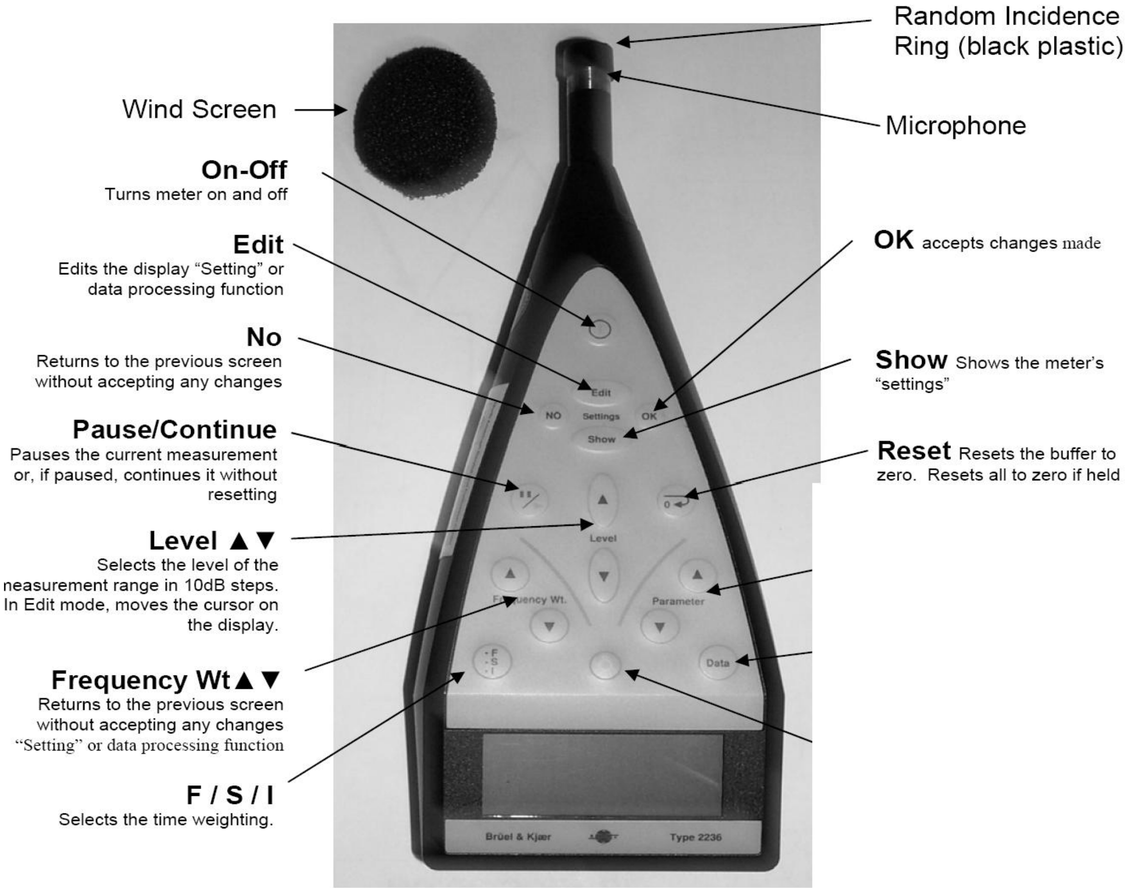

Fig 7: Sound Level Meter. B & K (2236-C Type)

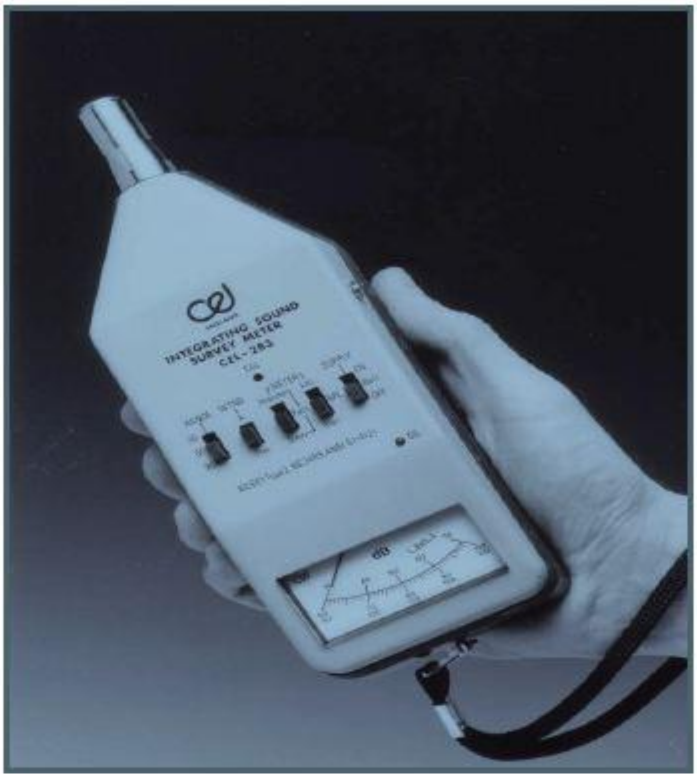

Fig 8: Integrating Sound Level Meter

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.

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 L_{EQ}, L_{im} or L_{TM} (3 or 6 second), 40Dbdynamic 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. 38
Microphone: 17 mm (0.67 inch) electrets condenser type

Frequency Response: dB (A) or Flat

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

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 sec, maximum or 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 +50°C operational. -15 to +60°C 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: 235mmx 75mm x 54mm (9.2in x 3in x 2.1in)

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:

- **Criterion Level:** exposure limit for 8 hours per day five days per week. Criterion level is 90dB (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. 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 9).

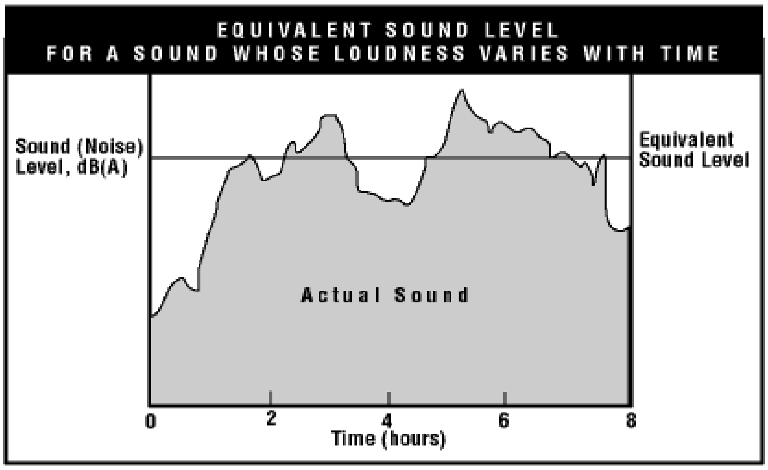

Fig 9: The shaded area under the line that shows how the sound level changes over time (the "curve") represents the total sound exposure over eight hours. Source (http://www.ccohs.ca/oshanswers/phys_agents/noise_measurement.html)

Fig 10: Noise Dosimeter: Source (www.niehs.nih.govhealthdocshearing-man.pdf)

Table 1: 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*	dB(A)	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)

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 11 provide very useful information by clearly identifying areas where there are noise hazards. The SLM must be calibrated before and after each use.

