LECTURE NOTES

SUBJECT-

MINE HAZARD & SAFETY

FOR 5TH SEMESTER MINING ENGINEERING STUDENTS

PREPARED BY-

BINAY MOHAPATRA

(LECTURER IN MINING)

SYNERGY SCHOOL OF ENGG, DKL

5^{th} Semester, MINING

MINE HAZARD & SAFETY

Name of the Course : **Diploma in Mining Engineering**

Course code:	Th.2	Semester -	5th
Total Periods:	60	Examination -	3 hrs
Theory Periods:	4P/week	Internal Assessment-	20
Maximum Marks:	100	End Semester Examination	80

RATIONALE/IMPORTANCE

As a Mining Engineer, one must be thoroughly conversant with various sources of mining hazards as also the remedial measures needed to be undertaken to avoid any mishap and able to understand total operation of rescue and recovery.

OBJECTIVES/OUTCOMES

After completion of the subject, students will be able to:

- Testing of different mine gases. Physiological effect on miners, detection of fire damp by flame safety lamp, explains the method of gas testing by CO-detectors & methanometer.
- Explain how firedamp is emitted in mines.
- Explain causes of mine fires & spontaneous heating.
- Define explosion, explain causes & elaborate necessary steps required for prevention of coal dust & firedamp explosion.
- Define mine inundation, explain causes & elaborate necessary preventive measures required.
- Describe lighting arrangement, lighting standards explain glare & its effect
- Explain the effect of noise & vibration on miners & mine structures & other surface structure.
- Explain rescue and recovery work when mine hazard occurs.

COURSE CONTENTS

1. Mine gases & gas testing

- Composition of atmospheric air. Different mine gases, their properties and physical effects .
- State fire damps, black damp, stink damp, white damp and after damp in mines.
- Describe flame safety lamp & its working principle.
- Explain gas testing by flame safety lamp by accumulation test & percentage test.
- State precaution for gas testing.
- Describe various parts of flame safety lamp, special features.
- State limitations of flame safety lamp.

2. Emission of firedamp in U/g workings

- Describe gradual exudation, blower & outbursts of firedamp in U/g workings.

3. Define fires & spontaneous heating

- Define incubation period
- Define spontaneous heating and its causes and effects.
- State preventive measures against spontaneous heating.
- Explain CO/O_2 ratio & CO_2/O_2 ratio.

4. Mine Explosion

- Describe coal dust explosion & fire damp explosion with their causes & prevention.
- State inflammability of coal dust & fire damp.
- Explain Coward's diagram.
- State prevention, suppression & treatment of dust.

- Describe sampling of dust in Mines.
- Stone dust barrier.

5. Mine Inundation

- State sources of water in mines & its danger.
- State precaution against inundation.
- Describe burnside safety boring apparatus.
- State precaution while approaching water logged area.
- Describe water dams- its construction & design. (Without derivation of formula)
- Explain water danger plan.
- Statutory provision for working near water body.

6. Mine lighting & illumination

- Define illumination and its units.
- Standards of lighting at different parts of mine as per mine regulation.

7. Noise and Vibration .

- Explain the effect of noise & vibration on miners & mine structures & other surface structure with respect to statutory provision.

8. Mine Rescue and Recovery

- Proto-IV, Proto-V, Drager BG-174, Self rescuer, Smoke helmet, Gas mask.
- Construction of Rescue brigade and their role in rescue and recovery operation.
- Mine Rescue rules 1985 Annexure I,II,III.

1. Mine gases & gas testing

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MINE AIR COMPOSITION

- When air enters any mine or other subsurface structure, it has a volume composition of approximately 78 percent nitrogen, 21 percent oxygen and 1 percent other gases on a moisture free basis.
- A more precise analysis is given in table below. However, as the air progresses through the network of underground openings, that composition changes.

Gas	Volume (%)	Mass (%)	Molecular weight (kg/kmol)
1. Nitrogen N2	78.09	75.52	28.01
2. Oxygen O2	20.95	23.15	32
3. Carbon dioxide Co2	0.03	0.046	44
4. Hydrogen	0.01	0.0007	2.016
5 Argon (Ar) and other rare inert gases like Xe, Kr, Ne)	0.93	1.284	39.943

Classification of Impurities

Non-toxic but explosive gases: Methane, Acetylene(C2 H2), Hydrogen (H2) etc.

Toxic gases: Carbon dioxide (CO2), Radon and its daughter products, etc.

Acutely poisonous gases: Carbon monoxide, Nitrous fumes, Sulphur dioxide, Hydrogen sulphide (H2S). Arsenic etc.

Suspended fine droplet: fog due to condensed water vapour

Solid impurities: dust, Smoke,

Miscellaneous impurities: Vapour of water, hydrogen (fuels and lubricants), metal like mercury, lead.

NITROGEN (N2)

General Properties:

- Nitrogen is a colourless, odourless and tasteless gas.
- It is slightly lighter than air with a specific gravity of 0.967.
- Density: 1.254 kg/Nm3Critical temperature: -146 c Critical Pressure: 35 atm.
- It is slightly soluble in water, 100 volume of water dissolvingat 15 c 1.8 volume of nitrogen.
- It is chemically inert; it is not combustible and hence also not a supporter of combustion.

There are three major sources of Nitrogen in mines:

- Production by the decomposition of organic substances
- Production from blasting using explosives (1 kg of nitroglycerine releases 0.135 m of nitrogen)
- Production from the strata through cracks

Physiological Effects:

Nitrogen has no known harmful effects on the human system but a higher concentration of nitrogen leads to deficiency of oxygen in the mine air. Thus, increase in nitrogen concentration indirectly leads to the physiological effects caused by a lack of oxygen on humans.

OXYGEN (O2)

General Properties

- It is a colourless, odourless, and tasteless gas with a specific gravity of 1.1047(Slightly heavier than air)
- Its molecular weight is 32.
- Density 1.428 kg/Nm3
- It is slightly soluble in water (3 volume dissolved in 100 volumes at 90 C)
- Critical temp -> -119 C. Critical Pressure 50 atm

In mines, the oxygen content of mine air decreases due to breathing by men, burning of flume safety lamp, absorption of by acidic mine water, oxidation of organic and inorganic substance, timber, Coal, and pyrite (FeS_2)

Physiological Effects:

Physiological effects of staying/working in an atmosphere deficient in oxygen

O2 Conc.	Effect
19%	*Flame height on flame safety lamp gets reduced by 50%*
17%	*Noticeable increase in rate of breathing. Increase in the concentration of carbon dioxide in the atmosphere.*
16%	*Flame lamp extinguished.*
15%	*Dizziness, increased heartbeat.*
13-9%	*Disorientation, fainting, vomiting sensation, headache, blue lips, and coma may occur.*
7%	*Coma, convulsions (violent uncontrollable contractions of muscles) or death may occur*
Below 6%	*The conditions may eventually lead to death*

CARBON DIOXIDE (CO2)

General Properties:

- Carbon dioxide is colourless, odourless and has a slightly acidic taste.
- The specific gravity of carbon dioxide is 1.519. It is found in low-lying place in mines. It is extremely soluble in water.
- Critical temp 31.9C.
- Carbon dioxide does not combustible and does not support combustion to sustain life.
- It is fairly soluble in water and forms carbonic acid when dissolved in water.

$CO2+ H20 <-> H2CO3 <-> H^+ + HC03$

It is produced in the mining from the following cause:

- Breathing of men, produced in the human body and exhaled in respiratory process.
- Burning flames
- Decay of mine timber
- Slow oxidation of coal in coal mines
- Blasting.
- Use of Internal combustion engine, Such as Diesel locomotives.
- Mine fire and explosion in after damp.

CO_2 Conc. & its Effects.

0.03 % - No effect- it is the. normal concentration of CO2 in air

0.50 %- Lung ventilation gets increased by 5%

2.00 % -Lung ventilation gets increased by 50%

3.00 %-Lung ventilation gets doubled, heavy breathing or panting on Exertion

5% to 10%-Violent panting leading to fatigue from exhaustion(extreme fatigue), headache

10% to 15% - Intolerable panting, severe headache, rapid exhaustion and collapse.

CARBON MONOXIDE (CO)

General Properties:

- Carbon Monoxide is a colourless, odourless and no irritating gas.
- Density: 1.250 kg/Nm-
- Critical temp: 140°C
- Critical pressure: 34.6 atm
- It is slightly soluble in water.
- Its specific gravity is 0.972, as its specific gravity is almost equal to that of air and therefore it exists at all levels in an underground opening.
- It burns with a blue flame and is explosivein presence of air at concentrations between 12.5% and 75%.
- The ignition temperature of CO is 873K

CO is produced by the incomplete combustion of carbonaceous materials.
It is also produced by internal combustion engines, blasting and spontaneous combustion in Coal mines. It can also be generated as a component of water gas (mixture of CO andH2).
When water is applied to coal for controlling the fire.

Physiological Effects

It is a deadly poisonous gas. Haemoglobin present in human blood has 300 times more affinity towards CO thanO2. The new substance formed by the combination of CO and haemoglobin is known as carboxy-haemoglobin. This is relatively stable and accumulates in the bloodstréam. This results ina reduction in the number of red cells for carrying oxygen to vital parts of the body. Thus, the physiological effects of CO arise because of the reduction in oxygen Supply to vital parts of the body.

Blood saturation -Symptoms
% CO. Hb

05 -10 *-Slight loss of concentration*
10 -2 *- Sensation of tightness across forehead, slight headache*
20- 30*- Throbbing headache, judgment Impaired*
30 -40 *-Severe headache, dizziness, disorientation, dimmed vision, nausea (vomiting), possible collapse*
40 -60*- Increased probability of collapse, rise inrates of pulse and respiration, convulsions*
60- 70*- Coma, depressed pulse and respiration, possible death*
70 -80 *-Fatal will lead to death.*

Permissible Limit: 50 ppm (0.0005%)

Detection of Carbon Monoxide

Canary birds
Colorimetric indicating detectors
1. Hoolamite tubes
2. M.S.A. ammonium-palladium-complex
Electric measuring instrument.
1. Drager multi gas Detector with hopcalite (MnO_2 +Cu20)

HYDROGEN SULPHIDE (H_2S)

General Properties

- It is a colourless qas having a sticky sheet taste and odourof rotten egg and has a sweetish taste.
- Specific gravity is 1.175.
- Density: 1.5 kg/Nm^3
- It is 1.2 times heavier than air
- Easily soluble in water.
- It is combustible and forms flammable mixture.
- It is a Poisonous gas.
- It burns with a light blue flame and is soluble in water.
- It is also known as Stink Damp.
- It is combustible and is explosive over a wide range of its concentration from 4.3 % to 45.5 %.

