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IIT(BHU) ,VARANASI STUDENT'S NOTES

MINE GASES

COURTESY:-MAYANK

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by ~~AHS~~

Properties of methane

CH_4 is colourless, odourless, tasteless and non-toxic gas. Mol. wt. 16. ~~Vatar~~ ρ at STP 0.716 kg/m³. lighter than air, ~~sq.~~ sp. gravity 0.559. slightly soluble in water 3.5% by volume at 1 bar and 293K diffuses 1.6 times as fast as air it is combustible and burns with a very ~~beatit~~ beautiful flame (blue) in air, but it is not a supporter of combustion and produces CO_2 & H_2O on being burnt.

$$CH_4 + 2\,(O_2 + 4N_2) \rightarrow CO_2 + 2H_2O + 8N_2$$

(1 in air, 10 in air)

It is is clear from eq. that proper oxygen balance occurs when CH_4 is 1/11 by volume or 9.5% by volume.

9.5% of CH_4 by volume is most explosive

It forms explosive mixture with air under suitable condition. Reaction gets self accelerated leading to explosion; this is the most hazardous character of methane. Particularly ~~in~~ all coal mines emit methane more or less.

Methane is responsible for several explosions inside mine.

Methane is lighter than air, so it accumulates at the roof, or roof cavity and rises in workings

Although methane is odourless, ...

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in some mines it is added with impurities and has characteristic odour like H_2S and SO_2. At ignition temp 650 – 750°C, this may be higher or lower than these limits depending on the type of ignitor that is source and method of ignition.

- Methane content air, presence of other impurities surrounding temp. and pressure, For eg, hot surface wire that are for igniting used in safety lamp ignite CH_4 at much higher temp. around 1200°C. This fact that with the quick heat ~~designation~~ dissipation by the wire gauge because of the surface area doesnot allow ~~the~~ to ~~the~~ rise to exhaust needed to cause explosion of the CH_4 outside the safety lamp.

- Methane air mixture ignites at 510°C when adiabatically compressed to 60 to 70 atmosphere in confined space, explosive pressure can reach upto 7 to 10 atm pressure. 7 to 8% methane mixture is most exactly ignited.

- CH_4 contact with hot source ignite with delay at 650°C. The delay is about 10sec. and at 1000°C it is 1 sec. Delay time diminishes with the increase of pressure. The delay b/w the ignition and application of heat source turn the lag on ignition. This is because of the fact that CH_4 start dissociating and burning only after a certain quantity of heat i.e. 92.53 KJ/mole. This property is utilised in dispensing safe ignition

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which produce very short duration flame. In presence of H_2 and other combustible gases reduces the lag so that in presence of 30% H_2 in the CH_4 completely eliminates the lag on ignition.

08/08/2012

Sources of CH_4

- CH_4 is commonly absorbed on the surface of microfissures and pores of coal while small proportions of it freely content.
- Absorbed gas is not released of pores. when coal is heated to 150°C.

and absorbed gas diminishes. CH_4 gas liberates from coal face broken coal from nearby seams from surrounding rocks.

- The ~~property~~ probability of encountering methane is more when working approach dyke, silt and fault or any geologically disturb-ed area or splitting of seams. Outburst of gas is followed by sudden emission of very large volume of CH_4 or CO_2. From strata with coal and coal dust from pores and cracks continuous emission of methane is observed.

As per Indian regulations % of inflammable CH_4 should not exceed 0.75% in the general body of air and 1.25% in

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any place in the mine. If CH_4 content exceeds 1.25% at the ~~f~~ working face electricity should be cut off. Short firing is prohibited locorunning discontinue main withdrawn from the mine other than safety lamp miners. Depending on gas concn. and liberation of CH_4 from the seams the collieries are divided into 3 categories as per coal mine regulations 1972.

① 1st Degree gassy seam — means CH_4% in general will not exceed 1% and emission rate does not exceed 1 m^3/ton of coal.

② IInd Degree of gassy seam — means CH_4% content exceeds 1% gas in general body and gas liberated more than 1 m^3/ton means (1-10) m^3/ton of coal.

③ IIIrd degree ~~coal~~ gassy seam — emission rate is more than 10 m^3/tone.

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Pressure of CH_4 in coal seams

CH_4 present in coal seam int two forms
① absorbed
② free

- free gas is present in pores & open cracks and forms only a very small portion upto 10% or less. of the total gas present in coal seam.

- In absorbed state most of gas is present only the internal surface of the coal in the monolecular layer due to very large internal surface area of coal it is upto 200 m^2/g. The internal surface area of coal bearing strata such as sand-stone and shale much smaller ~~as~~ and as such gas concn. in those rock is small.

~~A~~ Amount of free gas present in coal

$$Q_F = \frac{273 \eta P}{T P_0}$$

Q_F = free gas, m^3/ton

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η = total porosity . m^3/ton
P = absolute gas pressure in kPa
P_0 = atmospheric pressure (101.3 kPa)
T = absolute strata temp. (in kelvin)

Amount of absorbed CH_4

$$Q_a = \frac{abp}{1+bp}$$

Q_a = Quantity of CH_4 absorbed at given ~~temp.~~ pressure P and m^3/ton
a = Langmuir constant
b = Langmuir constant (1/p)

The constant a & b much more depend on T, moisture content and rank of coal.

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Types of Damps commonly present in mines :

The address of some of the gaseous impurities in mine atmosphere is known as damp to the miners. The word damp originated from the German word Dampf. Dampf meaning vapour, fog, fume or smoke. The common types of Damp met during mines

(i) Fire damp → ~~emission o~~ a mixture ~~(ii)~~ of CH_4 and air, it may be explosive depending of the composition of 5.42 to 14.8% CH_4 in air. Though CH_4 is not toxic its presence reduces the O_2 % in air. Normal human being can survive in 15% O_2 i.e. in an atmosphere containing 28% CH_4. Any further increase in methane will be danger to life.

(ii) Black damp → mixture of ~~ext~~ extinsive gases namely excessive N_2 and CO_2. It is also known as choke damp, Like fire damp the deep effect of black damp is mainly caused due to lack of O_2.

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(iii) Afterdamp → A mixture of gases left after an explosion of fire damp ~~are~~ or coal dust explosion, CO is the most ~~possible~~ toxic element in it. and death occurs mainly due to presence of CO in the event of mine explosion.