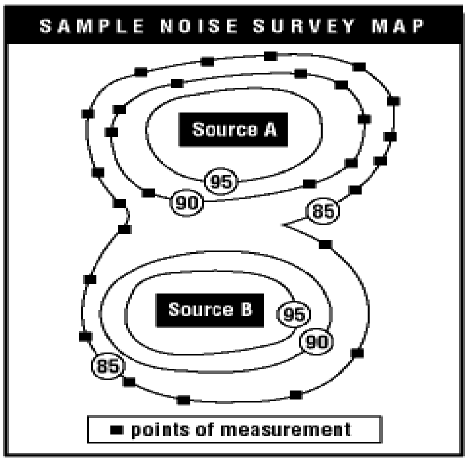

Fig 11: Sample of noise survey map

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

NOISE STANDARDS/ GUIDELINES

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: 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.

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).**

NOISE CONTROL

Noise 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.

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

- **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.

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

- **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.

- **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.

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

- **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.

Noise can be controlled at its Source, Transmission Path and Receiver.

Noise Control at Source:

Noise can control at source by using of **enclosures, mufflers, vibration isolation and damping.**

Using of Enclosure:

Application of an enclosure for noise control will produce a reverberant sound field within the enclosure, in addition to the existing direct sound field of the source. Both the reverberant and direct fields will contribute to the sound radiated by the enclosure walls as well as to the sound within the enclosure. Generally two types of enclosures are used i.e. **full enclosure and partial enclosure.**

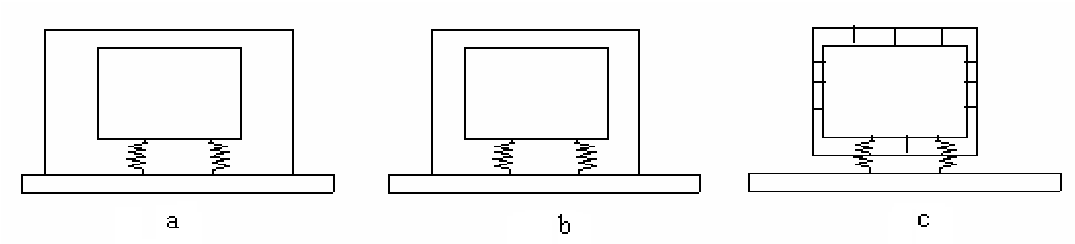

Fig 12: Enclosure Types: (A) Free Standing, Large; (B) Free Standing, Close Fitting; (C) Equipment Mounted, Close Fitting.

Using of Mufflers / Silencers:

- Two types of mufflers or silencers are used for noise control i.e. are either ***dissipative*** or ***reactive*** type.
- **Dissipative silencers** also known as absorption or absorptive silencers work on the principle of absorbing noise.
- **Reactive silencers** work on the principle of reflecting and tuned to provide maximum attenuation at specific frequencies and thus work as narrowband silencers.

❖ The performance of such a silencer is given by the following equation

$$TL= 4.2\propto^{1.4} L/D$$

Where

$\propto$ = absorption coefficient of material

L= length of duct

d= diameter of duct

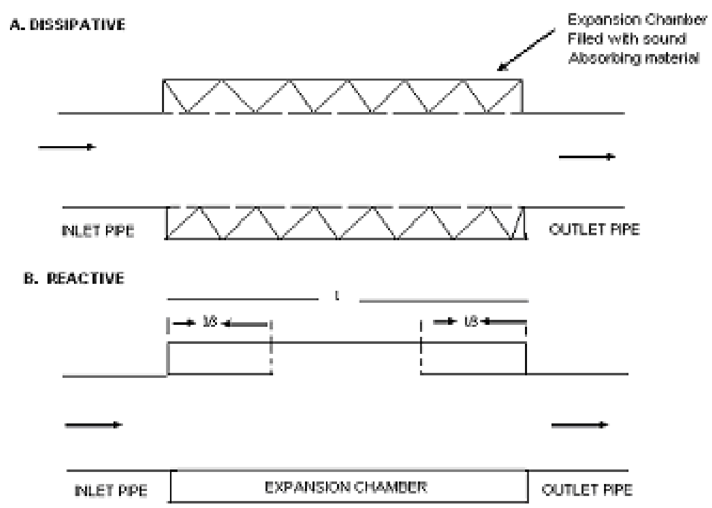

Fig 13: Mufflers a.Dissipative,

Using of Vibration Isolation:

Vibration isolation is applicable on the basis that structure-borne vibration from a source to some structure, which then radiates noise.

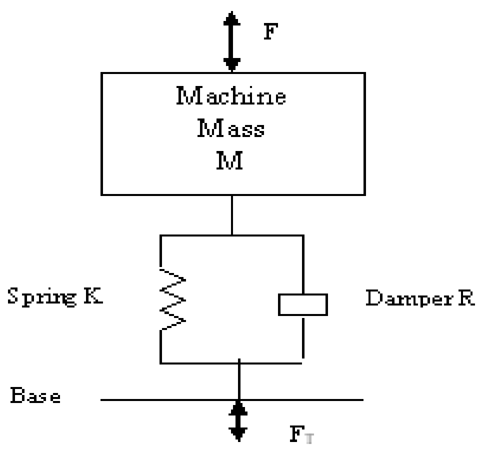

Fig 14: Vibration Isolating System

Using of Damping:

- **Damping** is a means of controlling resonant response to vibration; the process involved being that of dissipating energy by converting it in to heat and thus controlling the amplitude of the response to excitation at resonance.
- The greater the damping the less is the vibrating motion at resonance.
- Three types of damping applicable to mechanical system i.e. are:

  Viscous damping

  Dry friction damping (coulomb, damping) and

  Hysteresis damping

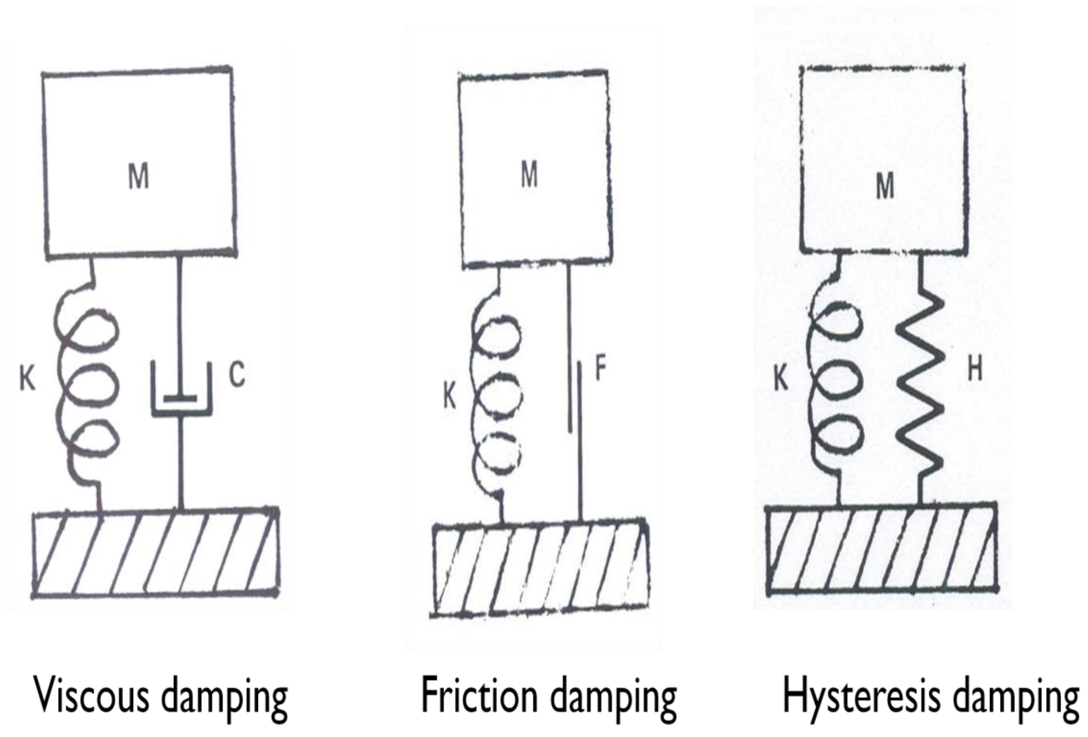

Fig 15: Types of Damping

Noise Control at Transmission Path:

Noise can control at transmission path by using of **barriers, screen and greenbelts etc.**

Using of Barrier:

- Barriers are placed between a noise source and receiver as a means of reducing the direct sound observed by the receiver.