H_2S is not very common in mines and usually occurs in firedamp and gob fires in sulphurous coal. It is formed naturally by bacteriallchemical decomposition of organic compounds and is often detected near stagnant pools of water in underground mines. It may also occur in natural gas and petroleum reserves and migrate through the strata in a weakly acidic water solution. In metal mines it is produced by the action of acidic water on iron pyrites which can be represented by the equation:

$$FeS_2 + 2H_20\ Fe(OH)_2 + H_2S + Si$$

Physiological Effects

Hydrogen sulphide has a very low odour threshold, with its smell being easily. Sensed by the human nose at concentrations well below 1 part per million (ppm) in air.

The odour increases as the gas becomes more concentrated, with the strong rotten egg smell recognizable up to 30 ppm. Above this level, the gas is reported to have a sickeningly Sweet odour up to around 100 ppm. However, at concentrations above 100 ppm, a person's ability to detect the gas is affected by rapid temporary paralysis of the Olfactory nerves pair cranial nerves that conduct impulses (from the mucous membranes of the nose to the olfactory bulb) in the nose, leading to a loss of the sense of smell. This unusual property of hydrogen sulphide makes it extremely dangerous to rely totally on the'sense of smell to detect the presence of the gas. The physiological effects of H2S poisoning are given below .

Concentration of H2S (Ppm)	Effects
50-100-	*Slight irritation to eyes and respiratory tract, headache.*
200-	*Intensified irritation of nose and throat.*
500 -	*Serious inflammation of eyes, nasal secretions, coughing, palpitations, fainting.*
600 -	*Chest pains due to corrosion of respiratory system, may be fatal.*
700 -	*Depression, coma, probable death.*
1000-	*Paralysis of respiratory.system, very rapid death.*

Nitrous fumes (NO)

The nitrous fumes are mainly produced by explosives containing nitro-glycerine and in exhaust fumes of diesel locomotives. They are also found in shafts and tunnels where heavy shot firing takes place in a confined place.

General Properties

Nitrous fumes are rarely found in mines and mainly consist of nitric oxide, nitrogen dioxide and nitrogen tetra-oxide. It quickly combines with oxygen to form nitrogen dioxide (NO) which has a pungent smell like that of fuming nitric acid. The original product is nitric oxide (NO) whio As NO2 cools down it is slowly converted to nitrogen tetra oxide (N204), which is a colourless gas. The specific gravity of NO is 1.036, specific gravity of NO, is 1.519 and specific gravity of N204 is 1.588. The nitrous fumes are highly soluble in water.

Physiological Effects

The brown fumes of NO2 get dissolved in water and produce nitrous acid (HNO2) and nitric acid (HNO3). These acids cause irritation and corrosive effect on eyes and respiratory system.

Concentration of NO2 (ppm)	Effects
60	*Minor throat irritation*
100	*Coughing may commence*
150	*Severe discomfort, may cause pneumonia later*
200	*Conditions are likely to be fatal to human beings*

SULPHUR DIOXIDE (SO2)

General Properties:

- This is a colourless gas with a very suffocating odour and a specific gravity of 2.264.
- It is 2.21 time heavier than air and it tends to settle into lying area.
- It is highly soluble in water.
- It is found in smaller quantities in afterdamp (Afterdamp is a mechanical mixture of gases found in a mine after an explosion. Afterdamp contains nitrogen and carbon dioxide as the chief constituents along with carbon monoxide, methane, water vapour, hydrogen, oxygen

and small quantities of H_2S and SO_2. A typical composition of afterdamp may be as follows: CO - 1.5%, C02-8%,O2-5%, CH4-0.3%, H2-0.2%, N2-85%) in some coal mines, but occurs abundantly in sulphide ore mines with fires. Blasting in rich sulphide ores also produces large quantities of SO2 and H2S. It is also released from the exhaust of internal combustion engines.

Physiological Effects:

SO2 is an irritating and toxic gas. At low concentrations it causes intense burning sensation to the eyes and the respiratory tracts.

Concentration of SO2 (ppm)	Effects
20	*Irritation of eyes and respiratory system*
50	*Severe burning sensation in eyes, nose and throats*
400	*Immediately dangerous to life*

HYDROGEN (H2)

General Properties:

- It is colorless, odorless, tasteless and non-toxic in nature.
- It is the lightest of all gases.
- Density 0.089 kg/Nm3
- It has specific gravity of 0.07. This makes it rise to the roof.
- Slightly soluble in water.
- It does not support combustion but is combustible.
- The detection of Hydrogen in fire gases is done mainly by gas analysis.

The sources of hydrogen in underground mines includes:

- Charging of batteries.
- Action of acids on metals.
- Action of water on hot coal (as water gas) or even some ofthe hot minerals.
- Rarely as strata gas and in afterdamp.

METHANE (CH4)

General Properties:

It is colourless, odourless and tasteless gas.

It has a density of 0.7168 kg/Nm3.

It has specific gravity of 0.554. That is the reason why it tends to rise to the roof of a mine working.

Methane gas is poorly soluble in water, but is soluble in organic solvents like alcohol and ethers.

It burns with a blue flame and produces carbon dioxide and water as products.

$$CH_4 + 20_2 \text{ -- > } CO_2 + 2H_20 + \text{Heat}$$

Lag on Ignition

'Lag on ignition' is defined as the time interval between the exposure of "CH4 Air" to an igniting source to the appearance of flame. This lag on ignition is dependent on the temperature of the igniting source. Lag on ignition is an important characteristic of methane gas. Methane gas starts burning only after absorbing 92.53 KJ/mol heat.

Temperature	Delay time
650 ^{0}C	10 seconds

1000 °C	1 second
1200 °C	1/15th of a second

Detection and Estimation

- Flame safety lamp
- Methanometer
- Ringrose automatic firedamp
- Firedamp interferometer/interference Methanometers

State fire damps, black damp, stink damp, white damp and after damp in mines

(a) Blackdamp ; It is a mechanical mixture of the extinctive gases, carbon dioxide and excess nitrogen; sometimes it is referred to as chokedamp or stythe.

(b) Firedamp : It is used either as (i) synonymous with methane or (ii) referring to the mechanical mixture of gases, chiefly inflammable, given off naturally from coal and consisting for the most part of methane, CH,.

(c) Whitedamp : It is synonymous with carbon monoxide, CO,

(d) Stinkdamp : It is synonymous with sulphuretted hydrogen, H,S (Hydrogen sulphide)

(e) Afterdamp : This is a mechanical mixture of gases existing in a mine after an explosion of firedamp or coal dust. Its composition is extremely variable but usually includes carbon monoxide, carbon dioxide, nitrogen and sometimes H,S and SO, with very small percentage of oxygen. The percentage of CO and CO, is much in excess of what is normally found in a mine.

Describe flame safety lamp & its working principle.

It was discovered by SIR HUMPHREY DAVY in 1815. It was discovered with dual purpose of detecting methane as well as mine illumination. Many modifications have been done to the flame safety lamp. Now a day the flame safety lamp (mostly used for methane detection) are based on MARASAUT-MUESELER principle.

Two gauzes instead of one Safety lock arrangement for relighting, controlled

The flame safety lamp can be divided into three main sections. It works on the principle of WIRE GAUZE

• J.K.DEY& sons introduced flame safety lamps with trade name VELOX.

• GL-50 is permitted by DGMS for gas testing in degree- 1&2 mines gassy coal mines.

• Gl-60 is permitted for all degree gassy mines

The different types of flame safety lamps are –

- GL-5 - for accumulation test
- GL-50 - for percentage test
- GL-60 - for percentage test

- GL-7 - for percentage test

The lamps consists of three separable sections (lower middle & upper) which can be screwed together for complete assembly and use.

Upper section

- ***Bonnet and chimney with hood for top feed provision.***
- ***Wire gauges***

Middle section with partly upper section

- ***Lower flange screwed on the fuel vessel.***
- ***Five Steel rods connecting the lower flange.***
- ***Thick toughened glass and asbestos gaskets.***

Lower section

- ***Fuel vessel fitted with a burner and a wick passing through.***
- ***Side oil-filling arrangements and spindle flame adjustment.***
- ***Oil vessel has retchet teeth at the top and provision for magnetic locking.***

PARTS OF A FLAME SAFETY LAMP

- BONNET-
- It protects the wire gauge from damage due to external hit.
- It also guards the flame against high air velocity.

- OUTER GAUGE

➢ The function of outer gauge is to prevent the passage of flame from outer gauge.

➢ While hot combustion gases passes heat is absorbed by gauzes which then dissipiate by way of radiation.

- INNER GAUGE

➢ The function of inner gauge is to prevent the passage of flame from interior to exterior of lamp.

➢ The gauzes are made of COPPER wire of 28 mesh.

- FUEL VESSEL
- Kerosene oil, motor spirit and ESSO-SOLVENT NO.1425, Solvent are used in lamps

- PILLARS
- A set of five pillars to protect the glass from external hit.
- The bonnet rests on pillar over the oil vessel.

- ASBESTOS RINGS

➢ Two asbestos rings are fixed at top and bottom of glass to prevent the gases to come outside.

- MAGNETIC LOCK

➢ Safety lamp should be kept securely locked.

➢ Magnetic lock is used to locking or unlocking the safety lamp.

➢ The magnetic lock prevents the lamp from opening underground for any purpose.