(iv) White Damp → A mixture of CO and air where the source of CO is other than explosion such as strata emission, diesel engine exhaust.

(v) Stink Damp → A mixture of air & H_2S is known as stink damp. It is more poisonous than even CO.

Role of O_2

properties → colourless, odourless and tasteless gas of sp. gravity equal to 1.105 i.e. slightly heavier than air, slightly soluble in

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water 5% by volume. It is highly active. It readily combines with large no. of gaseous elements & compounds. It is essential for all forms of life and combustions.

Reasons for O_2 deficiency in mines:

(i) By gradual oxidn of combustible substances like timber rocks and minerals like coal, pyrite.

(ii) Mine fires and explosions of methane air mixture and coal dust explosions.

(iii) The addition of mine gases such as CH_4, CO_2 in the mines due to release of such gases from strata and coal.

These were primary causes.

Secondary causes:

(i) Human breathing.

(ii) burning of flame safety lamps.

(iii) exhaust gases burning.

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Physiological effects of O_2 deficiency :

(i) Small deficiency — no serious effect.

(ii) Upto 17% O_2, breathing becomes faster and deeper.

15% O_2 — dizziness, buzzing in ears and rapid heart beat

13% O_2 — unconciousness after prolonged exposure

10% O_2 — unconsciousness in $\frac{1}{2}$ an hour, serious headache

7% O_2 — heavy banding, ~~pulse~~ palpitation, face turns red & blue, cells gets ~~dt~~ dulled and confused, rapidly leading to unconsciousness and finally death.

Low O_2 levels can causes shortness of breathe, mental retardation and death, 5 minutes of O_2 loss can cause complete failure of critical function of the brain to normal person.

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In people who are generally hypogic brain cells die ~~ex~~ after even shorter periods of complete O_2 lack (lag).

Decreased levels of inspired O_2 the lung disease occurs which decreases blood levels from the alveolies, causes low O_2 delivery to the tissues. This O_2 deficiency result in increased ~~metabolic~~ ~~aero~~ anaerobic metabolism. Instead of CO_2 and H_2O the end product of anaerobic metabolism are lactic and pyruvic acid, significant accumulation of these acids causes the intercellular pH to drop resulting in inactivation of enzymes and death of cells.

These are the effect of O_2 deficiency.

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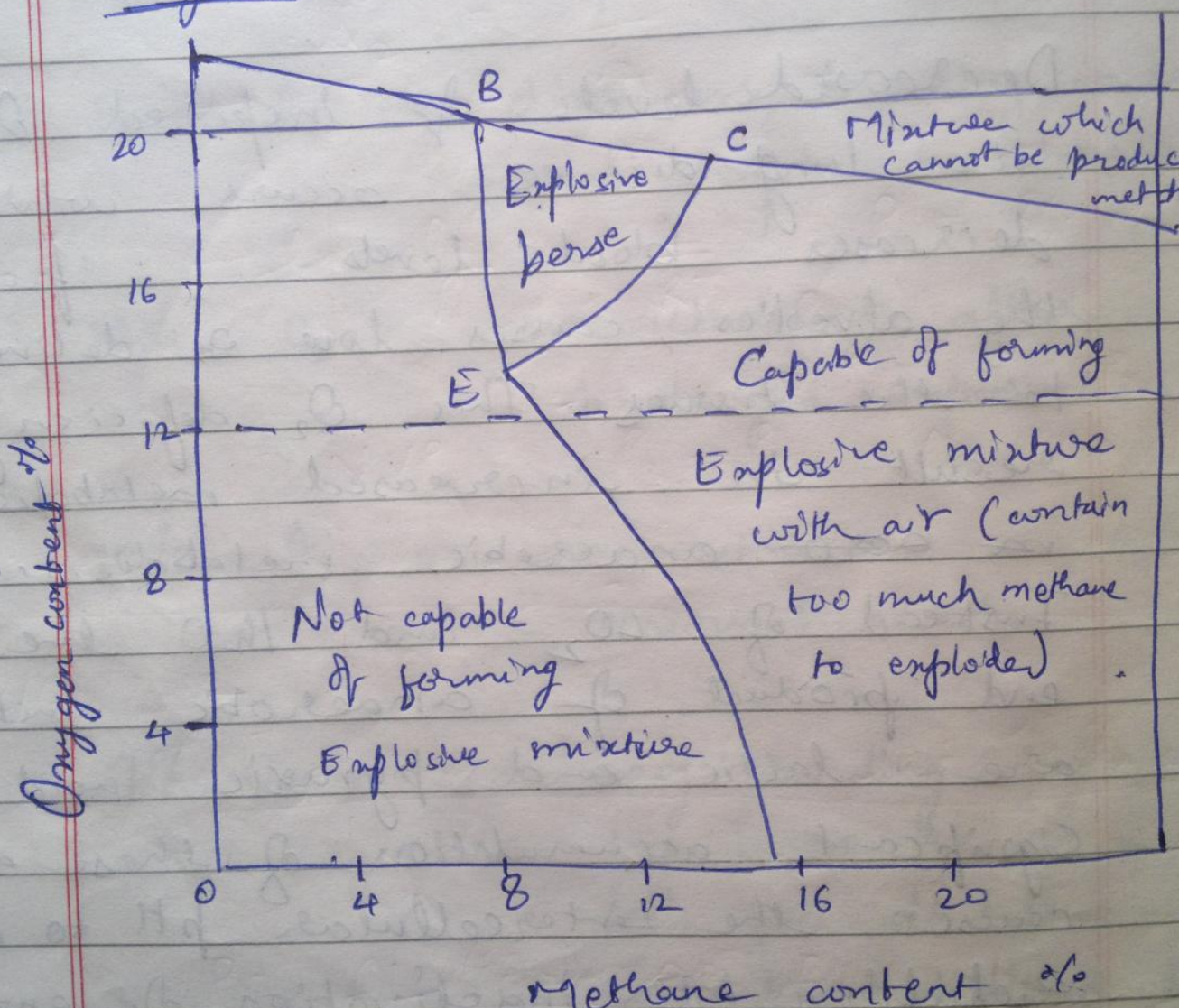
The effects of % of O_2 in air on the limits of explosability is shown in figure known as Coward Diagram.