- Basically it reduces the sound which enters a community or work place from high machineries and equipments by absorbing, transmitting or reflecting it back across the machineries or forcing it to take a longer path.

- Typical barriers are made of lightweight concrete blocks, asbestos board, cement board, sheet metal; fiber-glass panels and high-density plastic sheets.

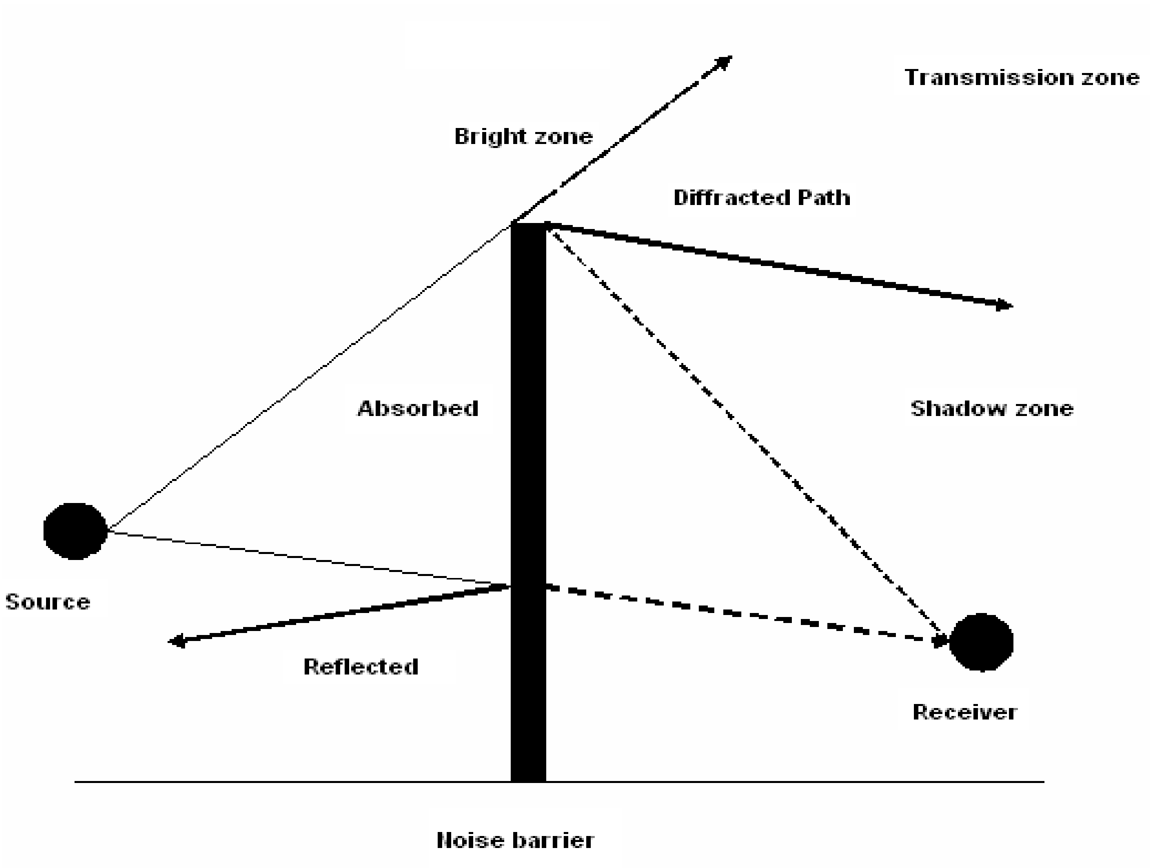

Fig 16: Noise Barriers

Noise Control at Receiver:

- ❖ Commercially two types of device for ear protection are used i.e. **acoustical muffs/ear muffs** and **ear plug.**
- ❖ Generally ear plugs are of two types i.e. **formable** and **preformed** ear plugs.
- ❖ The ear plugs that are compressed before inserting into ear are known as **formable** ear plug whereas plugs that cannot be compressed are known as **performed** ear plug.

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.

Fig 17: Ear muffs

Fig 18: Ear plugs

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

TYPES OF NOISE CONTROL

❖ ADMINSTRATIVE CONTROLS

- ✓ Avoiding from buying risks by embracing a "purchase calm" policy, there is a developing interest for quieter plant and manufacturers are reacting to this.
- ✓ Establishment of job procedures that will reduce employee exposure e.g. Job Rotation.
- ✓ Planned plant maintenance specifically for noise control.
- ✓ Setting targets for noise levels in existing work areas.
- ✓ Cover off noise management in employee induction and training.
- ✓ Cover off noise control in work agreements with contractors.
- ✓ Protection of visitors on site.
- ✓ Monitoring employees by initial audiogram and regular repeats.
- ✓ The use of warning signs.
- ✓ The use of hearing protection related to designated hearing protection areas.

NOISE CONTROL – ENGINEERING CONTROLS

- ✓ When attempting to reduce 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.

- ✓ **Machines enclosures** - 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).

- ✓ **Attenuation of Structure Borne Sound** - Preventing transmission of vibration from machines to the load-bearing structure can considerably reduce structure-borne sound:
- ✓ **Large heavy machines** should be mounted on foundations which are completely separated from buildings or other structures.

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

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

- ✓ **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.
- ✓ **Noise Insulated Rooms** - Cabins should be constructed of materials with good sound Attenuation properties and ideally will have:

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

Ventilation openings with attenuators such as acoustic louvers.

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

HEARING PROTECTION INCLUDES

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

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

- ✓ The need for hearing protectors;
- ✓ Defining hearing protector areas;
- ✓ Selection of hearing protectors
- ✓ Issuing of hearing protection to individuals;
- ✓ Cleaning, maintenance and replacement of hearing protectors;
- ✓ Training and education of people wearing hearing protectors.

CHAPTER 3

NOISE PREDICTION OF OPENCAST MINING MACHINERIES USING MATHEMATICAL MODELS

CHAPTER 3

NOISE PREDICTION OF OPENCAST MINING MACHINERIES USING MATHEMATICAL MODELS:

Introduction:

This chapter highlights the application of mathematical noise prediction models for prediction of opencast mining machineries noise. In this chapter, some independent noise prediction models like **VDI-2714**, **(OCMA, UK, 1972) model, Concawe model, ISO-9613-2 Noise prediction model, ENM – Environmental Noise Model** were discussed. Location and equipment selection were discussed.

Two mines were selected as per the requirement of noise prediction models. The first one is **Samleshwari opencast coal mine of Mahanadi Coalfields Limited** (MCL), Brajrajnagar (Jharsuguda, Odisha, India) and the second one is **Pathpahar Dolomite quarry of Bisra Stone Lime Company Limited (BSLC**), Birmitrapur (Sundergarh, Odisha, India). It was selected for frequency independent models .**VDI-2714.**

Outdoor Noise Prediction:

The sound pressure level (SPL, L_P) at an observation point may be defined as the sum of sound power level (L_W) of the source; a geometric spreading factor, K, which is dependent upon the type of source and accounts for geometrical spreading as the sound propagates away from the source; a directivity index, DI*M*, which accounts for directional properties of the source, including influences of reflections other than those in the ground plane and an **excess attenuation factor**,

A_E*:* The excess attenuation factor in turn is the sum of terms including ground reflection, atmospheric effects, etc. The general noise prediction model is written as the following

$$L_P = L_W - K + DI_M - A_E$$

For N sources, the sound pressure level may be computed as the sum of contribution as in the following equation:

L_P =

Where **L_{Pi}** is the sound pressure level due to the i_{th} source.