- GLASS

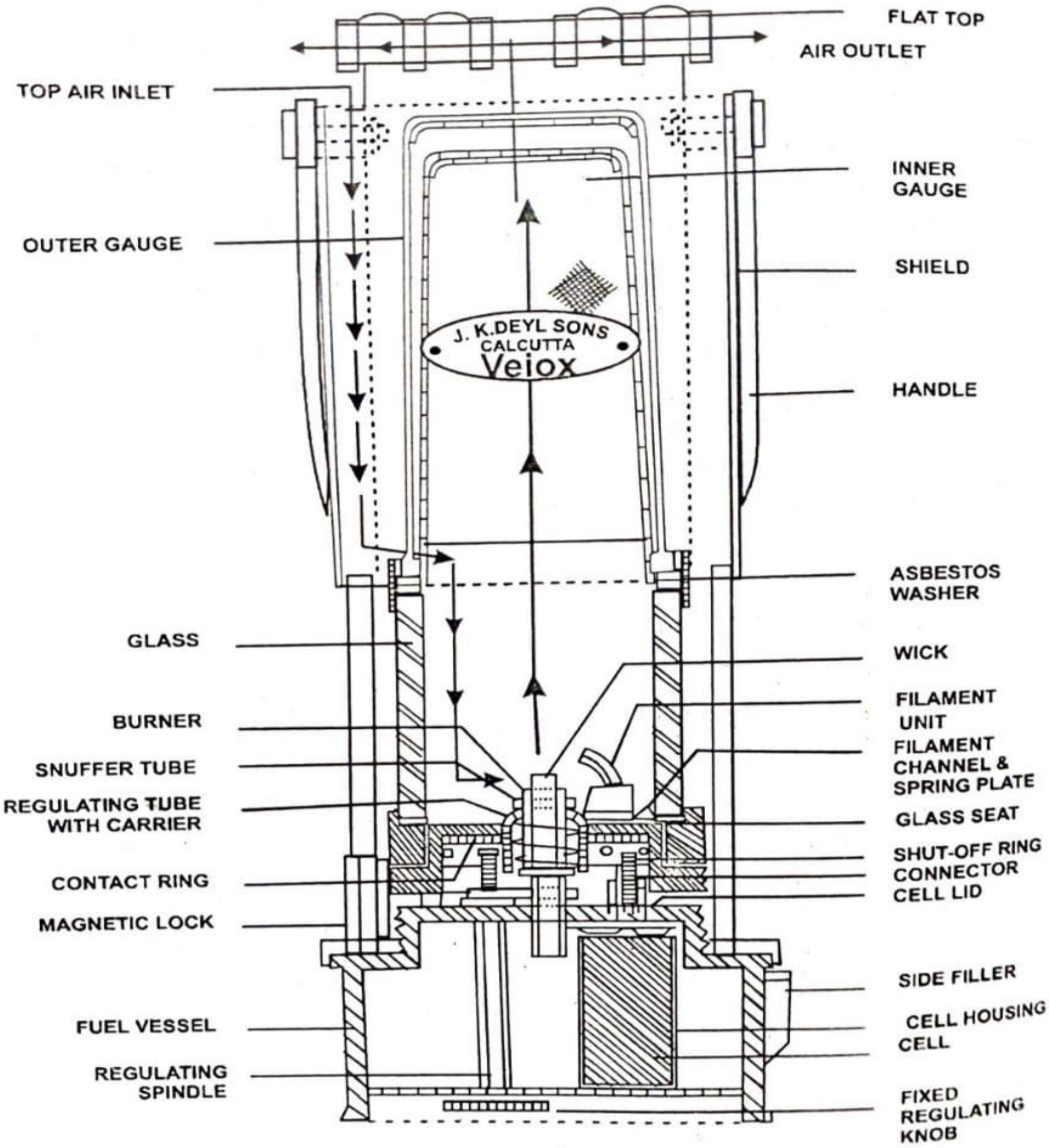
➢ It should be tough quality and of sufficient thickness so as to withstand the shock pressure when an explosion occurs inside the lamp.

➢ Toughened Glass cylinder should be 4-5 mm thick.

- WICK AND WICK ADJUSTER (Knob)

➢ Wick adjuster is to adjust lower or higher the flame.

- The wick passes through the wick holder.
- Wick may be flat or round, wider the wick longer the cap.



Velox GL-60 flame safety lamp.
Courtesy of J.K. Dey & Sons.

OPERATION OF FLAME SAFETY LAMP (Velox GL-7,GL-60)

- First outer gauge and inner gauge are inserted into the bonnet.
- Then one gasket is provided with the inner gauge.
- After that glass is seated on the gasket and again the gasket is provided on the other surface and finally the glass seat is fitted.

Before assemble the fuel vessel into the bonnet, the filler cap is to be opened firstly and poured petrol into the vessel till it is filled up.

OPERATION OF FLAME SAFETY LAMP (Velox GL-7)

- After fuelling the dry cells are put into the oil vessel.
- Then the oil vessel is attached with bonnet portion when it is locked automatically and the lamp gets ready for use.
- When the lamp is ready for use firstly the knob at the bottom of the fuel vessel is rotated 2-3 times clockwise by finger and at the same time pull down the knob thus circuit of filament is energized glow at once the wick is ignited.
- After lighted the lamp the knob is again rotated but anticlockwise just to avail the testing flame.
- As and when required, 13mm height flame can be obtained by adjusting mechanism with the help of the said knob.

Working Principle -

In methane air mixture, the flame safety lamp burns with a flame having blue coloured cap. The height of the cap is dependent on the methane concentration. At lower concentration of methane, the heat produced by flame is hot enough to ignite the-gas beyond a certain limit. As the concentration of methane increases, more heat is produced and it can make the temperature higher than the ignition temperature of methane in slightly larger vicinity, causing the height of cap to increase. It is interesting to know what will happen when the concentration of methane is in the explosive range (5-15%) When the concentration is in the explosive range, explosion in the lamp takes place producing carbon dioxide and extinguishing the flame. Normal flame - A lamp is carried in the mine with a normal flame. Under this condition the lamp burns with an - elongated flame without producing any soot.

Explain gas testing by flame safety lamp by accumulation test & percentage test.

TESTING OF METANE GAS

IN A COAL MINE WHERE METHANE GAS IS LIKELY TO BE PRESENT, IT IS TESTED WITH THE HELP OF A FLAME SAFETY LAMP IN TWO WAYS.

- Accumulation test.
- Percentage test.

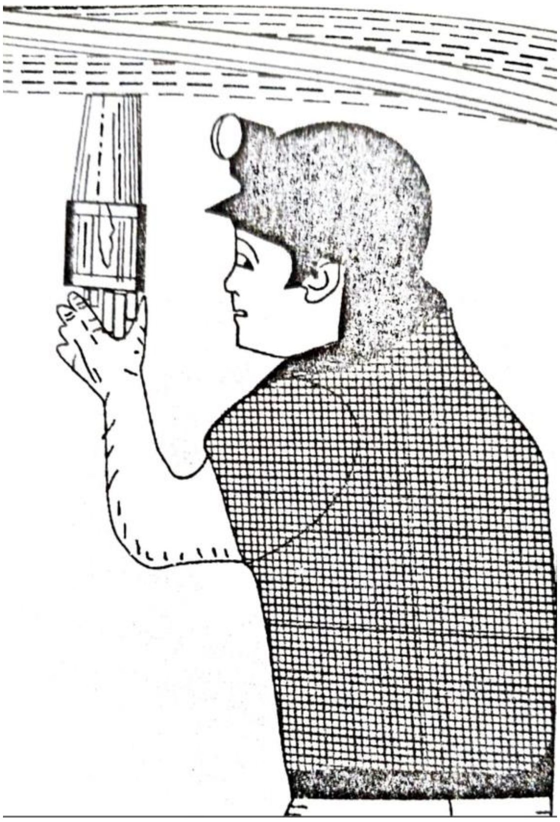
<u>ACCUMULATION TEST</u>

The purpose of this test is to ascertain if there is any accumulation of gas in places where it may be suspected or is likely to be accumulated.

PROCEDURE-

- To test for accumulation, switch off the cap lamp.
- Raise the flame safety lamp (GL-5) cautiously with normal size of flame.
- Then watch its behavior.

- If its elongates , i.e. if it spires or jumps, the percentage of gas can be taken as nearly 3% or more.
- No efforts should be made to raise the flame safety lamp higher than is necessary to test for accumulation because this results in keeping the flame in richer mixture of methane and air which may explode inside the lamp and extinguish the flame.



- Even if the mixture is not explosive the gas will burn inside the lamp and it may produce CO2 which will extinguish the flame,
- It is unnecessary to conduct the percentage test when the flame spires up in a safety lamp as it is clear that the gas percentage is not less than 3.

PRECAUTION OF GAS TESTING

- If by mischance , firedamp begins to burn within the gauge, it should in no circumstances be allowed to continue to burn. The examiner should shelter his lamp from the air current, hold it near the floor and retreat carefully to fresh air. If this is not possible, he should smoother out the flame by covering the air-inlet holes with a handkerchief.

PERCENTAGE TEST

In the usual testing procedure, known as cap test, the wick of the lamp is lowered until only a white fleck or a line in case of flat wick is left at the tip of the reduction zone. The lamp is slowly raised. The percentage of the gas present is indicated by the height of the cap produced by the burning methane, which is usually of a blue-grey color.

PROCEDURE-

- To conduct percentage test for methane with flame safety lamp, remove all bright light in the vicinity and switch off the cap lamp.
- Lower the flame of the lamp with the regulating knob till there is a continuous blue line across the top of the flame just above a speck of white light.
- This should be done at a place free from gas.
- When firedamp present in the air at the spot of a non-luminous flame (bluish) which varies in height depending on the percentage of the gas.

gas %	Minim. length of blue flame mm	Condition of Blue Flame
0.0	–	A slight cobalt-blue lined orange-yellow flame seen near the top of standard flame (flame length of about 2.5mm above upper edge of mouthpiece) A faint light is seen along cobalt-blue line.
1.0	7.0	Scarcely any formation of blue flame is seen as the flame colour is light and hence it is difficult to measure the length.
1.5	8.0	Blue flame becomes a little more distinct, especially the lower part turns somewhat clear.
2.0	9.0	Standard flame grows larger, and blue flame becomes distinguishable, but the top is invisible.
2.5	10.0	Colour of blue flame becomes clearer, but the top is still indistinct.
3.0	11.5	Top of flame becomes barely visible and blue flame seen clearer.
3.5	14.5	Blue flame clearly visible.
4.0	20.0	Blue flame becomes extremely clear and highly sensitive to a slight change of gas content.