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29/08/2012 (By AKS sir)

Discussion of Coward diagram

It is clear ~~that~~ from the Coward diagram that with the deficiency of oxygen, the limits of explosability narrow down and there is no explosion possible below an oxygen content of about 12%

There is no explosion possible below 12% whatever may be the methane concn. Similarly presence of excess inert gas like CO_2, N_2, water vapour also narrows down the explosability. On the other hand, the limits of explosability expand if CH_4 is associated with other combustible gases such as C_2H_6 & H_2. The explosability of CH_4 in air depends on the composition of mixture. In normal air the CH_4 concn upto 5% (4.8%) lead ~~more~~ no explosion though the mixture cannot burn also have above 14.5%.

Detection

Reduction of O_2 deficiency

The flickering of the flame of light of the flame safety lamp provide indication of low oxygen percentage.

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· Oil lamp → As a good warning of oxygen deficiency, & because of the regular fall of luminous intensity with the deficiency of O_2. Each one percent drop in O_2 content reduces the light ~~of Oil~~ from the lamp by 30%. In this ~~19% O_2~~

19% O_2 → luminous intensity drops to 2/3 of its normal air.

14-17% O_2 → flame extinguishes.

= Portable Oxygen indicators and monitors with warning devices such as ~~OSOR~~ OXOR can detect oxygen in the range of ~~0-25%~~ 0-5% with an accuracy of 0.2%. It gives an alarm when oxygen content falls below a ~~present~~ minimum value which is safer means.

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MSA electrochemical cells are available for oxygen detection in the range of 0-5%. It has short life. (about 6 months).

Russian portable detector → based on principle of oxidⁿ of copper by oxygen present in the sampled air. In the presence of NH_4Cl with excess of NH_3, the reduction in the volume of air sample after oxidⁿ and consequent vacuum created is indicated on a manometer which can be graduated in % of oxygen.

CO_2

Sources → Various sources of CO_2 are human breathing, slow oxidⁿ of coal, timber or any carbonaceous material. Burning of oil lamps, exhausts of I.C. engines, blasting fumes, action of acid water on carbonaceous rock, mine fires, mine explosions, emission from strata as in coal seams, spontaneous [illegible] of coal.

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Physiological effect → CO_2 when dissolved in water ~~a~~ forms carbonic acid, as the mucous membrane of eyes, nose, throat and whole of respiratory tract always remain watery. Presence of CO_2 in mine air could form carbolic acid on them. This could cause mild irritation. However at high concn of CO_2 say above 10%, there may be burning sensation on mucous membrane. In ~~human~~ breathing the ~~alveoli~~ alveolar ~~sacks~~ sacs facilitate the diffusion of O_2 from lungs to ~~do~~ blood and CO_2 from blood to lungs. The alveolar sacs in general contain 5.6% CO_2. If CO_2 content of alveolar air rises to 5.8% the breathing rate would be increased by two fold. Assuming there is sufficient O_2 an increase of CO_2 content in mine atmosphere to 3% ~~will~~ would cause doubling of breathing rate. At 10% CO_2, narcotic effect is produced and unconciousness would result within a few minutes. Normally this increase in CO_2 content in air % of O_2

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decreases and hence the physiological effect would be more severe.

05/9/2012

Nitrogen Oxides (NO_x)

NO_x nitrous fumes oxides of nitrogen occurs in 7 oxides form as ~~yello~~ NO, NO_2, NO_3, N_2O, N_2O_3, N_2O_4, N_2O_5. But from air-pollution point of view only two are important NO (nitric oxide) and NO_2 (nitrogen dioxide), these are in red brown colour, acidic taste, pungent smell, sp. gravity 1.59.

Sources : ~~high~~ Combustion of fossil fuels, oxidation of nitrogen compounds, that are chemically bound in the fuel molecules themselves. Forms inside mines due to heavy blasting operation, fumes of diesel exhaust and ~~mostly contain~~ explosive containing NG ~~where~~ undergoes combustion in place of detonation due to weak detonation. ~~and~~ detonation 63.2% CO_2, 31.6% Nitrous fumes are produced. On burning in drill hole 25.2% CO and 48.2% Nitric

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oxide. Small quantities also occur in exhaust gases of diesel engine; 0.1% of nitrous fumes besides nitroglycerine based explosives with oxygen imbalance produce nauxious fumes and excess of O_2 produces Nitrous fumes and deficiency → Nitrogen monoxide is produced.

Physiological effects

Nitrous fumes are very poisonous. Its poisonous effect starts after 3-4 hrs. Max^m tolerable limit for long exposure is 25 ppm. The man affected by nitrous fumes show immediate symptoms of cough, nausea, choking, perspiration headache and later develop serious bronchial troubles such as bronchitis, bronchopneumonia, which ~~can~~ may prove fatal within 48 hrs. Toxic oxides of nitrogen react with moisture to form nitrous and nitric acid in this manner, relatively small quantity of these gases may cause death by combining with moisture in the lungs and closing the respiratory passage

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∴ The death from exposure to the oxides of nitrogen may be very quick if exposure level is very high or may occur several days later as a result of pulmonary ~~od~~ edema or even weeks later as a result of infectious pneomonia. Industry environment small quantities of nitrous fumes causes growth of silicosis, NO can oxidize to NO_2 which can now react with hydrocarbon in the presence of sunlight to form photochemical smoke.

NO_2 also reacts with the hydroxy radicals (OH^-) to form HNO_3 which is washed out of the atmosphere as acid rain. ~~At an~~ At higher concn. ~~can~~ than normally found in atmosphere, →

→ ~~It~~ it is an acute irritant. Prolonged exposure to relatively low concns. has been linked to increased bronchitis in children and it can damage plants and when converted to nitric acid, leads to corrosion of metal surfaces.

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Nitrous fumes are highly poisonous; It is 7 to 10 times more toxic than CO. NO_2 is 5 times more toxic than NO. Person exposed to high concn. may not exhibit ill-effects for several days or weeks and fatalities may occur suddenly.

Nitrogen oxides combine with the haemoglobin of blood about 3 lakh times more readily than O_2 to form an extremely ~~any~~ stable compound, thereby reducing the oxygen carrying capacity of blood and fatalities may occur suddenly.

Detection

Almost all NO_x emissions in the form of NO which has no known adverse health effects at the concns. found in atmosphere. NO quickly combines with O_2.

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Tube type detector — Detects the % of nitrogen fumes by the help of change of colour in the tube. Filter paper soaked in starch and KI solution turns blue due to liberation of I_2 in presence of oxides of nitrogen.