There are many noise prediction models available in the literature. These prediction models are basically of two types, octave band frequency independent and octave band frequency dependent. The following sections represent octave band frequency independent model (Verein Deutscher Ingenieur(VDI)-2714) and octave band frequency dependent models viz. CONCAWE (Conservation of Clean Air and Water in Europe), ISO(International Standard Organization)- 9613-2, ENM (Environmental Noise Model) etc. Octave band independent model **(VDI-2714)** is generally based on the average octave band results. All the calculations of attenuation factors are determined in dB (A) only.

VDI-2714 Noise Prediction Model:

In 1976, the VDI (Verein Deutscher Ingenieur) draft code 2714 on Outdoor Sound Propagation was issued by the VDI Committee on Noise Reduction. It is the simplest among all the models. The sound pressure level at an environmental point is calculated from the following equation:

$$L_P\, dB(A) = \sum_{all\, sources}^{\log} \left[L_W + K_1 - 10\log(4\pi R^2) + 3dB - K_2 - K_3 - K_4 - K_5 - K_6 - K_7 \right]$$

L_W= Source power level $R_{e=}10^{-12}$ watts

K_1 = Source directivity index

$-10 \log (4\pi R^2)$ = Geometric spreading term including infinite hard plane coinciding with the source

R = Source to receiver distance

K_2= Atmospheric attenuation = 10 log (1 + 0.0015R) dB (A)

K_3 = Attenuation due to meteorological conditions = $[(12.5/R^2) + 0.2]^{-1}$ dB (A)

K_4 = Ground effects = 10 log [3 + (R/160)] - K_2- K_3 dB (A)

K_5 = Barrier value (0-10) = 10log (3 + 20 d) dB (A)

d= Barrier path difference

K_6 = Attenuation due to woodland areas

K_7 = Attenuation due to built-up areas.

The above calculations are performed in units of dB (A) only, not in octaves for the OCMA (Oil Companies Materials Association) and other models such as (VDI-2720, ISO-9613-2, CONCAWE etc.**VDI-2714** model is a frequency independent model. Using the above equation results can be calculated easily. This is very simple and widely used model.

Concawe noise prediction model:

In 1977, CONCAWE (Conservation of Clean Air and Water in Europe) contracted Acoustic Technology Ltd of Southampton to review the available literature to date on sound propagation in the atmosphere and to update the algorithms used in the petroleum consortium' s OCMA (Oil Companies Material Association) scheme, 1972. The sound pressure level received at a point remote from the noise source is a function of the acoustic power of the source and the various mechanism of attenuation. It is possible to separate the dominant factors affecting the attenuation of sound and examine the contribution of each individually. The major attenuation mechanism could be defined as:

- ✓ geometrical spreading
- ✓ atmospheric absorption
- ✓ ground effects
- ✓ meteorological effects
- ✓ barriers
- ✓ In-plant screening.

Thus, in a simplified form the sound pressure level at a remote point can be related to the source sound power level by the following expression:

$$\mathbf{L_P = L_W + D - \Sigma \mathit{K}\ (\mathit{dB})}$$

Where L_p is the sound-pressure level (dB re 20 μPa), L_w is the sound-power level (dB re 10−12W), D is the directivity index of the source in dB and ΣK is the sum of the losses defined above. The CONCAWE scheme requires octave band analysis. Meteorological corrections in this scheme are based on analysis of Parkin and Scholes' data together with measurements made at several industrial sites. The excess attenuation in each octave band for each category tends to approach asymptotic limits with increasing distance.

ENM: Environmental Noise Prediction Model

The Environmental Noise Model (ENM) was developed by RTA Technology Pty Ltd. in1985. The basic format of calculation is as follows;

L_W =

where

Lw= sound power level Db, R_E 10–12 watts

D= source directivity,

A_1= geometric spreading,

A_2= barrier attenuation

A_3 = air absorption

A4 = wind and temperature effects

A5 = ground attenuation

ENM follows generally the methods used in CONCAWE. Where the two models deviate is in the extent of usage of theory ENM being a relatively new model takes advantage of recent developments in the theory of ground effect and the effect of meteorology. The other notable difference is that ENM was produced as a computer program rather than a descriptive set of algorithms. ENM works in both 1/3rdoctave and 1/1 octave format from **25Hz to 20KHz**.

CHAPTER 4

CASE STUDIES

CHAPTER 4

NOISE SURVEY IN SAMALESHWARI OPEN CAST PROJECT: CASE STUDY

INTRODUCTION:

Original project of Samaleswari OCP was planned for 3 Mty capacities, which was sanctioned in August 1992. Subsequently, due to increase of coal demand from Ib-Valley Coalfield, the project was expanded to 4 Mty (Ph-I) and then 5 Mty (PH-II). Phase-III expansion to 7 Mty was approved in April 2007 annexing additional area. Phase-IV expansion of the project is proposed for incremental production of 5 Mty (Total of 12 Mty) to meet the increased demand of coal from the coalfield. It is proposed thatabout 0.61 sq.km. Area in the north of the approved OCP boundary and there by the barrier between Howrah-Mumbai railway line.

Fig 18: Aerial view of Samaleswari ocp

Fig. 19: Aerial view of Samaleswari ocp

LOCATION MAP

Samaleswari OCP is located to the west of Hingir Rampur colliery in Jharsuguda district in the state of Odisha. It is situated between latitudes **210°47'- 210°49'** North and longitudes **830°53'-830°55'**east as per survey of India.

Fig 20: Samaleswari OCP in Odisha map
(Source: Google image)

Samaleswari OCP is well connected by road. A concrete road of about 2.5 km connects this mine to Brajrajnagar railway station situated in the west. It is approachable from Sambalpur via Jharsuguda by road. Sambalpur is located at a distance of about 70 km. Jharsuguda is the district head quarter and is situated about 20km away from Brajrajnagar.

Mine Geology

Original assessment of the geology of the block in 1983 was based on 38 boreholes involving 7410.30m of drilling, in which Lajkura seam was intersected and dip side drilling was still under progress. On the basis of subsequent drilling, necessary modifications have also been incorporated. The drilling done in this area contents about 10898 55 Mte in 70 boreholes, covering an area of 4.38 sq. kms (excluding the extended area). Out of these, 37 boreholes have been drilled up to Ib seam and the rest 33 boreholes are up to Lajkura seam. The borehole density is about 16 boreholes/km^2, excluding the annexed area.

COAL SEAM DESCRIPTION

- Lajkura coal seam is presently being mined by open cast method in Samaleswari OCP whose capacity is decided to increase from 7Mty to 12 Mty.
- The total stratigraphical thickness of Lajkura horizon varies from 16.71 (O/B-145) to (O/B-192) Rampur colliery block.
- The seam is inter banded with coal, shaly coal, carb-shale, and shale.
- Parting between Lajkura horizon and Rampur horizon, is about 90m
- The seam consists of coarse-grained and granular sandstone.
- The effective thickness of the seam varies from 9.41m (O/B-133) to 25.49m (O/B-166), the average being 17 to 18m.
- Lajkura coal horizon has been intersected fully and /or partially in all the boreholes drilled in block under consideration.
- There is some deterioration towards the bottom portion of Lajkura seam in the south-western part of the block (O/B-131, 132, 133 & 138).