LIMITATIONS OF FLAME SAFETY LAMP

- A normal flame safety lamp can not measure methane concentrations below 1.5% with any degree of accuracy.
- It is therefore quite inadequate to measure the statutory permissible concentrations in a mine for which more accurate methanometers have to be used.

2. Emission of firedamp in U/g workings

- Describe gradual exudation, blower & outbursts of firedamp in U/g workings.

EMISSIONS OF FIREDAMP IN UNDERGROUND WORKINGS

Firedamp implies a gas or a mixture of gases which in combination with air can cause an explosion. usually it refers to the gases exudent from the strata containing mainly methane (80-96%) with others minor contaminants such as nitrogen, carbon monoxide, ethane, ethylene & ocassionally carbon dioxide and sulphurated hydrogen (H_2S). Normally 10% of nitrogen , 5% of higher hydrocarbons & 3.5% of carbon dioxide maybe found in firedamp, though as much as 20% nitrogen and 50% carbon dioxide have been recorded.

Firedamp emitted coal beds is often saturated with water vapours. firedamp or methane entraced in coal seam and the adjacent strata is given of in three ways:

1. GRADUAL EXUDATION OF FIREDAMP
2. BLOWERS / FEEDERS
3. OUTBURST

GRADUAL EXUDATION OF FIREDAMP

- Slow emission from pores and invisible cracks in the coal and adjacent strata through their exposed surface. This is a continuous and prolonged emission.
- Methane is emitted cheaply by the process of slow exudation from the seam and adjacent strata when fresh surfaces of coal and other methane bearing formation are exposed during the process of working.
- The size of the coal produced has the great influence on the amount of gas emitted at the face.

BLOWERS / FEEDERS

- In the form of blowers from visible cracks and openings in the coal or rock. These are generally short lived, but sometimes continue for years.
- Blowers are common in Indian mines. A blower in Moonbdi(1971) lasted for 2 years and gave about 4 million m^3 of gas.
- Blowers are mostly found in places which have been folded or faulted.
- They may last only for few days but in some cases even for some years.
- Discharge of gas is maximum in the beginning and reduces gradually until the gas is exhausted.
- Blowers are extremely dangerous because they are met unexpectedly and may affect not only the individual gallery but even the whole district, filling it with the mixture of gas and air which feels suffocating as well as inflammable.
- Since blowers can be generally associated with geological structures, precautions should be taken when advancing towards such structure in a mine.

OUTBURST:

- Sometimes methane maybe given out from the strata in violent outburst which emits large volume of gas in a short time along with a lot of small coal & fine dust.
  e.g- once such outburst that occured in the valley field colliery in UK in 1911, cause the advance of a level of 3m upto a small fault throwing about 90tonnes of small coal & killing 3 men.
- Outbrust generally occured in the vicinity of area in the geological disturbances owing to the confined gas in the disturbed zones. As the confining pressure is released by a working approaching the area.
- Sudden fracture of overhanging roof and consequent crushing of coal is a possible cause of methane outburst.

3. Define fires & spontaneous heating

- Define incubation period
- Define spontaneous heating and its causes and effects.
- State preventive measures against spontaneous heating.
- Explain CO/O_2 ratio & CO_2/O_2 ratio.

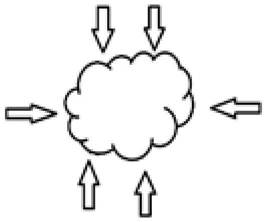
MINE FIRES & SPONTANEOUS HEATING

Spontaneous Heating

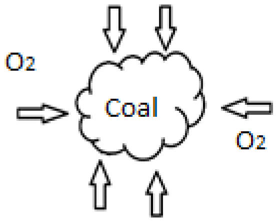
Spontaneous heating or combustion of coal or other carbonaceous matter may be defines as the process of self-heating resulting eventually in it is ignition without the application of external heat. The term spontaneous heating is generally use for coal.

How Spontaneous Heating Occurs

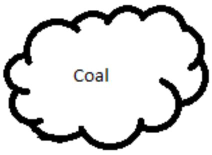
Exposed to air



Absorb oxygen

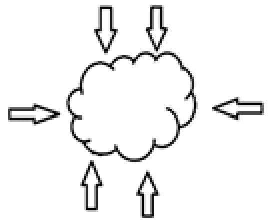


Formation of CO_2 and CO , water vapour. Evolution of heat during the chemical reaction.



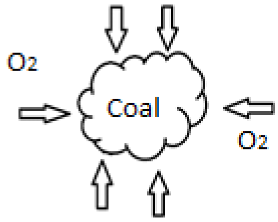
(Release of CO_2 and CO)

Gradual building of heat and slow rise in temperature.



(Oxidation is accelerated)

Temperature reaches the ignition point to fire the coal.



Causes of Spontaneous Heating:

1. Large quantity of coal left in the goaf .
2. Exposer of left over coal to air due to unsettled roof or incomplete stowing.
3. Presence of subsidence cracks and pot holes.
4. Leakage of air through parting of contigeous seam.
5. Air leakage through undogged surface bore holes over goafed and out pannel.
6. Entry of air through barrier with opencast working .
7. High pressure deferential across sealed goaf.
8. Extraction of coal beyond incubation period.
9. Fallen coal lying in old workings, poor ventilation not keeping the working isolated using coal as packing material in air crossing and cracks.

Gases Present in Mines.

1. Methane (CH_4)- Firedamp, Mars gas

2. Black damp- Excess nitrogen with Co_2
3. White damp- Co (Most poisonous gas)
4. Stink damp- Hydrogen sulphide (H_2S)
5. After damp- Mixture of Co, Co_2, H_2S etc (After blasting)
6. Nitrogen oxide- NO
7. Sulphur dioxide- SO_2
8. Hydrogen-H
9. Gob Stick- Air with Sulphur Dioxide

Factors affecting Spontaneous heating:

i. Chemical Composition of Coal

High moisture and high volatile coals are more susceptible to spontaneous heating (high rank coal) high carbon contain is less liable to spontaneous heating.

ii. Banded Constituent of Coal:

The bright bond (Vitrain & Clairain) are more liable to spontaneous heating as compare to durain and fusain.

iii.Friability:

Coal which is easily crushed and broken into smaller size is more liable to spontaneous heating than hard coal.

iv. Presence of Iron Pyrites:

Coal containing iron pyrites in diseminatted form is much liable to spontaneous heating.

v. Nature of Adjoining Strata:

If the adjoining strata contains sandstone, then it is more liable to spontaneous heating as the heat to oxidation of coal is dissipated fast. In case of shale, the thermal conductivity is one third of the sand stone.

vi. Depth of Seam:

The strata temperature and crushing effect of super incubation rocks of a coal seam increases with increasing depth. Both the factors accelerated the process of spontaneous heating.

vii. Thickness of seam:

Higher the thickness of coal seam, lower is the percentage of extraction, higher is the chances of spontaneous heating.

viii Geological Disturbances:

Fault plane and geological disturbances structure increases the chances of spontaneous heating.

Incubation Period:

This is the term to denote the period which elapses between the time when the coal is first subjected to conditions favorable for spontaneous heating and the time of indications of heating.

Preventive Measures/Precautions against spontaneous heating

During Depillaring:

- Depillaring with panels of such size that extraction can be complete within incubation period.
- Speedy extraction.
- Minimizing coal left in the goaf.
- Ensure regular fall of roof and goaf consultation by blasting the stooks/ribs left in the goaf.
- Proper stowing of Goaf.

Sealed Goaves:

- Good constructions, regular inspection and timely maintenance of isolation stoppings.

- Keeping low pressure difference across sealed off areas.
- Blanketing the surface above goaved panel.
- Regular air sampling and analysis to keep a watch and condition in sealed off area.

Unsealed Developed Workings:

- Simultaneous development and depillaring.
- Keeping old developed working isolated.
- Regular removal of fallen coal and thick stone dusting.
- Ensuring adequate ventilation.
- If the mine is to be worked by longwall method of mining without stowing, retreating longwall should be adopted.
- Main intake airway and main return airway should be kept as wide apart as possible to prevent air leakage.
- Sufficient ventilation should be provided at low water gauge.
- The entire to the panel should be minimum and provision should be made for construction of isolation stopping at the entries.
- Recesses should be cut in the advance in the roof, floor and pillar for speedy erection of isolation stoppings.
- Before sealing the extracted panel it should be heavily stone dusted.

CO/O_2 Ratio OR Graham's Ratio OR INDEX FOR Carbon Monoxide :

In any under ground coal mines , even at normal temperature some oxidation of coal takes place. In this process O_2 is consumed and CO is produced . This ratio CO produced / O2 consumed is known as Graham's ratio or Graham's index. The Ratio Indicates The Stages of Spontaneous Heating.

Graham's Index= $\frac{\text{CO Produced}}{}$ X100%

O_2 Consumed

- Graham's index is generally expressed as percentage(%).
- Graham's index for a mine remains more or less constant.
- If spontaneous heating occurs their is steady rise of the ratio with increase of temperature i.e. if the temperature of coal rises ,the ratio of CO produced to O2 consumed increased that means Graham's index increases.

  Graham's index= 0.5- Heating is certain
  Graham's index= 1.0- Serious heating approaching active fire.
- The ratio is also called CO/ O2 deficiency ratio.
- This ratio can therefore be used as guide to defect heating .
- To detect spontaneous heating, Graham's index for every depillaring district and air samples from sealed-off fire area is determined once a month by drawing samples of return air from depillaring district & air samples from sealed off fire area.
- If the successive tests show steady increase in ratio, steps shall be taken to determine the site of heating and to deal with it .
- In case of Indian coals the normal ratio for mines generally lies between 0 and 0.1%.
- Even a small steady rise to 0.5% may indicate heating. Over 1% serious heating, 2% or more active fire.

CO_2/O_2 Ratio OR Youngs's Ratio OR Respiratory quotient:

Respiratory quotient is the ratio of rate of CO_2 produced to the rate of O_2 consumed in breathing. The quotient implies unconsciousness due to CO_2 content.