Dragger uses diphenyl benzidiene as the reactant in the detector tube measurement and is detected in the range of 0.5 to 10 ppm, 2 to 50 ppm, 5 to 100 ppm. The reddish brown oxidn layer, containing a chromium compound and a yellow indicating layer of N-diphenyl benzidiene which changes colour to dark bluish grey in the presence of nitrous fumes.

Removal → Nitrous fumes are highly soluble in $H_2O(l)$ and can be effectively allayed by water spraying. Therefore use water sprayers before blasting. Use of a properly designed exhaust conditioner. The most effective means of drilling is nitrous fumes are to provide

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rapid dilution of exhaust gases with large quantities of fresh air to provide good ventilation.

12/09/2012

SO_2 (Sulphur dioxide)

It is a colourless gas with very suffocating odour, strong pungent smell. It is much heavier than air, sp. gravity = 2.264 and highly soluble in water. One volume of water dissolves 40 volume of SO_2 (1:40) at 293K; extremely poisonous gas, a concn. of 50 ppm (0.005%) is dangerous to life. A concn. of 0.015 to 0.019 % (or 150 to 190 ppm) is fatal within 30 to 60 minutes.

Sources: It is found in minute quantities in afterdamp in some coal mines but occurs abundantly in ~~com~~ some sulphide ore mines with fires.

Blasting in sulphide ore mines also produces SO_2. Explosion of sulphide dust which results from blasting

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produces large quantities of SO_2. Produced by oxid^n of sulphides or arise from the use of explosives containing sulphur.

Internal combustion engine exhausts (IC) ~~which is~~ It is formed in underground from explosives and burning of coal. Fossil Fuel combustion in power plant containing sulphur, significant non-combustion sources of SO_2 emission; from petroleum refinery, copper smelting, cement industry.

<u>Effect</u> : It is irritant like nitrous fumes; maximum permissible limit of concn. for prolonged exposure is ~~from~~ of 0.0005% or 5 ppm.

Concentration	Effect
0.321 ppm	Detectable by taste (acidic)
3 to 5 ppm	Detectable by odour
20 ppm	Irritation of eyes, nose and throat.
50 ppm	prolonged irritation of eyes, throat and [illegible] possible to

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400-500ppm ~~Nea~~ Immediately dangerous to life.

Sulphur dioxides are respiratory tract irritant. SO_2 affects the upper respiratory tract because of its high solubility in body fluids, SO_3 affects both the lower and upper respiratory tract and lungs because of its particulate droplet nature, carries it down into the deeper penetration into the respiratory tract.

Effects of SO_2 on the flow of air

In the respiratory system, can be ~~activated~~ aggregated by the presence of an aerosol such as NaCl.

Effect of SO_2 ~~on the~~ in presence of ~~A~~ aerosol which in itself has no effect is much greater than the effects of gas alone.

Aerosol probably absorbs SO_2 thus allowing deeper penetration of SO_2 in the respiratory

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Detection → Easily detected by its odour that are burning sulphur even at low concn. Tube type detectors using I_2, starch and KI potassium iodide as reagent are used for accurate determination. The Dragger tube type detector has a wide pre-cleaning layer of a copper compound to retain a blue indicating layer iodine / starch ~~to~~ which changes to white in the presence of SO_2, the measuring ~~length~~ range is 1 to 25 ppm.

Removal → Plentiful water spraying ~~in~~ eliminates SO_2

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Carbon monoxide (CO)

Odourless, tasteless, non-irritating gas, colourless and slightly lighter than air.

sp. gr = 0.97, with which it mixes easily. CO is not supporter of combustion but these combustible and explosive in the range of ~~7.5 to~~ 12.5 to 75% and at 30% it has the maximum explosion effect. Such mixture may be from following a mine fire or explosion. The temp. of ~~explosion 630~~ ignition is 630 – 810°C and burns with blue flame. It is not very soluble in water. 3.3% by volume at 0°C and 1 bar pressure. CO is not absorbed by charcoal or alkali which compose the absorbent of most gas mask. It may be oxidised by special catalyst such as hopcalite to CO_2.

Sources : CO may be formed inside mines due to many reasons. Some of them are : (i) In some coal mines coal seam may contain small quantity of CO and this is liberated with other

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gases mainly CH_4, N_2 and CO_2. Underground mine fire gas ~~caus~~ are coal dust explosion for formation of huge amount of CO.

(ii) Blasting operation : quantity difficult to determine such as detonation, Oxygen balance, generally 1 kg of explosive liberates 40l of CO at STP. In IC engine exhaust contains CO at different level of concn. Diesel engine produces several litre of exhaust per hp per minute = 200 - 400 ppm

(iii) CO is formed in mines as a result of uncontrolled combustion of substances such as timber and coal. Burning of a sinking timber frame, to under given condition and generate 95 m^3 of CO. And this can create totally poisonous atmosphere in a working of 10 m^2 in cross-section and more than 1km long.

(iv) 1 kg of coal dust of 75% carbon burning in a favourable condition can ~~yeld~~ yield of about 155 m^3 of CO. Small quantity of CO may produce from slow oxidation of timber

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03/10/2012

CO saturation in blood %	% Concentration (ppm) which can cause saturation level with time	Symptoms
10	0.004 (40 ppm)	Not noticeable apart from slight shortness of breathing upon muscular exertion. (exposure time 4-5 hrs)
20-25	0.012 - 0.014 (120 - 140 ppm)	Slight shortness of breathing and palpitation fatigue and ~~fit~~ feel like taking rest (exposure: 3-4 hrs)
30-33	0.028 - 0.04 (280 - 400 ppm)	Severe headache, irritability, quick fatigue, dulling of intellect. (exposure 3 hrs)

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40-50%	0.045 - 0.08 (450-800 ppm)	Intense headache, weakness, fainting upon exertion upto 1 hr
60-70%	0.1% - 0.112% (1000-1120 ppm)	Unconciousness with death after a time (30-40 min)
80%	0.16 % (1600 ppm)	Immediate death within 5 minutes.