WORKING PLAN

Fig 21: Working plan of Samaleswari OCP

MAJOR MACHINERY USED

Fig 22: Surface miner

Fig 23: Hydraulic shovel

Fig 24: DUMPERS AND ROPE SHOVEL

FIELD VISIT & DATA COLLECTION

The field experiments were carried out at mechanized unit of Samaleswari Open Cast Project. The main noise sources at the projects were as follows: Surface miners, shovels, dumpers and dozers. 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 Samaleswari OCP. 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 average of fifeteen values of noise level of each source was 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 of40 -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.

WORKING FORMULA FOR SOUND LEVEL MODELLING

VDI-2714 Noise prediction model

$$L_P\, dB(A) = \sum_{all\,sources}^{\log} \left[L_W + K_1 - 10\log(4\pi R^2) + 3dB - K_2 - K_3 - K_4 - K_5 - K_6 - K_7 \right]$$

L_W= Source power level $R_{e=}10^{-12}$ watts

K_1 = Source directivity index

$-10\log(4\pi R^2)$ = Geometric spreading term including infinite hard plane coinciding with the source

R = Source to receiver distance

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K_4 = Ground effects = 10 log [3 + (R/160)] - K_2- K_3 dB (A)

K_5 = Barrier value (0-10) = 10log (3 + 20 d) dB (A) = 10log3 = 4.77 dB

d= Barrier path difference=0

K_6 = Attenuation due to woodland areas =0

K_7 = Attenuation due to built-up areas =0

SIMULATION STUDY OF SHOVEL NOISE

Table no 3: Simulation study of shovel noise

Distance from Source	Measured field data(dB)	K1	10 log 4πr^2	K2	K3	K4	VDI (dB)	Avg % error
1	102.5	6.365	10.98	0.0065	0.0787	4.084	91.9458	
2	102	6.865	17.01	0.013	0.3	4.476	85.296	
3	98.5	10.365	20.55	0.019	0.629	4.15	81.747	
4	98	10.865	23.031	0.025	1.019	3.763	79.257	
5	97.5	11.365	24.96	0.032	1.428	3.356	77.319	
6	97.5	11.365	26.55	0.038	1.827	2.96	75.72	
7	96.5	12.365	27.89	0.045	2.197	2.592	74.371	
8	95	13.865	29.05	0.051	2.529	2.262	73.203	
9	93	15.865	30.07	0.058	2.822	1.971	72.174	
10	92.5	16.365	30.98	0.064	3.076	1.72	71.255	19%
11	91.5	17.365	31.81	0.071	3.297	1.501	70.416	
12	91.5	17.365	32.57	0.0774	3.486	1.315	69.6466	
13	91	17.865	33.26	0.0838	3.65	1.153	68.9482	
14	90.5	18.365	33.91	0.0908	3.79	1.015	68.2892	
15	89	19.865	34.51	0.0966	3.91	0.898	67.6804	
16	88.5	20.365	35.07	0.102	4.01	0.801	67.112	
17	88	20.865	35.59	0.109	4.11	0.703	66.583	

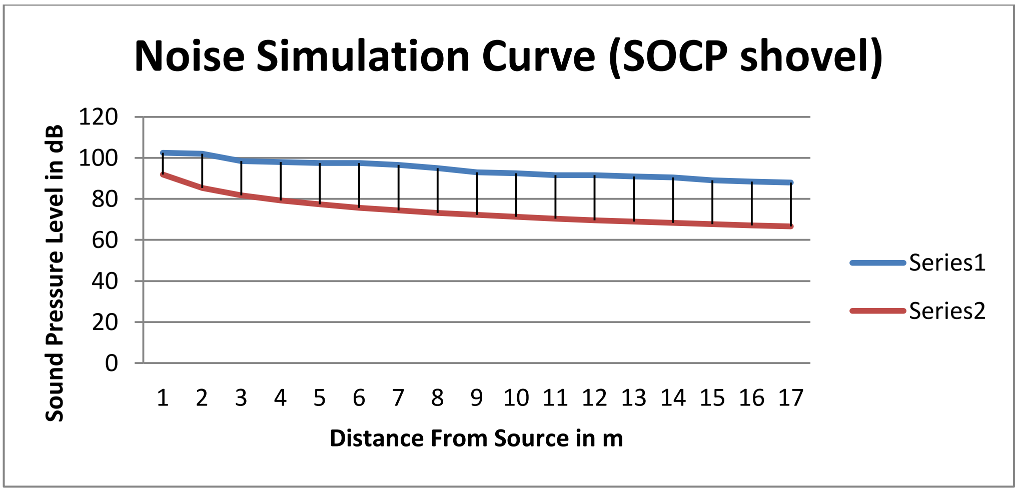

Fig 25: Noise simulation curve

Series 1= Measured data vs distance from the source

Series 2= Predicted data vs distance from the source

SIMULATION STUDY OF DOZER NOISE

Table no 4: Simulation study of dozer noise

Distance from Source(m)	Measured field data	K1	10 log 4πr^2	K2	K3	K4	VDI	Avg % error
1	100.5	6.955	10.98	0.0065	0.0787	4.084	90.5358	
2	100	7.455	17.01	0.013	0.3	4.476	83.886	
3	98	9.455	20.55	0.019	0.629	4.15	80.337	
4	97.5	9.955	23.031	0.025	1.019	3.763	77.847	
5	97	10.455	24.96	0.032	1.428	3.356	75.909	
6	95	12.455	26.55	0.038	1.827	2.96	74.31	
7	95	12.455	27.89	0.045	2.197	2.592	72.961	
8	93.5	13.955	29.05	0.051	2.529	2.262	71.793	20%
9	93.5	13.955	30.07	0.058	2.822	1.971	70.764	
10	92	15.455	30.98	0.064	3.076	1.72	69.845	
11	91.5	15.955	31.81	0.071	3.297	1.501	69.006	
12	89.5	17.955	32.57	0.0774	3.486	1.315	68.2366	
13	88.5	18.955	33.26	0.0838	3.65	1.153	67.5382	
14	88	19.455	33.91	0.0908	3.79	1.015	66.8792	
15	87.1	20.355	34.51	0.0966	3.91	0.898	66.2704	
16	87	20.455	35.07	0.102	4.01	0.801	65.702	
17	86.6	20.855	35.59	0.109	4.11	0.703	65.173	

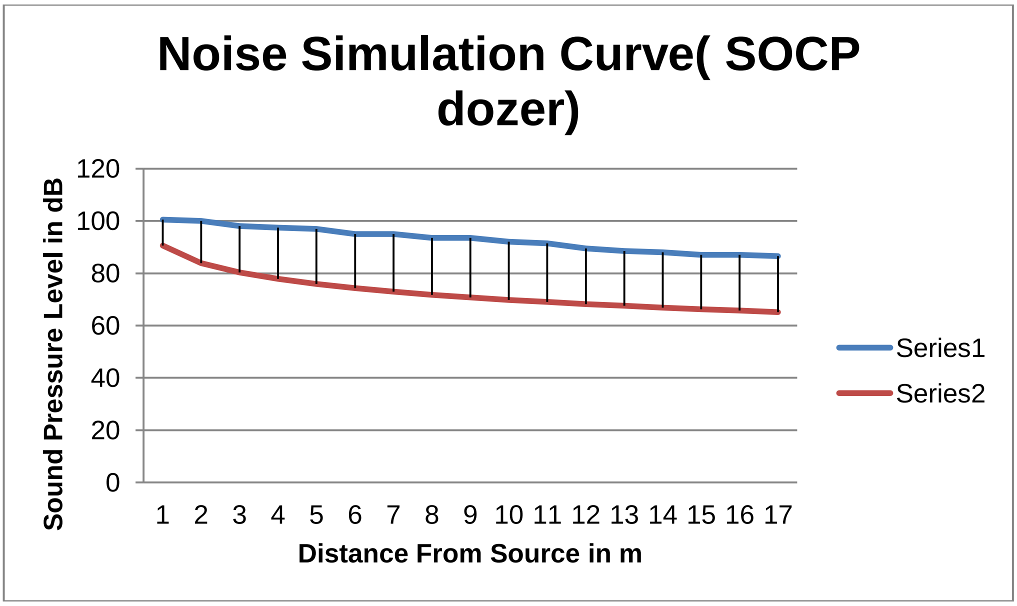

Fig 26: Noise simulation curve (SOCP dozer)