4. Mine Explosion

- Describe coal dust explosion & fire damp explosion with their causes & prevention.
- State inflammability of coal dust & fire damp.
- Explain Coward's diagram.
- State prevention, suppression & treatment of dust.
- Describe sampling of dust in Mines.
- Stone dust barrier.

MINE EXPLOSION

An Explosion Is a Sudden Combustion Process Of Great Intensity Accompanied by release Of Large Quantiles Of Heat Energy And In Which Original Gas Or Solid Substances (Like Coal Dust) Is Converted Instantaneously Into Gasious Products.

- It Is Accompanied By Violence Of A Large Scale.

Explosion In Coal Mines Are –

- Firedamp
- Coal Dust
- water Gas

Firedamp Explosion:

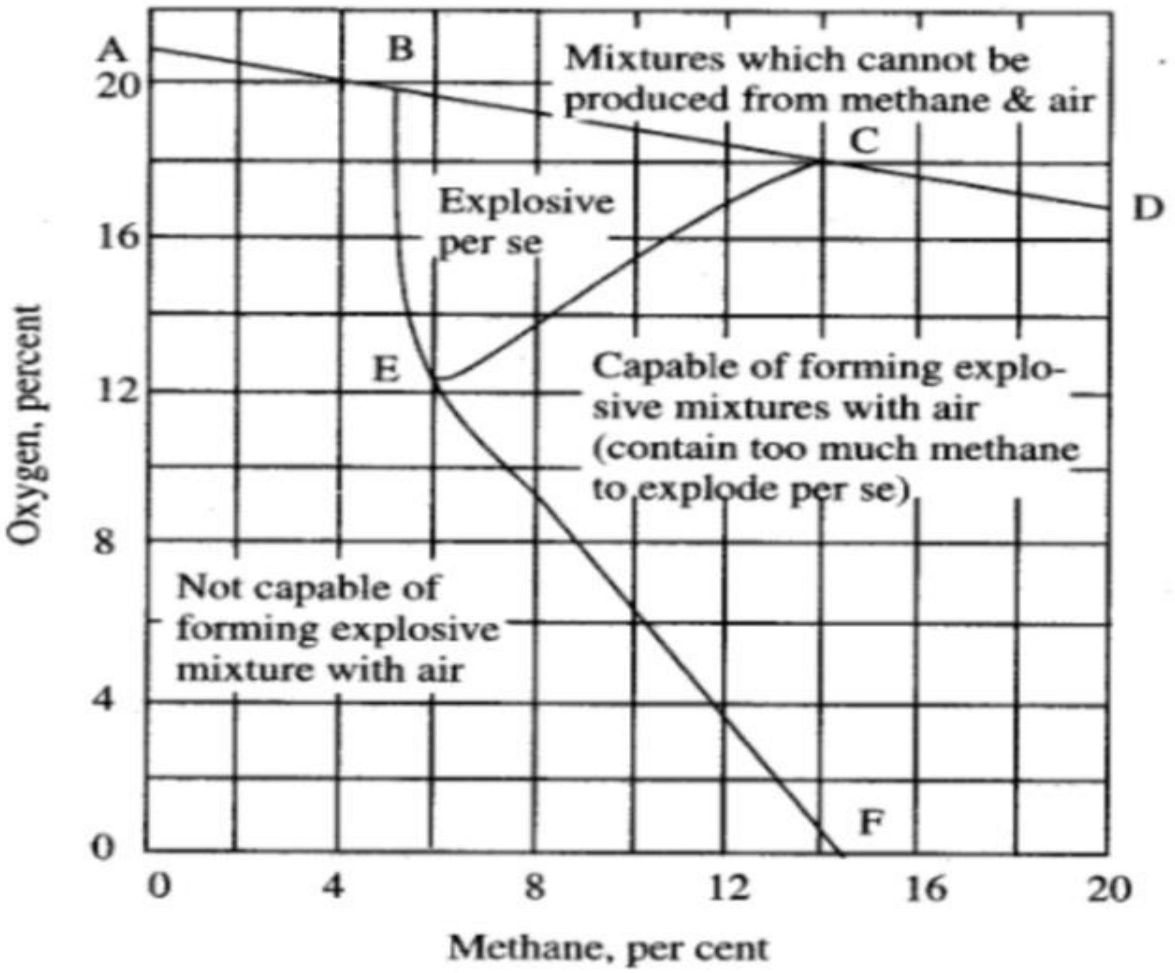
- Presence Of Firedamp In Air Between (5.4 To 14.8%) Form An Explosive Mixture.
- If A Suitable Source Of Ignition Is Available The Mixture Results In An Explosion.
- If Once Ignited The Mixture Will Allow The Flame To Be Self Propagated.

Inflammability Of Firedamp:

- When Methane Comes In Contact With A Heat Source Of Sufficient Intensity, it Burns.
- But When A Methane Air Mixture Air Mixture Contains 5.4 To 14.8% Methane, It Explodes, Once Ignited It Propagates.

- When Methane Content Is Less Than 5.4% It Doesn't Explode Because The Mixture Is Too Thin And heat Produced Is Not Adequate. This Is Know As Lower Limit Of Inflammability.
- Above 14.8% Methane (CH_4) It Doesn't Explode, Because The Mixture Is Too Rich In Fuel And Oxygen Present Is Not Adequate To Permit Rapid Propagation Of The Flame. 14.8% Is Know As Upper Limited Of In Flammability Of Methane.

Coward's Diagram:



- If Fire Damp Present In The Area Is Below 5.4% It Will Burn Away When Flame Is Applied To It . The Gas Is Then Combustible.
- If Gas Is Present In Air Above 5.4%, And If Sufficient Intensity Of Flame Source is Applied, Then It Will Cause The Mixture To Explode.

- The Figure Shows The Limits Of Explosibility With Different Percentages Of FireDamp And Oxygen

Form The Above Figure The Important Point are To Note Are-

- All Mixtures Lying Within The Triangular Are XYZ Are in Them Selves Explosive.
- All The Mixture Lying To The Right Of PYZ Contain Too Much Methane To Explode But They Will From Explosive Mixture When Mixed With The Right Amount Of Air.
- All The Mixtures Lying Left To The PYX Are Neither Explosive Nor Capable Of Forming Explosive Mixture With Air.
- Lower Limit Of Explosibility Remains Almost Constant At About 5.4% For All Percentage Of Oxygen Down To About 12.5%.
- The Higher Limit Of Explosibility Gradually Decreases From 14.8% To About 6%With Decreasing Percentage Of Oxygen.
- No Percentage Of Fire Damp Is Explosive When The Percentage Of oxygen Is 12%Or Less.
- A Firedamp Air Mixture May Become Explosive When Diluted With An Appropriate Quantity Of Air Which Brings The New Mixture With In The Triangle XYZ.

Significance Of Coward's Diagram:

- Coward's Diagram Is Significant When Sealing Of A Fire In A Gassy Mine And AlsoWhen Reopening A Sealed-off a fire in a gassy mine and also when reopening a sealed-off area.

Ignition Temperature Of Menthane:

- The Ignition Temperature Of Methane Is the Lowest Temperature To WhichMethane Air Mixture must Be Raised In Order To Set The Mixture Aflame.
- It Is Usually Taken As 650*c-750*c
- But Recent Investigation Have Show That It Is Not The Fixed Temperature And It Depends upon The Intensity of Heat Of Igniter, The

Methane Content Of Air ,The Various Impurities In Methane And The Pressure Under Which The Gas Mixture Is Confined.

Lag On Ignition:

- The Lag On Ignition To fire damp And Actual Moment Of Ignition Is The TimeInterval That Elapses Between Application Of A Source Of Ignition To Fire DampAnd the Actual Moment Of Ignition Of Gas.

Prevention Of Fire Damp Explosion:

- Avoiding Dangerous Accumulation Of Fire Damp Much Below The Lower Limit Of Explosibility.
- Avoiding Sources Of Ignition Which May Cause The Fire Damp Accumulation To Explode
  1. Proper Ventilation
  2. Regular Inspection
- In Degree -2 And Degree -3 Gassy Mines Where Electricity Is Used The Gas Should Be Less Than 0.8% .
- If It Exceeds 1.25% At any Time The Electric Supply To That District Should Be CutOff.
- If Electricity Is Used The Motors Switch Gear And Transformers Should BeProvided With Flame Proof Enclosures.
- If The Gas Emission Is Very High It Is safe Practice To Substitute Electric Power By Compressed Air Or To Arrange Methane Drainage.

Sources Of Coal Dust:

Major Sources Of Dust In Underground Mines Are Operation Of:
1.Coal Cutting
2.Drilling And Drilling For Roof Bolting
3.Blasting
4.Loading Of Coal
5. Transport Of Coal
6.Movement Of Mobile Machinery
7.Coal Handling Or Screening

Coal Dust Explosion:

- The coal dust when suspended in air as a cloud is capable of bursting in to an explosion and propagate it, even in the absence of firedamp .
- The coal dust to start the explosion, the dust should be in the form of cloud in the air, so dense that one can not see through it. The quantity amounts to 30-40 gm/m^3 of space .
- When coal dust explosion takes place it travels to practically all parts of the mine. Such circumstances generally exist after a firedamp explosion.
- The lowest temp. at which a fine dry coal dust cloud can be ignited and can cause the flame to travel throughout the dust air mixture is 700°c - 800°c.

Inflammability of Coal Dust:

- It may be defined as its ability to cause a flame to spread away from the source of ignition .Some coal dust are more inflammable than others.
- The lower limit of inflammability of coaldust is 1gm per CC (cubic cm) . But the higher limit is quite high and for Bituminous coal ,it is above 2000 gm /m^3 of space .

THE INFLAMMABILITY OF COAL DUST DEPENDS UPON THE FOLLOWING FACTORS –

1. Percentage of volatile matter
2. Fineness of particles
3. Percentage of inert or incombustible material
4. Percentage of moisture
5. Nature and intensity of ignition source
6. Percentage of firedamp
7. Age of the dust
8. Condition of dust distribution

Prevention of Coal Dust Explosion:

- Preventing production of coal dust in the mine.
- Wetting the coaldust as it is formed or sucking it out by dust extractor.
- Face and roof ,floors and slides up to 9m from the face to be washed and the accumulated coaldust to be taken out of the mine.
- Wetting the 'naturally wet' places by water in suck a motor that coal dust contains 30% of water in intimate mixture .
- Stone dusting
- Taking precautions to prevent firedamp explosion .
- Not lying electric cable in a haulage road.
- Preventing occurrence of blow out shot .