Concentration of CO in blood depends upon

(i) Concn. of CO in air
(ii) length of exposure
(iii) type of activity during exposure
~~(iv)~~

Degree of saturation can be determined by

$$b = \frac{4ate}{PTD}$$

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where b = blood saturation by carboxyhaemoglobin as a %.

a = concn. of CO in air (in ppm)

t = time of exposure in hours

e = factor to allow for amount of activity taken as
1 at rest
2 at walking
3 ~~at~~ for moderate work.

Q. A man walks for 30 minutes in a CO level of 600 ppm. What blood saturation will evaluate.

Ans- $b = \frac{4ate}{100} = \frac{4 \times \overset{600}{\cancel{0.06}} \times 0.5 \times 2}{100}$

$= \frac{4 \times \overset{300}{\cancel{0.03}} \times 2}{100}$

$= \cancel{\frac{0.12 \times 2}{100}} \cancel{0.0024\%}$

$= 24\%$

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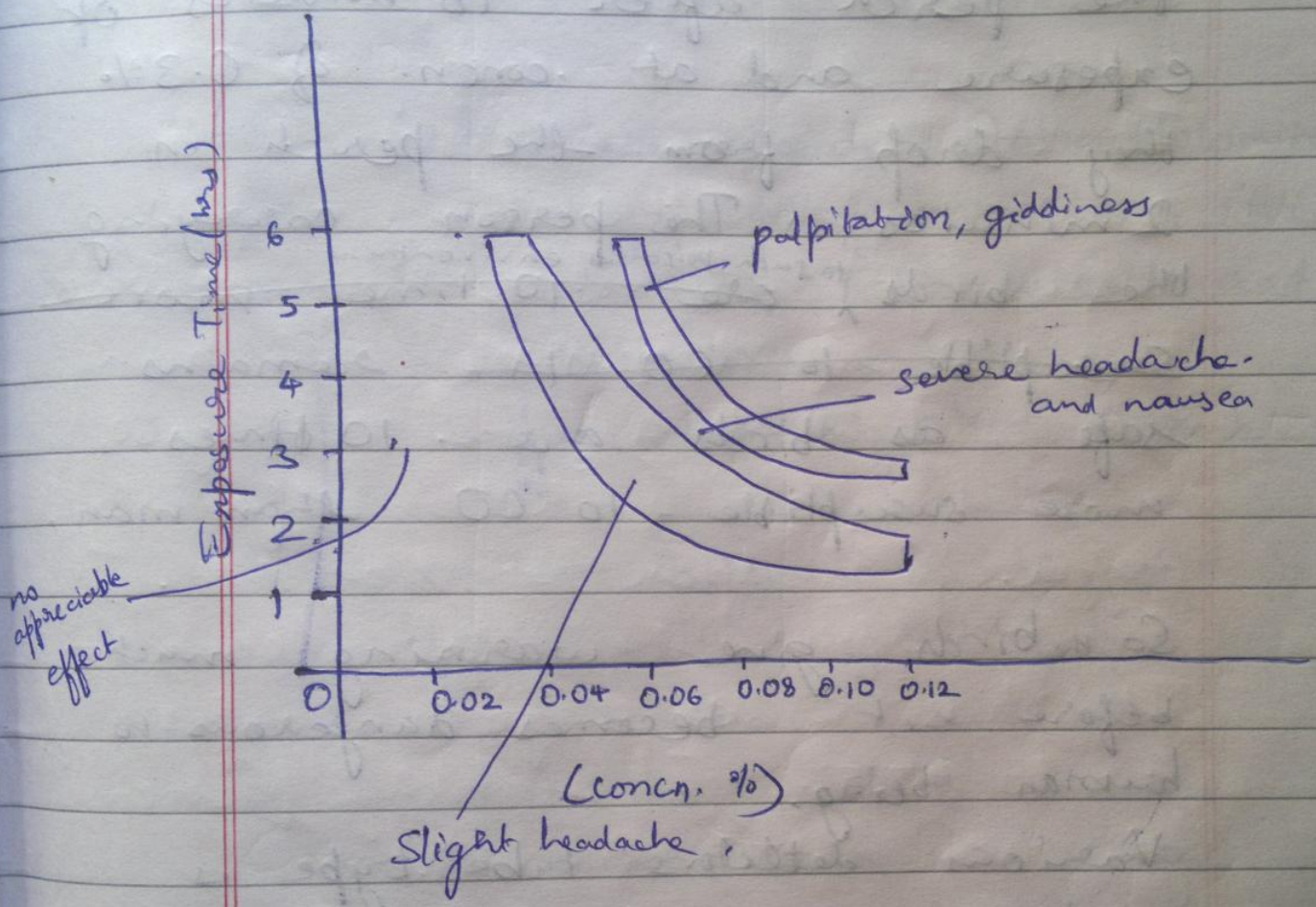
Toxicity of CO as a function of concn. and time



~~Reduction~~ Detection → Some birds like Canary, It is an European bird, In India it is called murail. These birds are very sensitive to CO gas. These birds by nature are very restless when they are carried in a cage to mine environment

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initially their movement decreases and they sit on the perch at a concn. of ~~0.05%~~ 0.15% CO the birds show distress in 3 minutes and they fall from the perch after 18 minutes of exposure and at concn. of 0.3% they drop from the perch in 2 minutes. The person carrying the birds to such poisonous environment ~~are 10 times more susceptible to CO th.~~ remains safe as birds are 10 times more susceptible to CO than man.

So, the birds give warning much before it becomes dangerous to human being.

Various detectors tube type is available for ~~in~~ detection of CO concn. In this MSA CO detector, also work on the principle of colour change of che. compound. ~~into~~. Unlike ~~drag~~ the other detector, MSA detector detects the concn. of gas by comparing the colour on chart by colour obtained.

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Date
Page

The colour chart is prepared for ~~0.1 to 0.6~~ 1, 2 and 5 squizzes of aspirator bulb of 50 cc volume.

The range of MSA CO detector is 10 - 1000ppm.

Various detectors mainly ~~Dolar~~ Holamite Tube detector, ~~NH_2~~ Ammonium, Platinum complex detector, P.S. Detector and Hopcalite Tube detector.
(Learn about these)

(Determination of gas will be asked in test)

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19/09/2012

Sulphorated Hydrogen or Hydrogen sulphide (H_2S)

It is also known as stink damp. It is colourless, has sweetish taste and smell like rotten eggs. It is slighty heavier than air. sp. gravity = 1.2. It is soluble in water. One volume of water being capable of dissolving $2\frac{1}{2}$ vol. of H_2S at 293K temp. It is combustible and burns with a light blue flame, giving SO_2 and water but with insufficient oxygen free sulphur is liberated. It doesnot support the life of combustion. It has wide range of exposibility 4.3 to 45.5%. It is highly poisonous gas even more than CO.