Series 1= Measured data vs. distance from the source

Series 2= Predicted data vs. distance from the source

Table no 4: Simulation study of dumper noise

Distance from Source	Measured field data(dB)	K1	10 log 4пr2	K2	K3	K4	VDI(dB)	Avg % errors
1	102.4	5.78	10.98	0.0065	0.0787	4.084	91.2608	
2	101.2	6.98	17.01	0.013	0.3	4.476	84.611	
3	99.3	8.88	20.55	0.019	0.629	4.15	81.062	
4	98.4	9.78	23.031	0.025	1.019	3.763	78.572	
5	97.5	10.68	24.96	0.032	1.428	3.356	76.634	
6	95	13.18	26.55	0.038	1.827	2.96	75.035	
7	94.2	13.98	27.89	0.045	2.197	2.592	73.686	
8	93	15.18	29.05	0.051	2.529	2.262	72.518	20%
9	92.61	15.57	30.07	0.058	2.822	1.971	71.489	
10	90.9	17.28	30.98	0.064	3.076	1.72	70.57	
11	89.9	18.28	31.81	0.071	3.297	1.501	69.731	
12	88.5	19.68	32.57	0.0774	3.486	1.315	68.9616	
13	88.12	20.06	33.26	0.0838	3.65	1.153	68.2632	
14	87.4	20.78	33.91	0.0908	3.79	1.015	67.6042	
15	86.5	21.68	34.51	0.0966	3.91	0.898	66.9954	

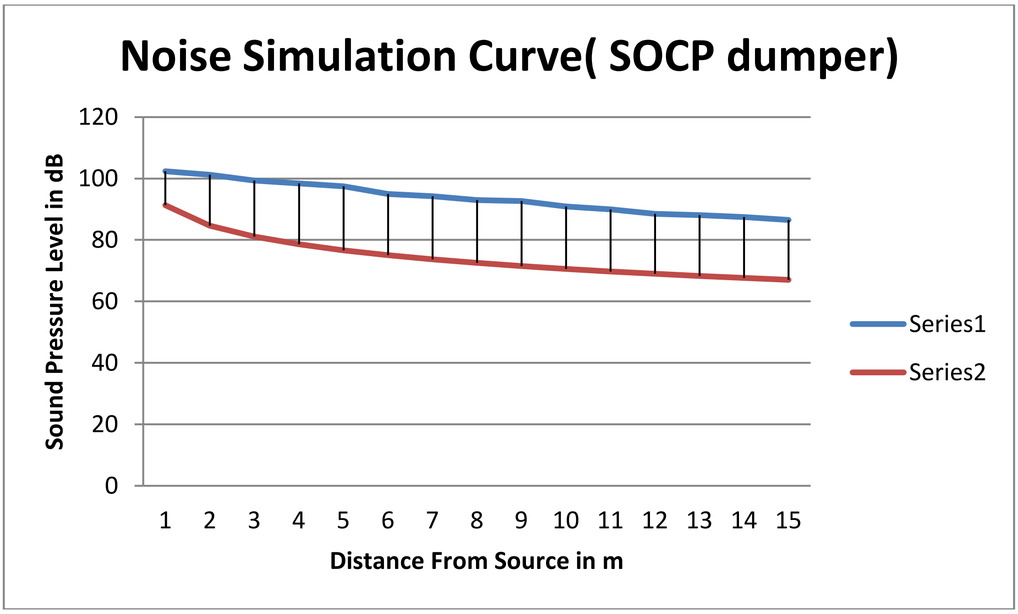

Fig 27: Noise simulation curve (SOCP dumper)

Series 1= Measured data vs. distance from the source

Series 2= Predicted data vs. distance from the source

RESULTS AND DISCUSSION

Results of predicted sound pressure levels of machineries at Samaleswari OCP are presented in given. The maximum sound pressure level was found at rope shovel of 102 dB (A) &Dumpers of 103dB (A). During the field study it was observed that the workers engaged in loading and unloading 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.

Also, it can be seen that, the sound pressure levels were greater than that acceptable level (90dBA).The measured noise level at the management building and the workshop area in. Measurements of noise levels in Samaleswari OCP prove that the workers are suffering from high noise levels more than the acceptable levels.

Noise control methods for Dumpers

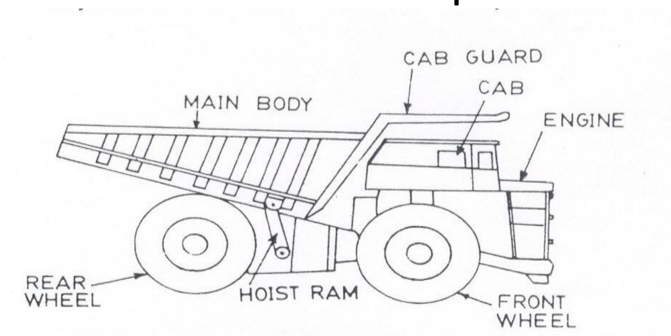

Fig 28: Schematic diagram of dumper

- Noise control is possible in the cab section of the dumper. Proper acoustic material should be installed in the cab section and replace the cracked and the missing window glass.
- All openings to the outside are closed.
- Engine compartment treatment using acoustic foam.
- Upgrading of all engine silencers.
- Restriction of hours of operation and routes.
- Multiple muffler system for control of exhaust noise.
- Acoustic shielding or encapsulation of power trains

Noise control methods for Shovels

- Use silencers at the cab position.
- Use vibration isolation.
- Fan blade damping (coating).
- Change of Fan RPM.
- Sound-absorptive material should be installed on the walls and roof of the operator's compartment.
- Install a barrier behind the operator to provide isolation from the low-frequency noise emitted from the diesel engine

NOISE SURVEY IN PATHPAHAR DOLOMITE QUARRY: CASE STUDY 2

Introduction

Fig 29: Location of BSL Mines

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°15' N to 22°30'N latitude and 84°30'E to 84°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 in1922. 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 mining purposes, 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 265MT 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 onto 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.