Suppression and Treatment of Dust:

At the face-

1. By water infusion
2. By use of water sprays on the coal cutting machines picks and shearer picks.
3. By the use of sharp picks on the coal cutting machines and shearer. Blunt picks produces more coaldust .
4. Use of gummer of the coal cutting machine keeps in collecting the dust at the one place and prevents it's dissemination in air at the face.
5. By selecting right type of explosives like Armstrong air breaker, cardox, hydrox etc. produces lumpy coal.

During Transport of Coal:

1. Coal tubs and mine cars should spillage proof.
2. Haulage track should be well laid to prevent derailment.
3. Belt conveyor should be properly aligned and so installed as to avoid spillage.
4. The fall of coal to the mine cars or tubs should be minimum.
5. Accumulation of coal dust should be removed at intervals below the conveyer rollers.
6. Water spraying at loading points, transfer points and over the loaded coal tubs helps in reducing coal dust.
7. Low velocity of ventilating air current to reduce formation of dust.

8. Dust at transfer points may be collected by the use of dust extractor.
9. Spraying or sprinkling stone dust.
10. Provisions of stone dust barriers or water barrier.
11. The recommended chemical like $cacl_2$,calsolene, oil, shell non ionic detergent 47-c, coalest x-5, and coalset for wetting dust of low moisture are also used.

Dust Sampling:

1.Sampling plan-

In every district return air ways up to 200m from the last face and all the haulage tramming and conveyor road ways shall be divided in sampling zones of 150m (or smaller). Each zones shall be divided into three sub zones a,b.c . Zones and sub zones are marked or a plan of mine working to a scale of 1:2000 to prepare a dust sampling plan .

2.Notice boards-

Zones and sub zones shall be marked in the underground working on notice boards .

3.Sampling interval-

- Sample shall be collected from every zones once in 30 days .
- Samples shall be collected from sections a, b or c in rotation such that during every period of 30 days, all samples are collected from section a, b or c .
- From all other road ways ,samples shall be collected once in 3 months.
- Samples shall be collected in a systematic manner ,but if no case with in 24 hours of cleaning dusting of zone.
- If there are 4 district in the mine work of one district shall be complete in 1 week.

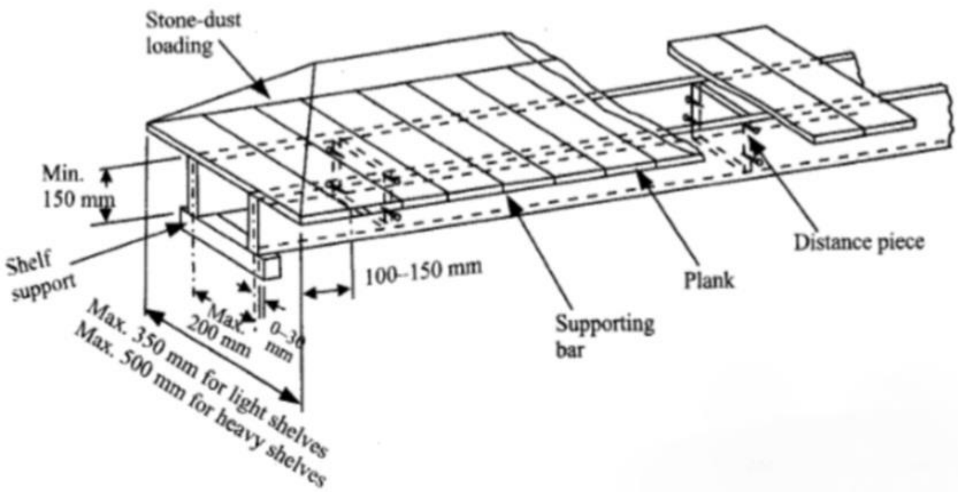
Procedure of Sampling:

- From zones treated with incombustible dust , samples shall be collected by the method of 'strip sampling' . In strips of about 10cm wide, at uniform interval not exceeding 5m .
- From zones treated with water, samples shall be collected by the method of spot sampling . A spot collection shall be made for every metre of length sampled, along a zigzag path .
- Depth of sampling; from roof or side maximum 5mm from roof or floor maximum 10mm.
- Each samples shall be thoroughly mixed and reduced to 30 gram by coning and quartering. It shall be sealed in a water proof container and levelled properly and send to laboratory for testing.

Record:

Within 7 days of sampling, resulting of sampling shall be recorded in the sampling resister and signed by sampling in charge the in charge shall be then put up to the manager for counter signature.

Stone Dust Barrier:



- Stone dust barriers are provided to prevent an explosion extending from one part of the mine to other.
- They are required in all seams of degree-2, degree-3 and development working of degree-1 seams in which there is likely would occurrence of inflammable gases (CH4) in dangerous quantities.
- A stone dust barrier consists of shelves placed side by side and each consists of planks placed one above the other and loaded with stone dust.
- These are placed on supports in the main roadways of an underground mine in such a manner that the planks collapses with the shock of an explosion there by causing the stone dust to disperse in air and form a thick stone dust cloud smothers the flame and prevents ignition and explosion of coal dust.
- Stone is provided in addition to the normal measures like coaldust wetting or stone dusting adopted in a coal mine to counter the danger of coal dust.
- If there is accumulation of fire damp in the roof a stone dust barrier may fall to arrest an explosion.
- The DGMS circular recommended adoption of “Polish” type of stone dust barrier.
- In this type of barrier, the stone dust rest on planks which runs longitudinal in the roadway and rest on a rigid frame. The frame (150mm depth) are rest on their edges on two fixed rigid brackets.
- Neither the frame nor the planks are fixed to each other or to the fixed brackets.

- According to the loading at the shelves and total quantity of stone dust on the shelves the barrier maybe ;

  Light also called primary or first barrier.

  Heavy also called secondary/second barrier.

- Light type barriers are intended for use nearest to the possible point of ignition. They are lightly loaded shelves not more than 35 cm in width.
- Heavy type of barrier are intended for use further from possible site of explosion which contains more dust.
- To ensure its successful operation, a barrier must be provided in shelves which collapse in the event of an explosion.
- For a light barrier, a roadway (3m x 3m) cross-section would need 11 shelves each with 100 kg of stone dust.
- If the same roadway is equipped with heavy barrier needs 16 shelves 200 kg of stone dust with 8 lightly loaded shelves each with 100 kg of stone dust.
- 1/3rd of the shelves comprising a heavy barrier should be lightly loaded shelves and the remainder are heavily loaded.

LOCATION OF STONE DUST BARRIER

- The stone dust barrier should be sited as near as potential source of the ignition.
- In the bord & pillar working, it is sufficient to provide a single barrier of heavy type at a sufficient distance from the face.Such a barrier should be provided at a distance of not less than 150m from the nearest working place and not more than 400m from the farthest place.
- The barrier shall be kept advanced to their new position when necessary .
- The heavy barrier will have to be provided with all the entries to the district.

- In case of longwall workings, a barrier of light type should be installed in all longwall belt conveyor roadway within 50-120m from the nearest point of the face.
- A second barrier heavy type should be placed further out by 200-350m from the face where there are more than one seams are worked from the same shaft. Heavy type barrier should be sited with the roads adjacent to the shaft landings at a distance of 100-150m from the landing .
- These barrier should as far as possible be so arranged that they are in the middle of a straight stretch of road at least 200m in length.

MAINTENANCE OF BARRIER

The proper maintenance of the barrier is the first importance. It should be the responsibility of a specially appointed competent person like ventilation officer to examine and maintain the barrier in the satisfactory condition for the purpose & the duties of the competent person should include;

- Examining once in every week all stone dust barrier.
- Testing the dispersibility of the dust by taking same in hand and blowing on it. If it shows a tendency to cake or consolidate, the dust in the barrier should be removed.
- Repairing in damage to the shelves and other parts of the barrier.
- Supervising the errection of new barriers as required.
- Writing a report on such inspection and required action to be taken. The report should be countersigned by the manager or under manager in the book maintained for such reports. Any defect in the stone dust barrier should be removed immediately. If this is not possible, shot firing should be stopped in the district. The barrier should be moved at intervals to ensure that they are maintained constantly with the recommended phase of distances at the recommended place.

- A bord should be provide near each barrier on which the following information is recorded;

- ➢ Cross-section of the roadway.
- ➢ Total dust loading of the barrier.
- ➢ Number and loading of shelves.
- ➢ Date of last removal of the stone dust.
- ➢ Reference number of the barrier.
- ➢ Date of last inspection.
- ➢ Signature of the competent person appointed specially for the maintenance of the barriers.

5. Mine Inundation

- State sources of water in mines & its danger.
- State precaution against inundation.
- Describe burnside safety boring apparatus.
- State precaution while approaching water logged area.
- Describe water dams- its construction & design. (Without derivation of formula)
- Explain water danger plan.
- Statutory provision for working near water body.

MINE INUNDATION

Q.What is Inundation in mine?

Ans: -The sudden inrush of water into a mine is called inundation.

SOURCES OF WATER IN MINES:-

UNDERGROUND SOURCES: -

1. Waterlogged old workings,goaf or sump.
    - In the same seam or section.
    - Lower seam or lower section.
2. At a place which is at higher levels from the present working.
3. Any other place in upper seam a fault passing through the new working.

SURFACE SOURCES: -

1. Flowing water- River, Canals, Jores
2. Standing water- Ponds, Tanks, Lakes
3. Accumulated waters in low line area, subsidence area & abandoned opencast mines.

CAUSES OF INUNDATION:-

1. The inaccuracy of old plan.
2. The lack of old plan.
3. Errors of judgement or neglect of precautions.
4. Unexpected presence of old shafts, bore holes or drift connecting old galleries full of water.
5. Unexpected variation in the throw of faults.

6. Encroaching intentionally or unintentionally of working in adjacent mines by crossing the common boundaries when the state of working of adjacent mines.
7. Sudden collapse of water bearing strata due to faulty method of working or insufficient roof supports.
8. Sudden bursting of a dam to hold water.
9. Conducting depillaring operation below or near a river, pond or tank.