Sources : After damp and gob fires in coal mines. If the coal contains sulphur H_2S is a product of bacterial decay of animal and vegetable matter containing sulphur. It is expelled from coal by heat being one of the first gases to be given off, hence it frequently occurs in the atmosphere produced by gob fires.

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Sometimes found in solution in stagnant water in coal mine working due to the action of bacteria. In animal and other organic compounds considerable quantities of H_2S has been found in acidic mine water particularly if such water has been lying stagnant in poorly ventilated area. The gas being highly soluble in water is usually dissolved in the stagnant water. can be released in dangerous quantity by a slight disturbance such as fall of piece of rock into the water. Spontaneous combustion of coal containing sulphur methane blowers and outburst gives small quantities of H_2S. In metal mines due to action of acid mine drainage with iron pyrite gypsum decaying of timber or organic matter in water. Incomplete detonation and burning of blasting fuse blasting in heavy metal sulphide ores. It is given off from blasting of certain explosives. These are the sources to which H_2S gas occurs in mine.

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Effect: It is poisonous in nature maximum elongable concn. for prolonged ~~explosion~~ exposure is 10 ppm.

Concn and symptoms:

(i) 50 to 100ppm effects a person in 1/2 an hour. Irritation in eyes and respiratory tract.

(ii) If concn. is 100 to 200 ppm loss of order after explosion of 15 minutes.

(iii) 200 to 700 ppm increased eye irritation headache, diziness, nausea, dryness and pain in nose, throat and chest.

(iv) 700 to 1000ppm — unconsciousness and death in 30 min to 1 hour.

(v) 1000 to 3000ppm — rapid paralysis of respiration and death in few minutes.

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Detection of H_2S

Presence of H_2S can be easily detected by the typical odour of rotten eggs even at very low concn. 0.025 ppm. However the odour may not be detected at high concn. say over 100 ppm as the sense of odour is impaired.

Filter paper soaked in lead acetate solution initially turns brown and subsequently to black by H_2S action.

Dragger multi gas detector can detect hydrogen sulphide MSA H_2S detector work in the line of dragger operators. The detector tube is packed with white granules of activated alumina coated with silver cyanide where mine air is drawn through detector tube by the aspirator bulb. The white colour compound change to grey black in presence of H_2S. A scale is provided to read the concn. of gas. directly by measuring of length of colour change portion in the detector tube then squeezes of the aspirator bulb of 60% to be applied before measuring the concn. The range of apparatus is (0-400 ppm)

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10/10/2012

Detection of CO

CO requires very sensitive instrument for its detection. We can develop personal CO monitor model EC-800 weight 350 gm, LCD digital readout, Principal of operation is by oxid^n of CO and the heat of oxid^n generates signal for detecting its presence.

GFG → This instrument uses the principal of che. absorption technique of CO determination. CO is also monitored by Unor-1 and Unor-2 utilising a technique for infra rays for detecting the gas. The instrument ~~exp~~ extremely sensitive and not suitable for use inside mines.

Sensors used for detection of CO are

→ electrochemical type → In this chemi-absorption.

→ semiconductor type → ~~a chemical sensor~~

→ and chemical sensor stain Tube type [illegible] Iodine Pentoxide, Palladium chloride are

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used.

→ Catalytic oxidation → In this Hopcalite

- Stain tubes ~~were~~ are extensively used for determining the content of CO in general pit area. Its range is from 10 - 1000 ppm.

→ Property of blood turning pink by absorbing CO has also been used for testing the ~~air~~ gas.
The air containing CO is drawn through a light ~~straw~~ coloured solution of blood and ~~a~~ the colouration produced compared with colour-chart calculated for different concn. of gas.
Accuracy → 0.01 to ~~0.02%~~, 0.2%

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CO detector tube

Detector tube containing a suitable gel such as alumina, silica gel ~~from~~, ~~ie~~ pumice stone, ~~& intergated with~~ impregnated with a chemical which react with CO of the mine air to produce ~~at~~ a colourimetric chain. The estimation of % of CO can be — ~~Distinguishing of the~~

on the basis of matching the change in colour with standard set ~~calculated~~ calibrated against the % of CO or noting the length of tube over ~~of~~ which the change of colour occurred.

The ~~det~~ detector tube are sealed at both ends and can be kept for 2 yrs in this condition. During use, seals are broken and mine air is drawn through the tube by means of 1 to 10 squeezes of aspirator. Having an air displacement of (150 – 200 cm^3)

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Hoolamite Tube — This consists of a glass tube filled with iodine ~~pentoxide~~ pentaoxide and ~~fum~~ fuming sulphuric acid (containing 40% of sulphur trioxide in sulphuric acid solution) soaked in pumice stone a known vol. of air is sucked through the tube by operating a rubber aspirator. The iodine pentaoxide liberating I_2 and the grey colour of the reagent in tube turns green, brown or black depending on the concentration. The concn. of CO is obtained by comparing the colour produced with standard colour chart. range ~~from~~ for this is 0.1 to 1% and not sensitive to lower concn.

MSA CO detector

or Ammonium Palladium complex colourimetric detector. A glass tube containing ~~L-O~~ yellow silica gel impregnated with

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Palladium sulphate and ammonium molybdate

Mine air is drawn into the tube by an aspirator bulb.

The CO in the air reacts with NH_4Pd complex producing oxides predominantly that of the molybdenum which turn the yellow colour to sets of green depending on the concn. of CO.

Range 0.01 to 0.04%

Sensitivity → 0.001%

P.S. Detector

Large tube containing silica gel impregnated with light yellow potassium palladium sulphide.

CO in air turns light yellow potassium palladium sulphite to brown and the ~~yellow~~ length of staining for one end of the tube indicates its concn.

The instrument can readout a concn. of 0.005% CO with an accuracy of ± 20% of the reading

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Hopcalite Tube detector

Based on the generation of heat on the conversion of CO to CO_2. It consists of analysing cell containing Hopcalite a specially prepared mixture of MnO_2 and CuO. The air is drawn into the cell by a hand operated pump. CO in air can be catalytically oxidised by Hopcalite and ~~slight~~ the rise in temp. so produced is recorded by the thermocouple connected easily to a meter which is calibrated in the % of CO. The instrument can read 0.005 to 0.015 %.