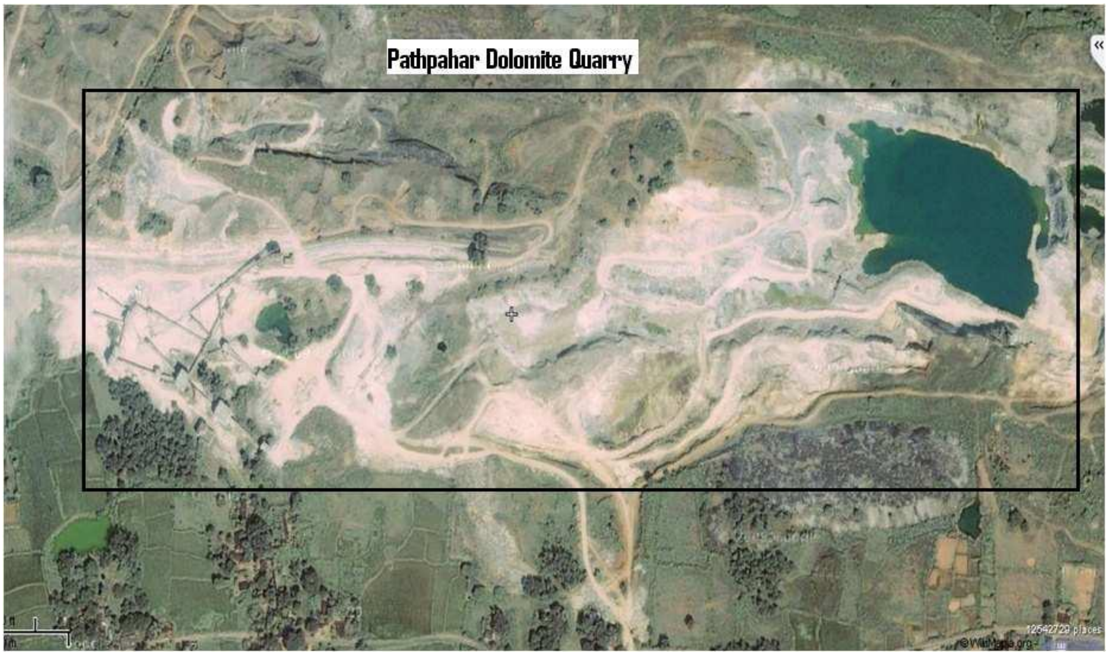

Fig 30: Aerial view of Pathpahar Dolomite quarry
Source http://wikimapia.org/

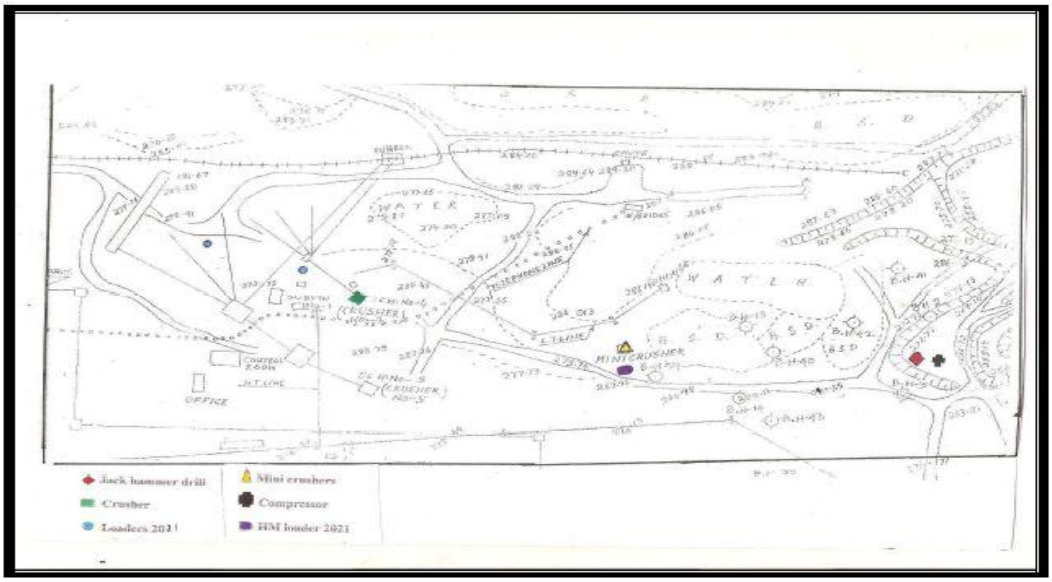

Fig 31: Location of noise sources in Pathpahar mines

NOISE SIMULATION STUDY OF JCB LOADER

Bucket capacity: 0.8 m^3

Power: 50hp

Table no 6: Noise simulation study of JCB loader

Distance from Source(m)	Measured field data in dB	K1	$10\log4\Pi r^2$	K2	K3	K4	VDI in dB	Avg % error
1	111	5.871	10.98	0.0065	0.0787	4.084	99.9518	
2	110.4	6.471	17.01	0.013	0.3	4.476	93.302	
3	108.7	8.171	20.55	0.019	0.629	4.15	89.753	
4	106.5	10.371	23.031	0.025	1.019	3.763	87.263	
5	105	11.871	24.96	0.032	1.428	3.356	85.325	
6	104.3	12.571	26.55	0.038	1.827	2.96	83.726	
7	103.7	13.171	27.89	0.045	2.197	2.592	82.377	
8	102.1	14.771	29.05	0.051	2.529	2.262	81.209	17%
9	100	16.871	30.07	0.058	2.822	1.971	80.18	
10	98.9	17.971	30.98	0.064	3.076	1.72	79.261	
11	97.8	19.071	31.81	0.071	3.297	1.501	78.422	
12	95.5	21.371	32.57	0.0774	3.486	1.315	77.6526	
13	94.2	22.671	33.26	0.0838	3.65	1.153	76.9542	
14	93.9	22.971	33.91	0.0908	3.79	1.015	76.2952	
15	92.1	24.771	34.51	0.0966	3.91	0.898	75.6864	

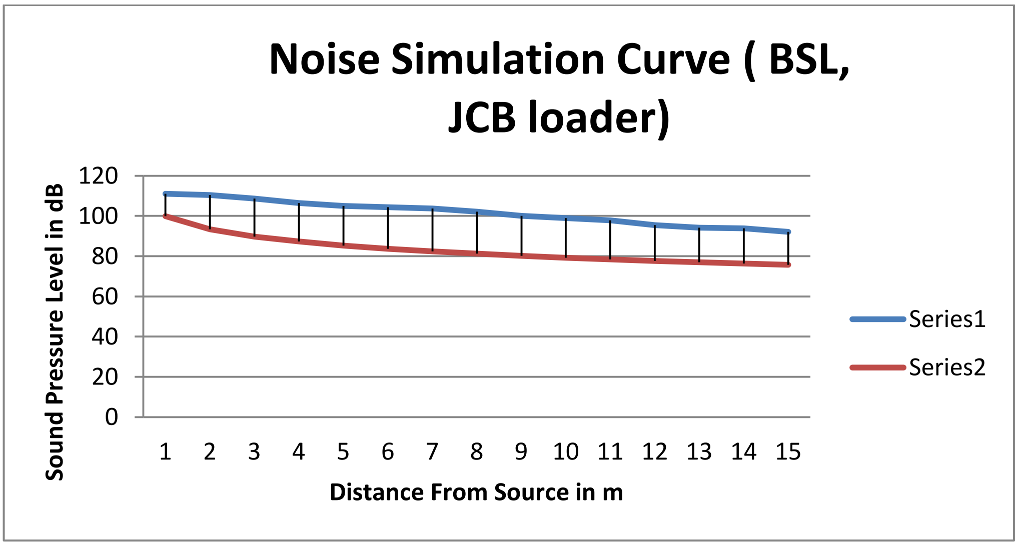

Fig 32: Noise simulation curve (BSL, JCB loader)