PRECAUTIONS AGAINST INUNDATION:-

- Maintain a surface plan of the mine with contours and showing particularly low line area, water courses, bore holes, wells, dams, quarried outcrop zone, HFL of stream and rivers.
- Cut suitable drains around the periphery of the quarry & near the incline mouth to prevent inflow of rain water or surface water into the mine workings.
- Roof of the underground working should be covered up to 15m where the surface rocks are not well consolidated.
- When the waterlogged quarry or incline is present near a underground working leave a sufficient thickness of solid mineral more than 60m.
- If the strata above the mineral or coal bed are permeable and outcropping in a river or lake, caving method of depillaring should be avoided unless the mine has adequate pumping capacity.
- The surface cracks present due to caving method of depillaring may allow water into the mines through such broken ground. Adequate pumping capacity to deal with such inflow of rain water is essential.
- Leave sufficient barrier of solid mineral from adjacent mine from the rise side of the mine.
- The underground dams should be of adequate dimensions and well anchored in the floor and roof stones and in side to prevent leakage.
- If there is limited power or non-availability of pumps, during rainy seasons it is a good practice to keep in readiness pump foundation

in holding down bolts, so that the same pump can be readily dismantled and shifted to the rise side foundation and recommission without much loss of time.

- Do not make any working vertically below and within 15 metres of either bank of river, canal or boundary of a lake or tank without permission of the appropriate authorities.
- Observe the precautions made in the mining regulation when approaching waterlogged workings.
- During the rainy seasons, if the mine workings are near a river or lake, arrangement should be made for ringing an alarm in the attendance plot of his and other suitable points when the water level reaches a pre-determined level indicating approaching danger.
- From time to time and particularly before rainy seasons, the water danger plan shall be updated.sources of danger and precaution any measures shall be reviewed and inspected and corrective action shall be taken.

BURNSIDE SAFETY BORING APPARATUS

- It is a special boring machine for safe drilling of boreholes at any angle underground against waterlogged workings for;
  a) determining thickness of barrier
  b) tapping and draining water
  c) making advance holes when driving exploratory headings
- The machine is usually trolley mounted and in two units;

(1) Drive unit &

(2) drilling unit

- Construction and main parts of drilling unit are shown in the figure.
- Boring rods dia 38mm, length 1.5m(due to underground limitations) fitted in the front with 56mm Tungsten carbide tip bit.
- Reamer dia 110mm.

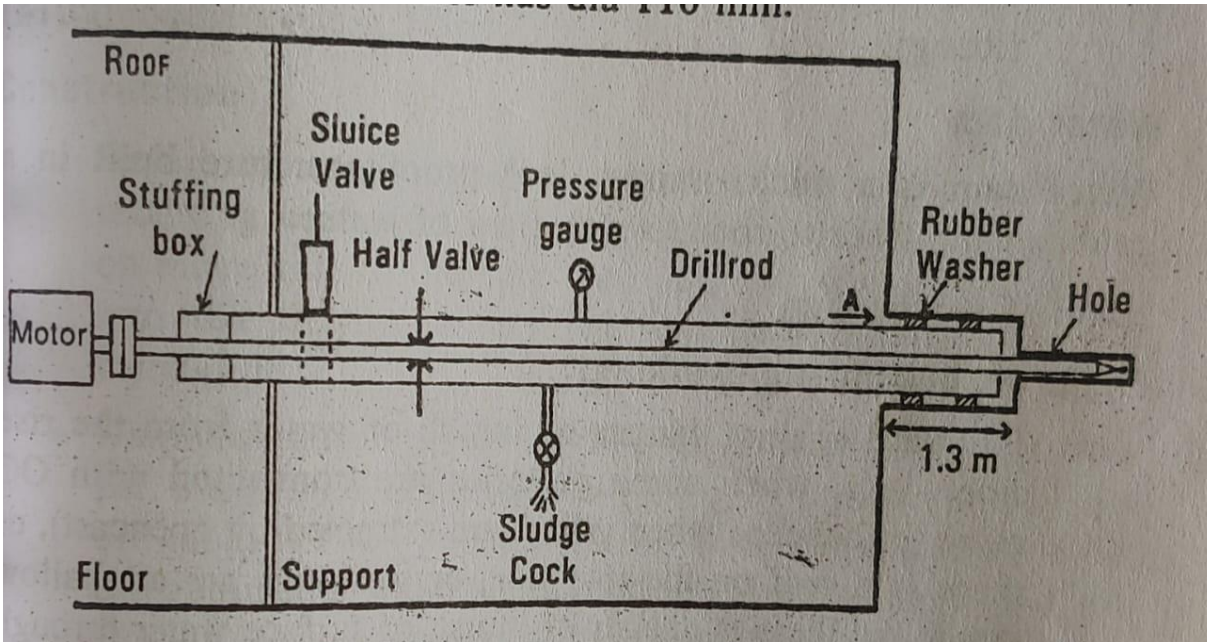


Fig : Safety Boring Machine

INSTALLATION AND WORKING:-

- A normal hole 56mm dia about 1.5-2 m long is drilled in the desired direction.
- First 1m is reamed to 110mm and a stand pipe is inserted and it is secured to the strata by rubber sealing bushes (anchoring buttons) and lightning bolts outside.
- To commence drilling (AW) drill rods are pushed in through the stuffing box and valves. On starting the motor, drill rods coupled to it rotate.
- As drilling progresses, more rods are added outside the stuffing box.
- Drill cuttings fall through the sludge cock.
- When water is tapped, the two-rubber faced clamp type half valves are closed to prevent discharge of water.
- Water pressure forces the drill rods out to expose a joint to detach a drill rod. Process is repeated until all drill rods have been withdrawn.
- Sluice valve through which rods operate is then used to stop or controlled flow of water.
- The safety boring attachment of the machine can shut off water at a pressure up to $45 kg/cm^2$ and average possibility of danger from water inundation.

- After the water is tapped, the full length of rods and drill bit can be withdrawn to outside and the stuffing box is unscrewed & then the drill bit can be withdrawn.

SPECIAL FEATURES: -

- Flow of water can be regulated, controlled, stopped when rods are in hole.
- Drill rods can be withdrawn and flow of water stopped on controlled while the bore hole is under pressure.

PRECAUTIONS WHILE APPROACHING WATERLOGGED AREA: -

1) Working shall be advanced strictly as per the layout approved by the DGMS as contained in manager's scheme.
2) Height and width of workings shall be as per the manager's scheme, but shall not exceed 2.4 m in any case.
3) Advance bore holes shall be drilled as per approved pattern using safety boring machine. There shall be at least one bore holes on each side, the centre of the working face & sufficient bore holes on each side, where necessary bore holes above & below at intervals of not more than 5m. The holes shall be constantly advanced to maintain a barrier at least of 3m.
4) If seepage of water not normal to seam is noticed, actions shall be taken as per the emergency orders. Workings shall not be advanced further; persons shall be withdrawn and information sent forthwith the manager.
5) Work shall be constantly supervised.
6) Record shall be kept in bound paged book kept for the purpose showing height and width of such workings, number of boreholes driven, diameter & length of each borehole, places at which bore holes are driven.
7) Other precautions;
    - Prompt and efficient support.

- Good ventilation up to the face.
- Frequent checks of CH_4, CO & H_2S.
- Use of safety lamp.
- Readiness of pumping arrangements.

8) Inspection of escape route. It shall be free from depression and shall have deep drains and handles.

WATER DAMS: -

Water dam is a thick, strong, leakproof structure built in a gallery from floor to roof to stop flow of water.

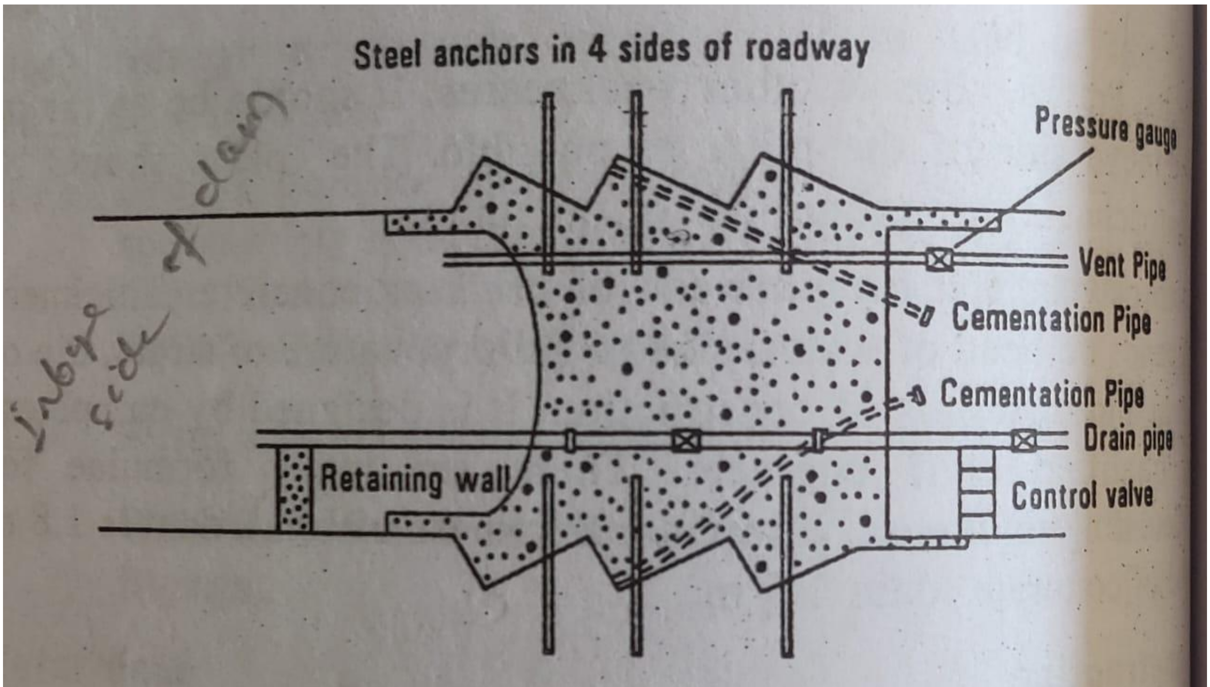


Fig : Plain Concrete Dam

Need of water dam: -

Dams are built in underground workings,

- To guard against danger of inrush of water from the rise side. (e.g. – when some galleries are connected with opencast working/mine or there is a goaf on rise side or working on the shallow depth and there is a danger of inrush of water through cracks and pot holes or there is inter-connection between upper seam likely to be flooded during rains.)