Ecolysers

It works on the principle of electrochemical cells that produce electric current in presence of CO.

Ecolyser Model No. 210 is very light in weight only 340 g. It has a wide range from 0.01 to 1999 ppm with a

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sensitivity of 1 ppm. It is a safe ~~of~~ apparatus for ug mine use. It is also incorporated with a gas testing facility for in accessible places.

Besides, Hydrocarbons are also emit in mines through diesel engine. Exhaust is the main source of hydrocarbon in mines. Unburnt hydrocarbons are of two categories:

→ Light fraction is mainly unsaturated hydrocarbon that are responsible for the aroma.

→ Heavier fraction is mainly saturated hydrocarbon i.e. responsible for forming smoke

Hydrocarbons are coughing. They are carinogenic i.e. can cause cancer,

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31/10/2

Methane Drainage

It is a process of removing the gas contained in coal seams and surrounding strata through pipelines. It is the only positive and reliable method of controlling high gas emissions in mines. When the gas content of the seam exceeds 8 m^3/ton the pre-drainage or advance-drainage ~~is required~~ of gas is essential for intensive and efficient mining techniques to be effective.

When the gas emissions into the mine from a seam exceeds 16 m^3/ton of coal mine then a general gas drainage system incorporating drainage of the goaf area becomes essential to control gas emissions in mines. This drainage is also known as Post-drainage.

Advantages of Pre and Post drainage:

1. Increased safety and reduced risk of ~~e~~ ignition and explosion.
2. Seams which are liable to be outburst can be ~~d~~ pre-drainage [illegible] the risk of

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outburst.

(3) Increased production as a result of fewer stoppages due to the gas percentage exceeding statutory requirements. Because mining activities need not to be slowed down or even completely stopped for a while to let the gas bleed from the frontly exposed area.

(4) Lower air volume flow rate requirement resulting in lower ventilation cost.

(5) Decreased air velocities at the faces resulting in lower dust concn. at the faces.

(6) The methane gas drainage at can be utilised as a source of power which pays back many times the cost of drainage. Due to High calorific value 33.4 MJ/m³ and 11.1 to 24.2 MJ/m³ for goaf gas.

(7) Pre-drainage has been shown to improve the roof conditions in certain mines as a result of the destressing of the coal seam due to contraction of the coal after desorption of gas.

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(8) The long advance bore holes used in pre-drainage help in the exploration of areas and in the location of the geological disturbances.

Disadvantages:

(1) Cost involved in setting a drainage system and on-going cost of drilling piping etc.

(8) Pre-drainage of gas from coal seams

Conditions of use:

(i) The Pre-drainage of gas from coal seams is adapted in case where high gas emissions during the development of headings and at the longwall results in stoppages at the face or in seams where outburst of gas and coal endanger workers and materials.

Methods adapted:

i) Advance drainage

ii) Lateral "

iii) drainage from upper and lower lying seams.

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iv) drainage from surface bore-holes.

(i) Advance drainage

It is practiced where high gas emissions are experienced in the drinage of the first exploration. Holes are drilled to protect the heading under development and are placed at a low angle and maintained a head of the face. ~~to~~ This helps to divert the movement of gas away from the face into the bore-hole. The length of the holes can vary 25 to 100 m at and the diameter of the holes is usually limited to 100 mm.

(ii) Cross measure Bore Hole Method

(i) Common method where cross-measure bore holes are drilled from roadways in a working seam usually the tail gate from an advancing longwall face.

(ii) The holes are drilled either

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upwards or downwards the former being more common because methane usually accumulates in the bed-separation cavities in the roof of the seam and ~~this~~ is driven out of these cavities at the roof breakes and collapse.

(iii) The holes are inclined dependi-ng on the dip of the strata. In flat seams the inclination is generally at an angle of 50°-60° from the horizontal over the waste. and inclination ~~45~~ less than 45° ~~of~~ produces less gas causes greater dilution of the gas and increases the chances of jamming of bore-~~holes~~ roads in the coal. Sometimes good results have been claimed ~~whi~~ with holes ~~have been~~ inclined towards the face but such holes have been found to ~~give~~ yield more diluted and smaller quantity of gas in British coal mines. Placing of bore-holes should normally be in the return

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since the ventilation pressure drives the gas in the goaf towards the return airway. Sometimes the dip of a seam may affect the natural flow of methane towards the rise side of the face besides the haulage in the ~~f~~ intake makes it difficult for the bulky drill to operate due to lack of space.

(iv) Bore holes should not be too close to each other nor too ~~fars~~ apart for adequate ~~drain~~ drainage.
Diameter of bore-holes → 65-90 mm
spacing b/w holes → 20-30 m.
Length → 15-100 m
(commonly 30-45 m)

(v) The length of Bore-holes depends on the presence of superjacent gas bearing seams which have to be intercepted for drainage. when such seams are present

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long holes do not have advantage as at greater heights ~~besides~~ the size of bed separation & cavities and quantity of gas accumulated in them becomes to measure. The holes are started out with a dia. ~~diam~~ length of 115 mm and column pipes 10 m long and 90 mm diameter are ~~d~~ cemented to them before they are drilled to full length.

The holes for methane drainage need special drilling machines capable of drilling long holes of large diameter cheaply. There is no definite relation b/w the face advance and the emission of methane from a bore-hole but ~~the~~ usually the rate of gas emission rises for the first 2 weeks until a maximum is reached ~~until a~~ at a distance of 30-50m from the face after which the rate of emission falls. A suction of less than 100-1000 Pa is necessary to drain the gas.