Series 1= Measured data vs distance from the source

Series 2= Predicted data vs distance from the source

NOISE SIMULATION OF HYDRAULIC SHOVEL

Shovel PC 300
Make: L& T Komatsu
Bucket capacity: 1.4 m^3

Table no 7: Noise simulation of Hydraulic shovel

Distance from Source	Measured field data (dB)	K1	$10\log4\Pi r^2$	K2	K3	K4	VDI	Avg % error
1	109.4	8.078	10.98	0.0065	0.0787	4.084	100.5588	
2	108.7	8.778	17.01	0.013	0.3	4.476	93.909	
3	108.2	9.278	20.55	0.019	0.629	4.15	90.36	
4	108	9.478	23.031	0.025	1.019	3.763	87.87	
5	106.9	10.578	24.96	0.032	1.428	3.356	85.932	
6	106.2	11.278	26.55	0.038	1.827	2.96	84.333	
7	105.7	11.778	27.89	0.045	2.197	2.592	82.984	
8	104.6	12.878	29.05	0.051	2.529	2.262	81.816	18%
9	104.1	13.378	30.07	0.058	2.822	1.971	80.787	
10	103.4	14.078	30.98	0.064	3.076	1.72	79.868	
11	102.5	14.978	31.81	0.071	3.297	1.501	79.029	
12	101.9	15.578	32.57	0.0774	3.486	1.315	78.2596	
13	100	17.478	33.26	0.0838	3.65	1.153	77.5612	
14	98.9	18.578	33.91	0.0908	3.79	1.015	76.9022	
15	98.1	19.378	34.51	0.0966	3.91	0.898	76.2934	

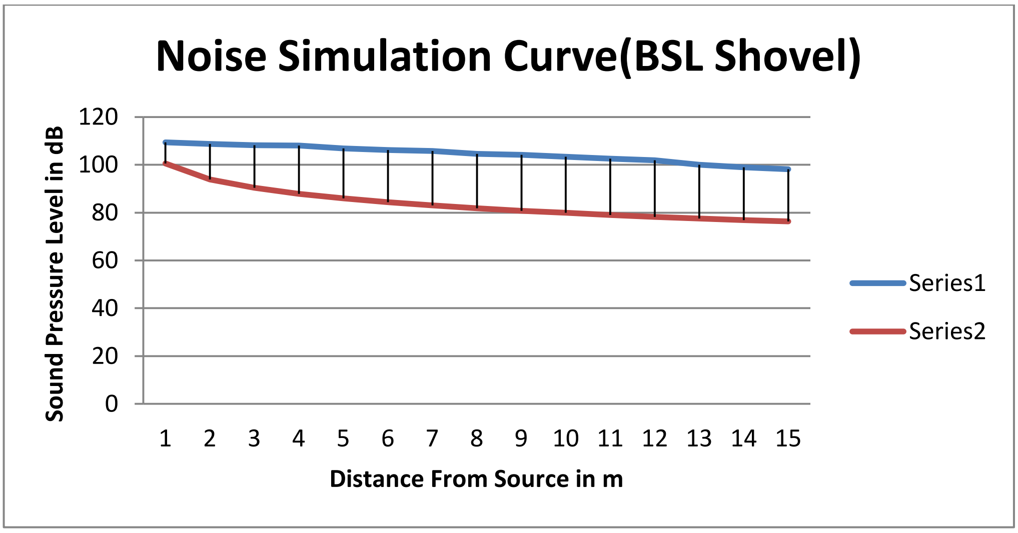

Fig 33: Noise Simulation Curve (BSL Shovel)

Series 1= Measured data vs distance from the source
Series 2= Predicted data vs distance from the source

NOISE SIMULATION OF DTH (Down the Hole) DRILL MACHINE

Table no 7: Noise simulation study of DTH drill machine

Distance from Source(m)	Measured field data(dB)	K1	$10\log4\Pi r^2$	K2	K3	K4	VDI(dB)	Avg % error
1	112	7.058	10.98	0.0065	0.0787	4.084	102.1388	
2	111.2	7.858	17.01	0.013	0.3	4.476	95.489	
3	110.3	8.758	20.55	0.019	0.629	4.15	91.94	
4	109	10.058	23.031	0.025	1.019	3.763	89.45	
5	108.9	10.158	24.96	0.032	1.428	3.356	87.512	
6	108.5	10.558	26.55	0.038	1.827	2.96	85.913	
7	102.9	16.158	27.89	0.045	2.197	2.592	84.564	
8	107.5	11.558	29.05	0.051	2.529	2.262	83.396	19%
9	106.4	12.658	30.07	0.058	2.822	1.971	82.367	
10	104.9	14.158	30.98	0.064	3.076	1.72	81.448	
11	103.2	15.858	31.81	0.071	3.297	1.501	80.609	
12	102.9	16.158	32.57	0.0774	3.486	1.315	79.8396	
13	100.4	18.658	33.26	0.0838	3.65	1.153	79.1412	
14	99.9	19.158	33.91	0.0908	3.79	1.015	78.4822	
15	98	21.058	34.51	0.0966	3.91	0.898	77.8734	

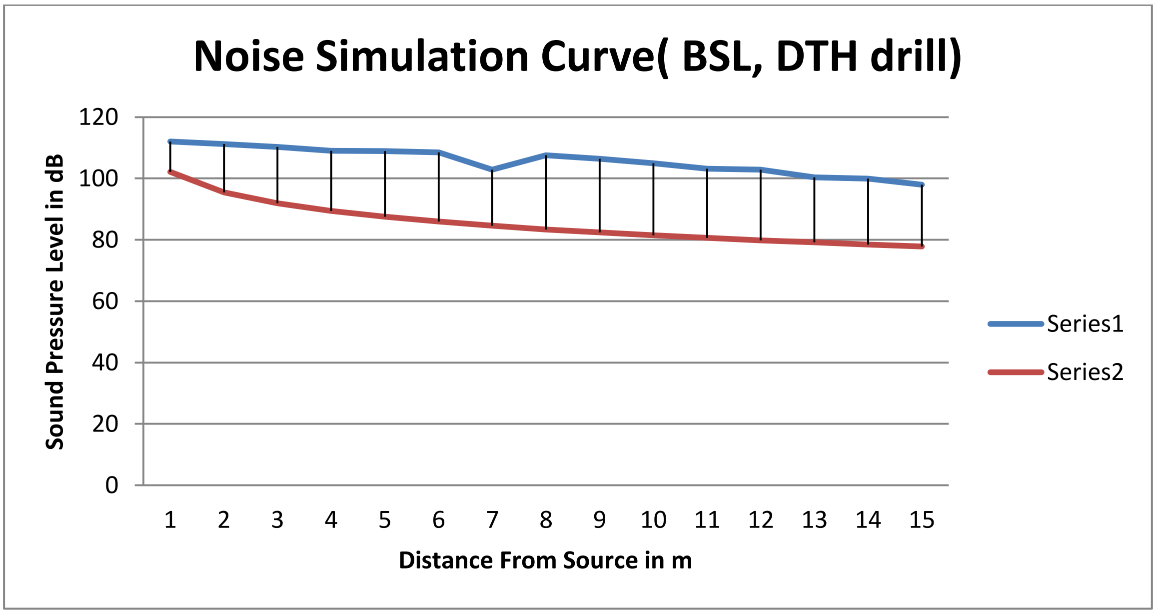

Fig 34: Noise simulation Curve (BSL, DTH drill)

Series 1= Measured data vs distance from the source

Series 2= Predicted data vs distance from the source

RESULTS AND DISCUSSION

Results of predicted or actual sound pressure levels of the machineries at Pathpahar dolomite quarry are presented in given. The maximum sound pressure level was found at Down the hole drill (DTH) of 117dB (A). This is due to the DTH dealing with hard core 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 protecting equipments 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. Also, it can be seen that, the sound pressure levels were greater than that acceptable level (90 dB (A)).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.

CHAPTER 5

CONCLUSION

CHAPTER 5

CONCLUSION

Provision of suitable work environment for the workers is essential for achieving higher production and productivity in both opencast and underground mines. Noisy working condition has negative effects on the worker's morale and adversely affects their safety, health and performance. In order to assess the of status 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 Odisha.

The results obtained indicated that the sound pressure levels of various machineries used in both mines of BSL, &open cast coal mines of MCL were higher than the acceptable limits (>90dB (A)). Both 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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