- To guard against eruption of water from adjacent old workings. (e.g. – when barrier is of inadequate thickness)
- To hold water during rains for pumping it out slowly in later months.
- To store water on the rise side for use as and when required.

LEGAL REQUIREMENTS: -

- 14 days prior to construct the dam, a notice is to be sent to the Regional Inspector giving details of position, design and construction.
- He may require amendments in the design.
- Dam is built under personal supervision of an Asst. manager or a graduate civil engineer.

SITE AND DESIGN: -

- SiTe of dam should be stable without danger of crush, free of faults, cracks, slip and other weakness. It should be as far on in bye side of the pillars as possible. The place should be approachable throughout life of the mine.
- Dam maybe flat or spherical of brick or concrete. Thickness depends on head of water, size of gallery, nature of strata, dip of seam and materials of construction. It is designed by competent and qualified civil engineer. There are many formulas for calculating thickness.
- Minimum thickness of brick dam is 1.8m and of concrete dam is 1.5m.

CONSTRUCTION: -

- Before constructing dam, the side is kept dry. A retaining wall 0.5m-1m height is built across the roadway or inbye side of the dam side and a drain pipe 75-200mm dia is passed through it.

- Dam foundation is cut inflow roof and sides manually as per the design and then dam is built. Several 30-50mm dia pipes are left in the dam for cement injection to make the appropment water type.
- Cement injection is carried out from bottom upwards to a pressure of 2.5 times of the expected water pressure.
- Drain pipe has several flanges so that the pipe is firmly fixed in the dam. A pipe of 20-25mm dia is placed through the dam near the roof for escape of air as water fills the roadway.
- It is fitted with a valve and a water pressure gauge. Roof and roadway of either side is bolted by girders.

ESSENTIAL FITTING: -

- Drain pipe (non-corrosive) of adequate size fitted with strong valve.
- Air vent pipe (20-25mm dia) with a stop valve; and,
- A check board.

WATER DANGER PLAN: -

- Water danger plan is a plan which shows all places that are waterlogged or become waterlogged.

It includes the following;

1. Position of mine.
2. Position of every bore hole, shaft, drift, every geological disturbance, subsidence area, fault plan etc.
3. Spot level of every junction of haulage roadway and at end of the headings (stratum control)
4. Every source of water such as river, jore, reservoir, waterlogged opencast workings lying within 60m of any part of the workings measured in any direction.
5. Surface contours at vertical interval not exceeding 5m (not exceeding 10m where there is no working below ground), over the whole area lying within 200m of any part of the workings.
6. Surface drainage system.

7. HFL (Highest Flood Level)
8. Reduce level (RL) of permanent benchmark.
9. Every goaf and pumping station, seam sections, every sump and water dams (with details of construction and reference of permission etc.)
10. Warning lines to draw the attention to danger of inundation by surface water, unconsolidated strata, water bearing strata & underground water.
11. Cross-section of river and water courses.
12. Inclined openings through opencast workings.
13. Statutory restriction line.

6. Mine lighting & illumination

- Define illumination and its units.
- Standards of lighting at different parts of mine as per mine regulation.

Illumination : The illumination, E, at a surface is measured in foot chandles or in meter candle (in the C.G.S. units). One meter candle is the intensity of illumination on a surface 1m distant from a source of one candela. flumination at a surface is inversely proportional to the square of the distance of the surface from the source of light, and directly proportional to cos 6 where gisthe angle between the normal to the surface and the direction of the light rays.

Ilumination of a surface (meter candle)

$$= (\text{Candela of source}) / (\text{distance in m})^2 \quad x \quad \cos\alpha$$

A meter candle is also termed a Lux .

The statement that the illumination at a surface is 4 meter candle implies that it is the same as if it were illuminated by a point source of four international candles placed at a distance of 1m from it. Light is the means; illumination the end effect.

Lumen (lm) ; This is the unit of light (uminous flux) emitted by a light source.

Lumens : emitted by a lamp = mean spherical c.p. x 4x

Lux: It is the unit of illumination in S.I. Units. A lux is an illumination of 1 lumen/m?.

The minimum amount of light required for reading, writing etc. is 10 lumen/m?, i.e. the light given off by 10 international candles at a distance of one m from the work. Much more light than this is required for reading without strain. In a factory in every part where persons are working or passing, illumination should be minimum 65 Lux.

Luminous efficiency is expressed in lumens per watt consumed and is from 10 to 20 in modern incandescent lamps, the higher values being for the larger lamps.

Reflection ; When light falls upon a surace, part of it is reflected and part absorbed. In the case of a transparent body majority of the light basses through. Only that part of light which is reflected is useful for illumination. A white surface is a good reflector of light and in underground mines, to improve the lighting effect, the following places have to be White-washed.

(a)everyshaft inset and shaft bottom or siding and every bypass which is in regular use.

(b) The top and bottom of every haulage plane, every regular top place, siding, landing, passbye and junction, except within 100 of the face ;

(c) every travelling roadway ;

(d)everyroom and place containing any engine, motor or other apparatus

(c) every first aid station below ground.

General lighting in mines : .

General lighting arrangements have to be provided in a mine at the followng places and if electricity is available the lights should be electric,

(a) On the surface at the pit top/incline top and in every engine roon if natural light is insufficient. .

(b) Below ground :

i)at every shaft inset and shaft bottom or siding which is in regular use.
ii)in every travelling roadway normally used by 50 or more persons during any shift.

iii)At the top and bottom of every self-acting incline in regular use.
iv) at every place on a haulage roadway, at which tubs are regularly coupled or uncoupled or attached to or detached from a haulage ; rope,
v) at every place at which tubs are regularly filled mechanically.
vi) at every room and place containing any engine, motor or other apparatus;
vii) at every place where any pillar is underey traction.
viii) at every first aid station below ground.

Every lighting fitting in underground coal mines has to be of flame proof design.

The standard of lighting laid down in Circular No. 14 of 1964 by thé D.G.M.S 4re as follows :

	Minimum average lumens/sq. ft
Pit bottom	1.5. to 3.0
Main junctions	1.25
Roadways	0.4
Haulage engines and control gear rooms	1.5

Flood lighting of depillaring areas (Deg. 1 gassy mines) 1.5 at floor level.

For depillaring areas Cir. 36 of 1969 by the D.G.M.S. recommends the following arrangements of lighting :

Deg. 1 gassy mines : Four or more 250-watt bulbs cluster if height of working in over 3m.

Deg. 2 or 3 gassy mines or mines having fire : Cluster of 15 to 20 cap lamps placed on a suitable stand, in addition to cap lamps for individual workmen.

7. Noise and Vibration .

- Explain the effect of noise & vibration on miners & mine structures & other surface structure with respect to statutory provision.

Noise

Hazard description

Exposure to noise levels exceeding those determined to be safe can result in noise-induced hearing loss. Exposure to high noise levels may also interfere with communication and may result in nervous fatigue with an increased risk of occupational injury. In opencast mines, workers are exposed to noise from many types of machinery, equipment and processes.

Assessment of risk

The competent authority should set standards for the maximum noise dose considered acceptable to prevent hearing impairment in the working environment on a daily basis and for the maximum peak noise level.

The assessment of risk should, as appropriate, consider the:

(a)risk of hearing impairment;

(b) degree of interference to communication essential for safety purposes; and

(c) risk of fatigue, with due consideration of the mental and physical workload and other non-auditory hazards or effects.

In order to prevent adverse effects of noise on workers, employers should:
(a)identify the sources of noise and the tasks that give rise to exposure to noise;
(b)seek the advice of the competent authority and/or the occupational health service about exposure limits and other standards to be applied;

(c) seek the advice of the supplier of processes and equipment used in the mine environment about expected noise emission; and

(d) if this advice is incomplete or in doubt, arrange for measurements by competent professionals in accordance with current nationally and/or internationally recognized standards and regulaions.

Noise measurements should be used to:

(a) quantify the level and duration of the exposure of workers and compare it with exposure limits, as established by the competent authority or internationally recognized standards;

(b) identify and characterize the sources of noise and exposed workers;

(c) create a noise map for the determination of risk areas; (d) assess the need both for engineering noise prevention and control and for other appropriate measures and their effect

(d) assess the need both for engineering noise prevention and control and for other appropriate measures and their effective implementation; ana (and control measures. evaluate the effectiveness of existing noise prevention

Vibration

Hazard description

Exposure of workers to hazardous vibration mainly comprises:

(a)whole-body vibration, when the body is supported on a surface that is vibrating, such as in vehicles or when working near vibrating industrial machinery; or

(b) hand-transmitted vibration, which enters the body K through the hands and is caused by various processes in which vibrating tools or work pieces are grasped or pushed by the hands or fingers.

Assessment of risk

If workers are frequently exposed to hand-transmitted or whole-body vibration, and obvious steps do not eliminate the exposure, the employer should assess the hazard and risk to safety and health resulting from the conditions, and:

(a) identify the sources of vibration and the tasks that give rise to exposure;

(b) seek the advice of the competent authority about exposure limits and other standards to be applied;

(c) seek the advice of the supplier of vchicles, machinecry and equipment about their vibration emissions; or

(d)if this advice is incomplete or in doubt, arrange for measurements by a competent person, in accordance with recognized standards and regulations and currently available knowledge.

Vibration measurements should be used to:

(a) quantify the level and duration of exposure of workers, and compare it with exposure limits as established by the competent authority or other standards to be applied;

(b) identify and characterize the sources of vibration and the exposed workers;

(c) assess the need both for engineering vibration control and for other appropriate measures, and for their effective implementation;

(d) evaluate the effectiveness of particular vibration-prevention and vibration-control measures;

(e)and if possible, determine the resonance frequencies.