(Refer fig. on next date)

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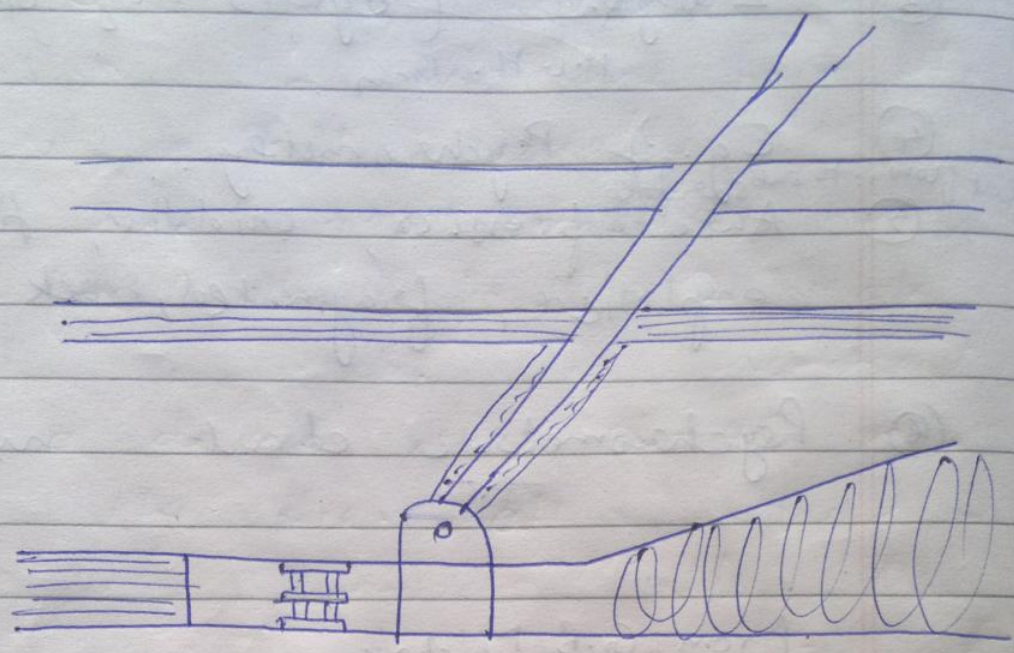
7/11/2012 (By AKS sir)

(Methane drainage)



Cross - Measure borehole method of methane drainage.

(Related to previous lecture)

Hirschbach Method

In this method headings with cross-sectional area of 5 to 7m² are driven at a height of 20-30m on the top of the working seam. They are so positioned that their vertical projections lie mid-way b/w the gate roads in the working seam. It is better to locate

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the drive in the coal seam 0.3-0.4m in thickness if such seam is available otherwise they may be driven in stone. However, to effect the economy and already existing drift are one driven for some other purpose may be chosen for methane drainage.

(i) First, both along the seam and cross-measure bore holes are drilled from these headings, Then the headings are sealed at the outlayer end by dams ~~to~~ through which pipes are laid

(ii) Second, methane is drawn from the headings through these pipes applying a suction of 2-3 KPa.

(iii) Although, it is costly method in comparison to cross-measure bore-hole method but due to high yield may be preferred.

(iv) Driving and drilling operations are done outside the seam and hence do not interfere with normal mining operations. ~~for~~ For retreating long wall and bord and pillar workings it is only the suitable method.

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(v) There is no definite relation b/w the face advance and the emission of methane from ~~the~~ a borehole. But usually the rate of gas emissions rises ~~from~~ for the first 2 weeks until a max. is reached at a distance of 30-40 m from the face. After which the rate of emission falls. As suction of less than 100-1000 Pa is necessary to drain the gas. The usual suction ~~the~~ being 1000-1500 Pa. The suction should be high enough to overcome the friction of pipe ranges but at the same time should not be so high that air may leak into the goaf and dilute the methane.

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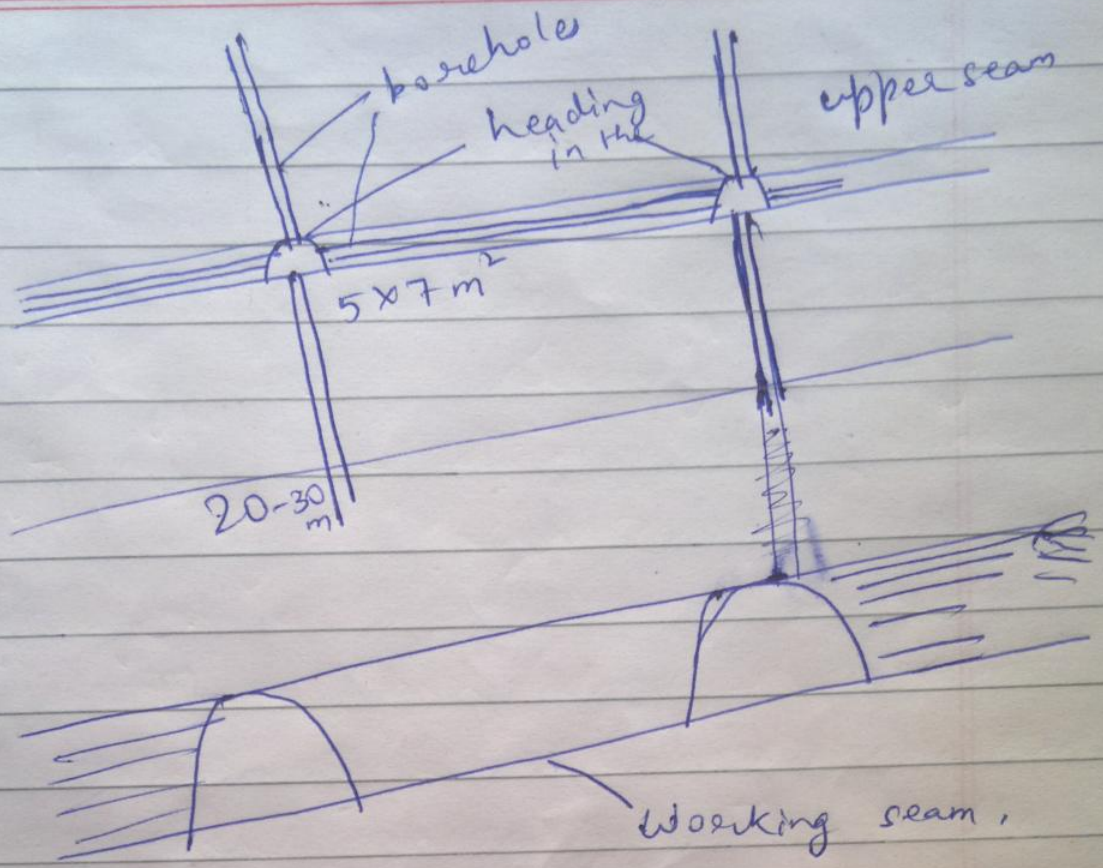

(Syllabus completed).

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